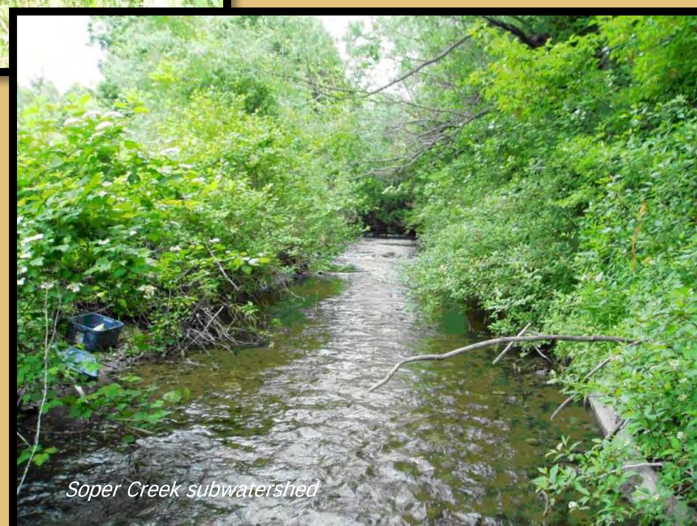
Bowmanville Creek Subwatershed



Soper Creek subwatershed

BOWMANVILLE/SOPER CREEK WATERSHED EXISTING CONDITIONS REPORT CHAPTER 16 – FISHERIES & AQUATIC HABITAT

FINAL – December 2011

Central Lake Ontario Conservation

DURHAM REGION

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1.0 INTRODUCTION

The aquatic habitat in a stream and the health of the fishery within it are influenced by numerous variables, including many of the topics discussed in other chapters of this report. These include:

- Flow and sediment regimes;
- Water quality and quantity;
- Land use and land cover (including wetlands and riparian habitats);
- Local climate, geography, physiography and surficial geology.

While many of these topics have been discussed previously, each will be discussed briefly within this chapter in relation to the fisheries and aquatic habitat of the Bowmanville and Soper Creeks starting with a general discussion of each topic, followed by a more detailed examination by subwatershed.

Legislative Requirements

Under Section 35 of the Fisheries Act, the Central Lake Ontario Conservation Authority (CLOCA) has a Level 3 agreement with the Department of Fisheries and Oceans Canada (DFO) to review development proposals including Municipal Class Environmental Assessment (EA) projects. In this agreement, CLOCA conducts initial reviews on projects to determine if there will be an impact to fish and fish habitat. If impacts are likely, CLOCA will determine if and how the proponent can mitigate potential impacts. If potential impacts can be mitigated, the Authority will issue a Letter of Advice. If impacts to fish and fish habitat cannot be fully mitigated, the Authority works with the proponent and DFO to prepare a fish habitat compensation plan, at which time the project is forwarded to the local DFO office for authorization under the Fisheries Act.

In addition to Fisheries Act requirements, the Authority works to protect hazard lands such as floodways, erodible or unstable soils, watercourses and wetlands through the Conservation Authorities Act and Ontario Regulation #42/06. This regulation requires a permit from the Conservation Authority prior to various works taking place within a floodplain or regulated area. Further, the Act allows regulations that pertain to the use of water, prohibit or require permission to interfere in any way with the existing channel of a watercourse or wetland, and prohibit or require a permit to undertake development (e.g. construction, structural alterations, grading, filling) in areas where the control of flooding, erosion, dynamic beaches, pollution or the conservation of lands may be affected. This is called "Development, Interference with Wetlands and Alteration to Shorelines and Watercourses Regulation, #42/06".

2.0 STUDY AREA AND SCOPE

The Bowmanville/Soper Creek watershed is situated entirely within the Regional Municipality of Durham and covers an area of approximately 170 km^2 including 92km^2 and 77 km^2 for each the Bowmanville and Soper Creek subwatersheds, respectively (Figure 1). Bowmanville and Soper creeks merge just north of Lake Ontario in the Bowmanville Coastal Wetland Complex. Including tributaries, Bowmanville Creek is approximately 240 km in length and Soper Creek is 200 km. The headwaters of Bowmanville/Soper originate in the Oak Ridges Moraine. The Bowmanville/ Soper Creek watershed is comprised of the following 5 subwatersheds: Hampton, Haydon, Tyrone, Bowmanville Main, and Bowmanville Marsh. Soper Creek watershed is further divided into the following 4 subwatersheds: Mackie, Soper North, Soper Main, and Soper East.

This chapter summarizes the current state of the aquatic habitat within the Bowmanville/Soper Creeks and its fisheries resources at both the watershed and subwatershed scale. In addition, relevant historical information regarding fisheries in the watershed is provided. Key indicators of aquatic habitat conditions are described including Strahler stream order, stream slope, instream barriers to fish migration including movement of sediment and large woody material, riparian vegetation, thermal regimes, land use and land cover. In addition, fish species composition and distribution will be discussed as it relates to these habitat conditions.


Chinook Salmon

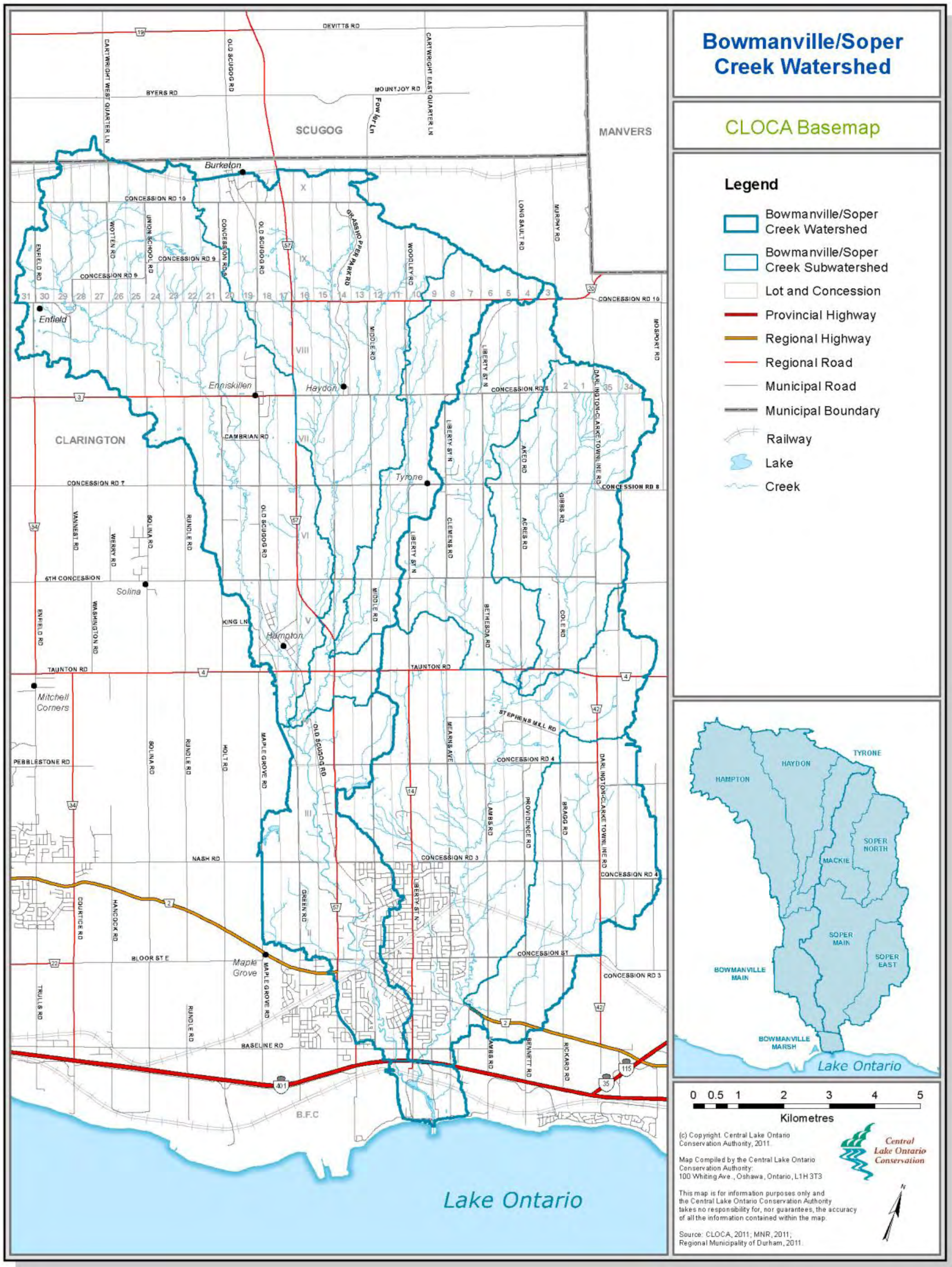


Figure 1: Bowmanville/Soper Creek watershed

3.0 METHODOLOGY

Habitat characteristics were assessed using the Ontario Stream Assessment Protocol (Stanfield et al., 1998) and from 1:10,000 Ontario Base Map (OBM) data obtained from the Ontario Ministry of Natural Resources (MNR).

Fish communities have been assessed throughout the watershed since 1998 according to fish sampling methods from the Ontario Stream Assessment Protocol (Stanfield et al., 1998). This watershed was sampled during 1998/1999 and 2006 with some supplemental, Conservation Area management plan and/or long-term monitoring sampling occurring during 1996 and 1997, 2000-2006 and 2008-2010. Sample locations were randomly selected at numbers suitable to accurately represent a number of varying instream habitat conditions, physiographic regions within the watershed and adjacent land use types. The Bowmanville Marsh represents a different habitat type, and as such was sampled using boat electrofishing as part of the Durham Region Coastal Wetland Monitoring Project (2002–2010).

For greater detail on the methodology used to assess aquatic habitat and fisheries, the reader is referred to the 2010 CLOCA Aquatic Monitoring Report and the Aquatic Monitoring Program, 2009 – 2013.

While every effort has been made to accurately present the findings reported in this chapter, factors such as significant digits and rounding, and processes such as computer digitizing and data interpretation may influence results. For instance, in data tables no relationship between significant digits and level of accuracy is implied, and as a result values may not always sum to the expected total.


Bowmanville Marsh

4.0 FINDINGS

4.1 Bowmanville/Soper Creeks Watershed

4.1.1 Aquatic Habitat

4.1.1.1 Strahler Stream Order and Slope

Stream-order is a classification system based on a drainage network and uses the Strahler Method (1964). Based on this method, streams increase in order upon converging with a stream of equal order. For example, a first-order stream (typically headwaters) is a small stream without tributaries. A second-order stream begins at the confluence of two first-order streams and continues until it meets with another second-order stream, forming a third-order stream, and so forth.

Stream-order is directly related to other morphometric and fluvial characteristics and can be useful in describing fish habitat. Based on concepts developed by Strahler (1964), stream-order is directly related to length, width, depth and discharge. As order increases, so too does the size of the stream and the current flowing within. Stream-order is also related to stream slope (or gradient). As stream-order increases, stream slope decreases. Finally, stream-order is related to fish species diversity, where fish diversity increases as a function of stream-order (Mackie, 2001). Stream-orders 1 to 3 can be described as narrow, with an erosional substrate (e.g., rocks, boulders) and an input of leaf-litter. Stream-orders 4 to 6 are wider, characterized by riffle and pool areas, and contain both erosional and depositional (e.g., sand) substrate. Stream-orders greater than 7 are wide, often with turbid water and contain depositional substrates (Mackie 2001).

The dendritic nature of Bowmanville/Soper Creeks gives rise to the majority of stream length as first-order tributaries, which come together to form fewer large-order streams (Figure 2). First-order streams represent over half (~64%) of the total stream length in the watershed (Table 1). The numerous streams that originate upon the Oak Ridges Moraine and Lake Iroquois Beach emphasize the importance of these physiographic features as groundwater recharge and discharge areas. The Bowmanville/Soper Creek is at its largest, 5th order, for only 1km or 0.23% of the total stream length.

Table 1: Bowmanville/Soper Creeks watershed Strahler Stream Order
Total stream length (km) and proportion of the total stream length (in parenthesis) by stream-order of each subwatershed in the Bowmanville/Soper watershed (values calculated from the 2010 CLOCA drainage layer).

Strahler Stream Order					Grand Total
1	2	3	4	5	
279.69	75.18	48.29	33.91	1.00	224.21
(64%)	(17%)	(11%)	(8%)	(1%)	100%

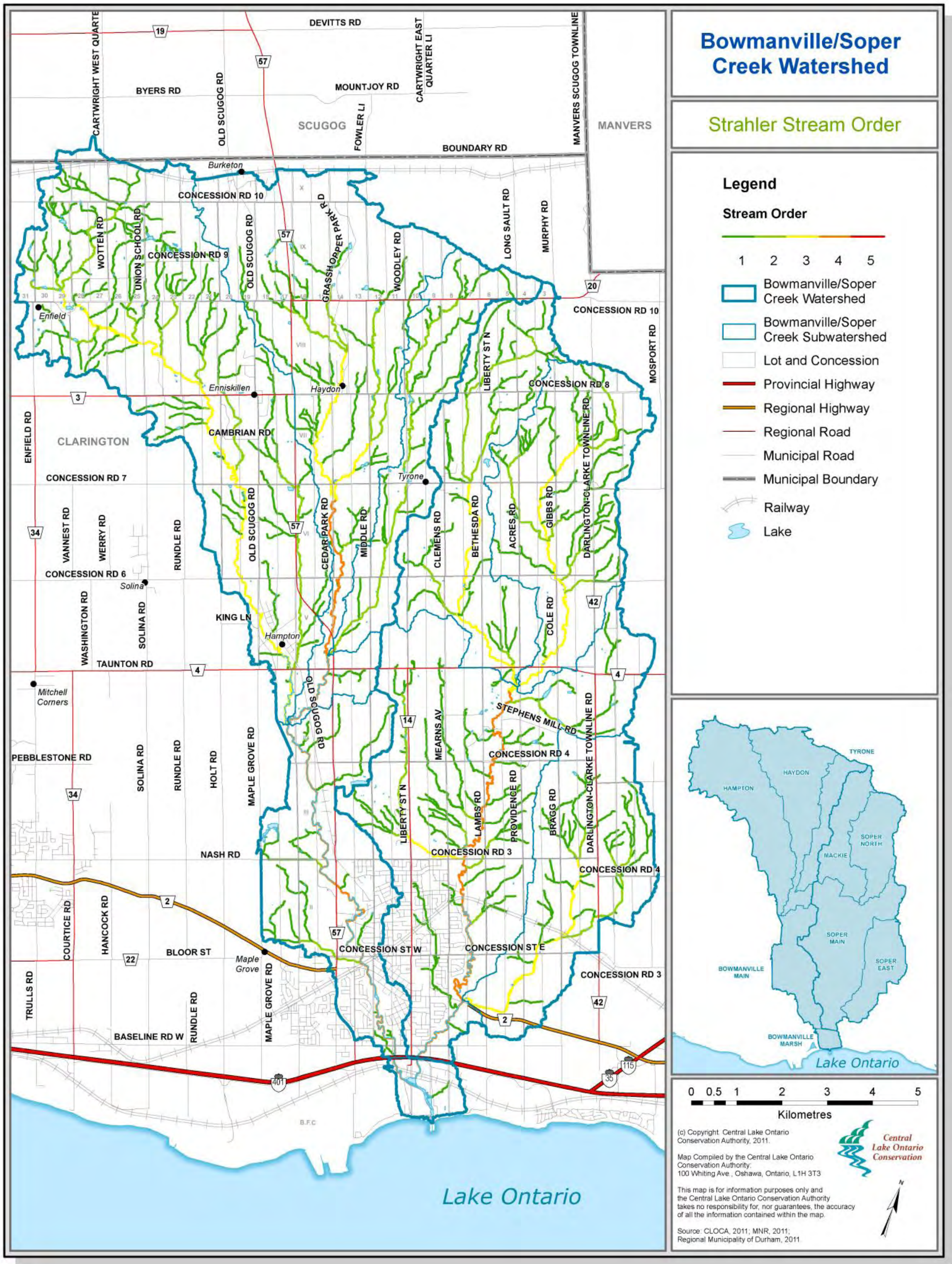


Figure 2: Strahler Stream Order of the Bowmanville/Soper creeks

The slope or gradient of a stream is one of a number of variables used to characterize the type of habitat available to aquatic organisms. Gradient can be used to predict fish habitat structure. The substrate in high gradient streams is typically composed of large materials such as boulders, cobble and gravel, because fast-flowing water tends to wash smaller particles downstream. Silts and sandy materials characterize the substrate of low gradient streams, since water velocity is low enough along the channel bottom water interface to allow fine materials to settle out (Mackie, 2001).

Examination of gradient maps may also reveal areas of potential groundwater discharge. In high gradient areas, where the energy of flowing water has scoured away soil materials, the water may be flowing at the elevation of the water table and leading to the discharge of groundwater. The identification of groundwater seepage areas assists in identifying habitat suitable for the reproduction of salmonids such as Brook Trout.

Stream-order and slope determine the water velocity of a stream, which dictates the types of habitat and aquatic organisms found within streams. Some fish species are adapted to fast-flowing water, while others are more suited to slower velocities. Understanding stream-order and slope provides insight into fish habitat and communities within the watershed.

The rise of the creek (elevation in m) was divided by the length of the creek (m) to determine slope. Slopes were categorized into four groups: low slope (0.0 to 0.3%), moderate slope (0.3 to 1.0%), steep slope (>1.0 to 5.0%), and very steep slope (>5.0%). A profile of the Bowmanville and Soper watershed from the headwaters on the Oak Ridges Moraine planning boundary and Till Plain to the outflow into Lake Ontario, including location of physiographic and geographic features can be found in Figure 3 and Figure 4.

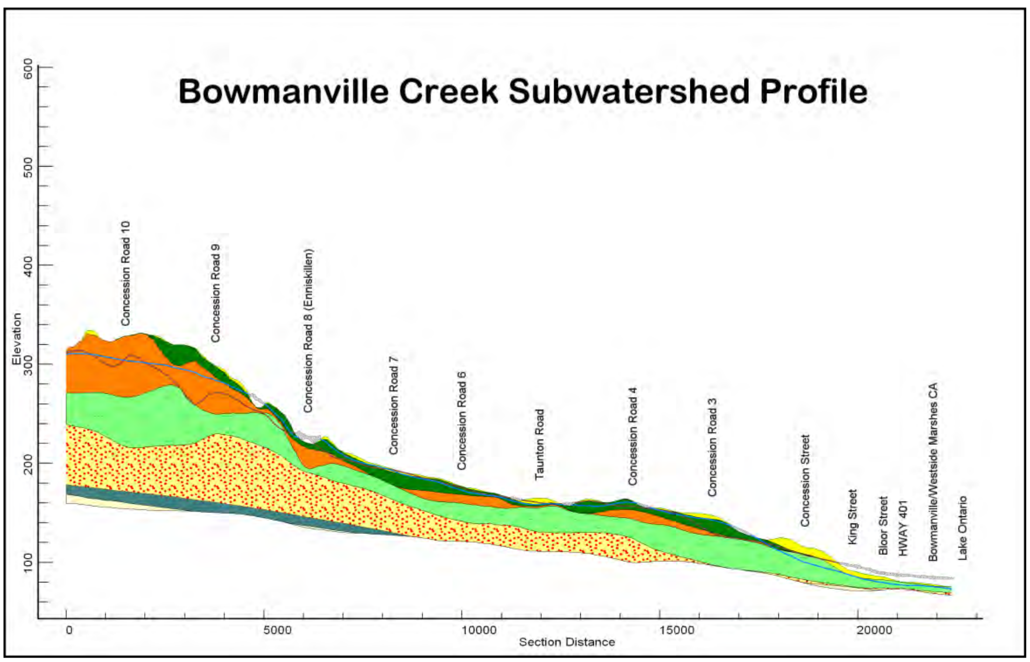


Figure 3: Bowmanville Creek subwatershed geologic profile

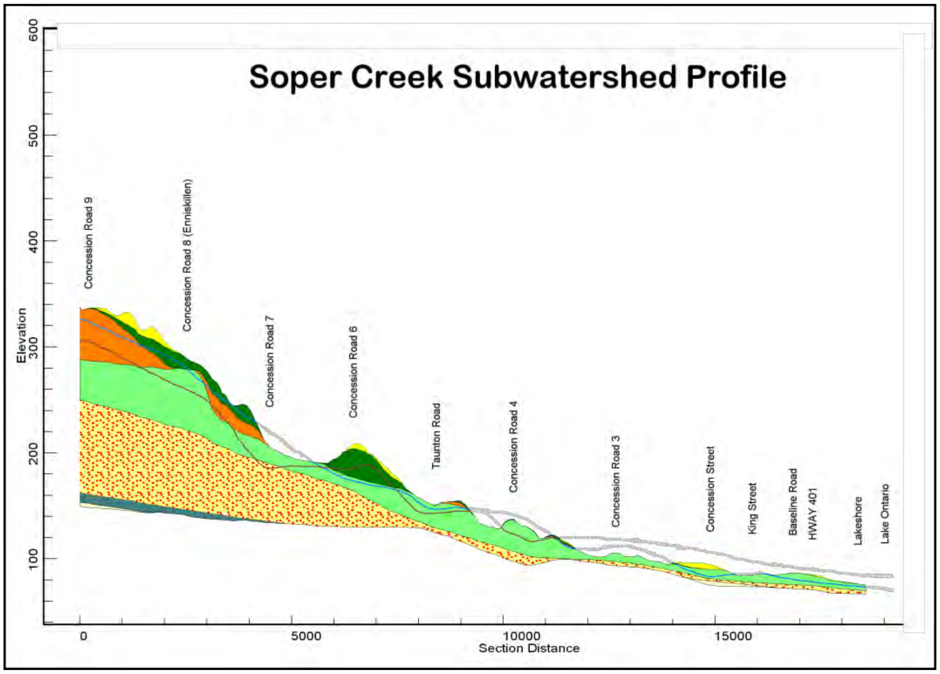


Figure 4: Soper Creek subwatershed geologic profile

4.1.1.2 Instream Barriers

Instream barriers may be any type of water control structure, culvert, or weir that obstructs or limits fish movement, particularly from accessing upstream habitat, or causing fish to congregate at the base of the barrier for prolonged time periods. Not only do instream barriers have direct effects on fish, they also affect water quality and habitat conditions within the stream. Impoundment of water behind a physical structure causes the sediment to settle out from the stream water, leading to silt build-up in the pond and sediment depravation downstream. Sediment depravation downstream of the barrier causes an increased rate of stream bank erosion as the sediment-reduced water flowing past the barrier has more energy and scours the stream banks more quickly. This also leads to increased erosion of sediments in depositional areas of the lower stream reaches. Sediment accumulation in a pond requires periodic dredging, or sediment will be flushed into downstream creek sections. Flushing silt downstream can smother fish spawning beds and habitat.

In some cases within the watersheds, instream barriers act to separate upstream fish communities from down-stream fish communities. The isolation of upstream fish populations may be either beneficial or detrimental. For example, an instream barrier may be beneficial by protecting upstream fish populations from competition of invasive species, or it may be detrimental by restricting migrating species like Rainbow Trout from accessing spawning habitats upstream of an impassible barrier.

Instream barriers within the Bowmanville/Soper Creek watershed were assessed based on the obstruction of migratory fish species. Currently, there are 14 known instream barriers within the watershed (Figure 5). A detailed description and photographs of each of these barriers can be found in the *Bowmanville Creek Watershed Aquatic Resource Management Plan* (CLOCA 2000) *and Central Lake Ontario Fisheries Management Plan* (CLOCA 2007).

4.1.1.3 Riparian Vegetation

Riparian vegetation plays an important role in water quality and aquatic life. A buffer strip of riparian vegetation helps filter land-flowing water before it enters the stream, provides shade to help moderate stream temperature, provides allochthanous nutrient input (e.g. external nutrients like dead leaves or other terrestrial debris), and helps to maintain the stability of the stream bank (Mackie, 2001). While all streams benefit from riparian cover, lower order streams (see highlighted columns in Table 2) in particular benefit greatly from riparian cover and the positive effects are apparent in higher order areas downstream.

Environment Canada (EC) guidelines (EC, 2004) indicate that 75% of stream length should have 30m riparian vegetation buffers on each side of the stream. Currently, riparian calculations completed by CLOCA look at total stream length that intersects natural areas based on the Ecological Land Classification (ELC) system (OMNR, 2007). Since width of riparian vegetation is not considered in this calculation, the values presented in this report are not directly comparable to EC targets, and for that reason it is important to emphasize two points. Firstly, that the values in this report should not be used as a direct comparison to the guidelines set out by EC. Secondly, once values are calculated using a methodology comparable to EC guidelines, it is anticipated that lower values will result, but this is not evidence of a degrading watershed but rather a result of different methodologies. That being said, while values may not be directly comparable, general trends may be representative of overall conditions.

