Bilberry Creek 2023 Catchment Report

Catchment Features

Area	13.1 square kilometres 0.31% of the Rideau Valley watershed
Land Use	0.28% agriculture 62.08% settlement 7.60% forest 3.50% meadow 24.06% transportation 0.33% water body 2.15% wetlands
Surficial Geology	77.04 % clay 1.76% organic deposits 11.94% sand 2.64% Paleozoic bedrock 13.68% diamicton
Watercourse Type	2023 thermal conditions **cool-warm** to **cold-cool**
Invasive Species	Twelve invasive species were identified in 2023: banded mystery snail, bull thistle, common buckthorn, curly leafed pondweed, garlic mustard, glossy buckthorn, Himalayan balsam, honey suckle, Japanese knotweed, Manitoba maple, purple loosestrife, wild parsnip.
Fish Community	Thirty-four fish species have been observed from 2009 to 2023; game fish species included: black crappie, bluegill, brown bullhead, burbot, channel catfish, largemouth bass, logperch, northern pike, pumpkinseed, rock bass, sauger, silver redhorse, smallmouth bass, walleye, white sucker, yellow bullhead and yellow perch

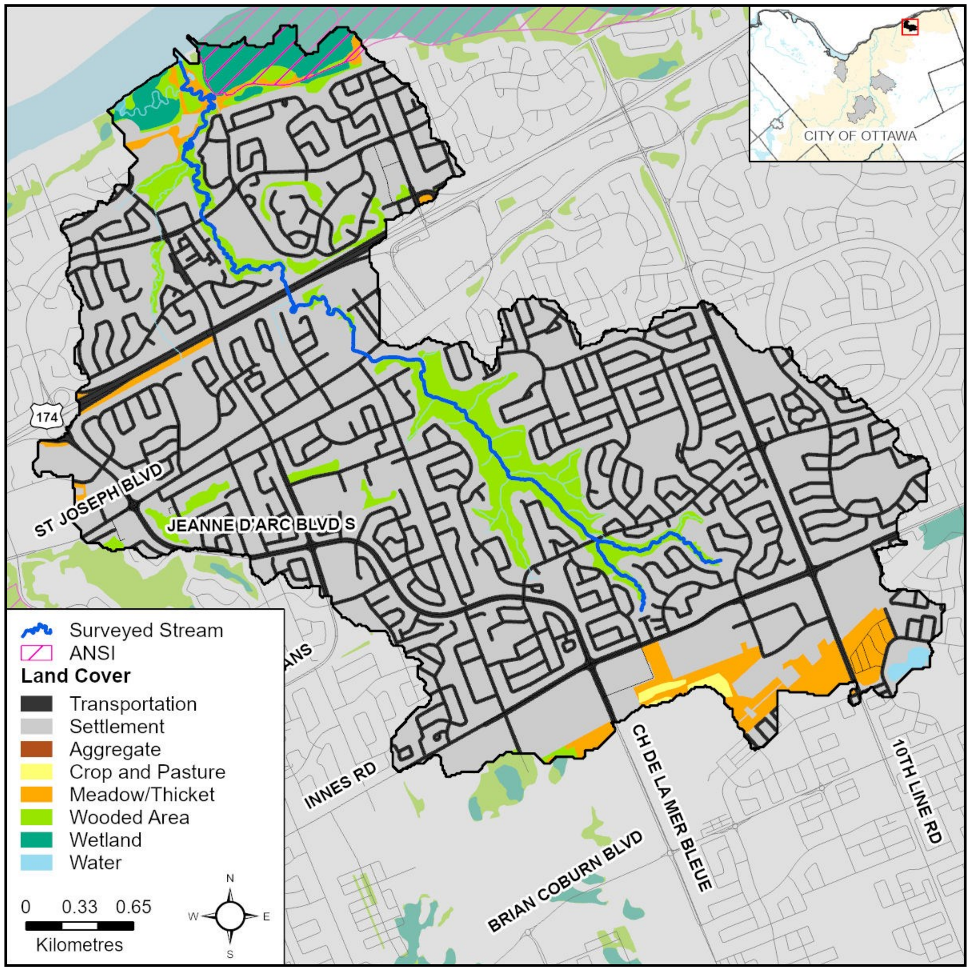


Figure 1 Land cover in the Bilberry Creek catchment

Vegetation Cover

Type	Hectares	Percent of Cover
Wooded Areas:	**99.41**	**77.97%**
Hedgerow	0	%
Plantation	0	%
Treed	0	%
Wetlands*	**28.09**	**22.03%**
Total Cover	**127.51**	**100%**

*Includes treed swamps

Woodlot Analysis

Size Category	Number of Woodlots	Percent of Woodlots
1 Hectare	10	32.26%
1 to <10 Ha	20	64.52%
10 to <30 Ha	0	0%
>30 Ha	1	3.23%
Total Cover	**31**	**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 2023 collaborative.

Introduction

Bilberry Creek is a tributary of the Ottawa River with it's headwaters beginning just north of Innes Road. From there, the creek runs though a forested ravine between housing subdivisions, crossing under St. Joseph Boulevard, Highway 174 and Jeanne D'Arc Boulevard prior to feeding into the Ottawa River. There is significant pressure on the creek from stormwater runoff, especially during rain events. This is due to the intensive land use surrounding the creek, despite having it's headwaters run through a forested valley. In 1945, the main branch of Bilberry Creek only had two major road crossings, and the land use was largely agricultural (RVCA, 2015). Since then, most of the catchment has been developed and many headwaters features have been lost. The remaining reaches have been greatly altered with piping, stormwater drains, channelization and shoreline hardening including armourstone, rip rap, and gabion baskets Development within the catchment has resulted in channel widening and active erosion, and the stream is still in transition from those changes. (RVCA, 2015). During storm events, water is rapidly carried from the tributaries and stormwater drains of Bilberry Creek to the main branch, and water levels rise dramatically shortly after any precipitation. With such a rapid delivery of stormwater, contaminants from roadways and sewers are flushed directly into the creek and carried out into the Ottawa River. (RVCA, 2015)

Bilberry Creek was previously surveyed in 2015 under the City Stream Watch program. In 2023, 71 sections (7.1km) 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 71 sections.

Mouth of Bilberry Creek at the Ottawa River

Stormwater outlet in culvert underneath St. Joseph Blvd

Bilberry 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 Bilberry Creek. Buffers greater than 30 meters were present along 60 percent of the left bank and 62 percent of the right bank. A 15 to 30 meter buffer was present along 21 percent of the left bank and 20 percent of the right bank. A five meter buffer or less was present along 11 percent of the left bank and 12 percent of the right bank. The buffer width evaluation on the sections surveyed of Bilberry Creek are below the recommended guidelines from Environment and Climate Change Canada.

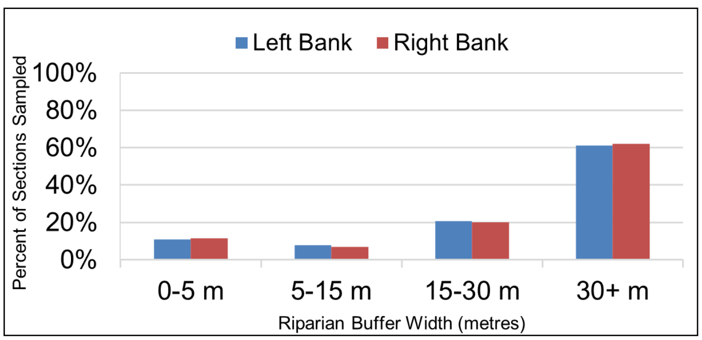


Figure 2 Vegetated buffer width along Bilberry Creek

Vegetated buffer greater than 30 meters in width along Bilberry Creek behind Lacroix Ave

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.

Bilberry Creek surveyed riparian zones were mostly natural, with 56 and 57 percent of the right and left banks having dominant natural riparian vegetative communities. Alterations to the riparian buffer accounted for 11 percent of the right bank and 10 percent on the left bank; highly altered conditions were observed on four percent of each the right and left banks. These alterations were associated with infrastructure such as roadways and piping.

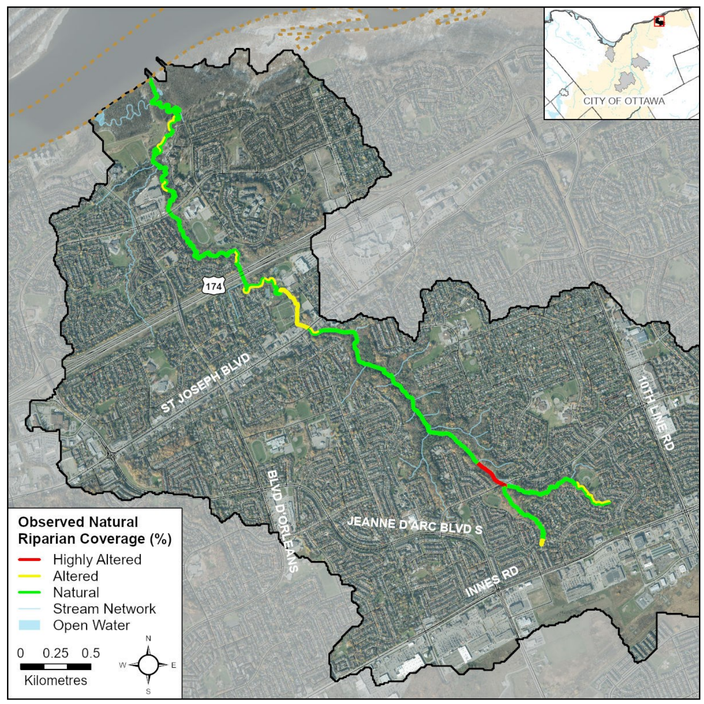


Figure 3 Riparian buffer alterations in Bilberry Creek

Roadway infrastructure on Jeanne D'Arc Blvd along Bilberry 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 catchment 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 94 percent and 86 percent of the sections surveyed, being the most common land uses observed. Wetlands were present in three percent of the surveyed areas, and meadow was present in 21 percent of sections.

Aside from the natural areas, the most common land use in the catchment was residential with 75 percent of the sections containing residential properties. Infrastructure, such as roads, bridges and culverts were observed in 39 percent of sections, while commercial land use was observed in six percent of sections. Recreational land use was also fairly common; observed in 46 percent of sections.

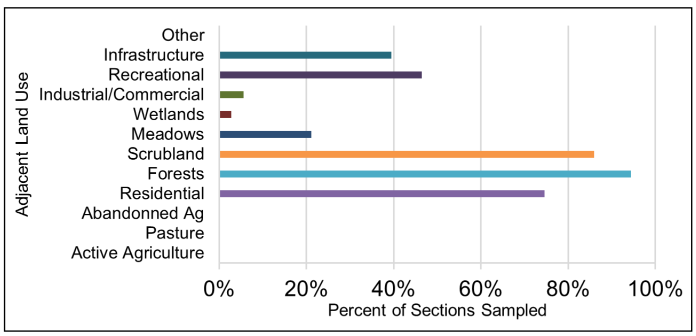


Figure 4 Adjacent land use 100 meters from each shoreline and percentage of presence along Bilberry Creek

Section along Bilberry Creek with forest, meadow and residential land uses near Sugar Creek Way

Bilberry 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 71 sections surveyed in the Bilberry Creek catchment, with 38 sections remaining without any human alteration. Of the areas surveyed, 34 sections fell in the classification of natural. Natural sections had a riparian buffer greater than 15 meters in width and natural shorelines.

Ten 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 culverts.

Nine of the surveyed sections were highly altered. The riparian buffers were less than five meters in width and shoreline alterations were found on most of the sections. This included rip rap and storm water outlets which were present at road crossings. These sections were mostly found near road and highway infrastructure.

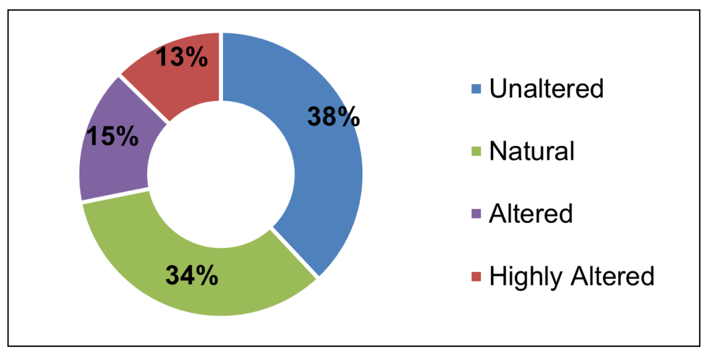


Figure 5 Anthropogenic alterations along Bilberry Creek

One of many unaltered sections of Bilberry Creek near Sugarbush Court

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 51 percent of the left bank and 56 percent of the right bank of the sections surveyed.

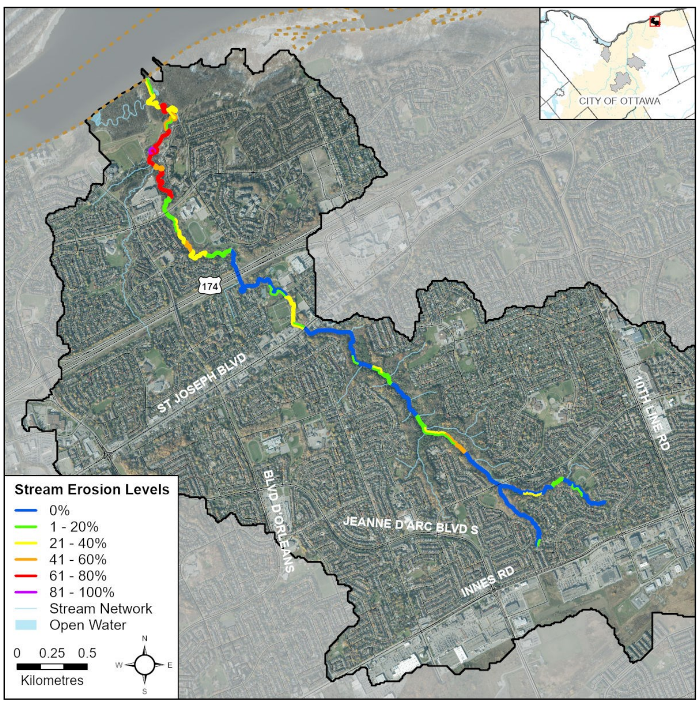


Figure 6 Erosion levels along Bilberry Creek

Bank erosion along Bilberry Creek near Bilberry 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 Bilberry Creek. Along the left bank, 46 percent of sections had undercut banks; and the right bank had 45 percent of sections with undercut banks.

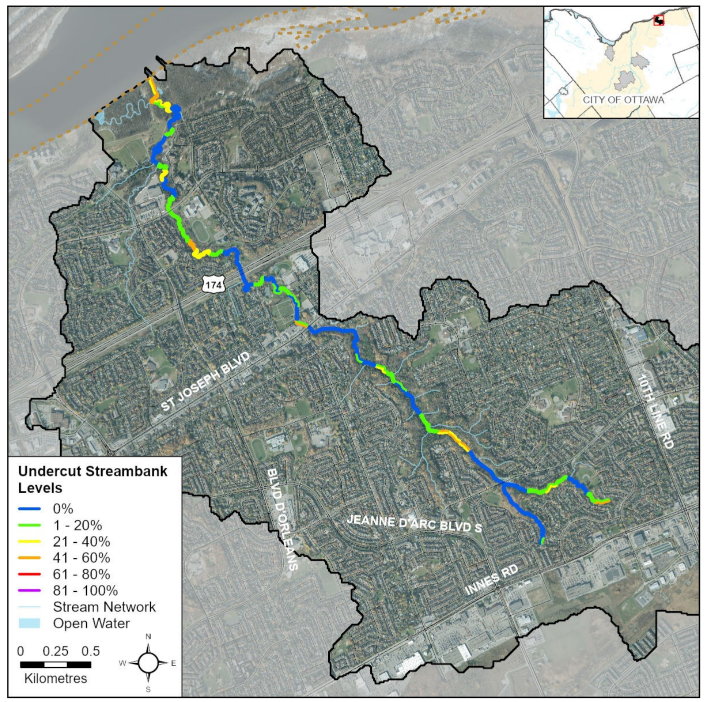


Figure 7 Undercut stream banks along Bilberry Creek

Undercut banks 400m upstream of the mouth of Bilberry 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, 67 of them, had some level of shade covering, with 16 of them having 81-100% shade and canopy cover. No cover was observed in four of the sections.

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

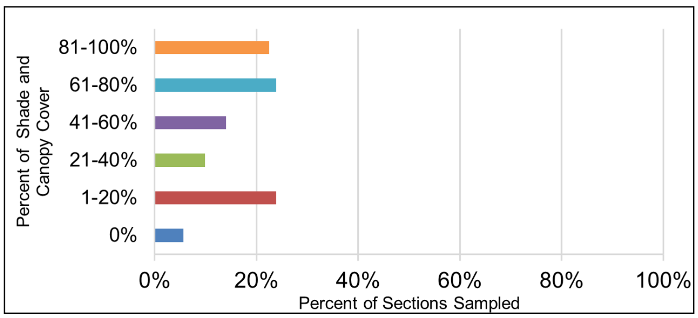


Figure 8 Stream shading along Bilberry Creek

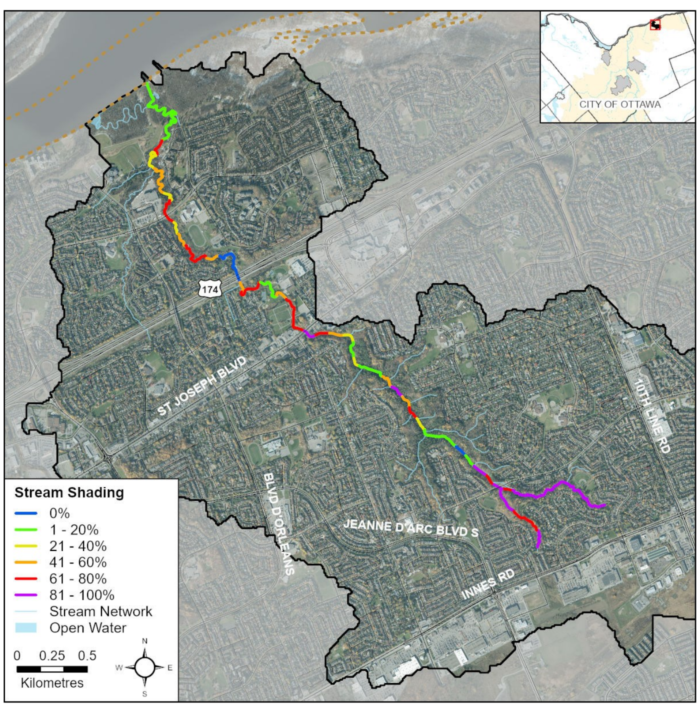


Figure 9 Stream shading along Bilberry Creek

A mix of trees and plants comprised the majority of shading. Overhanging plants, mainly narrow leaved emergent plants, were seen in 61 percent of the left banks and 56 percent of the 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 Bilberry Creek. Of the surveyed portions, 82 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.

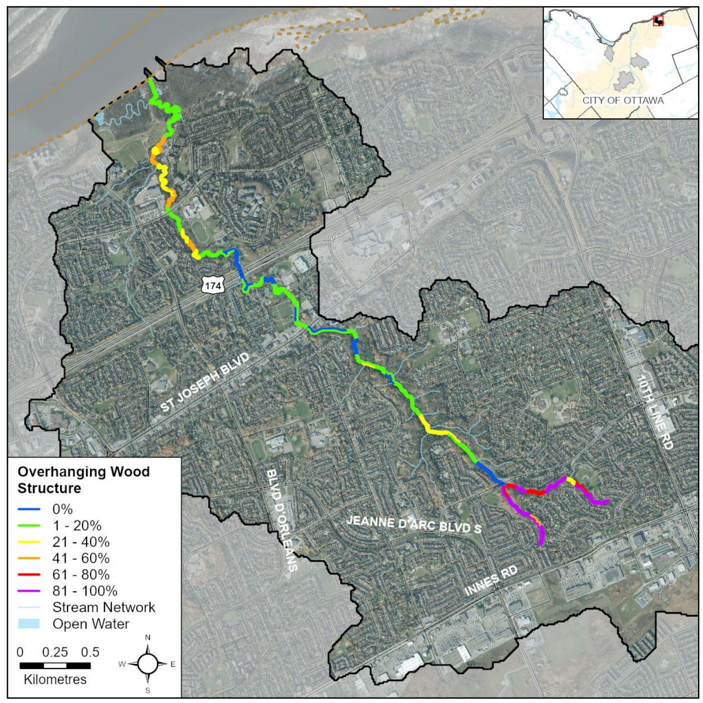


Figure 10 Overhanging trees and branches along Bilberry Creek

Overhanging trees and branches contribute most of the shading along Bilberry Creek

Bilberry 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: four percent had no complexity; eight percent had a score of one; 37 percent scored two; and 35 percent scored three. Fifteen percent of the sections surveyed scored four for habitat complexity.

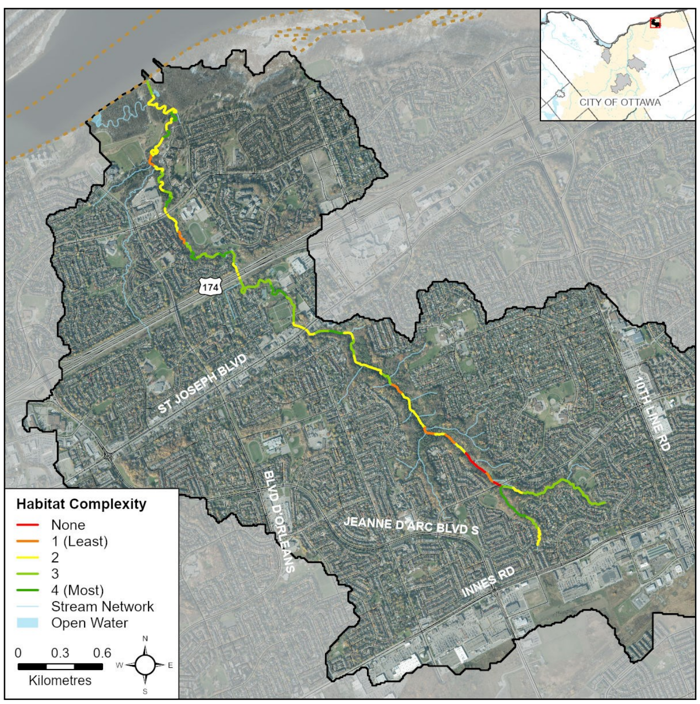


Figure 11 Instream habitat complexity along Bilberry Creek

Section of Bilberry Creek with complex habitat features including cobble 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 Bilberry Creek was observed to be fairly homogenous in 62 percent of sections surveyed, and heterogenous in the remaining 37 percent. Figure 12 shows the substrate types observed. It is a system dominated by clay, with 79 percent of sections containing this type of substrate. Most sections surveyed also contained cobble. Other substrate types included sand, gravel, silt and boulders. Bedrock was observed in seven percent of sections.