Riparian vegetation cover in the Bowmanville/Soper Creek watershed is good relative to the other watersheds in CLOCA jurisdiction, having a total of 73% of its stream length intersecting natural riparian areas (Table 2). By stream-order, the proportion of riparian cover is greatest along fifth- (100%), fourth- (97%), third (96%), and second (89%) order streams, and worst along first (61%) order streams. In other CLOCA watersheds, similar stream-order/riparian cover ratios have been identified. In this watershed, fifth-order streams only account for approximately 1 kilometer (or 0.23%) of overall stream length in the Bowmanville/Soper Creek watershed, all of which is located in the Bowmanville Marsh subwatershed south of Highway 401. Riparian cover is especially important for low-order streams, which are more affected by environmental change than large-order streams (EC 2004); however, only 70% of the total stream length of first to third-order streams has adequate riparian buffers. While it is difficult to make watershed-wide predictions of stream and fishery quality based on the absence of riparian vegetation, it is known that riparian cover benefits aquatic life and the low proportion of riparian cover in the watershed may be correlated with poor stream and fishery health in some areas.

Bowmanville Creek subwatershed

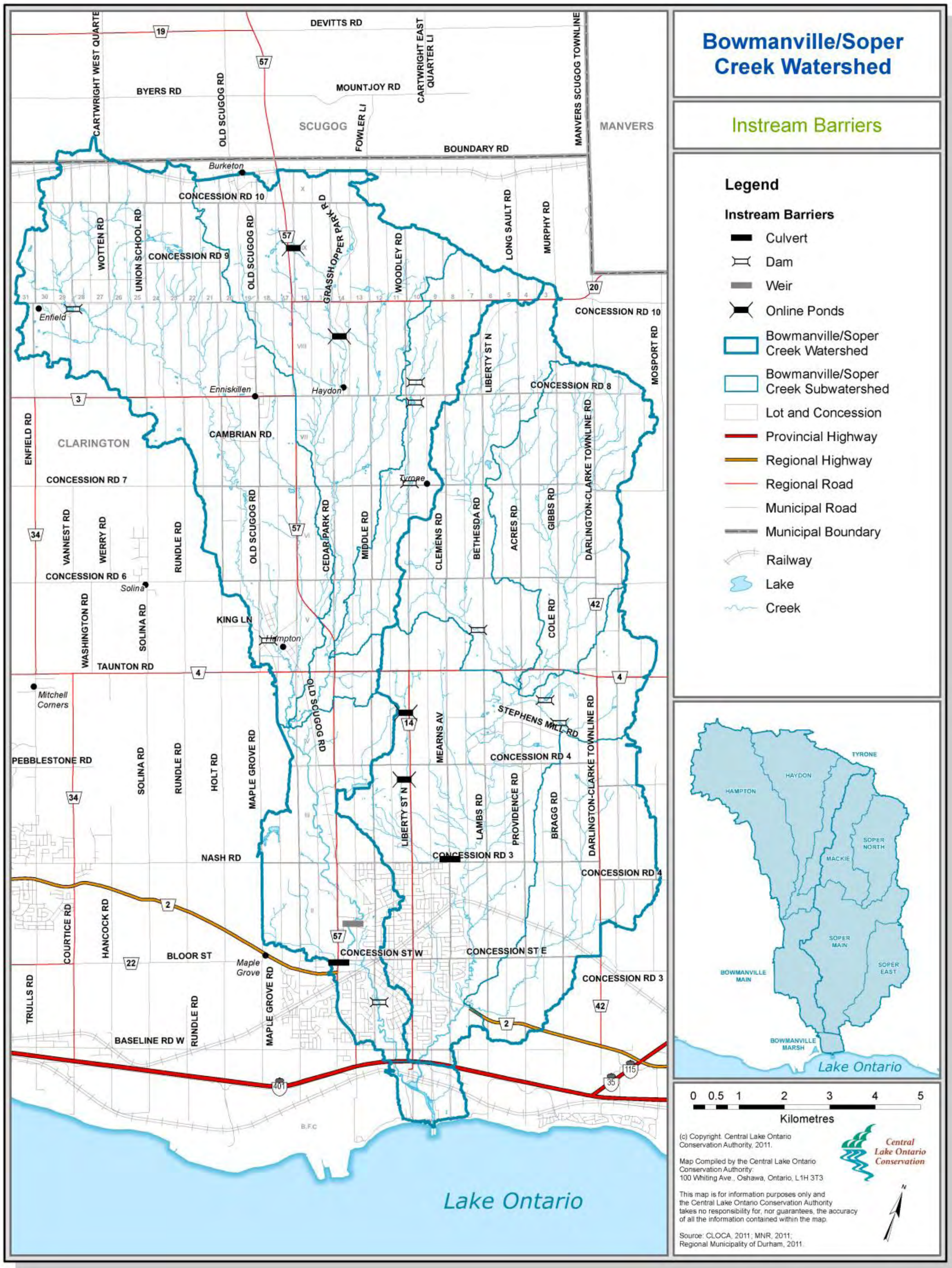


Figure 5: Instream Barriers in the Bowmanville/Soper watershed

Table 2: Status of riparian vegetation in the Bowmanville/Soper watershed.
Total stream length (km) intersecting natural areas based on ELC (OMNR, 2007) communities and resulting percentage of total stream length with cover (in parenthesis) by stream-order. Highlighted columns represent lower order streams which benefit greatly from riparian cover and may be given priority when determining areas for restoration.

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
170.47	66.98	46.49	33.04	1.00	317.98
(61%)	(89%)	(96%)	(97%)	(100%)	(73%)

4.1.1.4 Stream Health

Landscape Influences

Natural land cover and various land uses have direct and indirect effects on the physical, chemical, and biological characteristics of streams (Figure 6). The use of models to quantify the impacts of land use on aquatic ecosystems has become a powerful tool and is well represented in scientific literature (Kilgour and Stanfield, 2006; Stanfield and Kilgour, 2006; Stanfield et al., 2006). To quantify the relationship between land use disturbance and aquatic ecosystem health in southern Ontario streams, Stanfield and Kilgour (2006) developed a locally derived model called the Land Disturbance Index (LDI) which incorporates fish, benthic invertebrates, instream habitat and landscape data from sites across the north shore of Lake Ontario, including CLOCA watersheds. The LDI model predicts a threshold response for fish communities in response to increased land disturbance such that salmonids are present in streams with low amounts of impervious cover and an absence from those with high amounts of impervious cover (Stanfield and Kilgour 2006). The high to moderately disturbed areas are manifested through below average water quality and high stream temperatures.

Temperature is a limiting factor for the survival and productivity of fish and other aquatic organisms. All fish species have specific temperature requirements, and these requirements can change throughout their various life-stages. Some fish species are considered cold/cool-water fishes because their productivity is optimized in cooler water temperatures; whereas, species which are considered warm-water fishes have optimal productivity in warm temperatures. Cold-water contains more dissolved oxygen than warm-water, and can support fishes that are sensitive to dissolved oxygen levels, such as trout and salmon. Warm-water fishes are able to tolerate lower oxygen levels.

Temperature data provide an understanding of fish communities and habitat use, and can be used to predict the productive capacity of a particular habitat or stream reach. Stream temperature can be affected by a number of factors such as riparian vegetation cover, groundwater input, stormwater input, and climate change. By comparing historical and recent trends in stream temperature, degradation in thermal stability can be identified and management recommendations can be focused on the protection or rehabilitation of particular stream temperatures. The reader is referred to Chapter 10 – Water Temperature for additional detail regarding stream thermal classifications within the watershed.

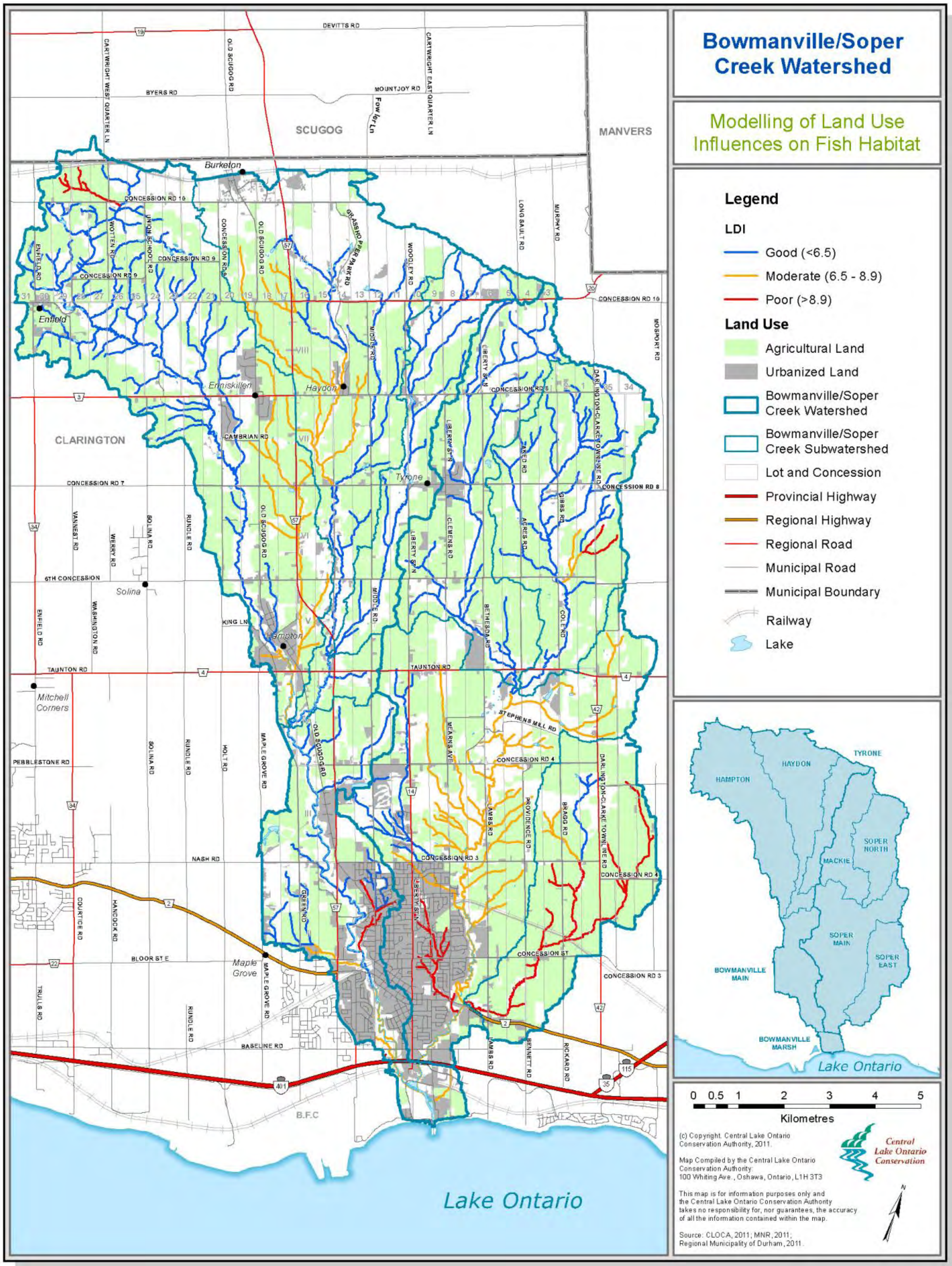


Figure 6: Modelled Landscape Disturbance on Fish Habitat in the Bowmanville/Soper watershed

4.1.2 Fisheries

The following section provides a brief summary of the fish community within Bowmanville/Soper Creeks. Additional information including fish species and family abundance can be found in the Central Lake Ontario Fisheries Management Plan (CLOCA/MNR, 2007), the Aquatic Resource Management Plan for the Bowmanville/Soper Creek Watersheds (CLOCA, 2000), or results from the 2006 CLOCA Aquatic Monitoring Program (CLOCA 2006 unpublished data).

Fish sampling was conducted using back-pack electrofishing at 45 stream sites in 1998/99 (Figure 7). Of these sites, 18 were revisited during the 2006 CLOCA Aquatic Monitoring Program along with 6 new sites. A combination of 31, new and historical, sites have been sampled throughout the Bowmanville/Soper watershed between 1996-1997, 2000-2005 and 2008-2010. In addition to stream monitoring, CLOCA conducts coastal wetland fisheries surveys using a boat electrofisher as part of the Durham Region Coastal Wetland Monitoring Project (DRCWMP). This project samples Bowmanville Marsh, one of 18 coastal marshes sampled for fisheries surveys through the DRCWMP.

Currently, there are approximately 39 fish species, representing 12 families, known to occur within the watershed including those found only within the Bowmanville Marsh (Table 3). While this only represents 53% of the 73 species known to inhabit CLOCA's jurisdiction and Lake Ontario, there may be other species using the creek that have not been identified due to the timing of sampling and biases associated with the sampling gear. Many of the fishes distributed within CLOCA's jurisdiction and Lake Ontario will use either stream, marsh or lake habitats; however, some species are particular to Lake Ontario or are present in the stream during part of the year but difficult to detect due to the timing of aquatic monitoring. These include: American Eel, Burbot, Lake Trout, Splake, Lake Herring and Rainbow Smelt.

Species at Risk are species that are at risk of extinction, extirpation, or endangerment and are designated in Ontario by the provincial Committee on the Status of Species at Risk in Ontario (COSSARO), or the Federal Committee on the Status of Endangered Wildlife in Canada (COSEWIC). As of May 2011, there are no aquatic species residing in the Bowmanville/Soper Creek watershed that are considered "at risk". Atlantic Salmon are extirpated from the Great Lakes, with the exception of a few observations following a 1996 stocking event, they have been absent from Bowmanville/Soper Creeks since the late 1800s. Recent restoration efforts are underway to reintroduce Atlantic Salmon into Lake Ontario through stocking and habitat rehabilitation. Soper Creek is being considered as a candidate for the future round(s) of stocking (OFAH, 2011). While not considered at risk, there are 2 federal candidate fish species that have not yet been assessed by COSEWIC but have been identified by Species Specialist Subcommittees or Aboriginal Traditional Knowledge Subcommittees as requiring detailed status assessment in Ontario. Candidate species are ranked into three priority groups (1 being high and 3 being low) to reflect their relative urgency with which they should be assessed. Included in this list are Slimy Sculpin and Rainbow Darter, and both are listed in priority group 2.

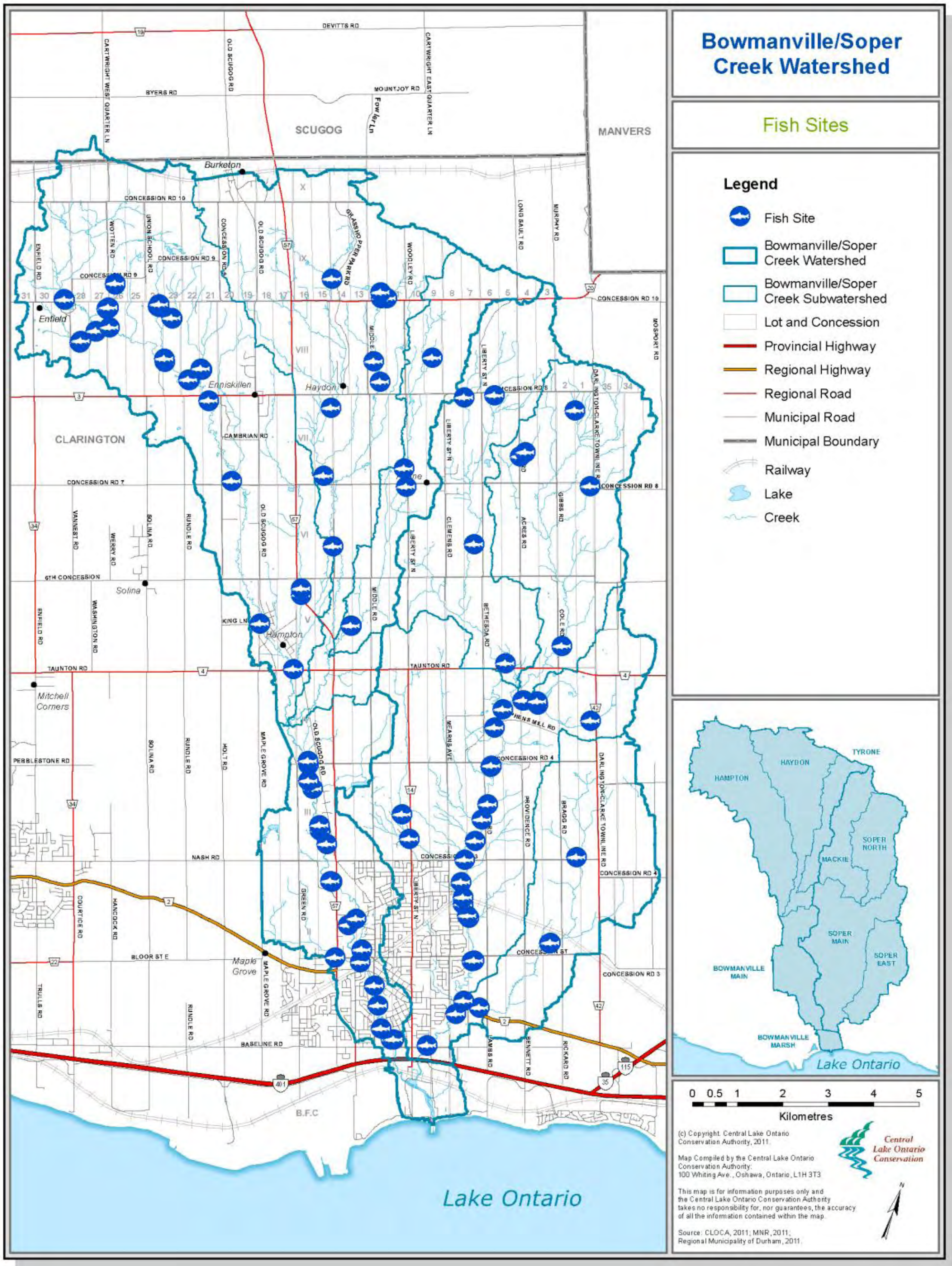
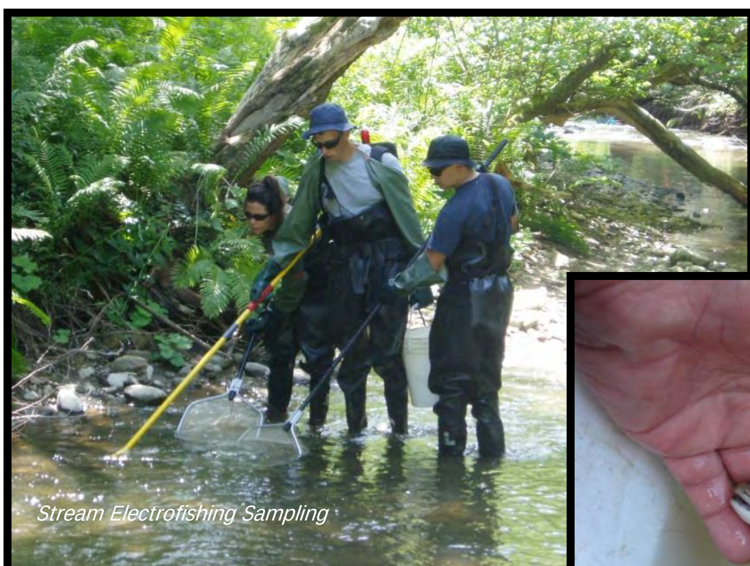


Figure 7: Fish Sampling Sites in the Bowmanville/Soper watershed

Six species have been introduced either through intentional or unintentional releases. Pacific Salmon were introduced intentionally into Lake Ontario, but some non-native fish species have been unintentionally released. Non-native introduced species that tend to harm the native environment or fishery are often termed 'invasive' or 'nuisance' species. Invasive species found within the Bowmanville/Soper watershed include Common Carp, Goldfish, Round Goby, and Sea Lamprey. Goldfish likely originated from the release of aquarium or water garden fish into local streams or ponds. Common Carp are abundant in Bowmanville Marsh where it has been known to uproot aquatic plants and increase turbidity inhibiting plant growth. Round Goby is present in the lower reaches of Bowmanville/Soper Creeks. This species is likely present in Bowmanville Marsh as well but has not been detected during boat-electrofishing surveys.

Salmonids make up the largest relative abundance and biomass of any of the families caught within Bowmanville/Soper Creek and is comprised of two main groups. Migratory Trout and Salmon, such as Chinook and Coho Salmon and Brown and Rainbow Trout, use the creeks for spawning and rearing habitat. Resident Trout, such as Brook and Brown Trout, use the creek for all their life-stages. Brook Trout are the only remaining native trout species within the watershed; however their habitat is easily impacted through land-use changes. As stream temperatures increase and riparian vegetation is removed, habitat quality for Brook Trout may be degraded to such an extent that populations in the watershed are compromised. Brook Trout, as well as other salmonids, require cold and cool-water habitat. Other species that are found in the watershed that require cold and cool-water can often be used as thermal indicators. Mottled and Slimy Sculpin are good examples of fish species that require cold clean waters and often are found in close proximity to Brook Trout populations in the northern less-disturbed reaches of Bowmanville/Soper Creek.



Stream Electrofishing Sampling

Brook Trout

Backpack electrofishing

Table 3: Known fish species within the Bowmanville/Soper watershed and the Bowmanville Marsh.

Number	Common Name	Family	Scientific Name
1	Alewife [24]	Clupeidae	*Alosa pseudoharengus*
2	American Brook Lamprey [1]	Petromyzontidae	*Lampetra appendix*
3	Atlantic Salmon [3]	Salmonidae	*Salmo salar*
4	Blacknose Dace [1]	Cyprinidae	*Rhinichthys obtusus*
5	Black Crappie [2]	Centrarchidae	*Pomoxis nigromaculatus*
6	Bluntnose Minnow [12]	Cyprinidae	*Pimephales notatus*
7	Brook Stickleback [1]	Gasterosteidae	*Culaea inconstans*
8	Brook Trout [1]	Salmonidae	*Salvelinus fontinalis*
9	Brown Bullhead [12]	Ictaluridae	*Ameiurus nebulosus*
10	Brown Trout [14]	Salmonidae	*Salmo trutta*
11	Chinook Salmon[14]	Salmonidae	*Oncorhynchus tshawytscha*
12	Coho Salmon[14]	Salmonidae	*Oncorhynchus kisutch*
13	Common Carp [24]	Cyprinidae	*Cyprinus carpio*
14	Common Shiner [12]	Cyprinidae	*Luxilus cornutus*
15	Creek Chub [1]	Cyprinidae	*Semotilus atromaculatus*
16	Emerald Shiner[2]	Cyprinidae	*Notropis atherinoides*
17	Fathead Minnow [12]	Cyprinidae	*Pimephales promelas*
18	Finescale Dace[1]	Cyprinidae	*Chrosomus neogaeus*
19	Gizzard Shad [2]	Clupeidae	*Dorosoma cepedianum*
20	Goldfish [124]	Cyprinidae	*Carassius auratus*
21	Golden Shiner [2]	Cyprinidae	*Notemigonus crysoleucas*
22	Johnny Darter [12]	Percidae	*Etheostoma nigrum*
23	Logperch [12]	Percidae	*Percina caprodes*
24	Longnose Dace [1]	Cyprinidae	*Rhinichthys cataractae*
25	Mottled Sculpin [1]	Cottidae	*Cottus bairdii*
26	Northern Pike [2]	Esocidae	*Esox lucius*
27	Northern Redbelly Dace [1]	Cyprinidae	*Phoxinus eos*
28	Pumpkinseed [12]	Centrarchidae	*Lepomis gibbosus*
29	Rainbow Darter [1]	Percidae	*Etheostoma caeruleum*
30	Rainbow Trout [14]	Salmonidae	*Oncorhynchus mykiss*
31	Rock Bass [1]	Centrarchidae	*Ambloplites rupestris*
32	Round Goby[14]	Gobiidae	*Neogobius melanostomus*
33	Sea Lamprey [14]	Petromyzontidae	*Petromyzon marinus*
34	Slimy Sculpin[1]	Cottidae	*Cottus cognatus*
35	Smallmouth Bass[12]	Centrarchidae	*Micropterus dolomieu*
36	Spottail Shiner [12]	Cyprinidae	*Notropis hudsonius*
37	Walleye[2]	Percidae	*Sander vitreus*
38	White Sucker [12]	Catostomidae	*Catostomus commersonii*
39	Yellow Perch [12]	Percidae	*Perca flavescens*

[1] Species caught during CLOCA Stream Electrofishing (1996-2006, 2008-2010)
[2] Species caught in Bowmanville Marsh (2002-2010 DRCWMP)
[3] Species likely present historically but not caught during 2002 or 2008 sampling
[4] Introduced/Non-native

4.2 Subwatershed Findings

4.2.1 Bowmanville Creek Subwatersheds (Hampton Subwatershed)

4.2.1.1 Aquatic Habitat

Strahler Stream Order

The Hampton subwatershed is located in the northern section of the Bowmanville Creek subwatershed mostly within the Oak Ridges Moraine. For this reason, Hampton Subwatershed is primarily first order stream (Table 4 and Figure 8), with the remainder comprising second and third-order streams. The Hampton subwatershed has the greatest stream length of any of the subwatersheds within the Bowmanville/Soper Creek watershed. Since low-order streams are more susceptible to environmental change, those subwatersheds with larger proportions of low-order streams (EC, 2004) like this subwatershed, may be more sensitive to land use changes. Because of its relative importance due to total stream length, the health of this subwatershed will have a direct impact on the health of the watershed downstream. The high quantities of ground water being discharged in the Oak Ridges Moraine is of critical importance for maintaining year round habitat in these small headwater tributaries as this discharge preserves base-flow and maintains consistent stream temperatures.