Figure 13 shows the dominant substrate types along the creek. From the assessed areas, clay was the dominant substrate type in 58 percent of sections surveyed with cobble being dominant in 21 percent of sections.

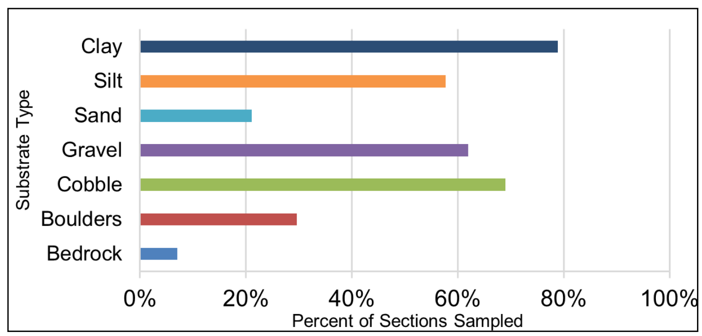


Figure 12 Instream substrate along Bilberry Creek

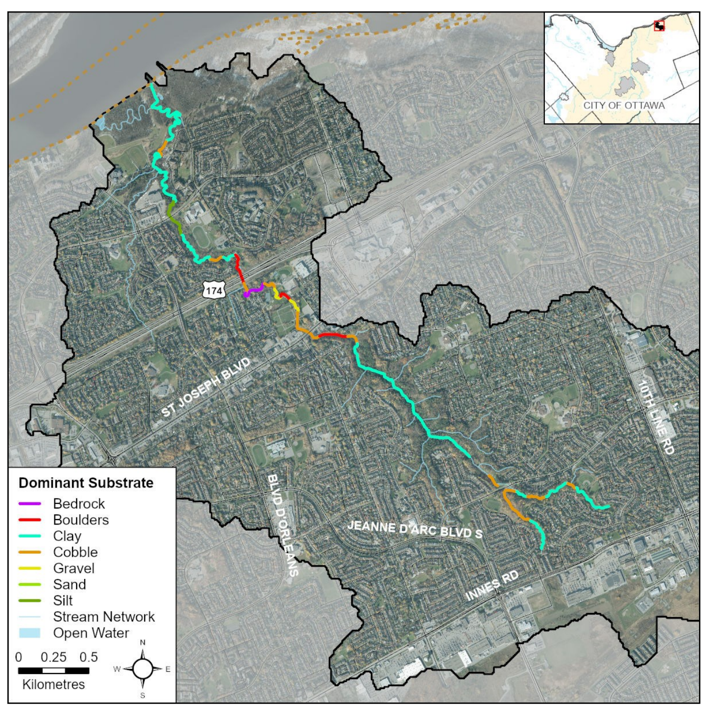


Figure 13 Dominant instream substrates along Bilberry Creek

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 Bilberry Creek has moderate diversity of morphological conditions, suitable for a variety of aquatic species and life stages; 58 percent of sections contained pools, 58 percent of sections contained riffles and 100 percent contained runs. Figure 15 shows the locations of sections surveyed which contained riffle habitat and the extent of presence within each section.

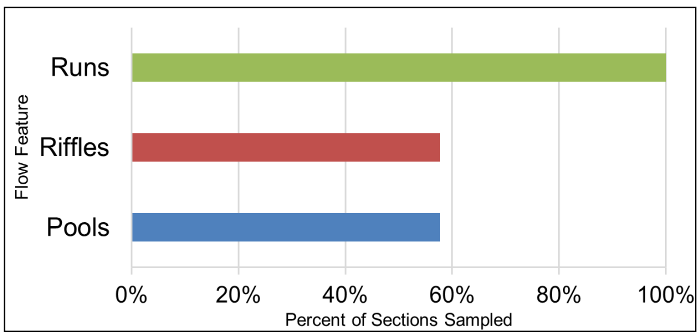


Figure 14 Instream morphology along Bilberry Creek

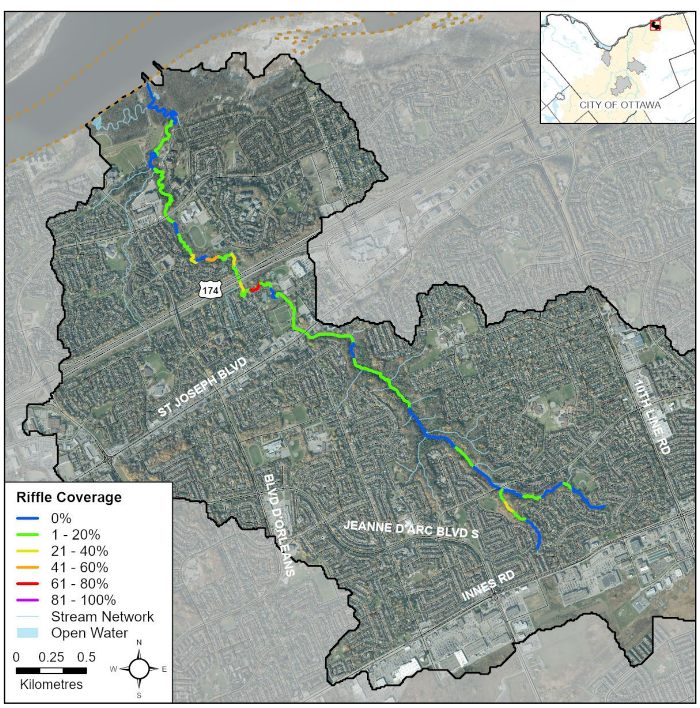


Figure 15 Riffle habitat locations along Bilberry Creek

Instream Wood Structure

Figure 16 shows that a large portion of Bilberry 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.

Instream wood structures found along Bilberry Creek are important for fish and wildlife habitat

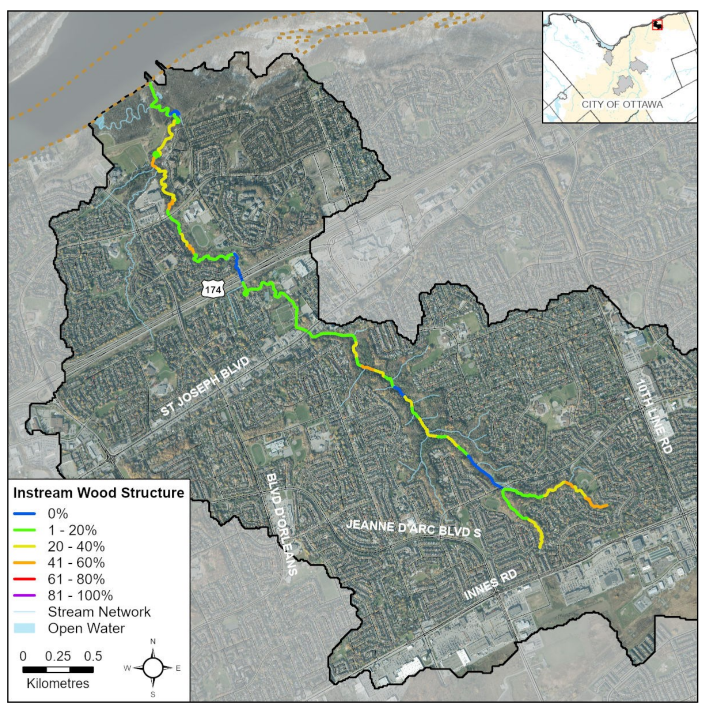


Figure 16 Instream wood structures along Bilberry Creek

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 Bilberry Creek. Vegetation types included: submerged vegetation present in six percent of sections; narrow-leaved emergent vegetation in 25 percent; free-floating in three percent; floating plants in three percent; algae in 46 percent and broad-leaved emergent in one percent of sections

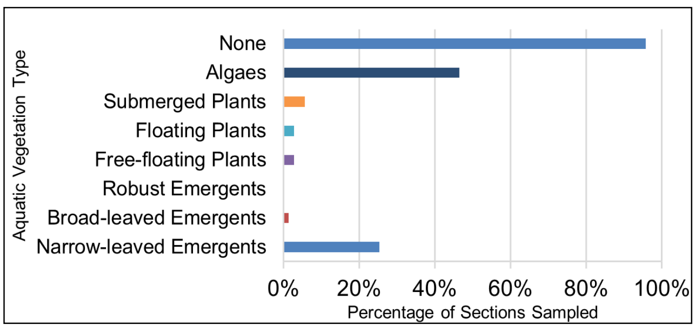


Figure 17 Aquatic vegetation presence along Bilberry Creek

The distribution of overall dominant types of instream vegetation is reflected in Figure 18 showing that in most reaches, no vegetation was observed to be dominant.

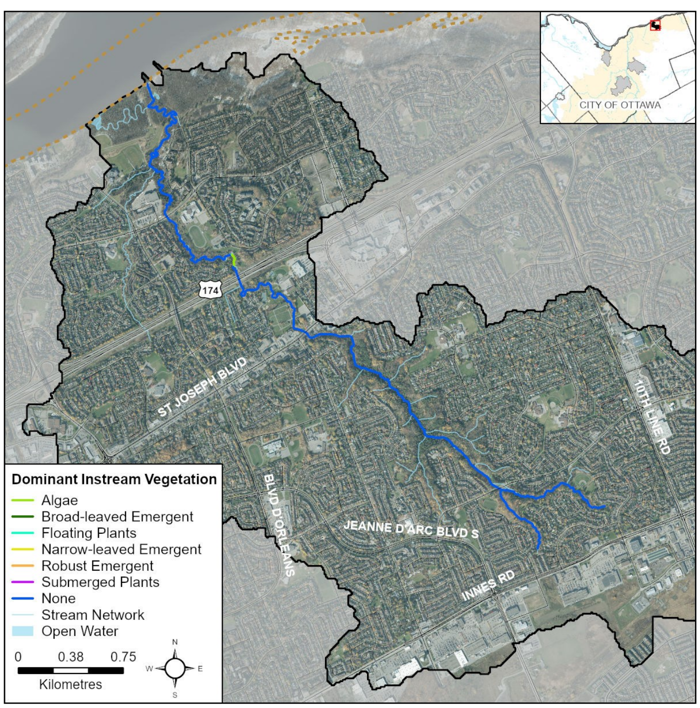


Figure 18 Dominant instream vegetation in Bilberry Creek

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, six percent of sections had low vegetation along Bilberry Creek. Rare abundance was observed in 69 percent of sections surveyed and no vegetation was found along 92 percent.

The low levels of vegetation on Bilberry Creek are the result of substrates dominated by clay and extreme fluctuations in water levels after rain events due to storm water runoff. Most types of vegetation, other than algae, have trouble establishing in these conditions.

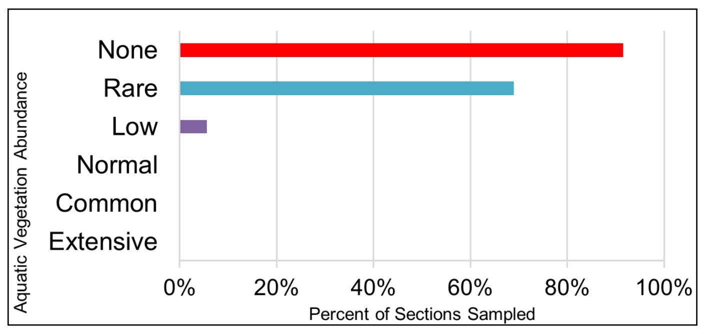


Figure 19 Instream vegetation abundance along Bilberry Creek

Section of Bilberry Creek dominated by clay with no instream vegetation near Lacroix Ave

Bilberry 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 were observed in all sections surveyed along Bilberry Creek, Figure 20 shows the diversity of species observed per section surveyed.