Table 4: Hampton subwatershed Strahler Stream Order
Total stream length (km) and proportion of the total stream length (in parenthesis) by stream-order of the subwatershed (values calculated from the 2010 CLOCA drainage layer).

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
76.90	19.92	18.01	0.00	0.00	114.83
(67%)	(17%)	(16%)	(0%)	(0%)	100%

Instream Barriers

Instream barriers within the Hampton subwatershed were assessed based on the obstruction of fish movement of migratory species. There are two known potential instream barriers within the Hampton subwatershed (Figure 9). Both of these dams are historically constructed barriers dating back to the mid-1800s. The barriers are summarized in Table 5 and a description of each is provided.

Table 5: Known instream barriers in the Hampton subwatershed
Fish passage indicates whether fish can move through the barrier to access upstream habitats (Salmonids indicates that only jumping species of salmon and trout can pass over the barrier).

Obstruction	**Type**	**Year Built**	**Status**	**Fish Passage**
Hampton Dam	Dam	1841/1990	Active	Not Passable
Enfield Dam	Dam/Pond	1860	Active	Not Passable

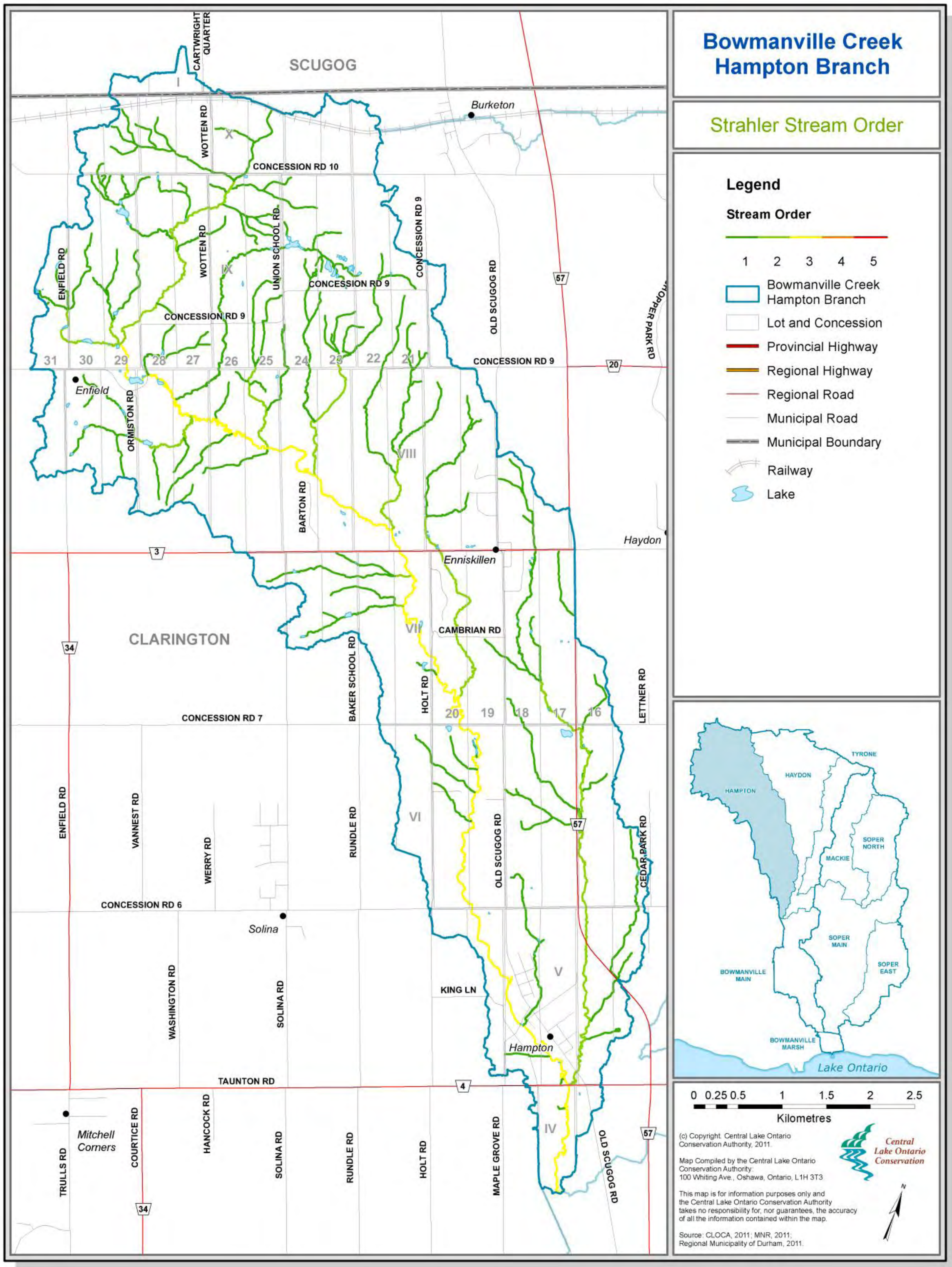


Figure 8: Strahler stream order of the Hampton subwatershed

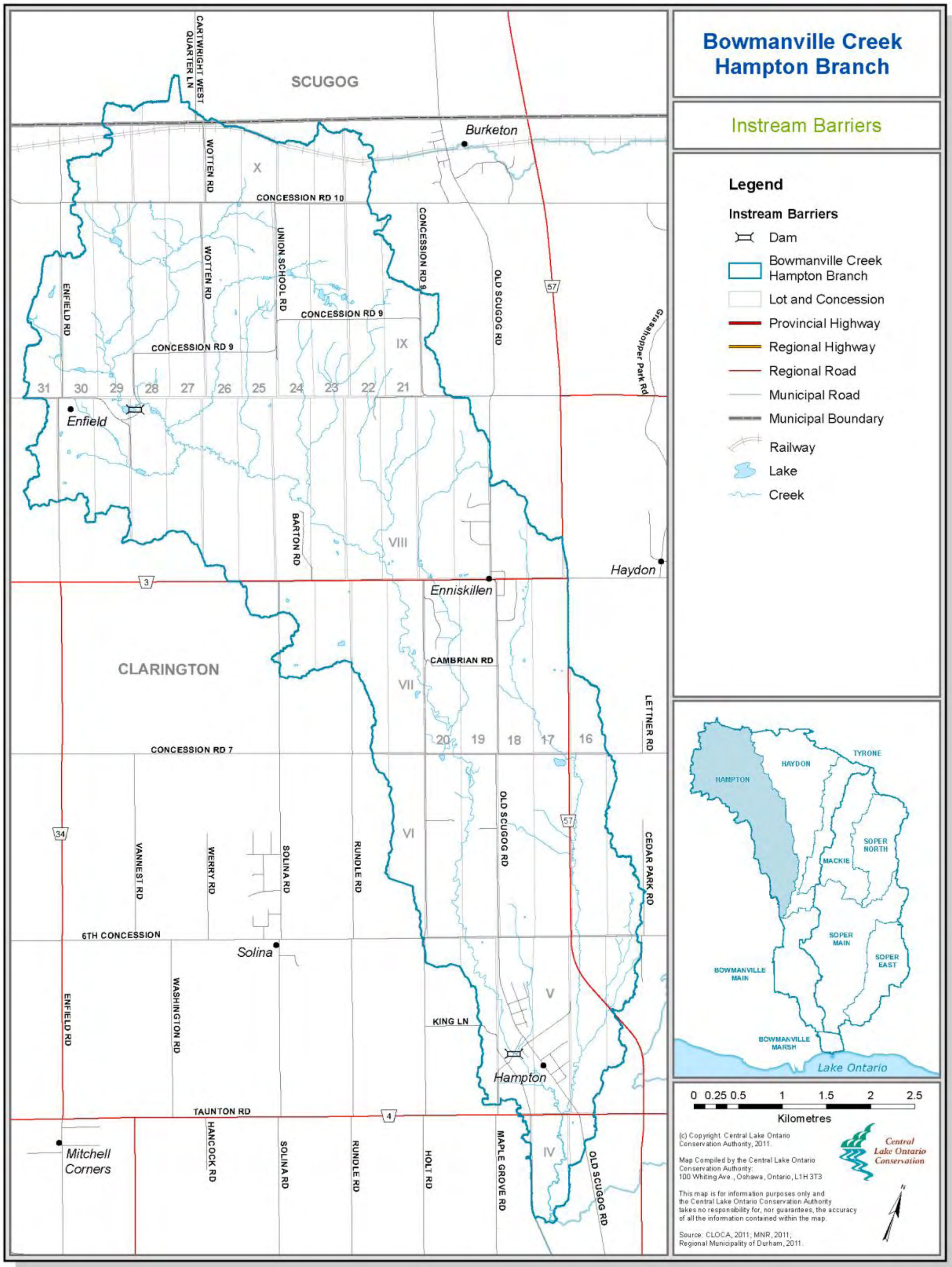


Figure 9: Instream barriers in the Hampton subwatershed

Hampton Dam

The Hampton Dam was originally built in 1841 to power a gristmill. After a sever rain event in 1986, which breached the dam, a control structure was installed. The design of this impassable structure protects upstream naturalized and native salmonid populations (Brook and Brown Trout) from the spawning runs of non-native anadromous fishes (Chinook and Coho Salmon). The barrier is two tiered and includes many concrete structures which "break up" flows making fish passage nearly impossible.

Enfield Dam

The Enfield Dam and pond was originally built in 1860 to power a saw mill. A top-draw standpipe overflow was built in the 1970's such that the sluiceway has water flow only during high flow conditions. Only the berm and top draw sluice way remain. This barrier is impassable to anadromous fishes, and isolates any upstream fish population. The barrier may be creating a refuge area for species such as Brook Trout from competition with other species of salmonids.

Riparian Vegetation

The Hampton subwatershed has a total of 71% of its stream length intersecting natural riparian vegetation (Table 6). This is slightly below the watershed average of 73%, which likely can be attributed to agricultural activity in the area. By stream-order, the proportion of riparian cover is greatest along third (98%) and second order streams (94%), and lowest along first order streams (59%). Riparian cover is especially important for low-order streams, which are impacted to a greater extent by environmental change than large-order streams (EC 2004).

Table 6: Status of riparian vegetation in the Hampton subwatershed
Total stream length (km) intersecting natural areas based on ELC (OMNR, 2007) communities and resulting percentage of total stream length with cover (in parenthesis) by stream-order. Highlighted columns represent lower order streams which benefit greatly from riparian cover and may be given priority when determining areas for restoration.

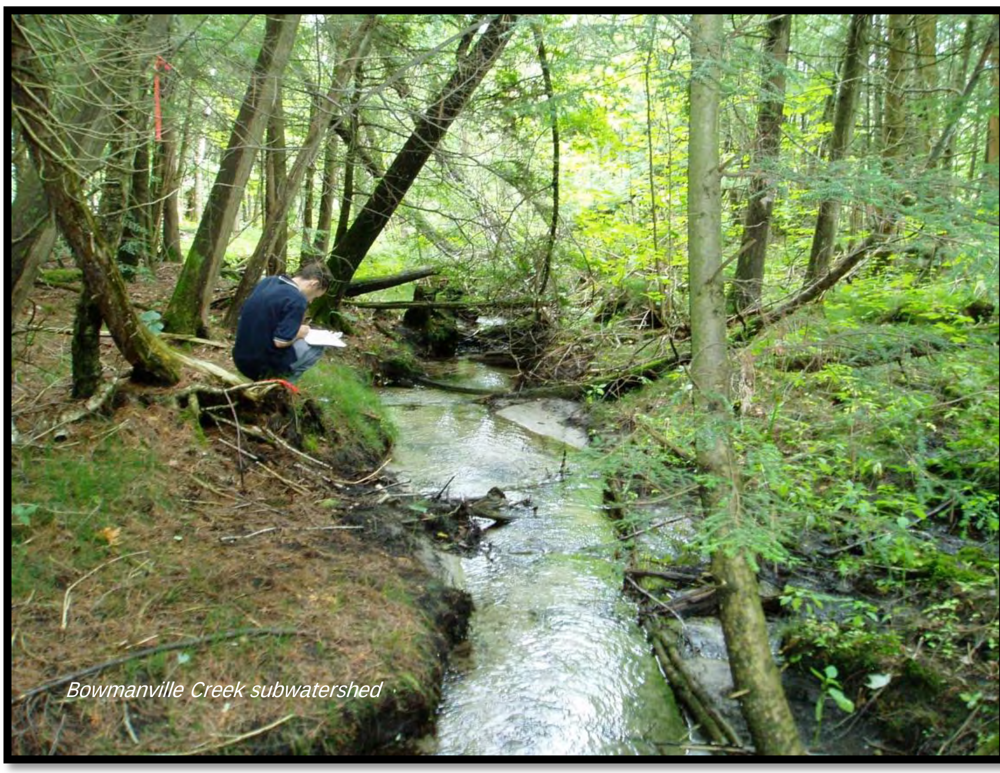
Strahler Stream Order					**Grand Total**
1	2	3	4	5	
45.60	18.75	17.67	0.00	0.00	82.02
(59%)	(94%)	(98%)	N/A	N/A	(71%)

Landscape Influences

Land disturbance in the Hampton subwatershed is categorized primarily as good (low level of disturbance) with some moderate and poor areas (moderate and high level of disturbance). One section at the north end of the subwatershed is categorized as poor and the east branch out of the hamlet of Hampton is categorized as moderate (Figure 10). The Hampton subwatershed has small amounts of urban land uses with the majority being comprised of agriculture and natural areas. Large natural valleys created by the watercourse provide vegetative riparian buffers which help mitigate the effects of agriculture in most locations. In areas where intensive agriculture exists with limited riparian buffer, classification was categorized as moderate or poor.

4.2.1.2 Fisheries

The Hampton subwatershed has a diverse fish community of 17 species, represented by six families. Figure 11 depicts the fish sampling sites as part of the aquatic monitoring programs within the subwatershed. Fish species caught in this creek are representative of primarily cold/cool-water fish (Trout, Salmon, Sucker, and Sculpin) with the presence of a few warm water species (Fathead Minnow and Pumpkinseed). The salmonid biomass in the Hampton subwatershed is lower than the watershed average which could be attributed to the barriers that impede migration of anadromous Trout and Salmon. The high species richness for a low order system could also be related to the fact that there is reduced pressure from piscivorous fish (a species that feeds primarily on eats, e.g. Northern Pike) allowing other species to inhabit the diverse range of habitat types found in this subwatershed.



Bowmanville Creek subwatershed

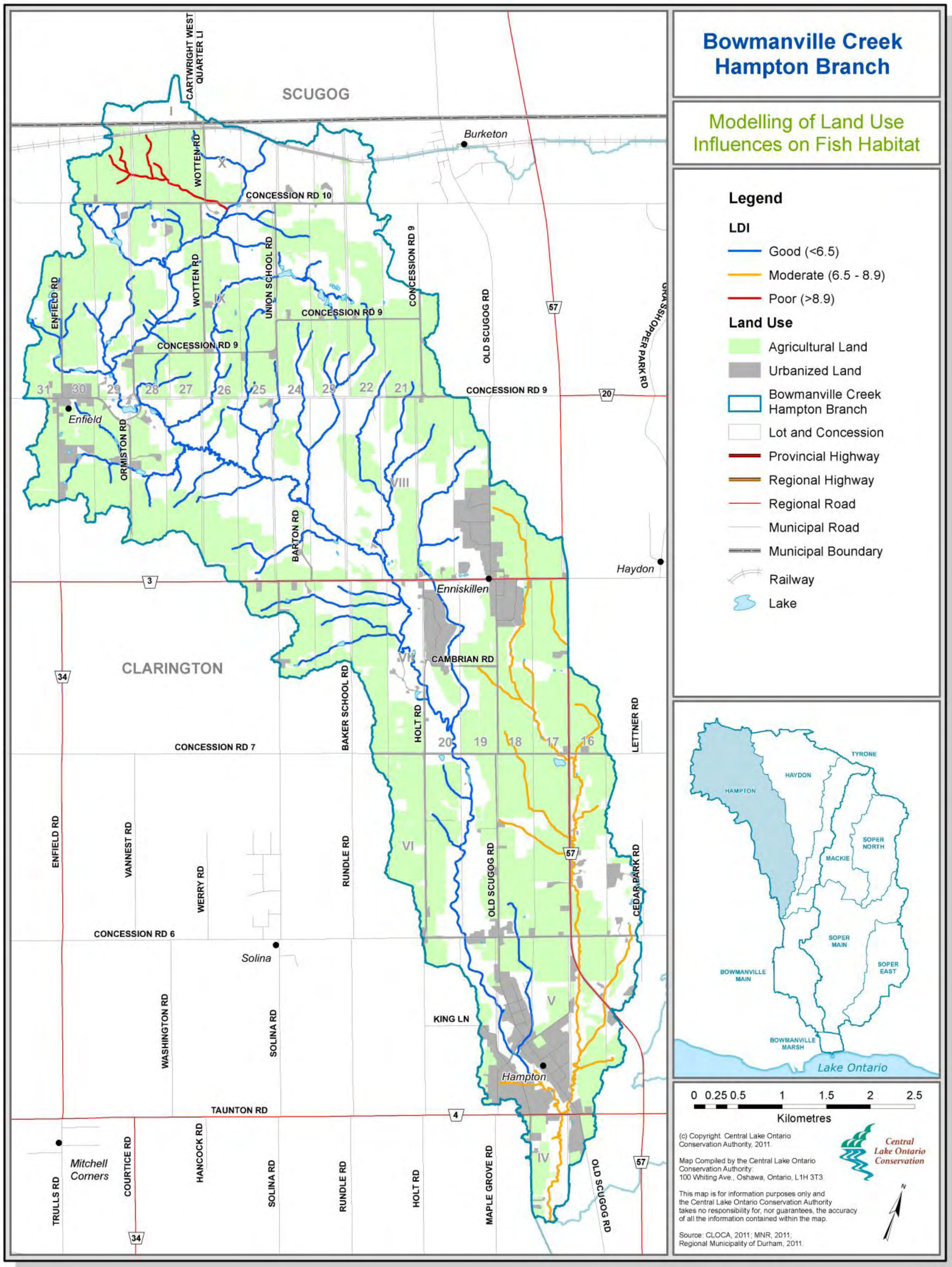


Figure 10: Modelled landscape disturbance on fish habitat in the Hampton subwatershed

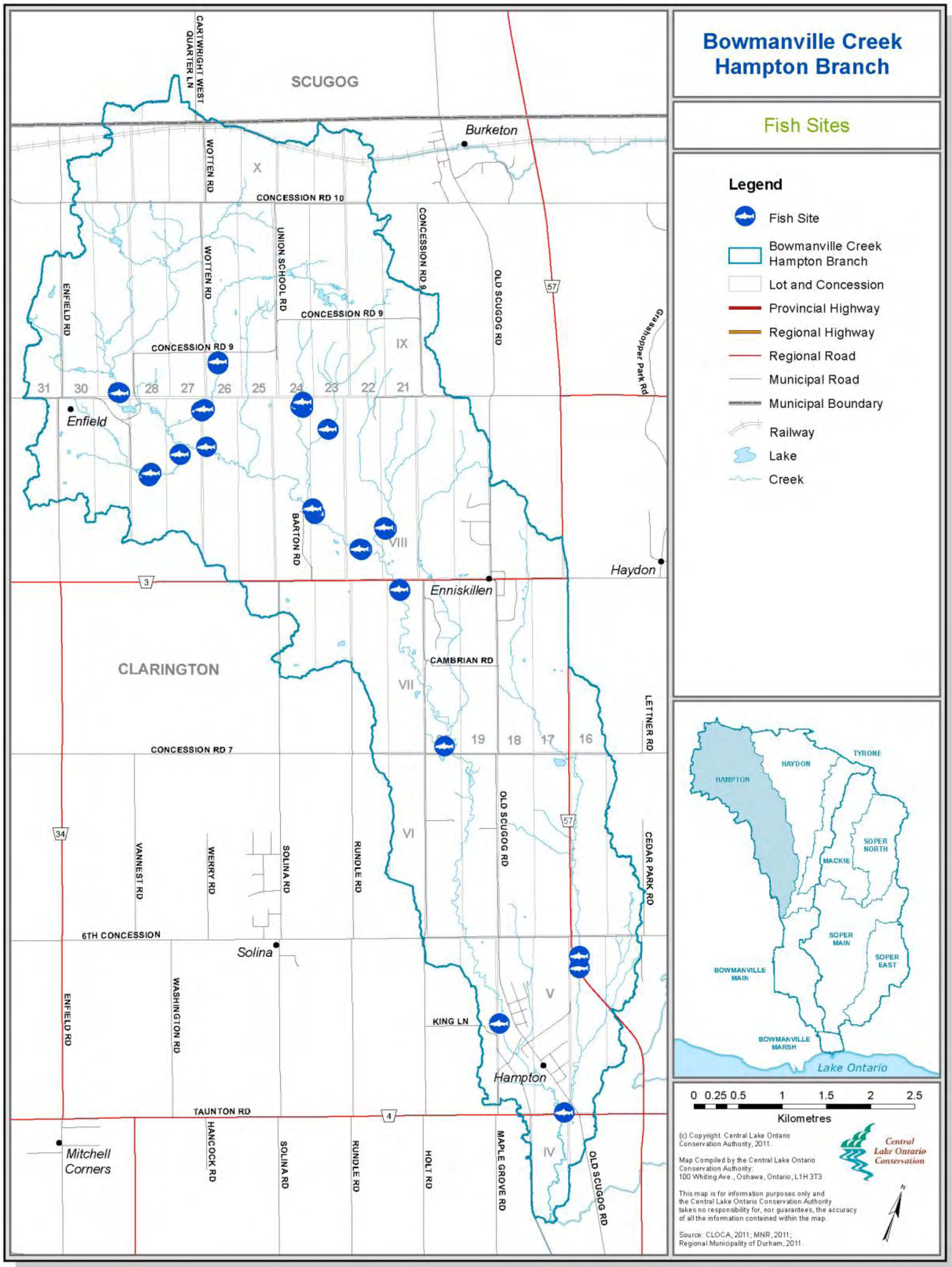


Figure 11: Fish sampling sites in the Hampton subwatershed

4.2.2 Bowmanville Creek Subwatersheds (Haydon Subwatershed)

4.2.2.1 Aquatic Habitat

Strahler Stream Order

The Haydon subwatershed is the second largest of all Bowmanville subwatersheds and is comprised primarily of low order streams (Table 7 and Figure 12). These low-order streams are more susceptible to environmental change than subwatersheds with greater proportions of high-order streams (EC, 2004). First-order streams represent 60% of the watercourses with the remainder being made up of similar lengths of second, third, and fourth-order streams. Since this watershed's headwaters are located largely within the Oak Ridges Moraine, the Haydon subwatershed benefits from strong groundwater discharge, important for maintaining the integrity of the first-order streams which in turn contribute flow and cold water downstream.

Table 7: Haydon subwatershed Strahler stream order
Total stream length (km) and proportion of the total stream length (in parenthesis) by stream-order of the subwatershed (values calculated from the 2010 CLOCA drainage layer).