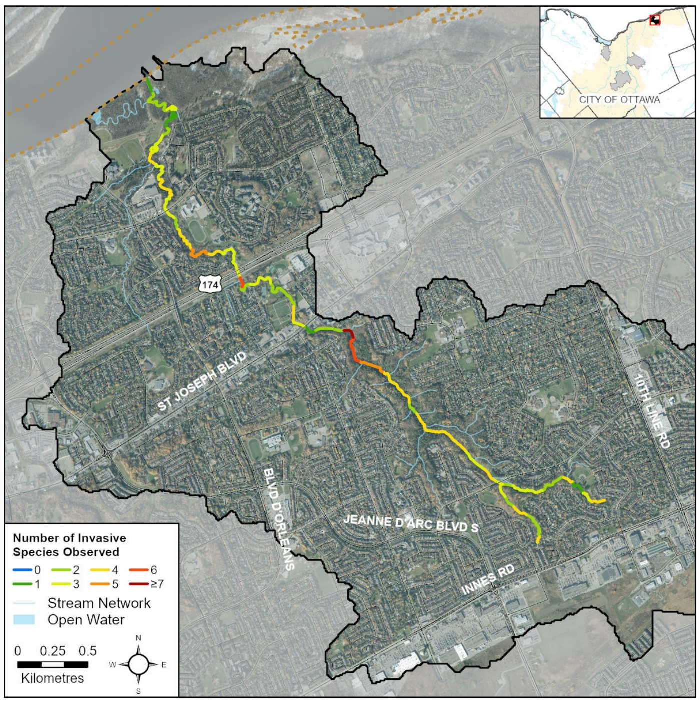


Figure 20 Invasive species diversity along Bilberry Creek

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

- banded mystery snail *(Viviparus georgianus)*
- bull thistle *(Cirsium vulgare)*
- common buckthorn (*Rhamnus cathartica*)
- curly-leaved pondweed (*Potamogeton crispus*)
- garlic mustard *(Alliaria petiolate)*
- glossy buckthorn (*Rhamnus frangula*)
- Himalayan balsam (*Impatiens glandulifera*)
- Japanese knotweed *(Reynoutria japonica)*
- non-native honeysuckles (*Lonicera spp.)*
- Manitoba maple (*Acer negundo*)
- poison/wild parsnip (*Pastinaca sativa*)
- purple loosestrife (*Lythrum salicaria*)

Invasive Japanese observed along surveyed portions of Bilberry Creek

To report and find information about invasive species visit

http://www.invadingspecies.com

Managed by the Ontario Federation of Anglers and Hunters

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 Bilberry Creek catchment.

Table 1 Wildlife observations along Bilberry Creek

Birds	American crow, American robin, black-capped chickadee, blue jay, common yellow-throat, downy woodpecker, grey catbird, great blue heron, mallard, Northern cardinal, ring-billed gull, song sparrow, white throated sparrow, yellow warbler
Reptiles & Amphibians	green frog, northern leopard frog
Mammals	chipmunk, cottontail rabbit, coyote, grey squirrel, racoon, red squirrel
Aquatic Insects & Benthic Invertebrates	amber snail, crane fly, stonefly larva, water strider, whirligig,
Other	bumblebees, cabbage moth, dragonflies, damselflies, dog-day cicada, grasshoppers, honeybees, jumping spider, mosquitos, white admiral butterfly, wolf spider

Bilberry 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.

Volunteer 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 21 shows the concentration levels found in the surveyed portions of Bilberry Creek. The Canadian Environmental Quality Guidelines of the Canadian Council of Ministers of the Environment (CCME) suggest that for the protection of aquatic life the lowest acceptable dissolved oxygen concentration should be 6 mg/L for warmwater biota (red line in Figure 19) and 9.5 mg/L for coldwater biota (blue line in Figure 19) (CCME, 1999). Most of the surveyed portions were found to have oxygen levels above the Canadian water quality guidelines for warmwater biota. Average concentration levels across the system were 8.5 mg/L.

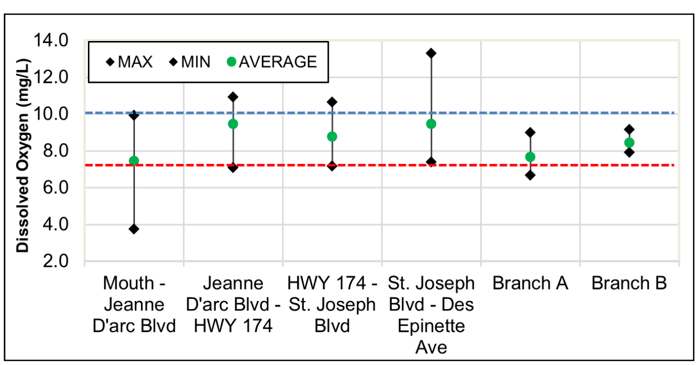


Figure 21 Dissolved oxygen ranges along Bilberry Creek

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 22 shows specific conductivity levels in Bilberry Creek. The average conductivity observed was very high overall at 1853 µs/cm. Conductivity levels were recorded at their highest at 3447µs/cm within sections between the mouth and Jeanne D'Arc Blvd. There was a slight decline in conductivity levels in the upper reaches of Bilberry Creek.

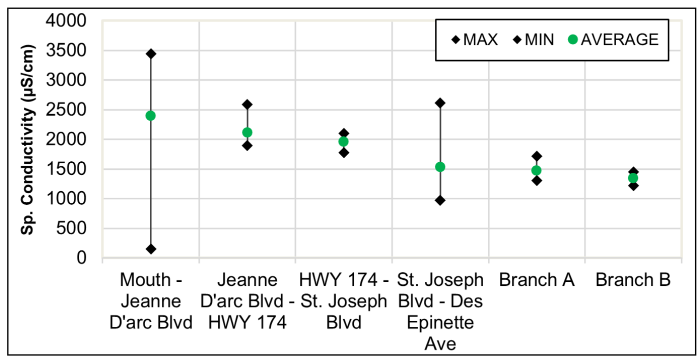


Figure 22 Specific conductivity ranges along surveyed sections of Bilberry Creek

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 23 shows Bilberry Creek had pH levels that meet the PWQO, depicted by the dashed lines. Average levels across the system were pH 7.93.

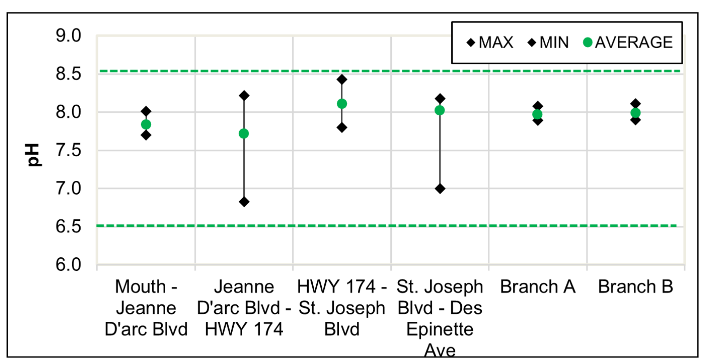


Figure 23 pH ranges along surveyed sections of Bilberry Creek

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 Bilberry Creek downstream of Jeanne D'Arc Blvd with **impaired** oxygen conditions (Dissolved oxygen levels of 3.75 mg/L and 38.7 % saturation)

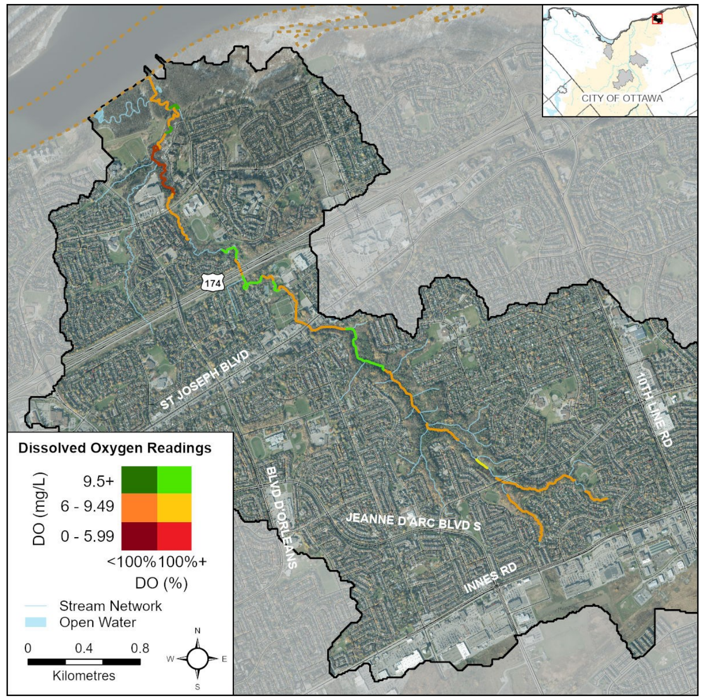


Figure 24 Bivariate assessment of dissolved oxygen concentration (mg/L) and saturation (%) along Bilberry Creek

Figure 24 shows the oxygen conditions across the areas that were surveyed in 2023. Dissolved oxygen conditions in Bilberry Creek were sufficient to sustain warm-water biota in the creek upstream of Jeanne D'Arc Blvd. In the sections between Jeanne D'Arc Blvd and Bilberry Drive, there were significant levels of impairment both in concentration and percent saturation. This area is dominated by clay and had little to no vegetation. There is very little riffle habitat which provides increased oxygen levels in streams. An increase in instream vegetation and riffle habitat would increase levels of oxygen in this area, as well as across the system.

Section on Bilberry Creek upstream of St. Joseph Blvd with **optimal** oxygen conditions for warm-water biota (Dissolved oxygen levels of 10.9 mg/L and 112.7 % 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 Bilberry Creek (1853.7 µS/cm) were above guidelines (500 µS/cm) used for the Canadian Environmental Performance Index (Environment Canada 2011).

Figure 25 shows relative specific conductivity levels in Bilberry Creek. Normal levels were maintained for most of the surveyed portions. Moderately elevated conditions were observed in sections downstream of Jeanne D'Arc Blvd. This area is highly influenced by stormwater from adjacent urban areas. This was also observed in sections directly downstream from where the creek is piped near Epinettes Ave.

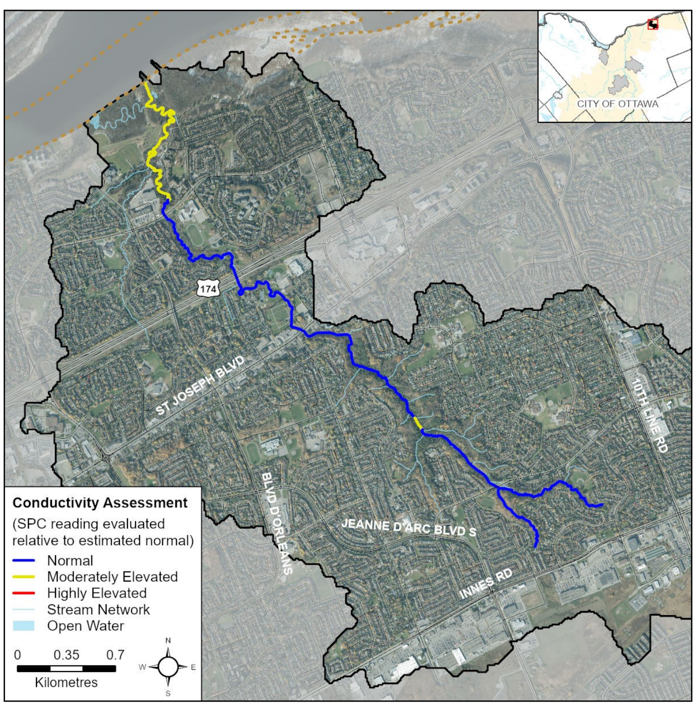


Figure 25 Relative specific conductivity levels along Bilberry Creek

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 26). Indicators included: seeps, iron staining and rainbow mineral film.

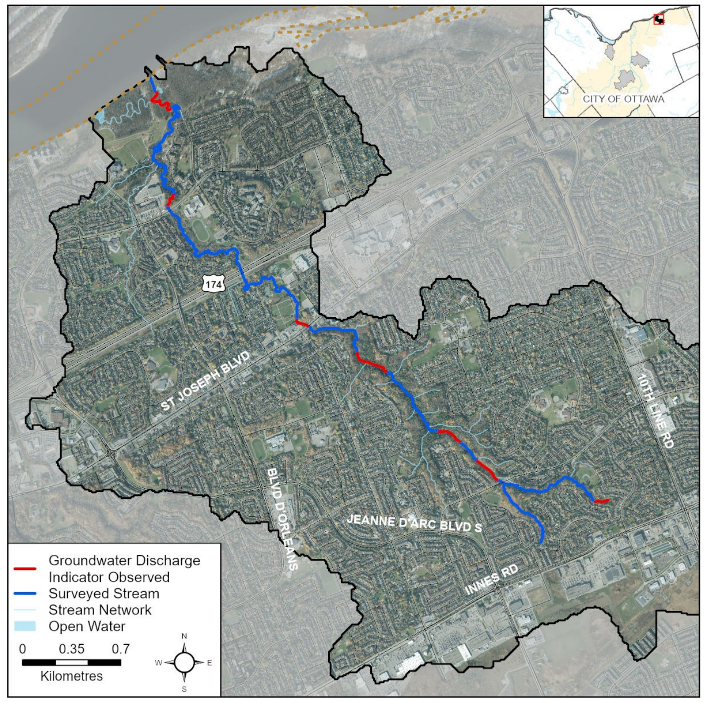


Figure 26 Groundwater indicators observed in the Bilberry Creek catchment

Visible seep observed branches in the upper reaches of Bilber-ry Creek

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

Figure 27 shows where thermal sampling sites were located. Due to instrument malfunction, only two data points were retrieved from the logger near Jeanne D'Arc Blvd. Analysis of data from the loggers (using the Stoneman and Jones, 1996, method adapted by Chu et al., 2009), indicated Bilberry Creek was classified as **cool-warm** at Jeanne D'Arc Blvd, **coolwater** at St. Joseph Blvd and **cold-cool** at Des Epinettes Ave. Figures 28 and 29 show a comparison of thermal conditions from 2015 and 2023. While there is limited data from 2015, it appears the thermal classification of the system is maintaining its **coolwater** status in 2023.

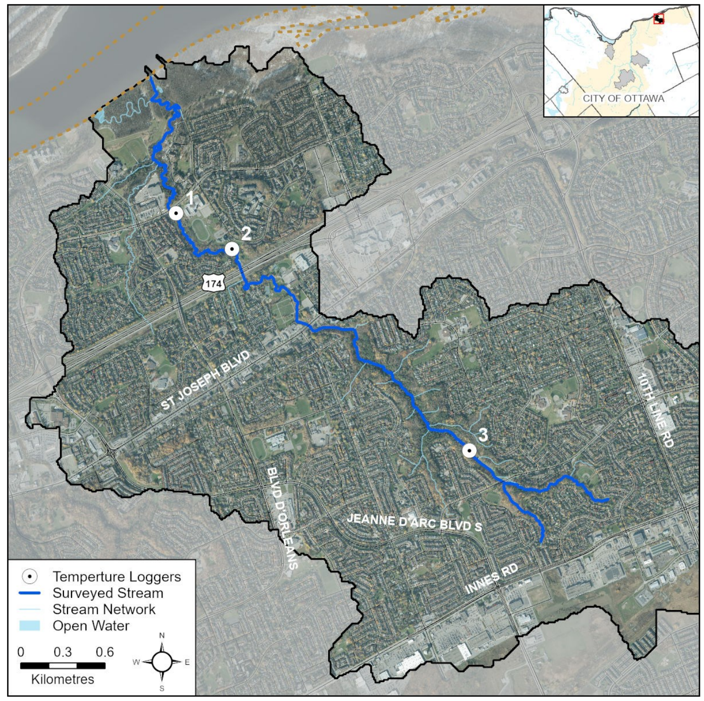


Figure 27 Temperature logger locations on Bilberry Creek

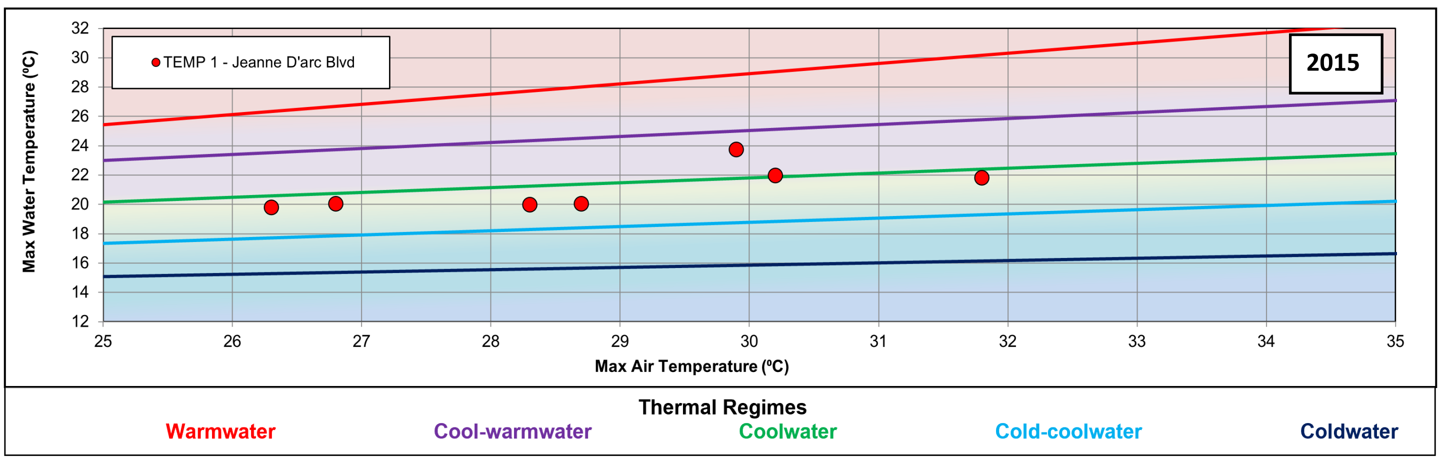


Figure 28 Thermal Classification for Bilberry Creek with the five thermal regimes adapted from Stoneman and Jones (1996) by Chu et al. (2009): conditions are in **coolwater** category for Bilberry Creek in 2015

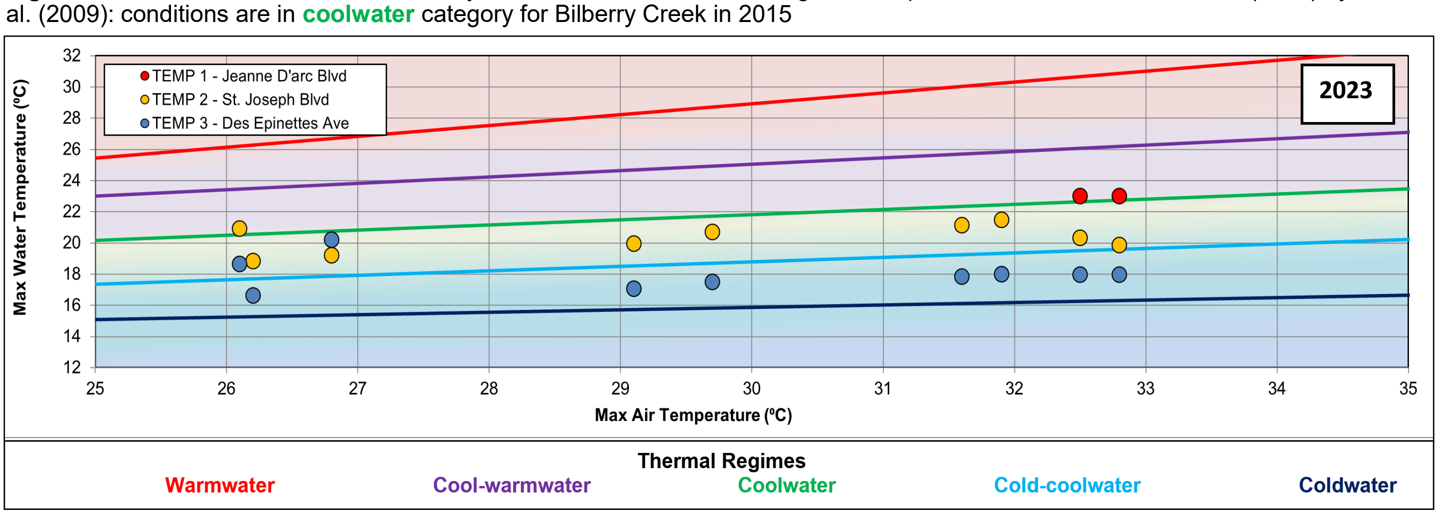


Figure 29 Thermal Classification for Bilberry Creek with the five thermal regimes adapted from Stoneman and Jones (1996) by Chu et al. (2009): conditions range from **cool-warm** to **cold-cool** for Bilberry Creek in 2023

Bilberry Creek Fish Community

Fish Community Summary

Five fish sampling sites were evaluated between May and July 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. Bilberry Creek had a mixed fish community ranging from cold to warm water species.

Table 2 Fish species observed in Bilberry Creek in 2023

Species	Thermal Class	MNR Species Code
black crappie *Pomoxis nigromaculatus*	**Cool**	BlCra
bluegill *Lepomis macrochirus*	**Warm**	Blueg
bluntnose minnow *Pimephales notatus*	**Warm**	BnMin
brook stickleback *Culaea inconstans*	**Cool**	BrSti
brown bullhead *Ameiurus nebulosus*	**Warm**	BrBul
burbot *Lota lota*	**Cold**	Burbo
central mudminnow *Umbra limi*	**Cool**	CeMud
common shiner *Luxilus cornutus*	**Cool**	CoShi
creek chub *Semotilus atromaculatus*	**Cool**	CrChu
fathead minnow *Pimephales promelas*	**Warm**	FhMin
goldfish *Carassius auratus*	**Warm**	Goldf
johnny/tessalated darter *Etheostoma spp.*	**Cool**	EthSp
largemouth bass *Micropterus salmoides*	**Warm**	LmBas
longnose dace *Rhinichthys cataractae*	**Cool**	LnDac
Northern pike *Esox lucius*	**Cool**	NoPik
pumpkinseed *Lepomis gibbosus*	**Warm**	Pumpk
white sucker *Catostomus commersonii*	**Cool**	WhSuc
yellow perch *Perca flavescens*	**Cool**	YePer
Total Species		**18**

The sampling locations where these species were observed, as well as RVCA historical sites, are depicted in Figure 30. 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 Bilberry Creek refer to page 22 of this report.