Strahler Stream Order					Grand Total
1	2	3	4	5	
35.97	10.60	6.48	7.27	0.00	60.31
(60%)	(17%)	(11%)	(12%)	(0%)	100%

Instream Barriers

Instream barriers within the Haydon subwatershed were assessed based on the obstruction of fish movement of migratory species. There is one known potential instream barrier within the Haydon subwatershed (Figure 13). This barrier is in need of further assessment and is summarized in Table 8 below and the following description.

Table 8: Known instream barriers in the Haydon subwatershed
Fish passage indicates whether fish can move through the barrier to access upstream habitats (Salmonids indicates that only jumping species of salmon and trout can pass over the barrier).

Obstruction	Type	Year Built	Status	Fish Passage
Haydon Branch Online Ponds	Ponds	Unknown	Unknown	Undetermined

<u>Haydon Branch Online Ponds</u>

Three online ponds exist within the properties along Grasshopper Park Road and one of the headwater streams of this branch arises in a pond. These barriers have not yet been assessed. One collection site was explored on this branch which yielded, among other species, Rainbow Trout. This collection site was located above two barriers, and the presence of Rainbow Trout indicates that these structures are either passable to anadromous fishes, or that these fish were stocked into the ponds.

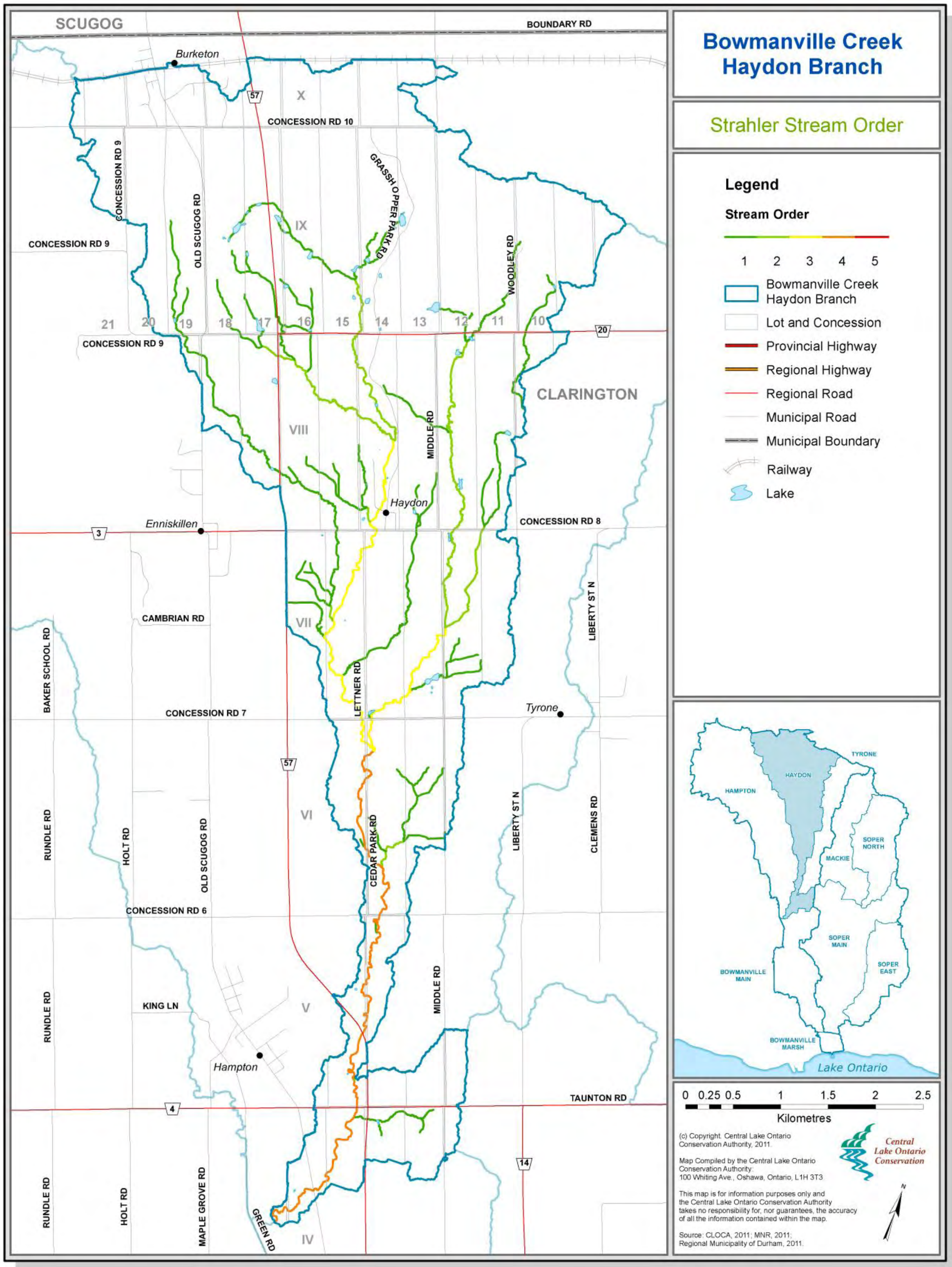


Figure 12: Strahler stream order of the Haydon subwatershed

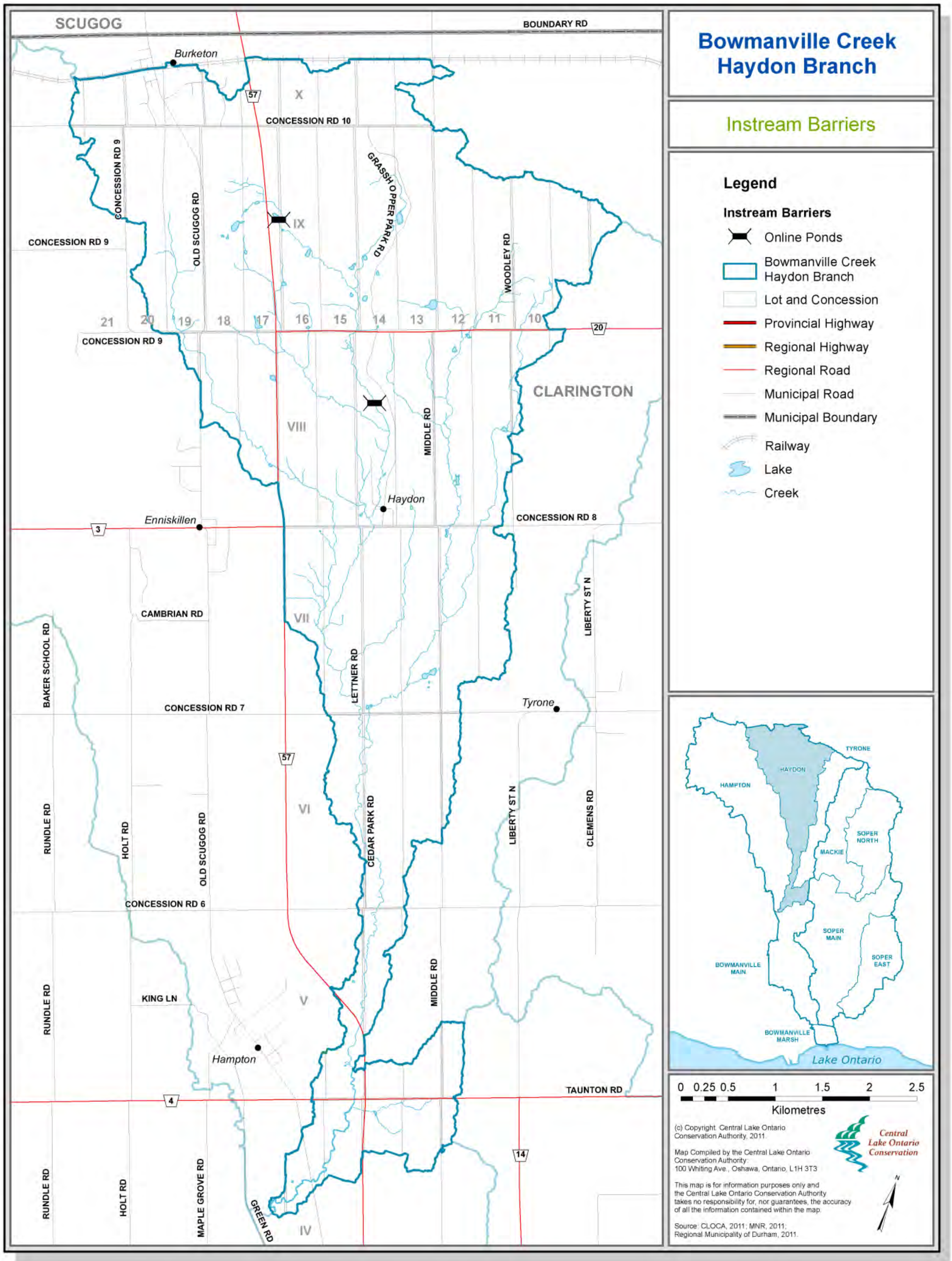


Figure 13: Instream barriers in the Haydon subwatershed

Riparian Vegetation

The Haydon subwatershed has a total of 68% of its stream length intersecting natural riparian vegetation (Table 9). This is slightly below the watershed average of 73%, which likely can be attributed to agricultural land uses in the area. By stream-order, the proportion of riparian cover is greatest along third, fourth (98%) and second-order streams (89%), and lowest along first (51%) order streams. The Haydon subwatershed has the second lowest percentage of riparian cover on first order streams of all the subwatersheds within the Bowmanville/Soper Creek watershed. Riparian cover is especially important for low-order streams, which are more susceptible to environmental change than large-order streams (EC 2004).

Table 9: Status of riparian vegetation in the Haydon subwatershed

Total stream length (km) intersecting natural areas based on ELC (OMNR, 2007) communities and resulting percentage of total stream length with cover (in parenthesis) by stream-order. Highlighted columns represent lower order streams which benefit greatly from riparian cover and may be given priority when determining areas for restoration.

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
18.27	9.41	6.24	6.99	0.00	40.90
(51%)	(89%)	(96%)	(96%)	N/A	(68%)

Landscape Influences

Land disturbance in the Haydon subwatershed is categorized as good and moderate (low and moderate level of disturbance) (Figure 14). This subwatershed is dominated by agricultural land uses with some residential areas. For most of the creek, riparian buffers are enough to mitigate the effects of agriculture and residential areas. In areas where the subwatershed was classified as moderate LDI, limited riparian buffers are not able to compensate for land use changes. This demonstrates that although riparian buffers are critical for the health of a watercourse, they alone cannot ensure good health.

4.2.2.2 Fisheries

The Haydon subwatershed supports a moderately diverse fish community of 11 species from 5 families. Figure 15 depicts the fish sampling sites as part of the CLOCA aquatic monitoring programs within the subwatershed. Fish species caught in this subwatershed are entirely representative of a cold/cool-water fish community (Trout, Salmon, Sucker, and Sculpin, and no warm water species). Representations of all of the salmonids found within this watershed are found in the Haydon subwatershed including: Brook, Brown, and Rainbow Trout, and Chinook and Coho Salmon. The moderate richness of fish species caught in the Haydon subwatershed is representative of its primarily low stream order and its species composition, which is typical of trout streams.

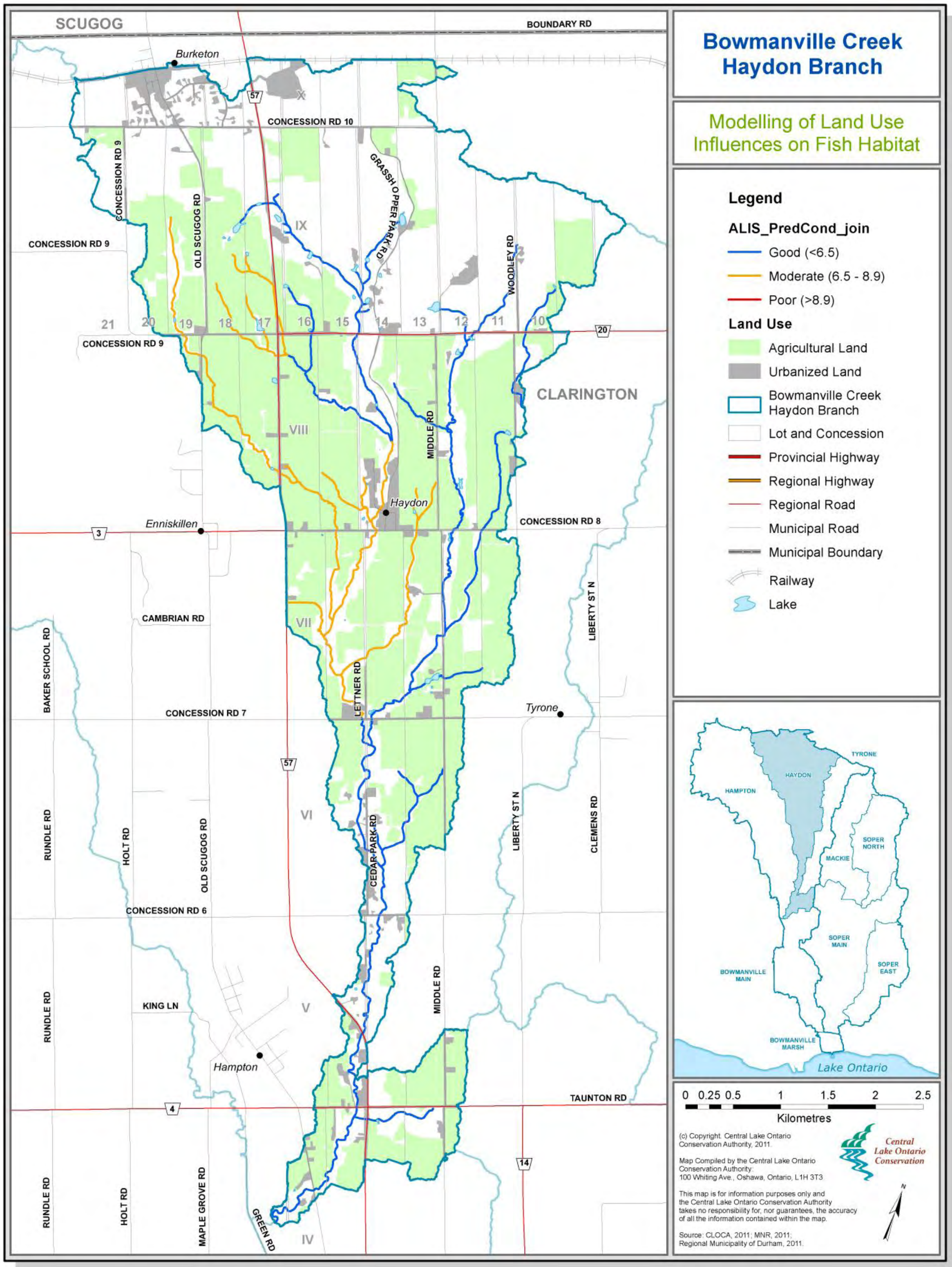


Figure 14: Modelled landscape disturbance on fish habitat in the Haydon subwatershed

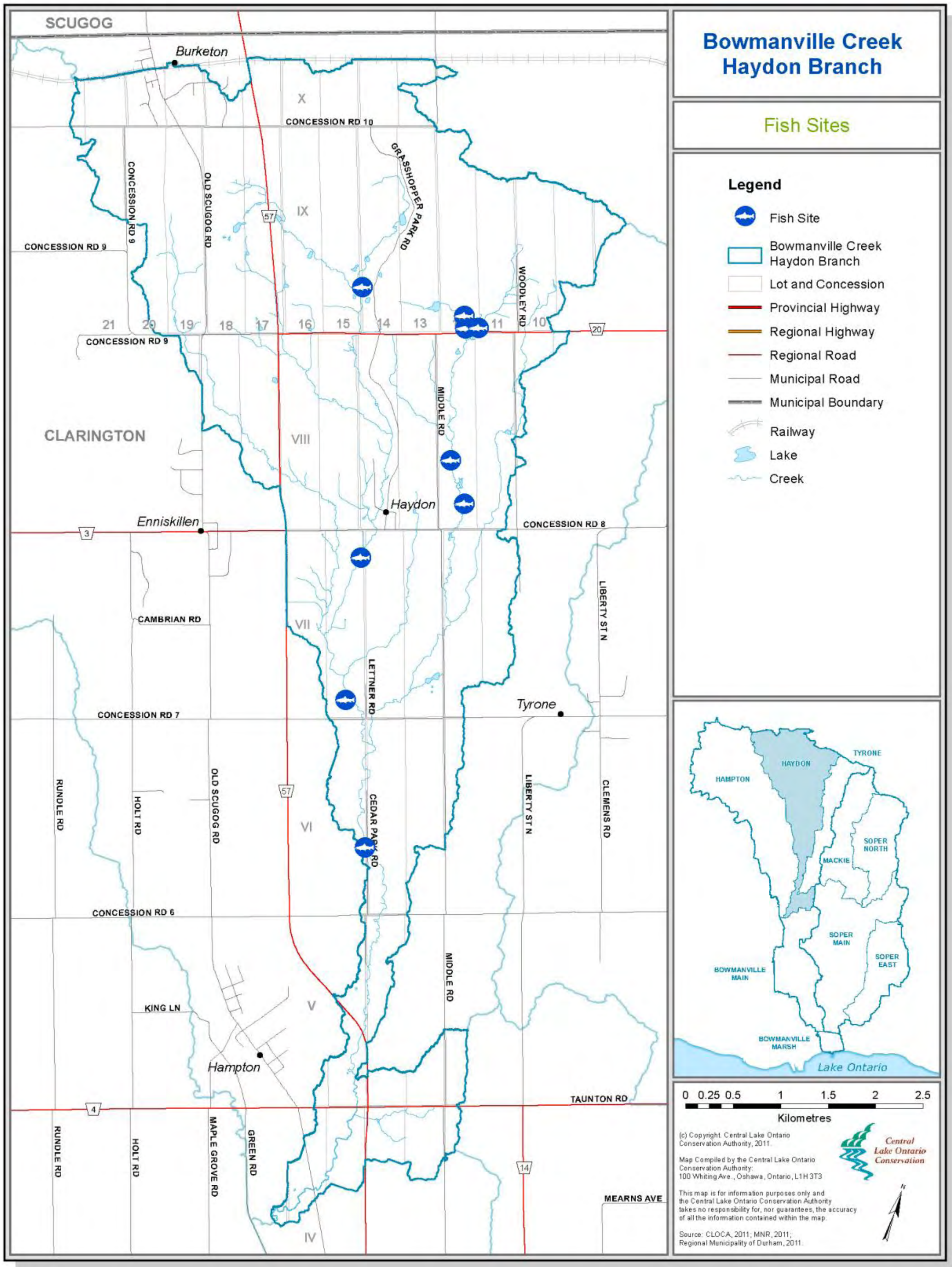


Figure 15: Fish sampling sites in the Haydon subwatershed

4.2.3 Bowmanville Creek Subwatersheds (Tyrone Subwatershed)

4.2.3.1 Aquatic Habitat

Strahler Stream Order

The Tyrone subwatershed is the second smallest watershed within the Bowmanville/Soper Creek watershed with only Bowmanville Marsh having shorter stream length. Like the other northern subwatersheds within the Bowmanville subwatershed, Tyrone subwatershed is comprised entirely of low-order streams (Table 10 and Figure 16). These low-order streams are more susceptible to environmental change than subwatersheds with greater proportions of high-order streams (EC, 2004). First-order streams comprise 61% of the watercourses with the remainder being made up of second-order (39%) streams. The groundwater discharge from the Oak Ridges Moraine will continue to play an important role in maintaining the health of this watercourse.

Table 10: Tyrone subwatershed Strahler stream order
Total stream length (km) and proportion of the total stream length (in parenthesis) by stream-order of the subwatershed (values calculated from the 2010 CLOCA drainage layer).

Strahler Stream Order					Grand Total
1	2	3	4	5	
16.96	11.02	0.00	0.00	0.00	27.98
(61%)	(39%)	(0%)	(0%)	(0%)	100%

Instream Barriers

Instream barriers within the Tyrone subwatershed were assessed based on the obstruction of fish movement of migratory species. There are three known potential instream barriers within the Tyrone subwatershed (Figure 17). Details of these barriers are summarized in Table 11 below and the following description.

Table 11: Known instream barriers in the Tyrone subwatershed
Fish passage indicates whether fish can move through the barrier to access upstream habitats (Salmonids indicates that only jumping species of salmon and trout can pass over the barrier).

Obstruction	Type	Year Built	Status	Fish Passage
Tyrone Pond	Dam	1846	Active	Not Passable
Boyle Pond	Dam	1960's	Active	Not Passable
Woodley Pond	Dam	1864	Active	Undetermined

<u>Tyrone Pond</u>

Tyrone Dam and Pond were built in 1846 to provide power for a grist mill and sawmill. The mill is now used as a sawmill and press for apple cider production. The structure is impassable to anadromous fishes. For many years, there have been no records of Chinook and Coho Salmon and Rainbow Trout upstream of this structure. A recent fish sample taken directly below the dam included Rainbow Trout. A site above the dam and immediately upstream of the pond included Brook Trout, Blacknose Dace, and Brook Stickleback. Of the Brook Trout, 58% were young-of-year, indicating a rearing area for this species.

The Tyrone Dam serves to isolate the native Brook Trout population making it free from competition from stocked fish such as the Brown Trout. Stocking records indicate that this branch of Bowmanville Creek has never been associated with a stocking program, save a possible pond stocking of the Boyle Pond. Isolated native populations of Brook Trout free from competition are rare on the north shore tributaries of Lake Ontario, and are certainly a unique feature within the Bowmanville Creek subwatershed.

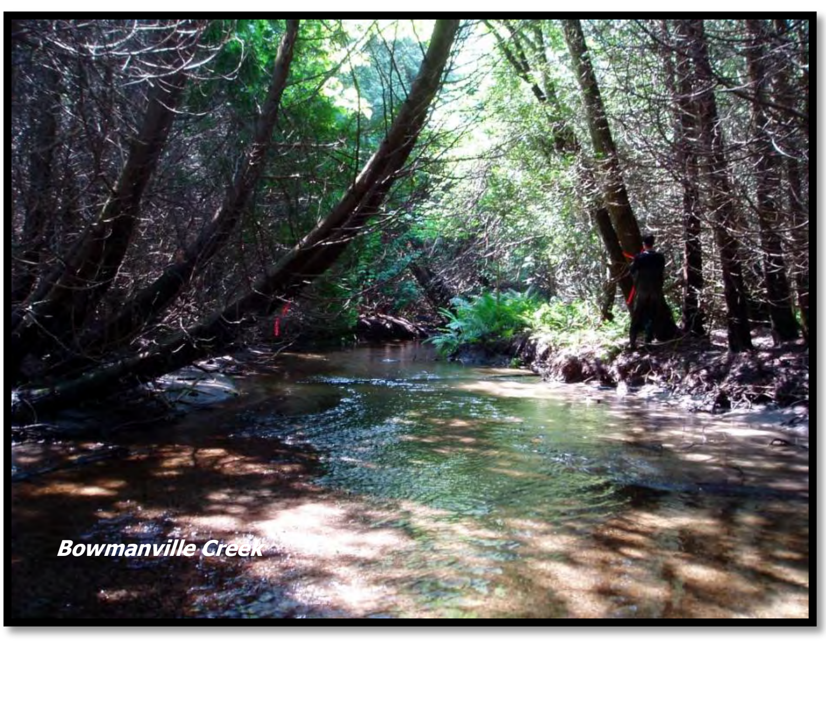
Boyle Pond

Boyle Dam and Pond, located one concession above the Tyrone Dam, was built as a recreational pond in the early 1960's. The pond outlet is a top-draw standpipe configuration and would preclude fish passage. Site specific thermal and fish population dynamics studies are recommended to determine the function of this pond with respect to fish habitat. Brook Trout have been sampled both above and below this structure, and it is not known if the proximity of this pond to others in the area impacts Brook Trout population. The cold water fishes in this area would benefit from a bottom draw outlet configuration, which would lower water temperatures outletting from the pond.

Woodley Pond

Woodley Dam is located upstream and relatively close to the Boyle Dam. The dam was built in 1864 to power a sawmill, a function which continues to date. The pond displays two top-draw sluices that create two small channels that join several metres downstream. A sample taken above the pond included only Brook Trout and Slimy Sculpin.

The Brook Trout consisted mainly of adult fish (82.4%). Further study of this branch is needed to determine if the existing pond presents thermal or migration problems for the native fishes and if removal of these barriers would have any biological, genetic, or cultural impacts.



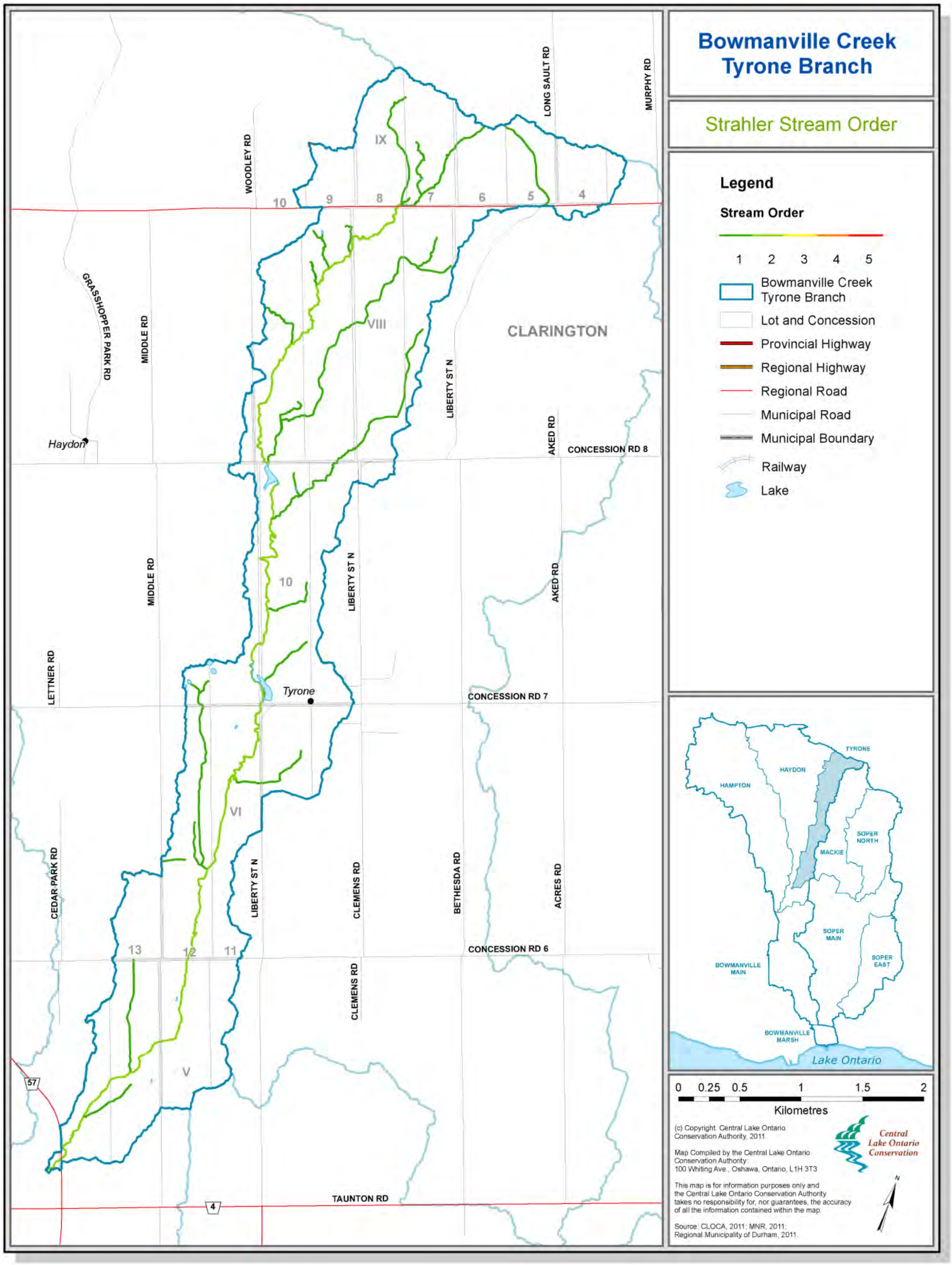


Figure 16: Strahler stream order of the Tyrone subwatershed

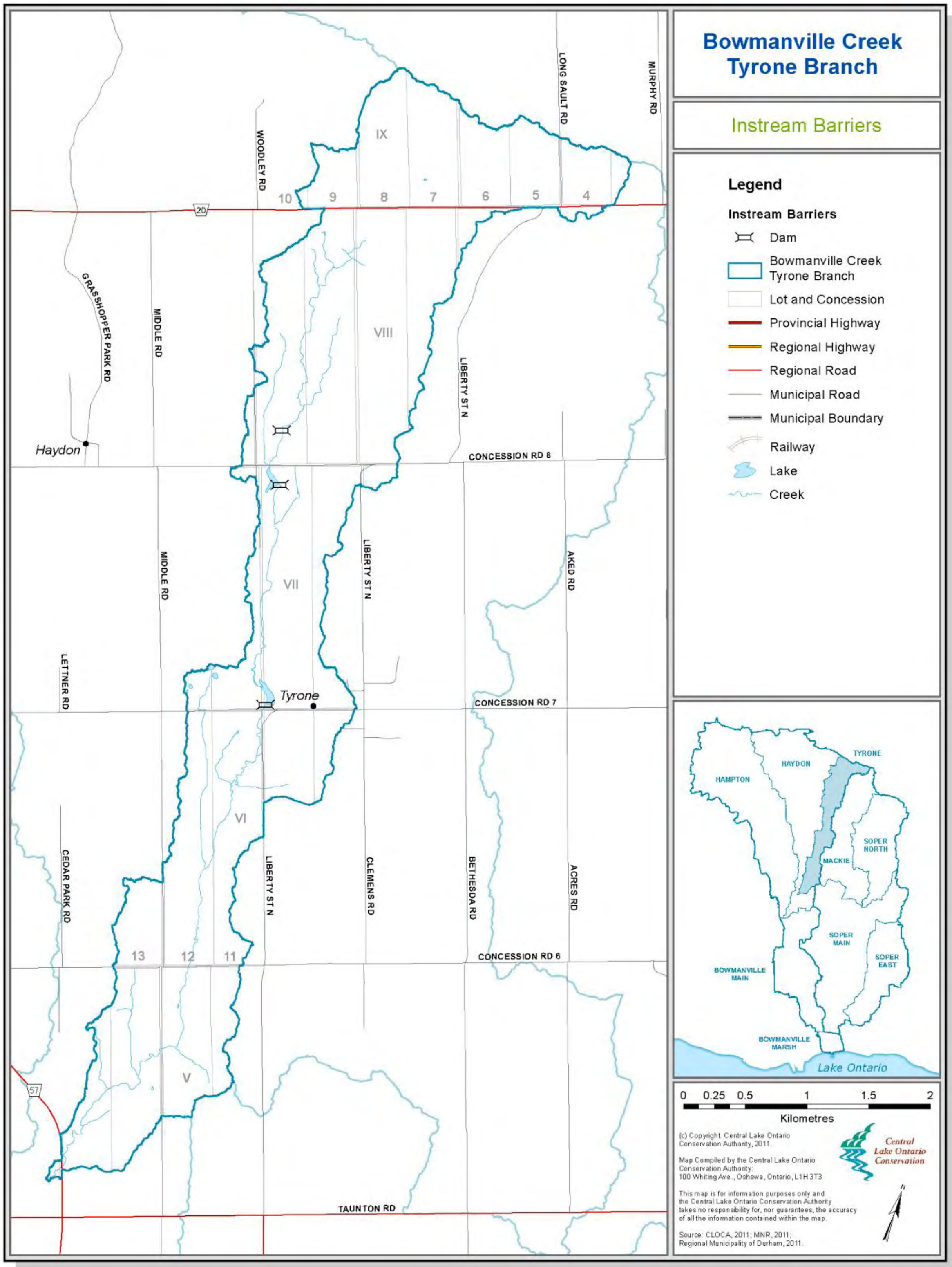


Figure 17: Instream barriers in the Tyrone subwatershed

Riparian Vegetation

The Tyrone subwatershed has a total of 79% of its stream length intersecting natural riparian vegetation (Table 12). This is well above the watershed average of 73%, which likely can be attributed to large natural valleys, woodlots and lack of urban land use. By stream-order, the proportion of riparian cover is greatest along second order (92%) streams and lowest along first order (71%) streams. The Tyrone subwatershed has the second highest percent riparian cover on first-order streams but also is one of the smallest subwatersheds based on stream length. Riparian cover is especially important for low-order streams, which are more affected by environmental change than large-order streams (EC 2004).

Table 12: Status of riparian vegetation in the Tyrone subwatershed
Total stream length (km) intersecting natural areas based on ELC (OMNR, 2007) communities and resulting percentage of total stream length with cover (in parenthesis) by stream-order. Highlighted columns represent lower order streams which benefit greatly from riparian cover and may be given priority when determining areas for restoration.

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
12.05	10.14	0.00	0.00	0.00	22.19
(71%)	(92%)	N/A	N/A	N/A	(79%)

Landscape Influences

Land disturbance in the Tyrone subwatershed is categorized as good (low level of disturbance) in all reaches (Figure 18). Although there are residential and agricultural land uses in this subwatershed, sufficient riparian buffers are capable of currently mitigating many of these effects. These results are consistent with the Tyrone subwatershed having above average riparian vegetation. The natural valleys and existing woodlots continue to provide a buffer between the creek and land use changes.

4.2.3.2 Fisheries

The Tyrone subwatershed supports a moderately diverse fish community of 10 species from 5 families. Figure 19 depicts the fish sampling sites as part of the CLOCA aquatic monitoring programs within the subwatershed. Fish species caught in this subwatershed are entirely representative of a cold/cool water fish community (Trout, Dace, Scuplins and Suckers). The moderate species richness caught in the Tyrone subwatershed is representative of its low stream order and its composition is typical of Trout streams. Brook Trout Catch-per-unit-effort (CPUE) and biomass in Tyrone subwatershed are above watershed average. This could be the result of the three dams in the watershed restricting migratory salmonids from competing with Brook Trout populations.

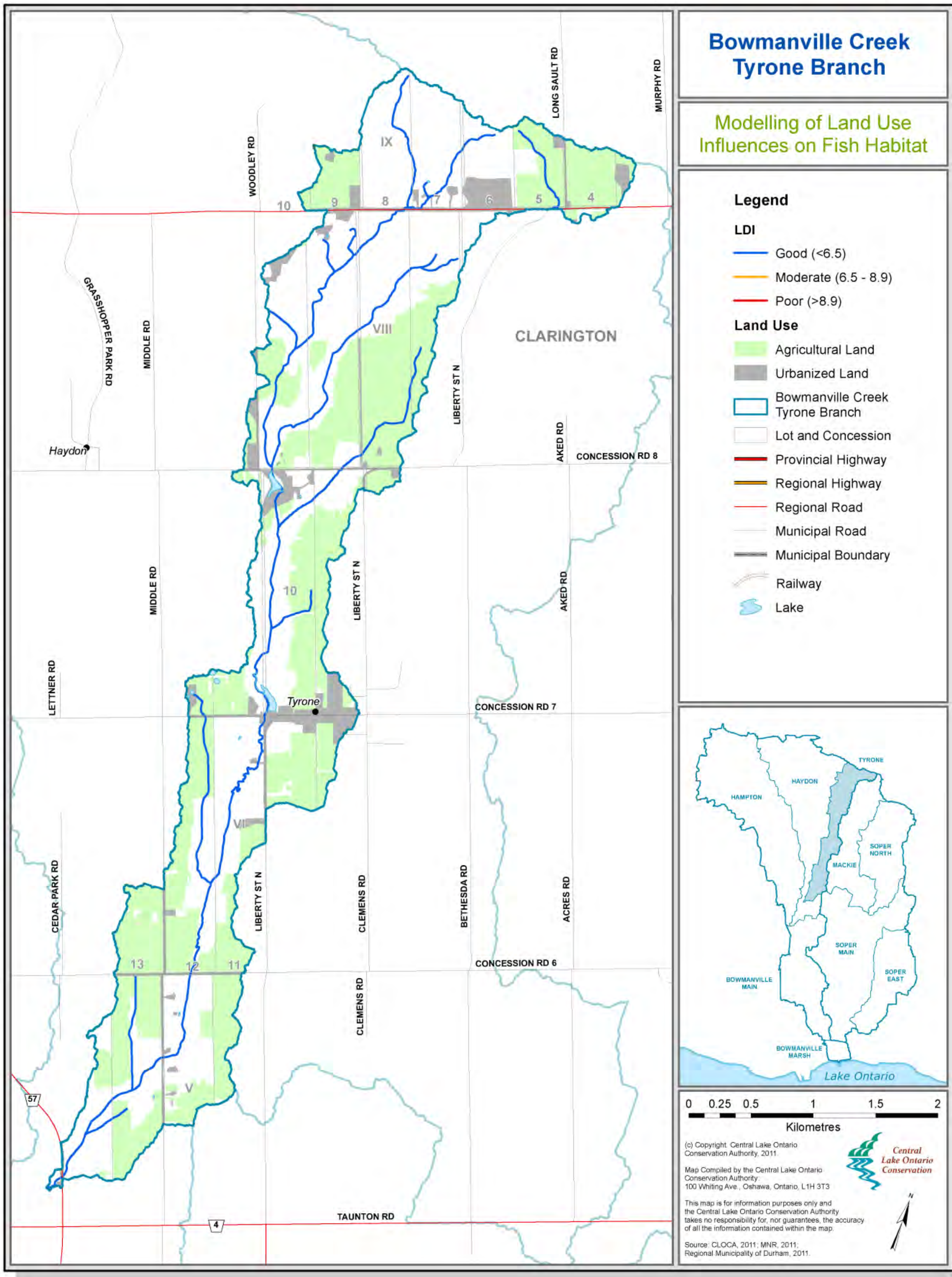


Figure 18: Modelled landscape disturbance on fish habitat in the Tyrone subwatershed

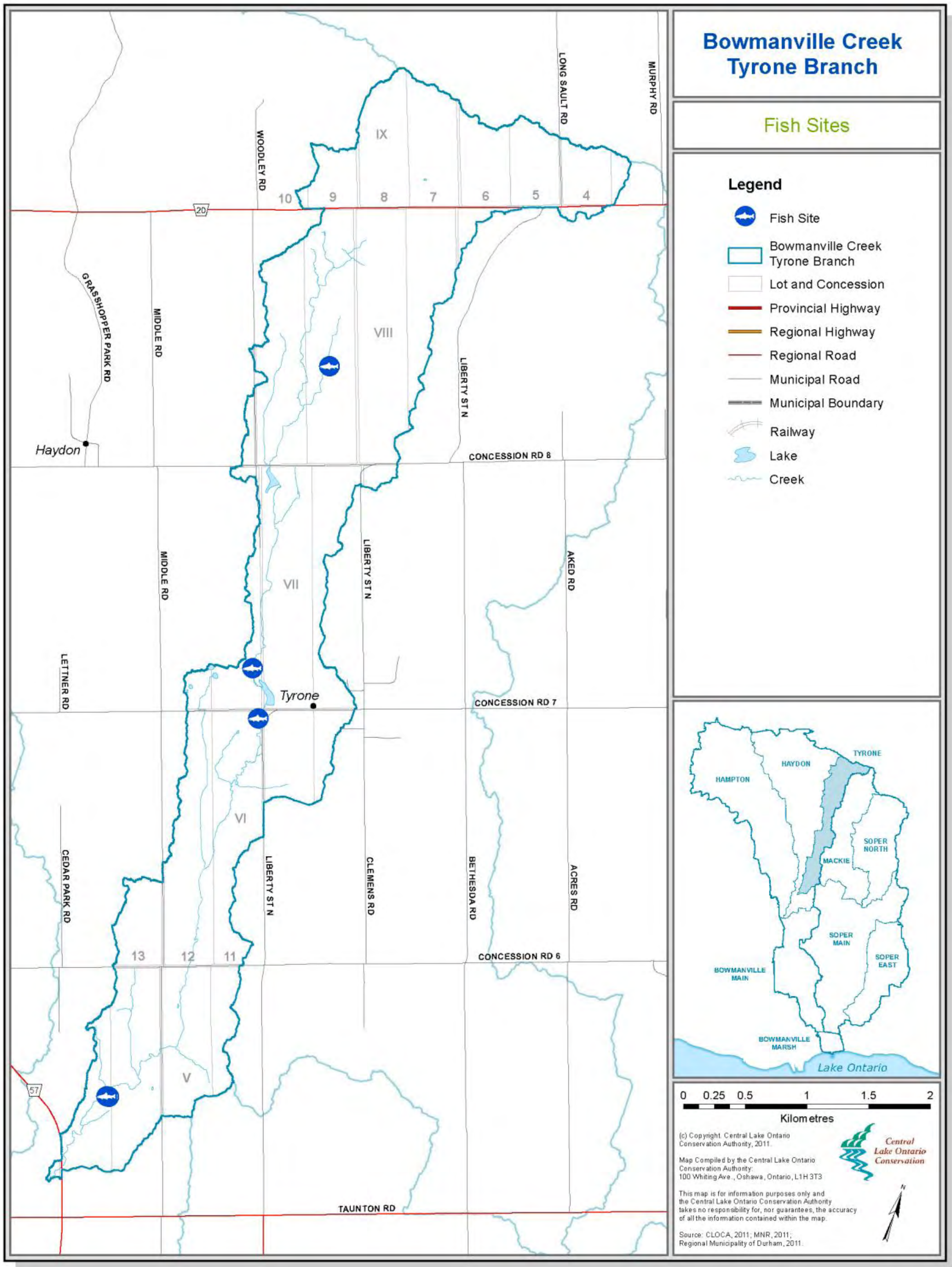


Figure 19: Fish sampling sites in the Tyrone subwatershed

4.2.4 Bowmanville Creek subwatershed (Bowmanville Main subwatershed)

4.2.4.1 Aquatic Habitat

Strahler Stream Order

The Bowmanville Main subwatershed is the third shortest stream length of all of the subwatersheds within Bowmanville Creek but has the longest section of fourth-order stream. The Bowmanville Main subwatershed is also comprised primarily of first-order streams (Table 13 and Figure 20). Forth-order streams make up the majority of the remaining stream length (35%). The low-order streams in this subwatershed will likely be more susceptible to environmental change than the high-order streams. Since much of this subwatershed is subject to various land-use changes (urban and agricultural), the groundwater fed first-order streams originating from the Lake Iroquois Beach will continue to play an important role in providing thermal refugia areas, moderating temperature and contributing to base flow levels in the higher-order streams.

Table 13: Bowmanville Main subwatershed Strahler stream order
Total stream length (km) and proportion of the total stream length (in parenthesis) by stream-order of the subwatershed (values calculated from the 2010 CLOCA drainage layer).

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
18.02	2.00	0.01	10.98	0.00	31.00
(58%)	(7%)	(0%)	(35%)	(0%)	100%

Instream Barriers

Instream barriers within the Bowmanville Main subwatershed were assessed based on the obstruction of fish movement of migratory species. There are three known potential instream barriers within the Bowmanville Main subwatershed (Figure 18). These barriers are summarized in Table 14 and a description of each is provided.

Table 14: Known instream barriers in the Bowmanville Main subwatershed
Fish passage indicates whether fish can move through the barrier to access upstream habitats (Salmonids indicates that only jumping species of salmon and trout can pass over the barrier).

Obstruction	**Type**	**Year Built**	**Status**	**Fish Passage**
Jackman Road Weir	Weir	1992	Active	Salmonids
Hwy. #57 Culvert	Culvert	Unknown	Active	Passable
Goodyear Dam	Dam	1910	Active	Salmonids

<u>Jackman Road Weir</u>

The Jackman Road Weir was built in 1992 and was a fish barrier within a small tributary of Bowmanville Creek. The weir was redesigned in 2006 to improve fish passage. Assessment of the redesign in facilitating fish passage has not been conducted.

<u>Highway #57 Culvert</u>

The Highway #57 Culvert is a steel culvert located at Highway #57 between Highway #2 and Stevens Road. The culvert was thought to be perched but actually is likely passable to most fish.

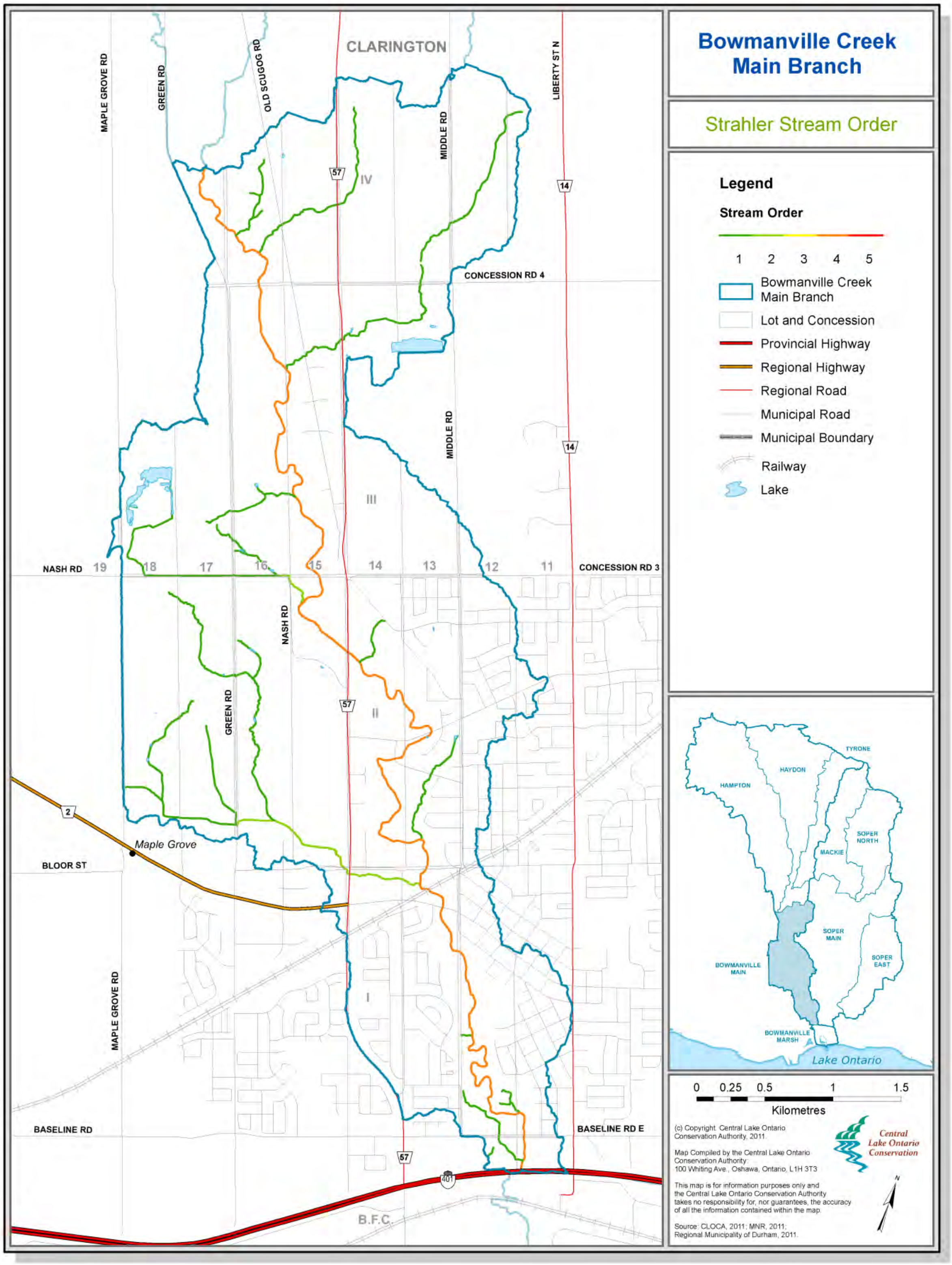


Figure 20: Strahler stream order of the Bowmanville Main subwatershed

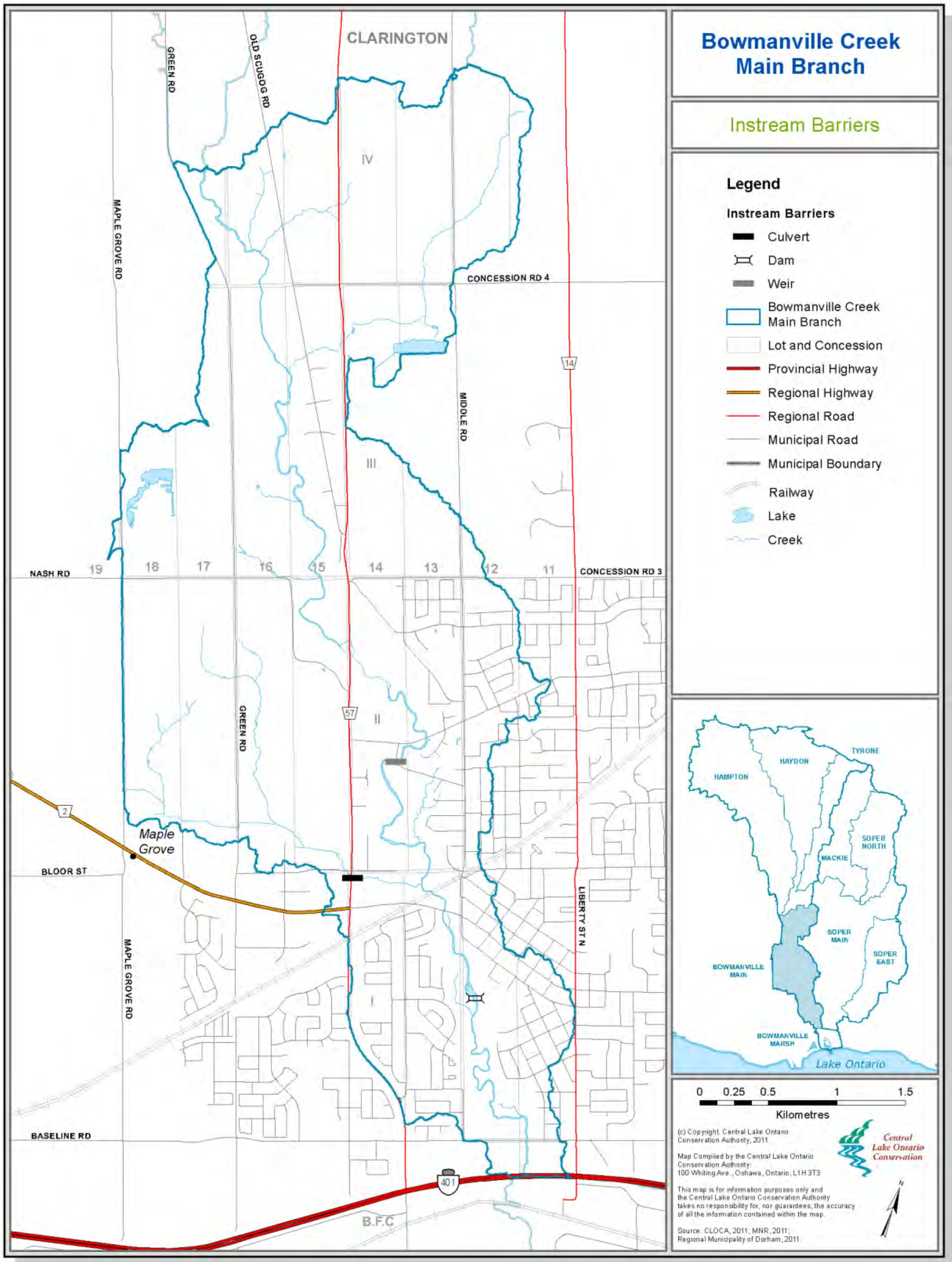


Figure 21: Instream barriers in the Bowmanville Main subwatershed

Veyance Dam (Goodyear Dam)