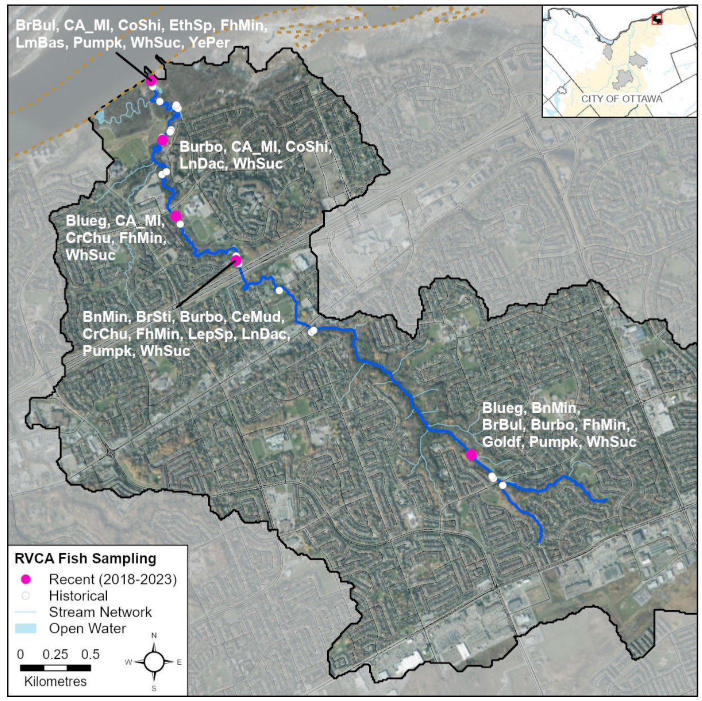
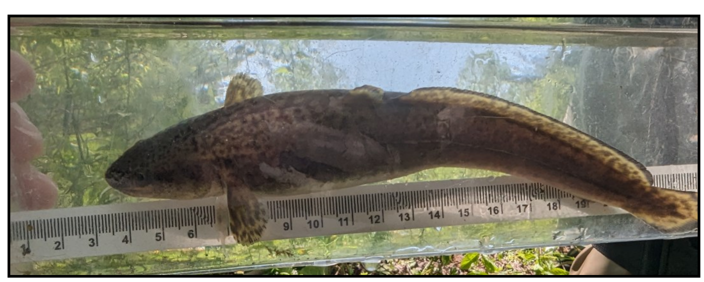


Figure 30 Bilberry Creek fish sampling locations and fish species observations from 2015-2023

Fish community sampling by electrofishing (above) and a burbot (below) observed in Bilberry 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 several migratory obstructions observed along the surveyed portions of Bilberry Creek. The migratory obstructions observed during stream surveys in 2023 are shown in Figure 31. Most were debris dams, which can be a result of high levels of erosion in this area, causing trees and debris to fall into the creek. Perched culverts, which are classified as grade barriers, were observed in two sections along Bilberry Creek.

Perched culverts create fish migratory obstructions and loss of aquatic habitat and seasonal grounds for many fish species

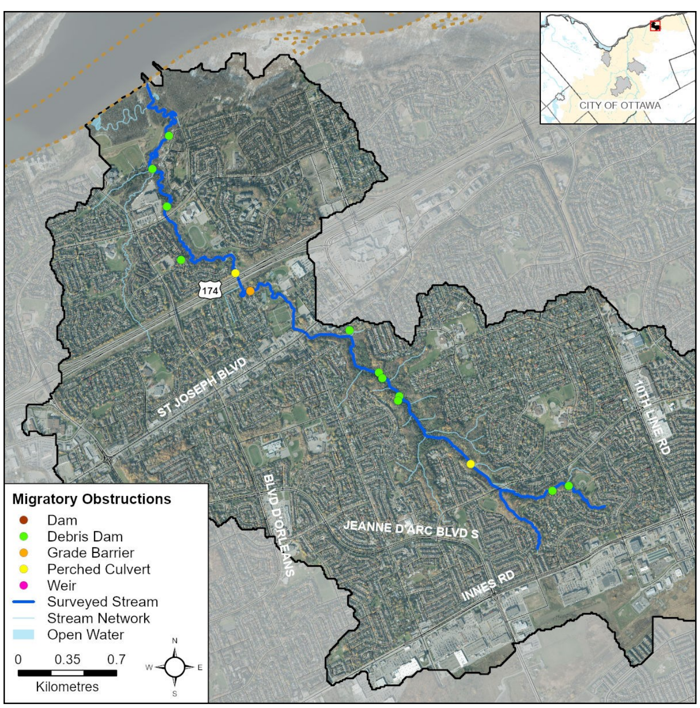


Figure 31 Locations of migratory obstructions along Bilberry Creek

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 11 beaver dams were identified on the surveyed portions of Bilberry Creek. Most dams were identified as active. Additionally, one beaver lodge was noted as well. The locations of the dams are shown in Figure 32.

An active beaver dam along Bilberry Creek west of Bilberry Drive

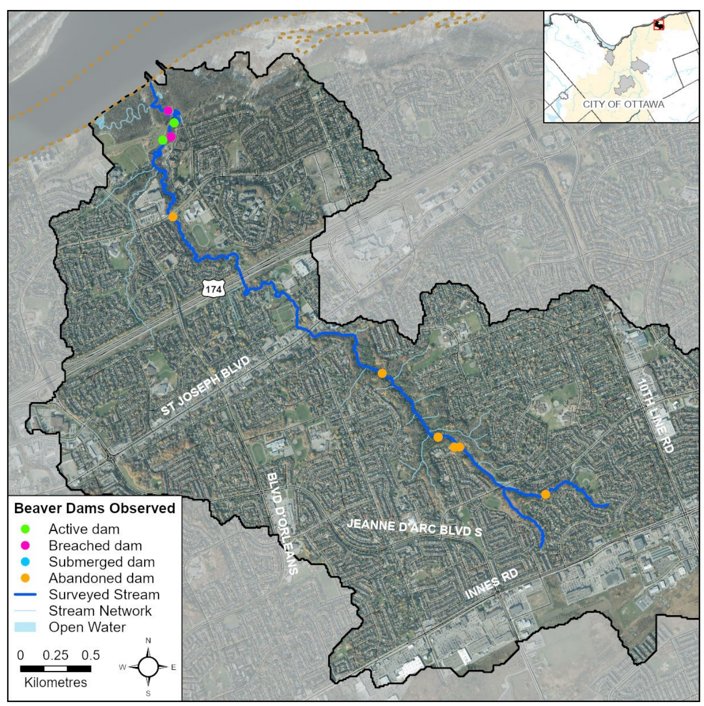


Figure 32 Locations of beaver dams along Bilberry Creek

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 five HDF sites were assessed in the Bilberry Creek Catchment (Figure 33).

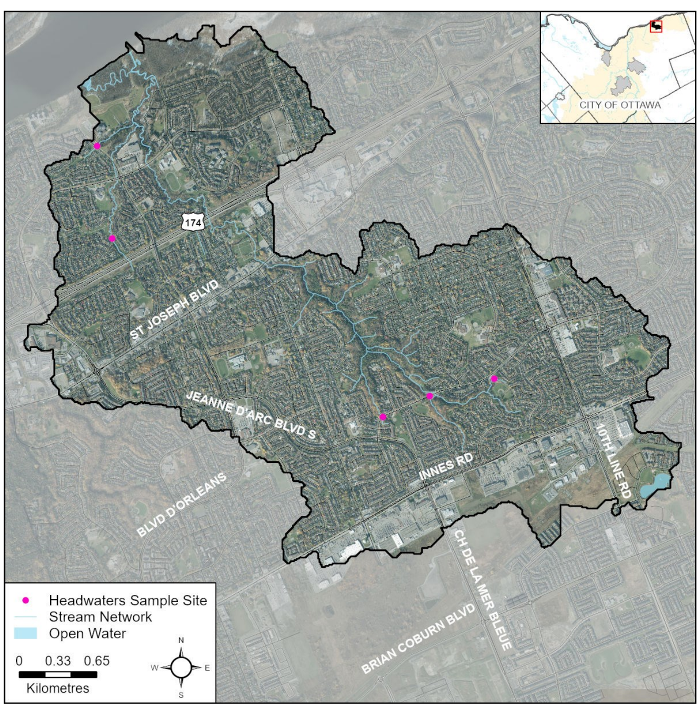


Figure 33 Location of headwater drainage feature sampling sites in the Bilberry Creek catchment

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 34 shows the feature type of the primary feature at the sampling locations. Four out of five of these features were determined to be natural, and one was channelized. It is common to see channelized features in suburban developments where the feature has been straightened to take up less space.

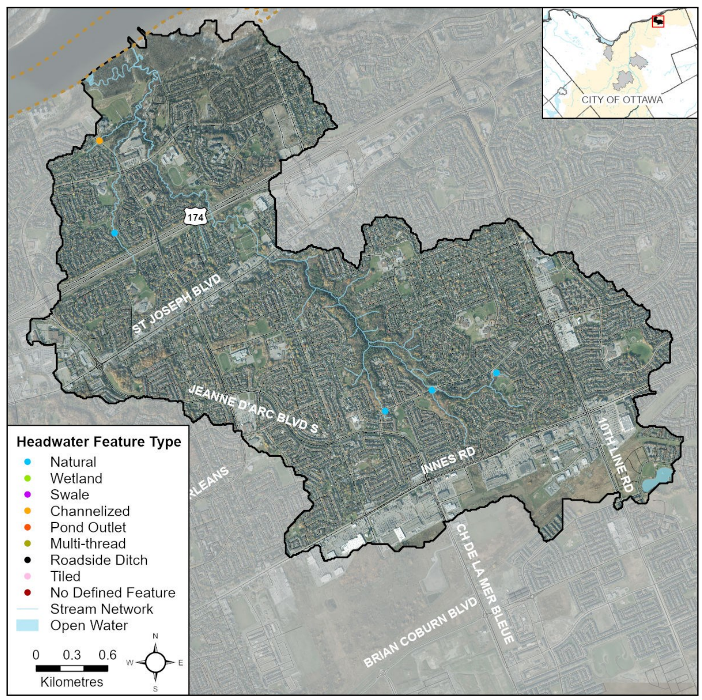


Figure 34 Map of Bilberry Creek catchment headwater drainage feature types

Channelized headwater drainage feature that flows through a neighborhood west of Orleans Blvd

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. Within the Bilberry Creek catchment, three features are considered intermittent and two features are perennial. Flow conditions in the Bilberry Creek catchment area are shown in Figure 35.