The Veyance Dam (formally known as the Goodyear Dam), located at the water inlet for the Veyance (Goodyear) Plant, was built in 1910 to provide a water source for the tire production facility. In 1988, a fishway was incorporated into the dam to provide access to upstream areas for species such as Chinook and Coho Salmon, Rainbow Trout and lake-run Brown Trout. This fishway was designed as an impassable barrier to migrating sea lamprey. There is some dispute as to the ability of the fishway to accommodate all size ranges of fish, and it has been suggested that only the largest and strongest salmon and trout can ascend the structure. The potential for improving fish passage at this site is being investigated by Valleys 2000, a local volunteer/community group in partnership with the Municipality of Clarington, the Ministry of Natural Resources and CLOCA.

Riparian Vegetation

The Bowmanville Main subwatershed has a total of 78% of its stream length intersecting natural riparian vegetation (Table 15). This is above the watershed average of 73%, which likely can be attributed to the natural valleys north of and within the Town of Bowmanville. By stream-order, the proportion of riparian cover is greatest along third (100%), fourth (99%) and second-order streams (90%), and lowest along first-order (65%) streams. Riparian cover is especially important for low-order streams, which are impacted more by environmental change than large-order streams (EC 2004).

Table 15: Status of riparian vegetation in the Bowmanville Main subwatershed

Total stream length (km) intersecting natural areas based on ELC (OMNR, 2007) communities and resulting percentage of total stream length with cover (in parenthesis) by stream-order. Highlighted columns represent lower order streams which benefit greatly from riparian cover and may be given priority when determining areas for restoration.

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
11.63	1.80	0.01	10.84	0.00	24.27
(65%)	(90%)	(100%)	(99%)	N/A	(78%)

Landscape Influences

Land disturbance in the Bowmanville Main subwatershed is categorized as good (low level of disturbance) in most reaches with some areas categorized as moderate and poor (Figure 19). This subwatershed is dominated by agricultural land uses with good riparian buffers in the upper reaches to high density urban land uses in the lower reaches. The effects of urbanization are compounded in areas where riparian buffers are limited and stormwater management is insufficient or non-existent in older residential areas.

4.2.4.2 Fisheries

The Bowmanville Main subwatershed supports a diverse fish community of 21 species from 7 families. Figure 20 depicts the fish sampling sites as part of the CLOCA aquatic monitoring programs within the subwatershed. Fish species caught in this subwatershed are representative of primarily cold/cool-water species (Trout, Salmon, Sculpin, Sucker, Dace) with the presence of a few warmwater species (Bluntnose and Fathead Minnow, Pumpkinseed and Goldfish). The high species and family diversity can be attributed to the diversity of stream orders and habitats in the subwatershed.

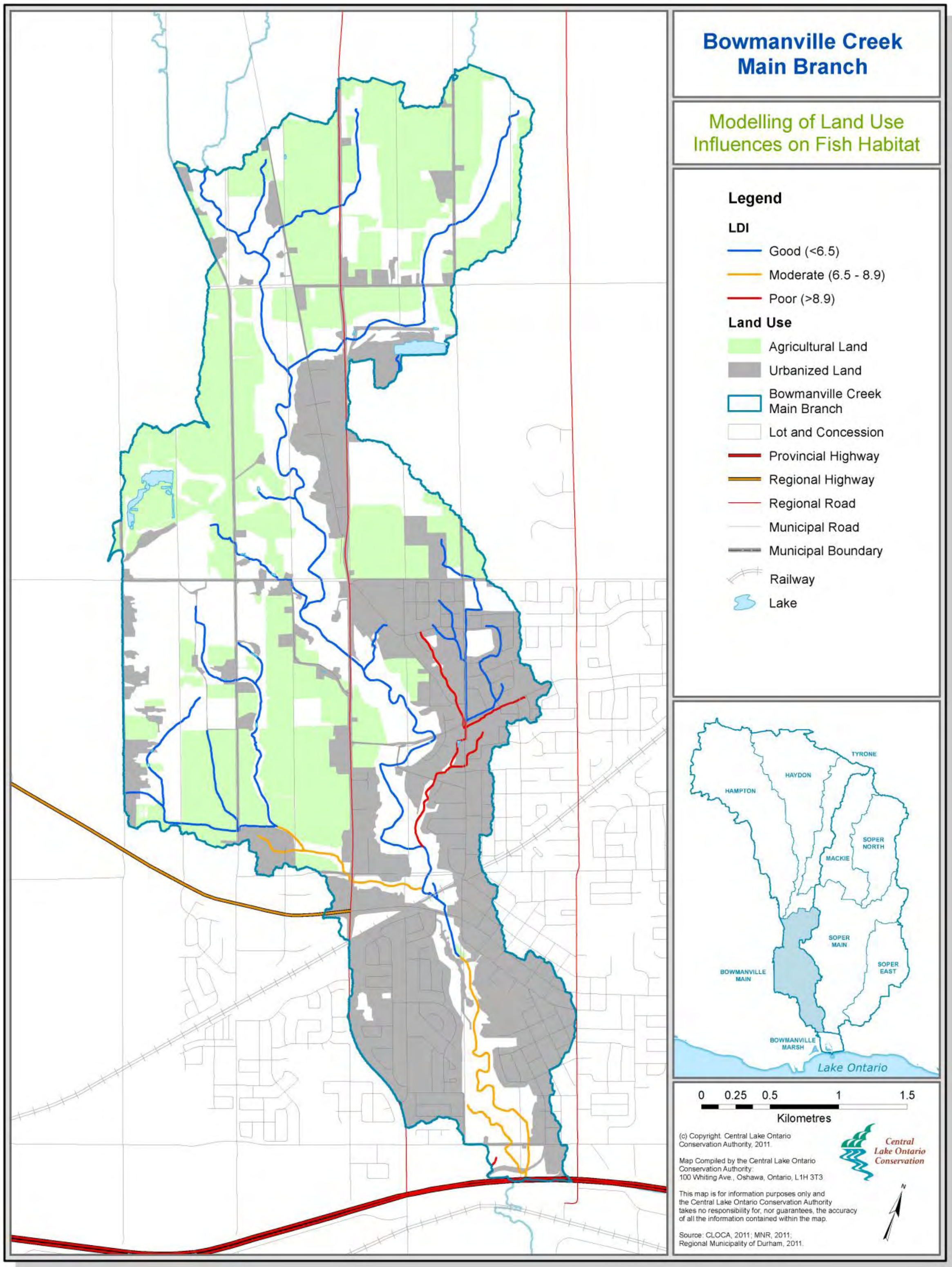


Figure 22: Modelled landscape disturbance on fish habitat in the Bowmanville Main subwatershed

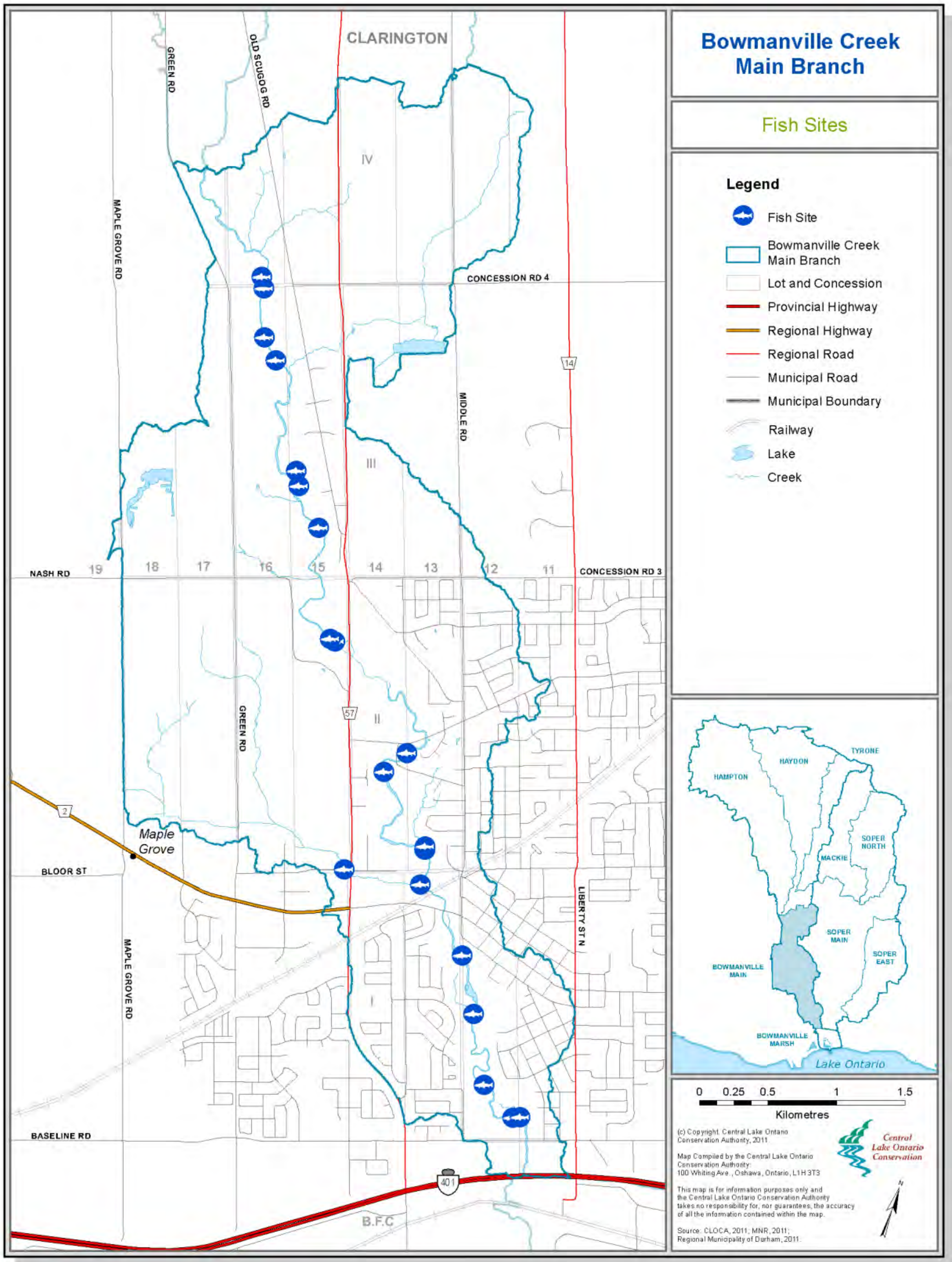


Figure 23: Fish sampling sites in the Bowmanville Main subwatershed

4.2.5 Bowmanville Creek Subwatersheds (Bowmanville Marsh subwatershed)

4.2.3.1 Aquatic Habitat

Strahler Stream Order

The Bowmanville Marsh subwatershed has the shortest stream distance and is comprised primarily of higher-order streams as it includes the confluence of the Bowmanville and Soper Creeks which are both fourth-order streams at this point (Figure 21). The resulting fifth-order stream is the only one found within the Bowmanville/Soper Creek watershed. Since this subwatershed has a higher proportion of high-order streams, this subwatershed should be the most tolerant of environmental changes (EC, 2004). First-order streams comprise 22% of the watercourses with the remainder being made up of fourth (50%) and fifth-order (28%) streams.

Table 16: Bowmanville Marsh subwatershed Strahler stream order
Total stream length (km) and proportion of the total stream length (in parenthesis) by stream-order of the subwatershed (values calculated from the 2010 CLOCA drainage layer).

Strahler Stream Order					Grand Total
1	2	3	4	5	
0.76	0.00	0.00	1.77	1.00	3.54
(22%)	(0%)	(0%)	(50%)	(28%)	100%

Instream Barriers

There are no instream barriers within the Bowmanville Marsh subwatershed.

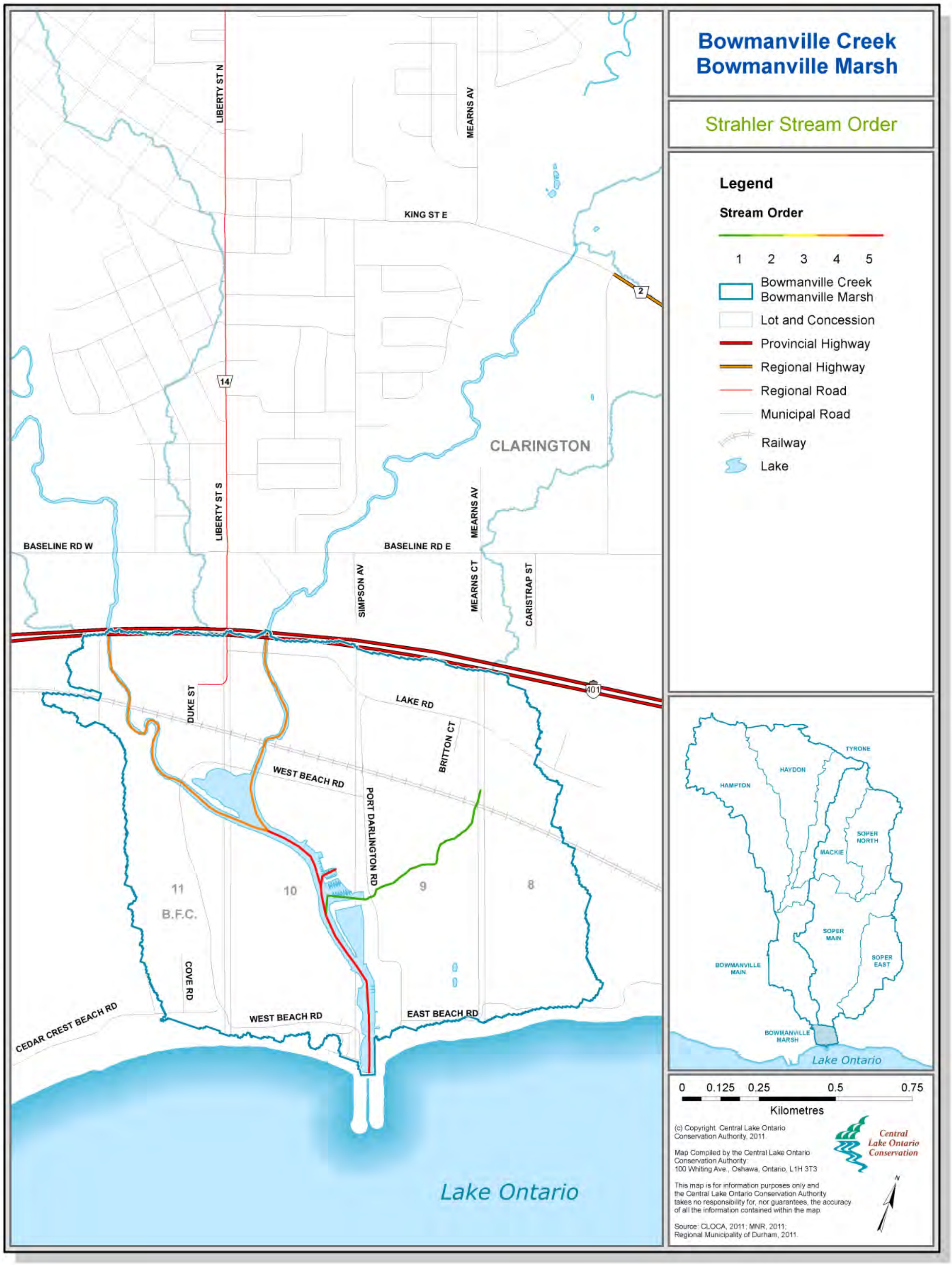


Figure 24: Strahler stream order of the Bowmanville Marsh subwatershed

Riparian Vegetation

The Bowmanville Marsh subwatershed has a total of 75% of its stream length intersecting natural riparian vegetation (Table 17). This is slightly above the watershed average of 73%, which likely can be attributed to much of the area being located around the Provincially Significant Wetland, Bowmanville Marsh. By stream-order, the proportion of riparian cover is greatest along fifth (100%) and fourth order streams (90%), and lowest along first (53%) order streams. Agriculture east of the Bowmanville Marina is the reason for the low first order riparian percentage. Riparian cover is especially important for low-order streams, which are more affected by environmental change than large-order streams (EC 2004).

Table 17: Status of riparian vegetation in the Bowmanville Marsh subwatershed
Total stream length with 30m riparian cover (km) and percent of total stream length with cover (in parenthesis) by stream-order. Highlighted columns represent lower order streams which benefit greatly from riparian cover and may be given priority when determining areas for restoration.

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
1.22	0.00	0.00	1.59	1.00	3.81
(53%)	N/A	N/A	(90%)	(100%)	(75%)

Landscape Influences

Land disturbance in the Bowmanville Marsh subwatershed is categorized as moderate (moderate level of disturbance) in all reaches (Figure 22). Land use is a combination of agriculture and urban uses. A high amount of impervious surfaces with insufficient stormwater management is likely the main contributing factor to the reduced score. Riparian buffers surrounding the marsh are present except for near the Bowmanville Marina. The riparian buffers are unable to compensate fully for the adverse effects caused by the urban land use in the area.

4.2.3.2 Fisheries

The Bowmanville Marsh has been sampled since 2002 through the Durham Region Coastal Wetland Monitoring Project (DRCWMP). The Bowmanville Marsh subwatershed supports a diverse fish community of 20 species represented by 7 families (Table 3). Since sampling typically occurs within the marsh during late summer, species that use the marsh at a different time of year are likely not captured. The species composition in Bowmanville Marsh subwatershed consists of both cold/cool-water species (Gizzard Shad, Northern Pike, Yellow Perch) and warmwater species (Brown Bullhead, Pumpkinseed, Fathead Minnow). Another warm water species present in the marsh is the Common Carp. The Common Carp is found in large numbers and is known to decrease aquatic vegetation and increase turbidity, reducing the natural productivity of the Marsh.

Bowmanville Marsh serves as an interface between several different habitat types and is of extreme importance not only for spawning, but for shelter and a food source. Plant consuming fishes use the marsh environment for feeding and are in turn fed upon by predaceous fish. The fish of this marsh and creek environment are subject to a variety of direct and indirect disturbances such as cumulative impacts of land use in the Bowmanville/Soper Creek watershed and boat traffic from Lake Ontario.

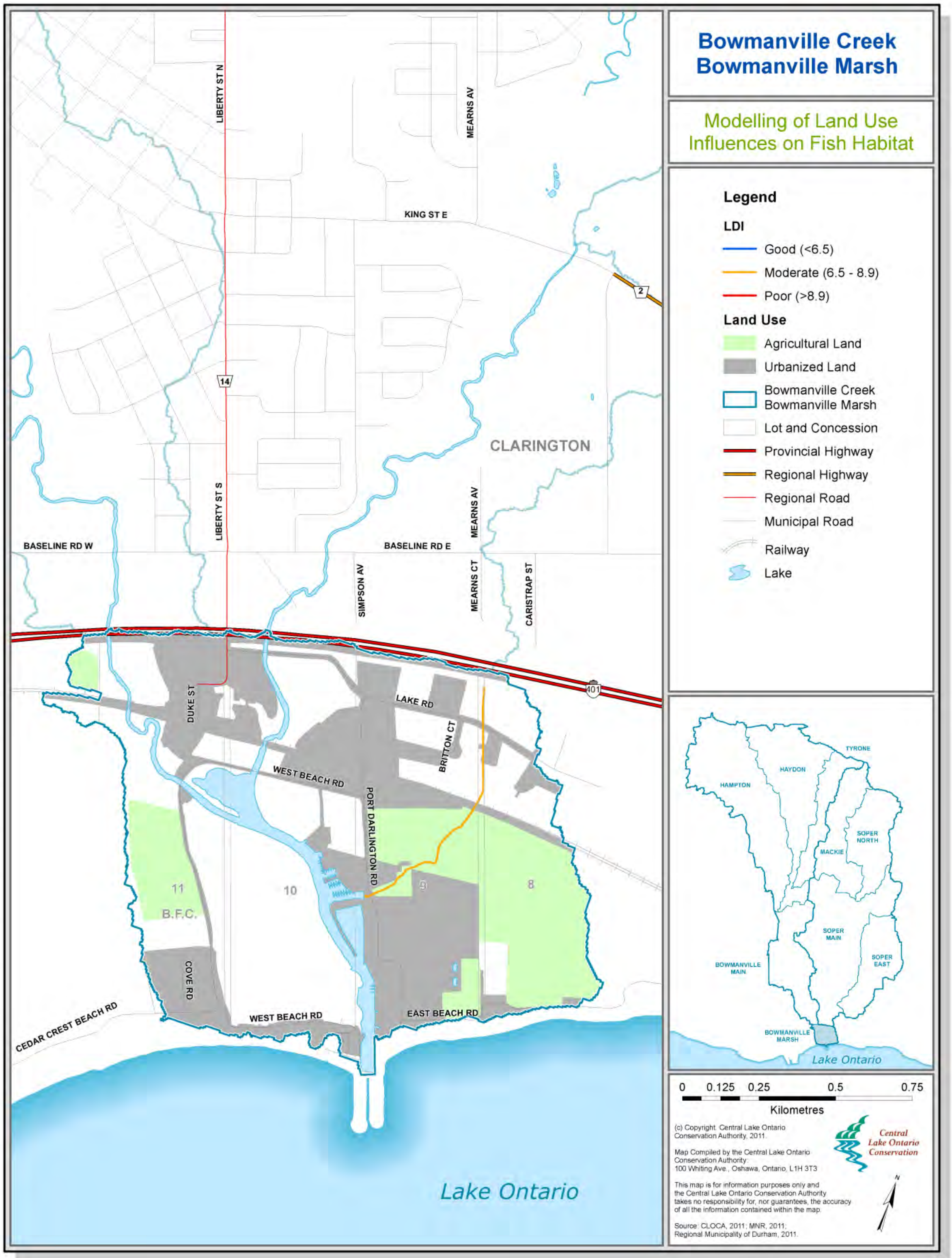


Figure 25: Modelled landscape disturbance on fish habitat in the Bowmanville Marsh subwatershed

4.2.6 Soper Creek Subwatersheds (Mackie Subwatershed)

4.2.5.1 Aquatic Habitat

Strahler Stream Order

Like most Bowmanville/Soper Creek subwatersheds, the Mackie subwatershed is comprised entirely of low-order streams (Table 18 and Figure 23). These low-order streams are more susceptible to environmental change than subwatersheds with greater proportions of high-order streams (EC, 2004). First order streams comprise 61% of the watercourses with the remainder being made up of second (23%) and third order (16%) streams. Most of these first order streams are derived from Oak Ridges Moraine groundwater discharge and the lower outwash area of the Till Plain. The streams will continue to play an important role in maintaining the overall health of the subwatershed and downstream watershed reaches.

Table 18: Mackie subwatershed Strahler stream order
Total stream length (km) and proportion of the total stream length (in parenthesis) by stream-order of the subwatershed (values calculated from the 2010 CLOCA drainage layer).

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
24.70	9.25	6.40	0.00	0.00	40.35
(61%)	(23%)	(16%)	(0%)	(0%)	100%

Instream Barriers

Instream barriers within the Mackie subwatershed were assessed based on the obstruction of fish movement of migratory species. There is one known potential instream barrier within the Mackie subwatershed (Figure 24). This barrier is summarized in Table 19 and a description of is provided below.

Table 19: Known instream barriers in the Mackie subwatershed
Fish passage indicates whether fish can move through the barrier to access upstream habitats (Salmonids indicates that only jumping species of salmon and trout can pass over the barrier).

Obstruction	Type	Year Built	Status	Fish Passage
Pumphouse Dam	Dam	1900's	Active	Salmonids (Spring)

<u>Pumphouse Dam</u>

The Pumphouse Dam is located west of Bethesda Road, north of Taunton Road. This dam was built in the early 1900's and was the original pool from which Bowmanville's water was supplied. The pool is no longer used as a water supply. A nearby golf course uses pools in the creek below this structure for irrigation purposes. There have been reports of Rainbow Trout traversing this structure during average spring flood events. During the summer in low flow conditions, this dam would present a drop of 118cm, which would prove to be a barrier to most fishes. Fall run anadromous fishes were found up to this structure but not above. Normal fall flows may not be sufficient to allow passage of Chinook and Coho Salmon.

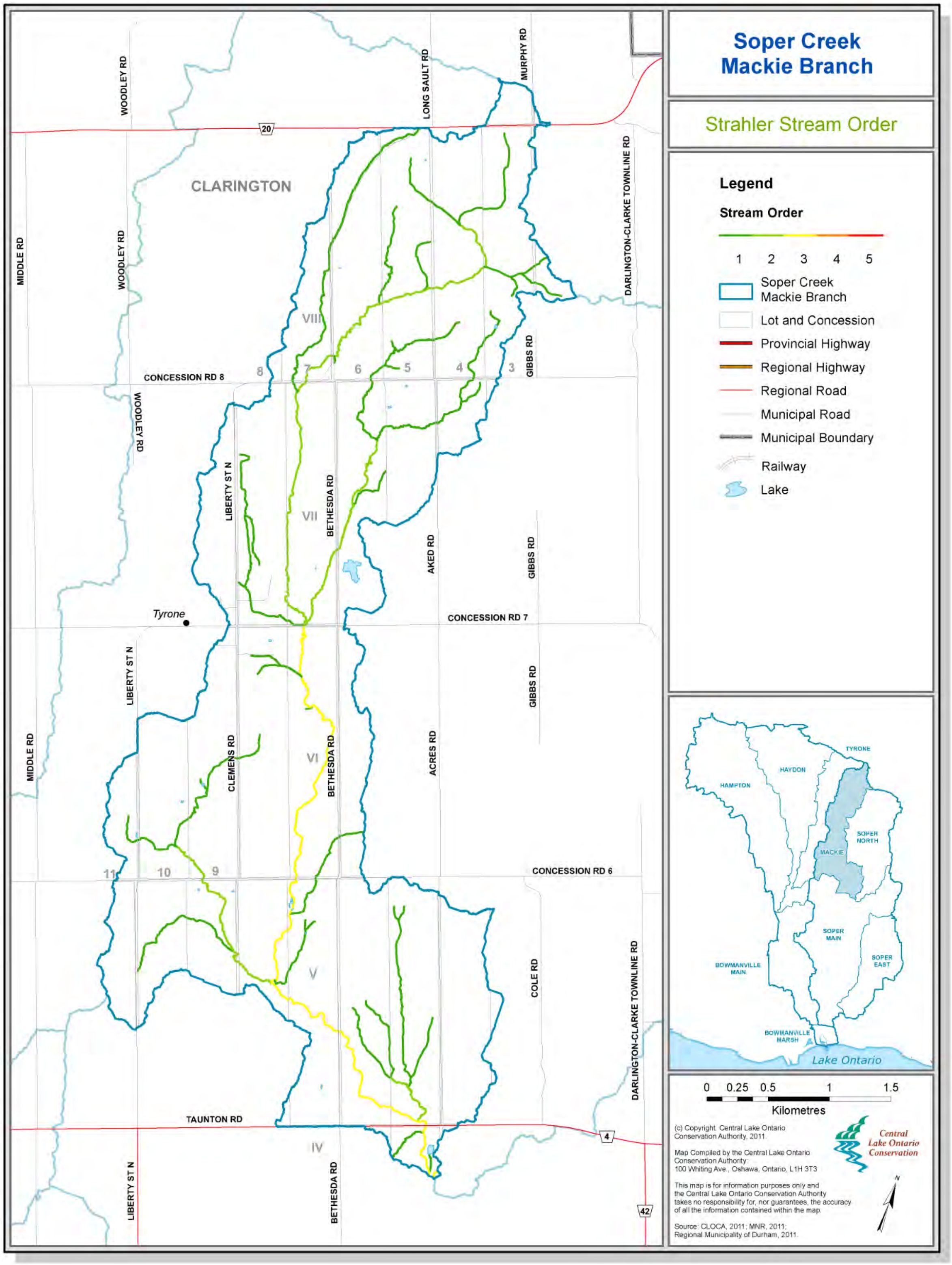


Figure 26: Strahler stream order of the Mackie subwatershed

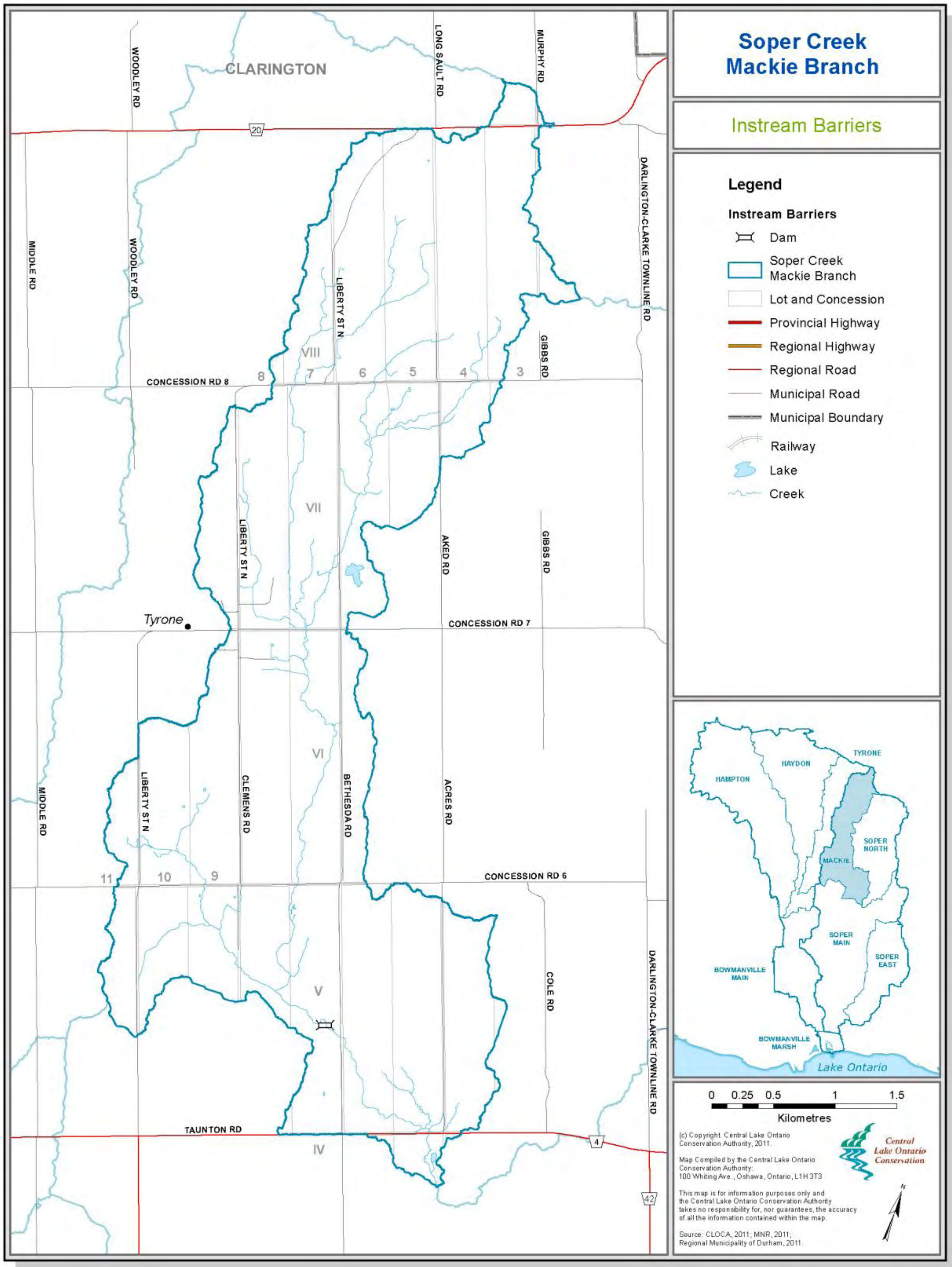


Figure 27: Instream barriers in the Mackie subwatershed

Riparian Vegetation

The Mackie subwatershed has a total of 81% of its stream length intersecting natural riparian vegetation (Table 20). This is well above the watershed average of 73%, which likely can be attributed to well vegetated valleys, existing woodlots and limited urban development. By stream-order, the proportion of riparian cover is greatest along third (96%) and second-order streams (95%), and lowest along first-order (71%) streams. The Mackie subwatershed has the second highest riparian coverage percentage of all the subwatersheds within the Bowmanville/Soper Creek watershed. Riparian cover is especially important for low-order streams, which are more affected by environmental change than large-order streams (EC 2004).

Table 20: Status of riparian vegetation in the Mackie subwatershed

Total stream length (km) intersecting natural areas based on ELC (OMNR, 2007) communities and resulting percentage of total stream length with cover (in parenthesis) by stream-order. Highlighted columns represent lower order streams which benefit greatly from riparian cover and may be given priority when determining areas for restoration.

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
17.60	8.77	6.12	0.00	0.00	32.49
(71%)	(95%)	(96%)	N/A	N/A	(81%)

Landscape Influences

Land disturbance in the Mackie subwatershed is categorized as good (low level of disturbance) in all reaches (Figure 25). Land use in the subwatershed is a combination of urban, agricultural and naturally vegetated areas. Currently, there is enough of a riparian corridor to mitigate the effects that urban and agricultural land uses have on watercourses. The combination of large amounts of forested areas in the northern sections of the subwatershed with well vegetated valleys throughout most of the rest of the subwatershed provides enough thermal protection and groundwater discharge to maintain good health throughout the subwatershed.


Brown Trout

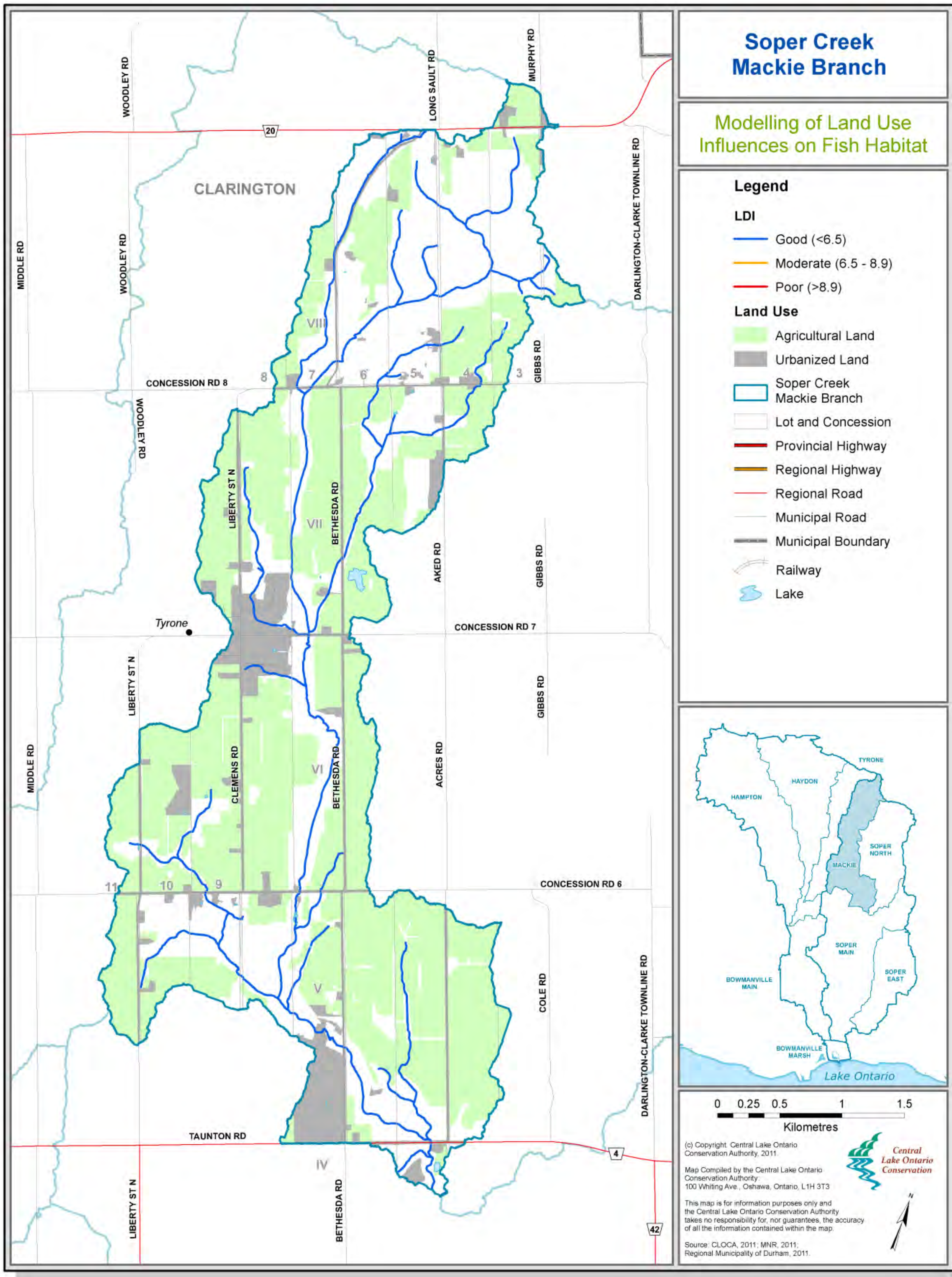


Figure 28: Modelled landscape disturbance on fish habitat in the Mackie subwatershed

4.2.5.2 Fisheries

The Mackie subwatershed supports a fish community of 8 species from 5 families. Figure 26 depicts the fish sampling sites as part of the CLOCA aquatic monitoring programs within the subwatershed. Fish species caught in this subwatershed are representative of primarily cold/cool-water fish (Trout, Salmon, Sculpin, Dace) with the presence of a warmwater species (Pumpkinseed – possibly a pond escapee). The moderate richness of fish species caught in the Mackie Creek subwatershed is representative of its low stream order, and its species composition is typical of Trout streams.

Soper Creek subwatershed

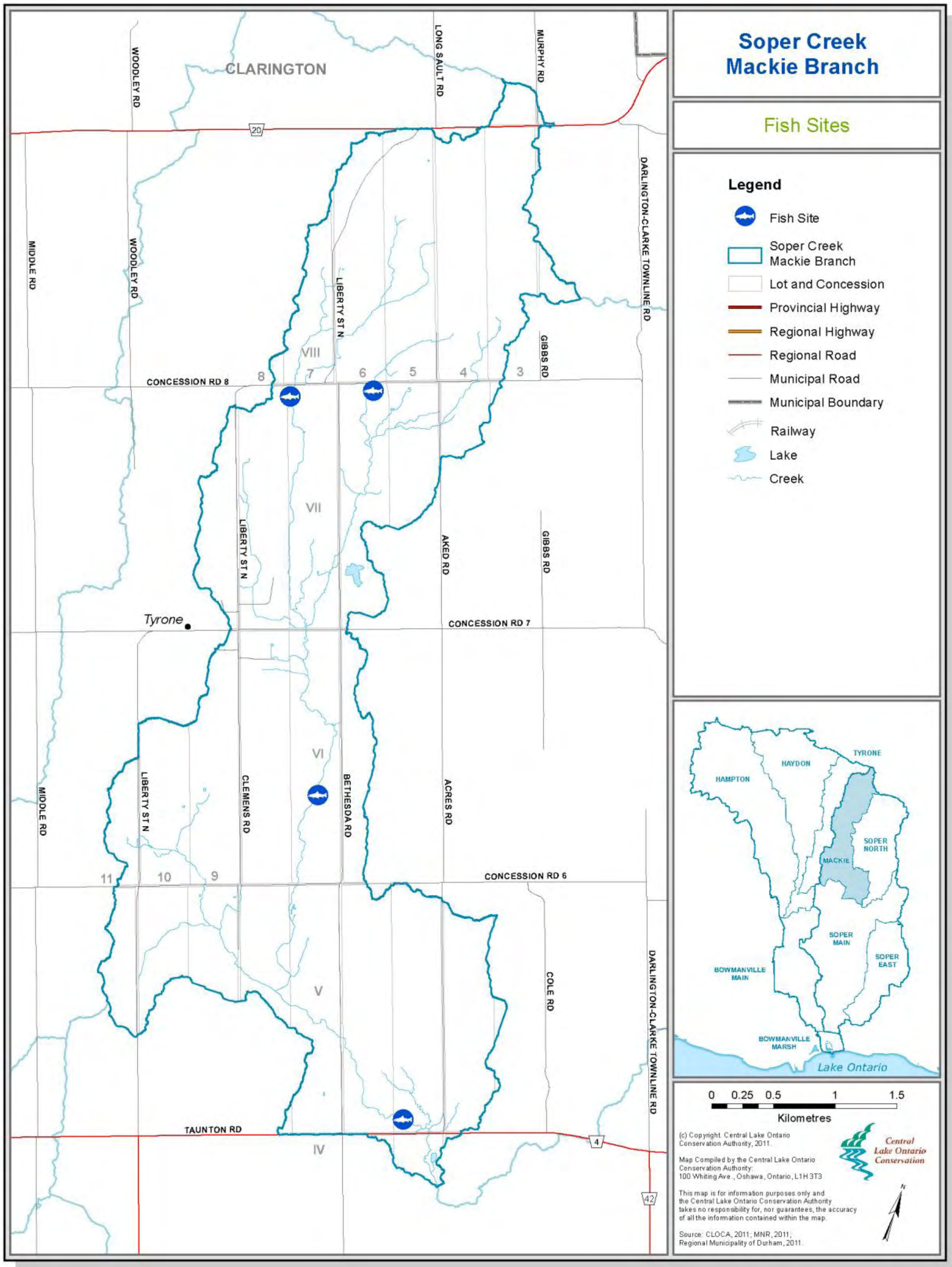


Figure 29: Fish sampling sites in the Mackie subwatershed

4.2.7 Soper Creek Subwatershed (Soper North Subwatershed)

4.2.6.1 Aquatic Habitat

Strahler Stream Order

Like most northern Bowmanville/Soper Creek subwatersheds, the Soper North subwatershed is comprised entirely of low-order streams (Table 21 and Figure 30). These low-order streams are more susceptible to environmental change than subwatersheds with greater proportions of high-order streams (EC, 2004). First order streams comprise 66% of the watercourses with the remainder being made up of second (18%) and third order (16%) streams. Most of these first order streams are derived from the Oak Ridges Moraine groundwater discharge and the lower outwash area of the Till Plain. These streams will continue to play an important role in maintaining the overall health of the subwatershed and downstream watershed reaches.

Table 21: Soper North subwatershed Strahler stream order
Total stream length (km) and proportion of the total stream length (in parenthesis) by stream-order of the subwatershed (values calculated from the 2010 CLOCA drainage layer).

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
32.50	8.79	8.00	0.00	0.00	49.29
(66%)	(18%)	(16%)	(0%)	(0%)	100%

Instream Barriers

There are no potential instream barriers within the Soper North subwatershed.

Fish identification and measurements

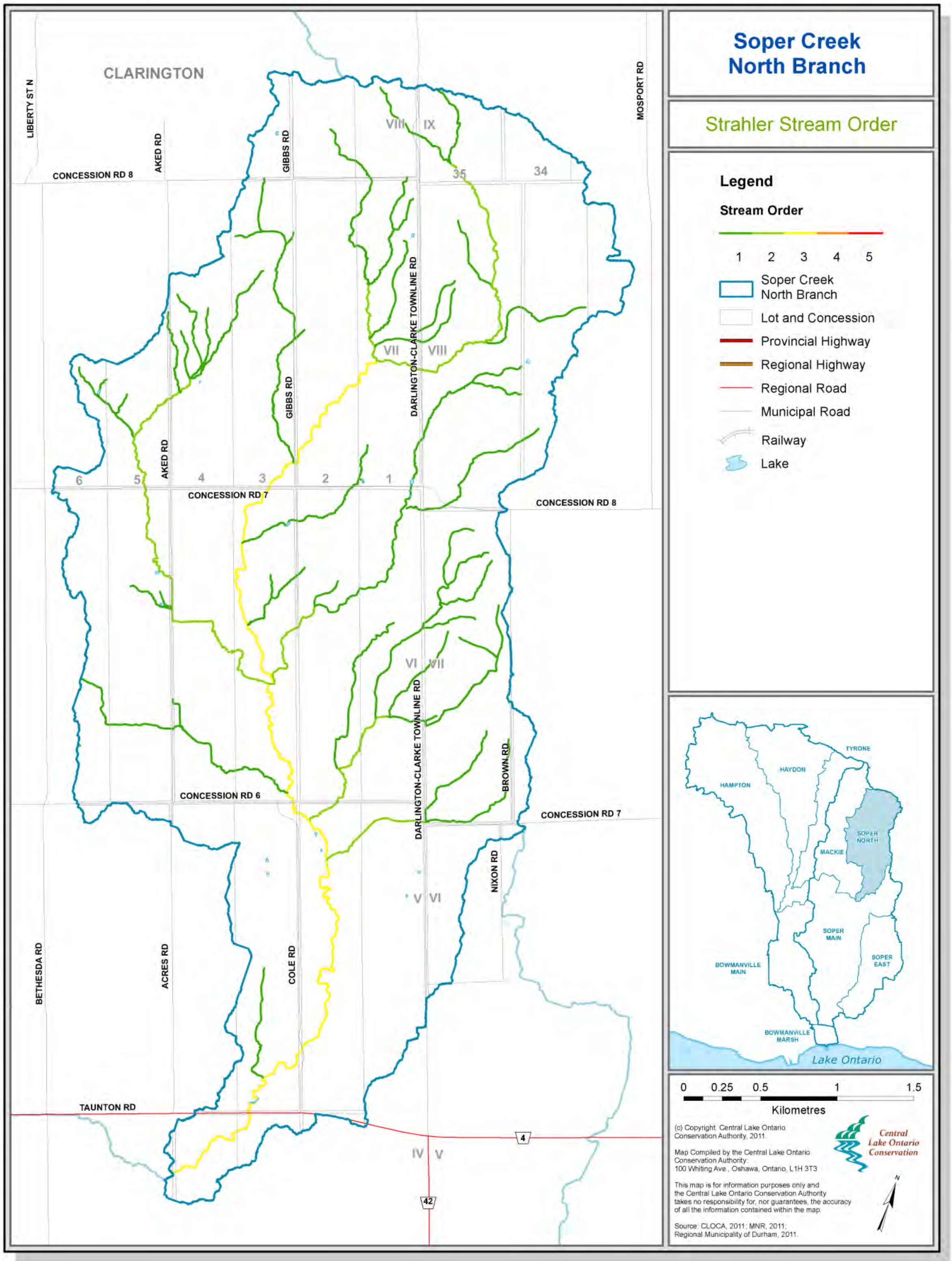


Figure 30: Strahler stream order of the Soper North subwatershed

Riparian Vegetation

The Soper North subwatershed has a total of 71% of its stream length intersecting natural riparian vegetation (Table 22). This is slightly below the watershed average of 73%, which likely can be attributed to the agricultural land uses in the area. By stream-order, the proportion of riparian cover is greatest along third (98%) and second order streams (86%), and lowest along first (60%) order streams. Riparian cover is especially important for low-order streams, which are more affected by environmental change than large-order streams (EC 2004).