Intermittent headwater drainage feature with spring and summer conditions north of HWY 174

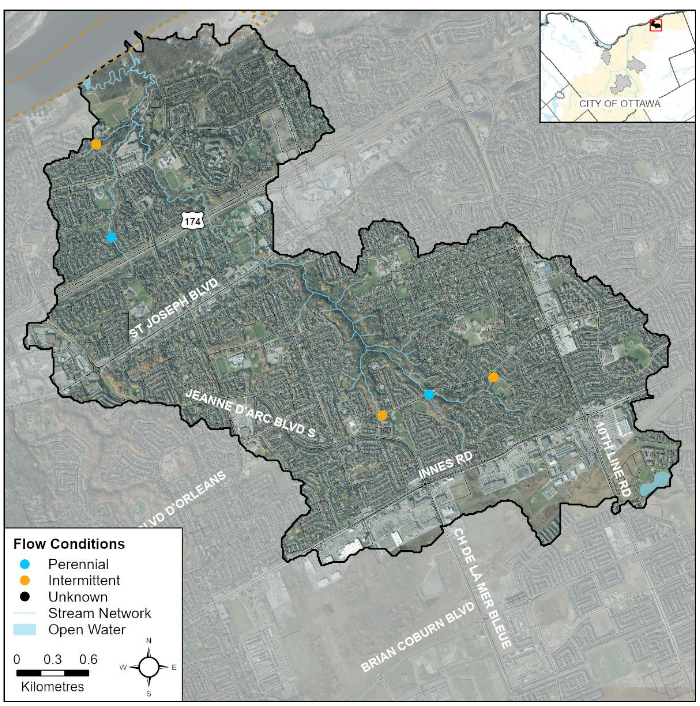


Figure 35 Headwater drainage feature flow conditions in the Bilberry Creek catchment

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 36 shows channel modifications observed in Bilberry Creek headwater drainage features. Modifications in this catchment for its headwater drainage features are channel hardening with rip rap or amourstone and historical channel straightening.

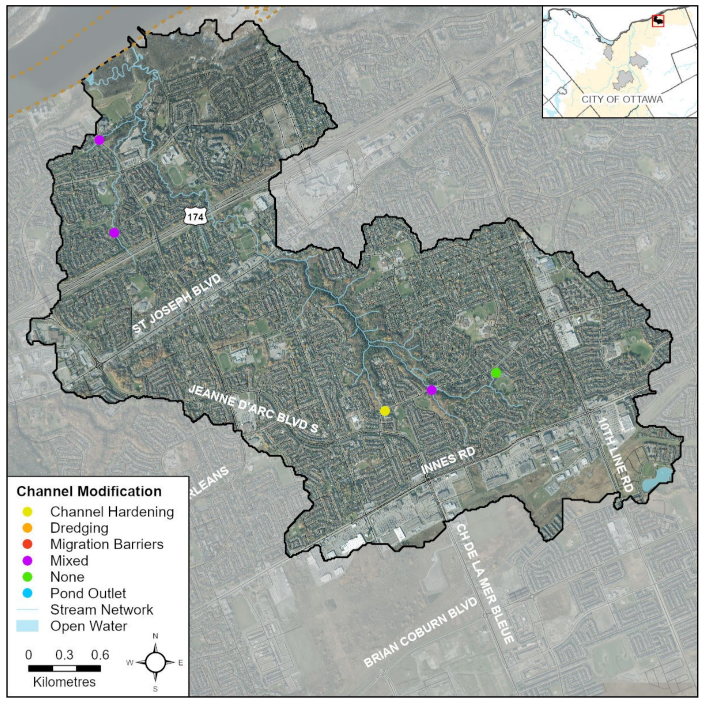


Figure 36 Headwater drainage feature channel modifications in the Bilberry Creek catchment

An example of the use of armourstone on a headwater drainage feature on Orleans Blvd

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 37 depicts the dominant vegetation observed at the sampled sites in the Bilberry Creek catchment. One feature was dominated by wetland vegetation. Four features had no vegetation in the spring, where flows and sediment transport are unmitigated by the lack of vegetation.

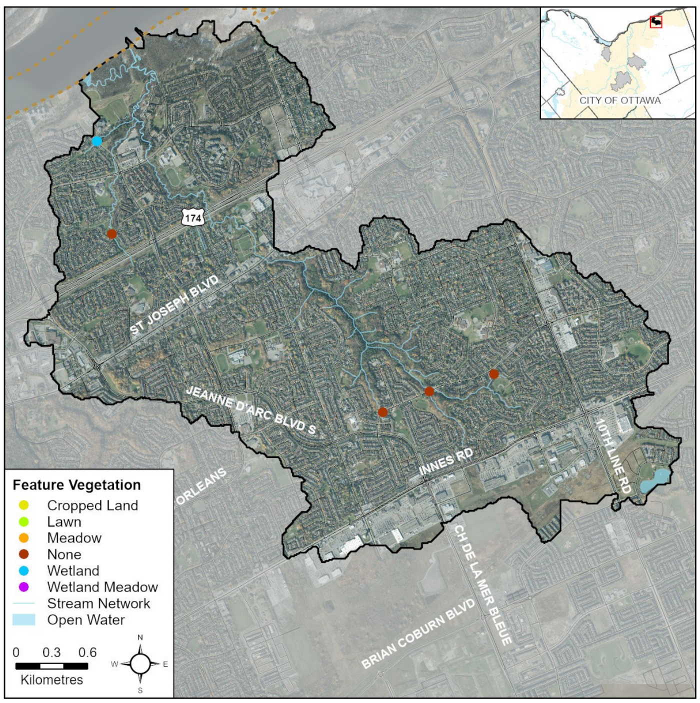


Figure 37 Headwater drainage in feature vegetation in the Bilberry Creek catchment

No feature vegetation within a headwater drainage feature west of Orleans Blvd

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 38 shows the type of riparian vegetation observed at the sampled headwater sites in the Bilberry Creek catchment. They are grouped as natural, and other riparian zones which have anthropogenic influences from agricultural areas, residential areas as well as road infrastructure.

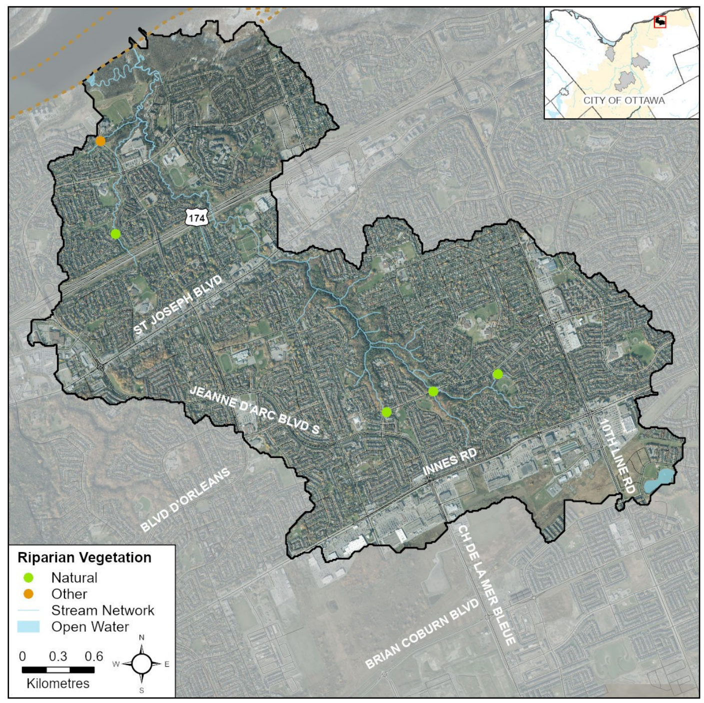


Figure 38 Riparian vegetation types along headwater drainage features in the Bilberry Creek catchment

Headwater drainage feature with natural scrubland and forest riparian vegetation on Des Epinettes Ave

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 minimal to substantial. Two features had evidence of minimal deposition levels and two features had moderate deposition levels. One feature had substantial amounts of deposition. Figure 39 shows the levels of sediment deposition observed in the catchment headwaters.

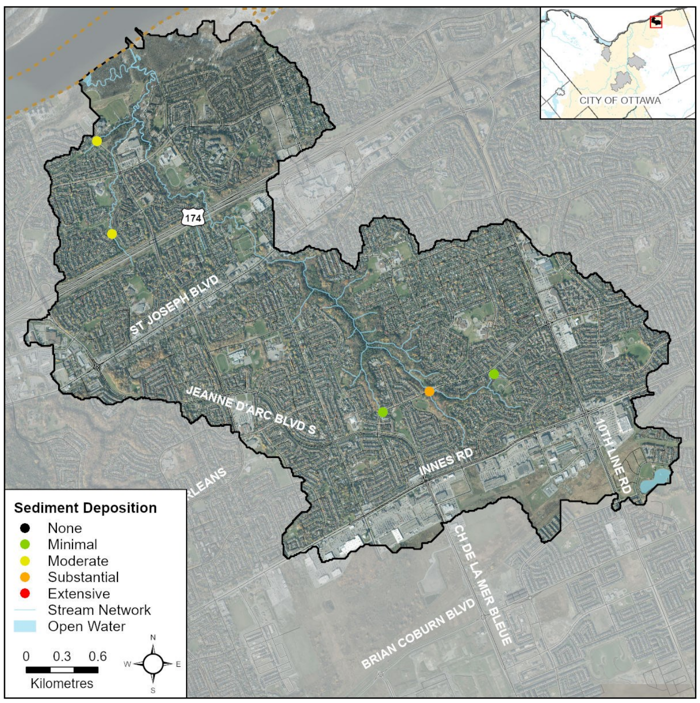


Figure 39 Headwater drainage feature sediment deposition in the Bilberry Creek catchment

Substantial sediment deposition observed in a headwater drainage feature on Des Epinettes Ave

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 Bilberry Creek catchment, roughness ranged from minimal to extreme with three features having 40% roughness or higher.

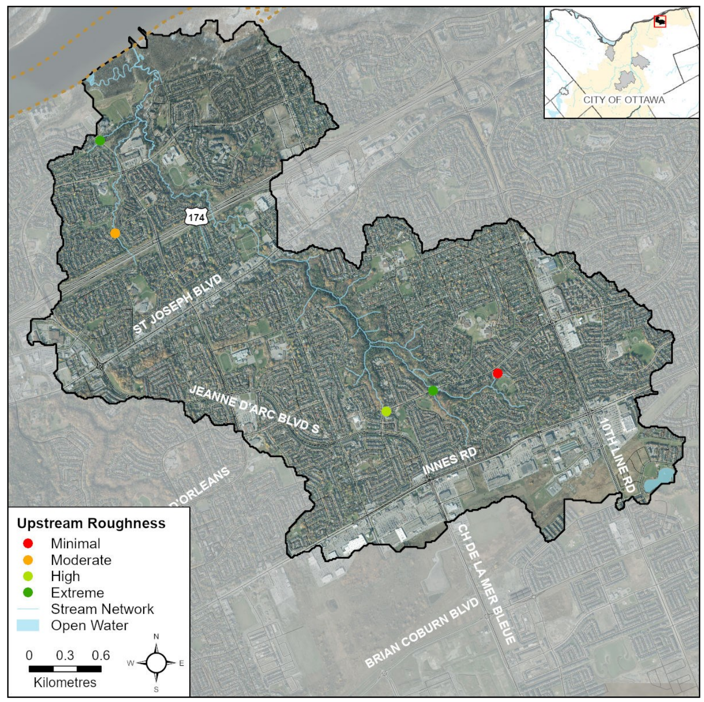


Figure 40 Headwater drainage feature roughness in the Bilberry Creek catchment

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

Stream Comparison Between 2004, 2009, 2015 and 2023

The following tables provide a comparison of observations on Stillwater Creek between the 2004, 2009, 2015 and 2023 survey years (RVCA 2004, RVCA 2009, RVCA 2015). Monitoring protocols since 2004 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 2009, 2015 and 2023.

Average pH decreased by 0.07 units from 2015 to 2023 and specific conductivity decreased from 2015 by 579.9 µS/cm. These slight changes may reflect seasonal variability. Average dissolved oxygen levels were found to be lowering with each survey year. Average dissolved oxygen dropped from 10.38 milligrams per liter in 2009 to 9.26 milligrams per liter in 2015. Average dissolved oxygen levels were found to be lower again in 2023. These changes can also be attributed to seasonal conditions and warmer temperatures which can lessen a stream's ability to hold more oxygen.

Average summer water temperatures range from cooler water in 2015 (15.9 C) to warmer values in 2023 (17.2° C), with 1.3 degrees centigrade of variation. 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, standardized stream temperature factors were calculated and summarized in Table 3. This factor was the same in both 2009 and 2015 at 0.73 but has since dropped to 0.67 in 2023.

Table 3 Water chemistry comparison (2009/2015/2023)

Water Chemistry (2009/2015/2023)				
Year	**Parameter**	**Unit**	**Average**	**STND Error**
2009	pH	-	8.13	± 0.04
2015	pH	-	8.0	± 0.02
2023	pH	-	7.93	± 0.12
2009	Sp. Conductivity	us/cm	1622.8	± 90.63
2015	Sp. Conductivity	us/cm	2433.6	± 126.71
2023	Sp. Conductivity	us/cm	1853.7	± 103.64
2009	Dissolved Oxygen	mg/L	10.38	± 0.16
2015	Dissolved Oxygen	mg/L	9.26	± 0.14
2023	Dissolved Oxygen	mg/L	8.5	± 0.41
2009	Water Temperature	ºC	16.66	± 0.32
2015	Water Temperature	ºC	15.90	± 0.26
2023	Water Temperature	ºC	17.2	± 0.39
2009	Standardized Stream Temperature[1]	ºC Water / 1ºC Air	0.73	±0.39
2015	Standardized Stream Temperature[1]	ºC Water / 1ºC Air	0.73	± 0.29
2023	Standardized Stream Temperature[1]	ºC Water / 1ºC Air	0.67	± 0.07

[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

Invasive Species

The percentage of sections surveyed where invasive species were observed had a significant increase of 13 percent (Table 4). In 2023, 100% of sections contained at least one invasive species. Most invasive species previously reported increased in 2023. Dog strangling vine, European frogbit and yellow iris were not reported in 2023. Two new invasive species were observed; banded mystery snails and bull thistle.

Table 4 Invasive species presence (% of sections) observed in 2015 and 2023 (NR are species that were not reported in that survey year)

Invasive Species	2009	2015	2023	+/-
banded mystery snail	NR	NR	1%	▲
bull thistle	NR	NR	13%	▲
common & glossy buckthorn	2%	48%	100%	▲
dog strangling vine	NR	6%	NR	▼
European frogbit	NR	3%	NR	▼
garlic mustard	6%	27%	27%	-
Himalayan balsam	NR	34%	42%	▲
honey suckle (non-native)	NR	1%	24%	▲
Japanese knotweed	NR	1%	4%	▲
Manitoba maple	2%	61%	61%	-
poison/wild parsnip	3%	13%	23%	▲
purple loosestrife	51%	60%	17%	▼
yellow iris	2%	1%	NR	▼
Total percent of sections	**55%**	**87%**	**100%**	▲

Pollution

Garbage accumulation on Bilberry Creek was found to decrease from 2009 to 2015, and decrease again from 2015 to 2023.Typically, creeks with a high stormwater influence are more prone to pollution as road pollution is easily flushed downstream. In 2023 the polluted sections contained garbage such as plastics, packaging, cardboard, pylons, beverage containers and tires. Table 5 shows pollution levels in three monitoring years.

Table 5 Pollution levels (presence in % of sections surveyed) comparison between 2009-2023

Pollution/Garbage	2009	2015	2023	+/-
floating garbage	88%	67%	70%	▲
garbage on stream bottom	55%	58%	51%	▼
unusual colouration	2%	0%	1%	▼
other	0%	0%	2%	▲
Total polluted sections	**97%**	**91%**	**86%**	▼

Pollution such as plastics accumulating on a beaver dam upstream of Jeanne D'Arc Blvd.

Instream Aquatic Vegetation

Table 6 shows increases in instream aquatic vegetation from 2015-2023. Free-floating plants (e.g. duckweed) and floating plants (e.g. water lilies) were present in comparable abundance in both survey years. There was a significant increase in narrow-leaved emergent plants (e.g. sedges) in 2023. Increases were also observed for broad leaved emergent plants (e.g. arrowhead) and submerged plants (e.g. pondweed). Algae and robust emergent plants (e.g. cattails) slightly declined in 2023. Between the two cycle years there has been an overall increase in vegetation abundance, although most of the creek does not contain any vegetation.

Table 6 Instream aquatic vegetation (presence in % of sections) comparison between 2015 and 2023

Instream Vegetation	2009	2015	2023	+/-
narrow-leaved emergent plants	5%	6%	25%	▲
broad-leaved emergent plants	0%	0%	2%	▲
robust emergent plants	0%	1%	0%	▼
free-floating plants	0%	1%	3%	▲
floating plants	0%	1%	3%	▲
submerged plants	3%	1%	6%	▲
algae	76%	48%	46%	▼

In both cycle years, most sections either had very little or no vegetation (above) or had abundant algae (below)

Fish Community

Fish sampling was carried out by the City Stream Watch program in 2009, 2015 and 2023 to evaluate fish community composition in Bilberry Creek (see Table 7). In total 34 species have been observed in Bilberry Creek. In 2009, 18 fish species were captured at five sites; in 2015, 33 species were observed in six sites; and 18 species were observed in five sites in 2023. Most sampling sites were replicated each survey year.

The majority of species observed in 2023 had been captured in previous years, with the bluegill and the invasive goldfish as new observations.

Table 7 Comparison of fish species caught between 2009-2023

Species	2009	2015	2023
black crappie *Pomoxis nigromaculatus*	X	X	X
bluegill *Lepomis macrochirus*			X
bluntnose minnow *Pimephales notatus*	X	X	X
brook stickleback *Culaea inconstans*	X	X	X
brown bullhead *Ameiurus nebulosus*	X	X	X
burbot *Lota lota*	X	X	X
central mudminnow *Umbra limi*	X	X	X
channel catfish *Ictalurus punctatus*		X	
common shiner *Luxilus cornutus*		X	X
creek chub *Semotilus atromaculatus*	X	X	X
emerald shiner *Notropis atherinoides*	X	X	
fallfish *Semotilus corporalis*	X	X	
fathead minnow *Pimephales promelas*	X	X	X
golden shiner *Notemigonus crysoleucas*		X	
goldfish *Carassius auratus*			X
johnny/tessalated darter *Etheostoma spp.*		X	X
largemouth bass *Micropterus salmoides*		X	X
logperch *Percina caprodes*		X	
longnose dace *Rhinichthys cataractae*	X	X	X
Species (continued)	**2009**	**2015**	**2023**
mimic shiner *Notropis volucellus*		X	
Northern pearl dace *Margariscus nachtriebi*		X	
Northern pike *Esox lucius*		X	X
pumpkinseed *Lepomis gibbosus*	X	X	X
rock bass *Ambloplites rupestris*	X	X	
sauger *Sander canadensis*		X	
silver redhorse *Moxostoma anisurum*		X	
smallmouth bass *Micropterus dolomieu*	X	X	
spotfin shiner *Cyprinella siloptera*	X	X	
spottail shiner *Notropis hudsonius*	X	X	
troutperch *Percopsis omiscomaycus*		X	
walleye *Sander vitreus*		X	
white sucker *Catostomus commersonii*	X	X	X
yellow bullhead *Ameiurus natalis*		X	
yellow perch *Perca flavescens*	X	X	X
Total Species 35	**18**	**33**	**19**

An invasive goldfish, observed for the first time in 2023

Monitoring and Restoration

Monitoring on Bilberry Creek

Table 8 highlights recent and past monitoring that has been done on Bilberry Creek by the Rideau Valley Conservation Authority's City Stream Watch program. Monitoring activities and efforts have increased in the Bilberry Creek catchment over the years.

Table 8 City Stream Watch monitoring on Bilberry Creek

Accomplishment	Year	Description
City Stream Watch Stream Monitoring	2004	4.5 km of stream was surveyed
	2009	6.5 km of stream was surveyed
	2015	7.1 km of stream way surveyed
	2023	7.1 km of stream way surveyed
City Stream Watch Fish Sampling	2004	Six sites were sampled
	2009	Five sites were sampled
	2015	Six sites were sampled
	2023	Five sites were sampled
City Stream Watch Thermal Classification	2004	Two temperature probes were deployed
	2009	Four temperature loggers were deployed
	2015	Three temperature loggers were deployed
	2023	Three temperature loggers were deployed
Headwater Drainage Feature Assessment	2015	Three headwater drainage feature sites were sampled
	2023	Six headwater drainage feature sites were sampled

RVCA staff and volunteer installing a temperature probe in Bilberry Creek upstream of Jeanne D'Arc Blvd

Potential Riparian Restoration Opportunities

Riparian restoration opportunities include potential enhancement through riparian planting. Opportunities were identified along Bilberry Creek surveyed areas (Figure 41).

Stream Cleanups and Invasive Species Control

Various riparian areas of Bilberry Creek can benefit from stream cleanups and invasive species control. Multiple Himalayan balsam removals took place in 2023, and potential cleanup opportunities have been identified.

Erosion Control

There are multiple areas along the creek that would benefit from erosion control measures to stabilize the banks. Bioengineering methods such as installation of fascines, brush mattresses, soil wrapping and livestaking of shrubs are some methods to prevent further erosion.

Volunteers removing Himalayan balsam along Bilberry Creek

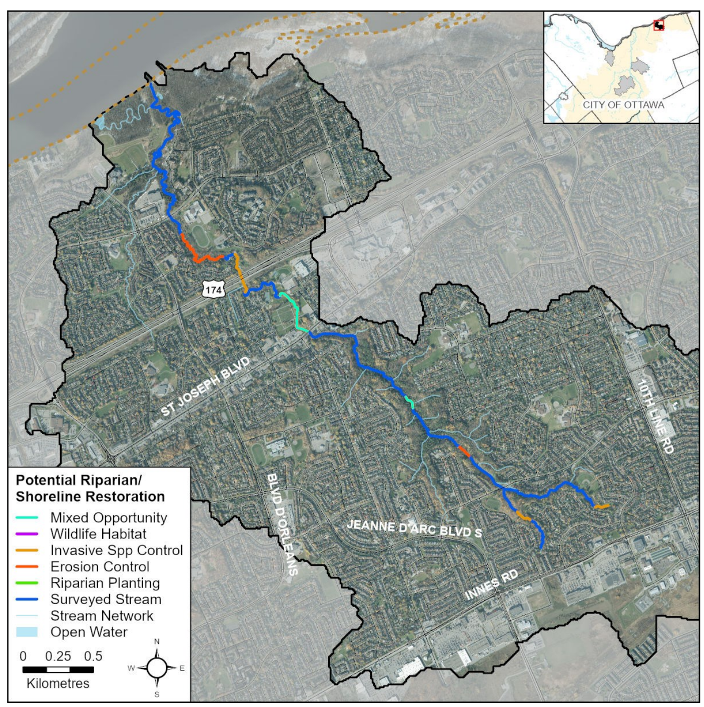


Figure 41 Potential riparian/shoreline restoration opportunities along Bilberry Creek and its headwater reaches

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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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