Table 22: Status of riparian vegetation in the Soper North subwatershed

Total stream length (km) intersecting natural areas based on ELC (OMNR, 2007) communities and resulting percentage of total stream length with cover (in parenthesis) by stream-order. Highlighted columns represent lower order streams which benefit greatly from riparian cover and may be given priority when determining areas for restoration.

Strahler Stream Order					Grand Total
1	2	3	4	5	
19.37	7.59	7.86	0.00	0.00	34.83
(60%)	(86%)	(98%)	N/A	N/A	(71%)

Landscape Influence

Land disturbance in the Soper North subwatershed is categorized as good (low level of disturbance) in most reaches with the exception of a couple reaches categorized as moderate or poor (moderate or high level of disturbance) (Figure 27). Sufficient natural areas and riparian buffers contribute to the low level of disturbance throughout most of the subwatershed. The areas that are categorized as moderate or poor health lack wide riparian areas and the buffers that are present are not capable of mitigating the effects of agriculture in the area. Since riparian vegetation is lacking in a couple of the first order streams where it is most important, restoration of the vegetative buffer is recommended. The Soper North subwatershed has little urban development which also contributes to its good overall health.

4.2.6.2 Fisheries

The Soper North subwatershed supports a moderately diverse fish community of 11 species from 6 families. Figure 28 depicts the fish sampling sites as part of the CLOCA aquatic monitoring programs within the subwatershed. It should be noted that this subwatershed is under sampled because of the random sampling design. The fish species caught in this subwatershed are representative of primarily cold/cool-water fish (Trout, Sucker, Sculpin, Dace) with the presence of a warmwater fish (Pumpkinseed – possibly a pond escapee). The moderate species richness of fish species caught in the Soper North subwatershed is representative of low stream order, and its species composition is typical of Trout streams.

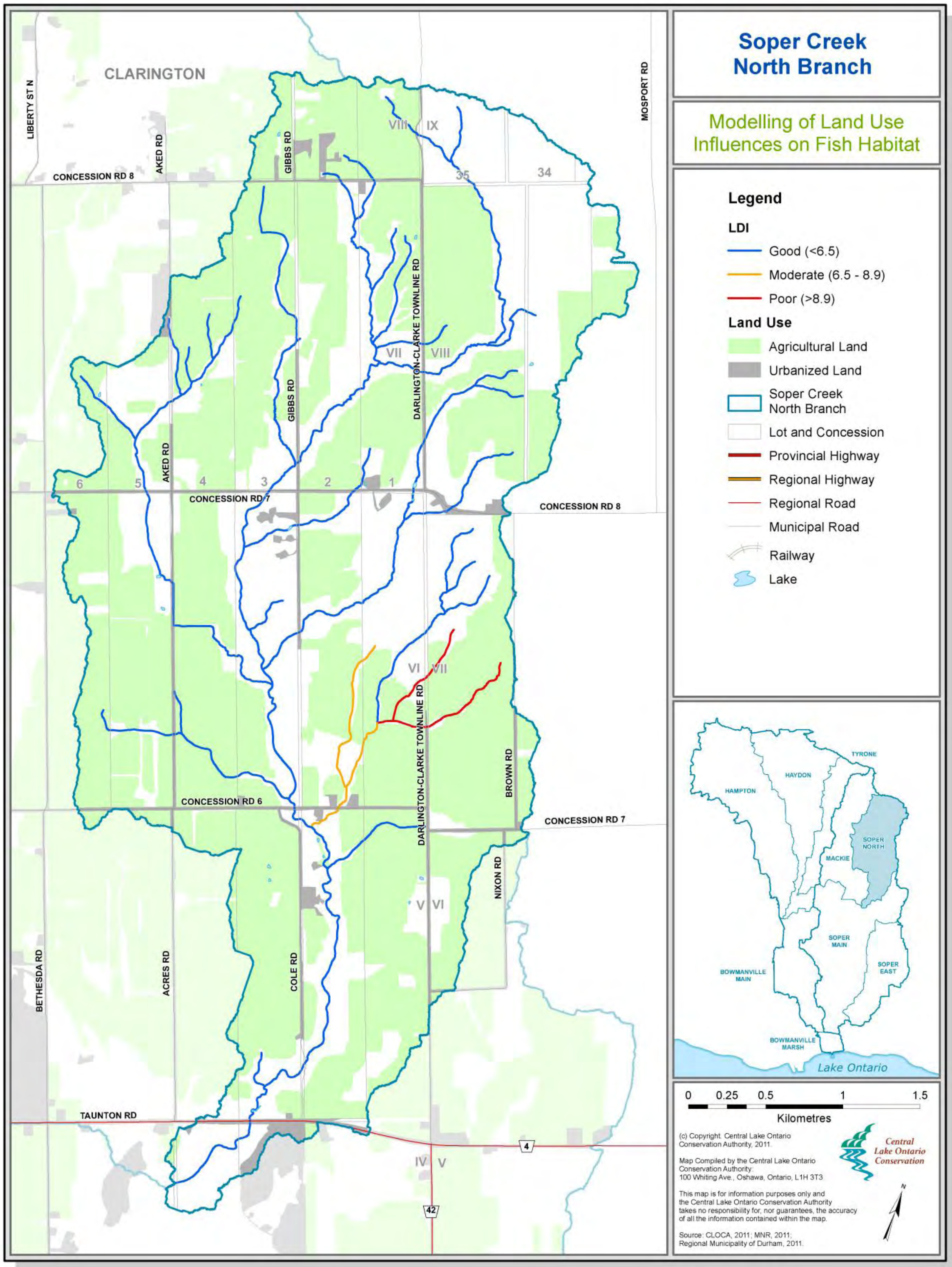


Figure 31: Modelled landscape disturbance on fish habitat in the Soper North subwatershed

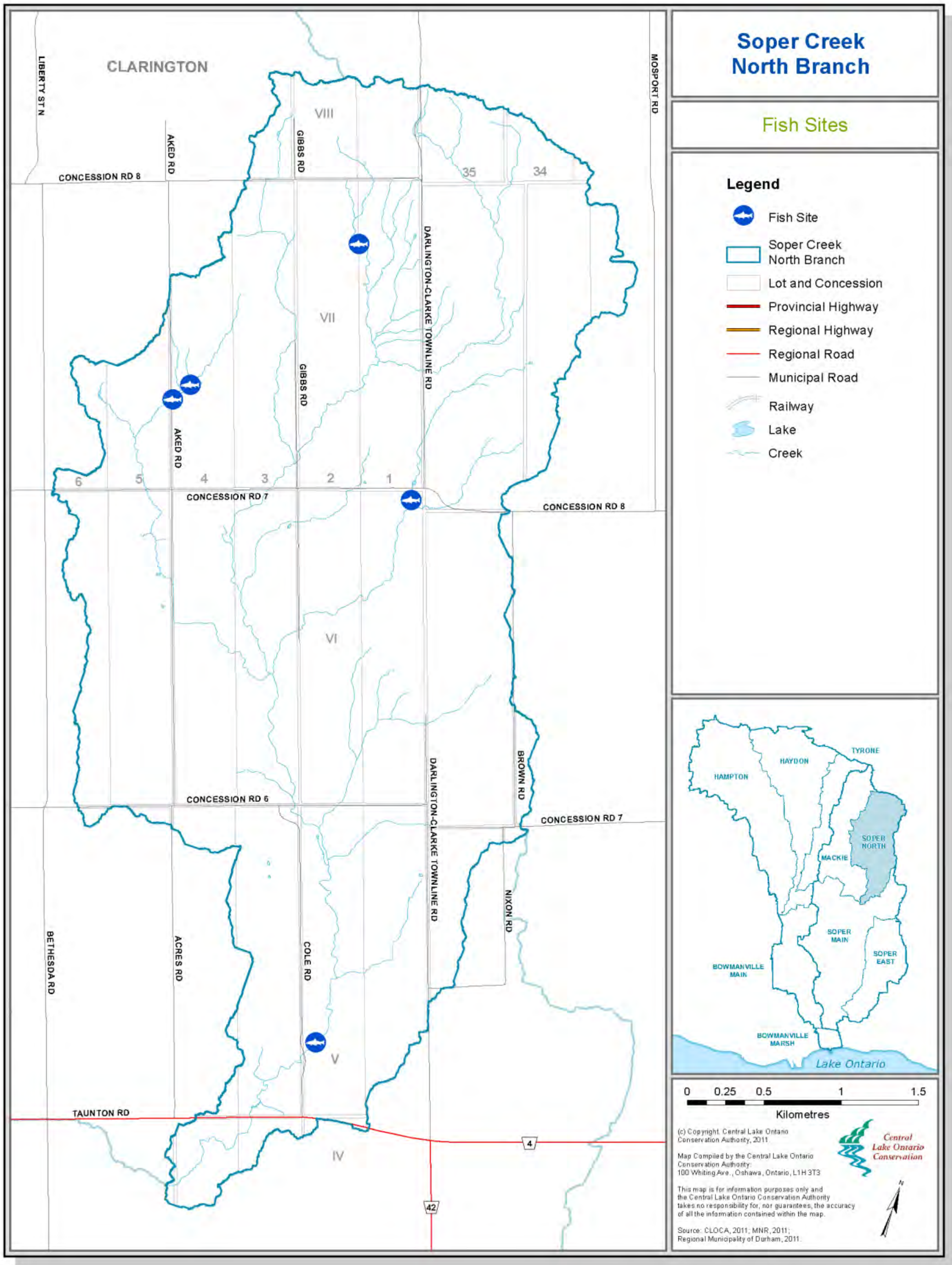


Figure 32: Fish sampling sites in the Soper North subwatershed

4.2.8 Soper Creek Subwatershed (Soper Main Subwatershed)

4.2.7.1 Aquatic Habitat

Strahler Stream Order

The Soper Main subwatershed contains the second highest stream length (74km) in the Bowmanville/Soper Creek watershed, second to Hampton Subwatershed (115km). The Soper Main subwatershed is similar to the Bowmanville Main subwatershed in that it has a combination of low-order streams and high-order streams (Table 23 and Figure 29). The low-order streams are more susceptible to environmental change than the high-order streams (EC, 2004) making the protection of the low-order streams of high importance. This is often overlooked as the low-order streams are often viewed as expendable. Within the Soper Main subwatershed 66% of all watercourses are first order streams with the remainder being second (12%), third (3%) and fourth order (19%) streams. The Soper Main subwatershed has the highest fourth order stream length of any of the Bowmanville/Soper Creek subwatersheds and as a result has high species diversity (19 species).

Table 23: Soper Main subwatershed Strahler stream order
Total stream length (km) and proportion of the total stream length (in parenthesis) by stream-order of the subwatershed (values calculated from the 2010 CLOCA drainage layer).

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
49.35	8.69	2.16	13.89	0.00	74.08
(66%)	(12%)	(3%)	(19%)	(0%)	100%

Instream Barriers

Instream barriers within the Soper Main subwatershed were assessed based on the obstruction of fish movement of migratory species. There are five known potential instream barriers within the Soper Main Creek subwatershed (Figure 30). Most of these barriers are associated with agricultural and recreational online ponds or road crossings within the Municipality of Clarington. These barriers are summarized in Table 24 and a description of each is provided.

Table 24: Known instream barriers in the Soper Main subwatershed
Fish passage indicates whether fish can move through the barrier to access upstream habitats (Salmonids indicates that only jumping species of salmon and trout can pass over the barrier).

Obstruction	**Type**	**Year Built**	**Status**	**Fish Passage**
Crooked Creek Pond	Dam/Pond	1960	Active	Not Passable
Tax Pond	Dam/Pond	Unknown	Unknown	Undetermined
Paladino Pond	Dam/Pond	Unknown	Active	Undetermined
Bowmanville Golf Pond	Dam/Pond	Unknown	Unknown	Undetermined
Mearns Avenue Culvert	Culvert	Unknown	Active	Salmonids

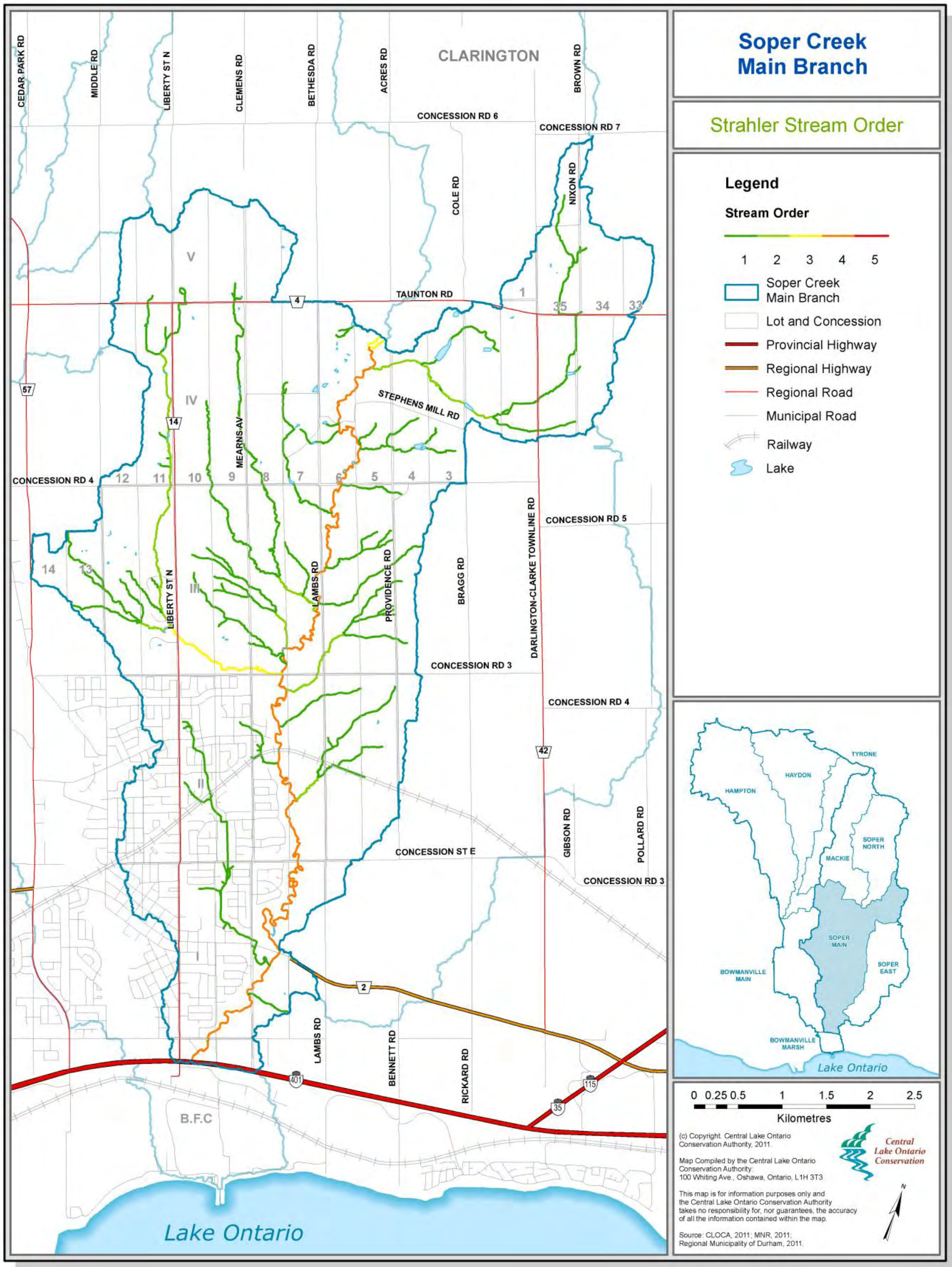


Figure 33: Strahler stream order of the Soper Main subwatershed

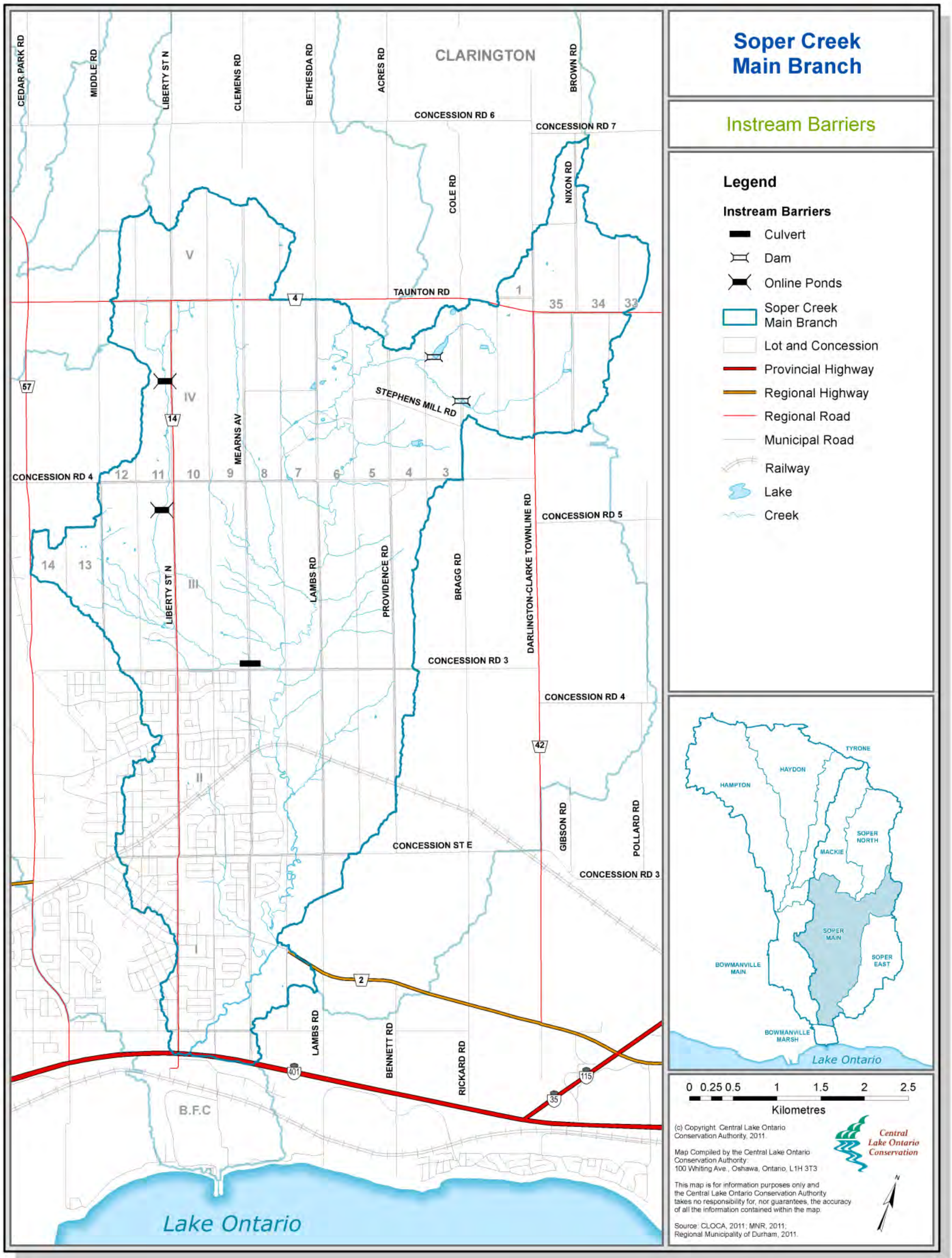


Figure 34: Instream barriers in the Soper Main subwatershed

Crooked Creek Pond

Crooked Creek Pond was created by an earthen berm which was installed in 1960 for crop irrigation. The pond used to include a top draw standpipe outflow but was converted into a bottom draw. This tributary would not normally be used as a migration route due to a small catchment basin and limited flows but the native fish species occupying the reach are likely benefiting from reduced outflow temperatures.

Tax Pond

Tax Pond is located south of Taunton Road, between Bethesda Road and Regional Road #42. The pond is often drained for agricultural purposes. Further study is required to determine if this potential barrier is passable to fish, although this tributary would not normally be used as a migration route due to a small catchment basin and limited flows. A site sampled upstream of the pond yielded Creek Chub and Blacknose Dace.

Paladino Pond

Paladino Pond is located west of Liberty Street, between Taunton Road and Concession #4. This pond includes a top-draw outlet with a perched culvert on the downstream side. Efforts to create a bottom-draw outlet that would provide for forage fish passage should be considered.

Bowmanville Golf Pond

The Bowmanville Golf Pond is located in Bowmanville Golf Course, west of Liberty Street and south of Concession Road #4. This pond includes a top-draw outlet. Efforts to create a bottom-draw outlet that would provide for forage fish should be considered.

Mearns Avenue Culvert

The Mearns Avenue Culvert used to be a perched culvert but was re-designed in 2005. The new structure is located north of Concession #3 on Mearns Avenue. Historical studies have noted the presence of anadromous Rainbow Trout immediately downstream and upstream of this culvert indicating that passage is possible, but due to a 50cm waterfall, traversing this structure was difficult for all but the strongest fish. The new design should make passage of this culvert much more realistic for more migrating species and higher numbers of individuals.

Riparian Vegetation

The Soper Main subwatershed has a total of 80% of its stream length intersecting natural riparian vegetation (Table 25). This is above the watershed average of 73%, which likely can be attributed to the natural valleys and existing woodlots within the subwatershed. By stream-order, the proportion of riparian cover is greatest along fourth (98%) and second-order streams (88%), and lowest along first (73%) and third order (76%) streams. Riparian cover is especially important for low-order streams, which are more affected by environmental change than large-order streams (EC 2004). It is interesting to note that even though the fourth order stream has a high value for riparian cover (98% as calculated by this methodology), the LDI is only moderate. This demonstrates that although riparian coverage is important, other factors and/or cumulative effects from poorly vegetated riparian areas on low-order streams upstream can reduce the water quality of downstream well buffered vegetated reaches.

Table 25: Status of riparian vegetation in the Soper Main subwatershed

Total stream length with 30m riparian cover (km) and percent of total stream length with cover (in parenthesis) by stream-order. Highlighted columns represent lower order streams which benefit greatly from riparian cover and may be given priority when determining areas for restoration.

Strahler Stream Order					Grand Total
1	2	3	4	5	
36.08	7.62	1.64	13.62	0.00	58.96
(73%)	(88%)	(76%)	(98%)	N/A	(80%)

Landscape Influences

Land disturbance in the Soper Main subwatershed is categorized as moderate (moderate level of disturbance) in most reaches, with some good (low level of disturbance) reaches and some poor (high level of disturbance) reaches (Figure 31). The areas of the Soper Main subwatershed that are categorized as moderately disturbed have some riparian buffers and groundwater inputs but not enough to fully mitigate the high proportion of agricultural and urban land cover in this subwatershed. The area that is categorized as good health is directly north of Bowmanville. Currently it has enough vegetative buffers and groundwater inputs to protect it from the urban and agricultural land uses in the area. As urban growth continues, strong riparian buffers will be important in ensuring the health of this subwatershed. The area that is considered poor health is located in the Town of Bowmanville. Much of this section of creek is piped and/or has stormwater contributions from urban development which contributes to its lower score.

4.2.7.2 Fisheries

The Soper Main subwatershed supports a diverse fish community of 19 species from 7 families. Figure 32 depicts the fish sampling sites as part of the CLOCA aquatic monitoring programs within the subwatershed. The fish species caught in this subwatershed are representative of primarily cold/cool-water fish (Trout, Salmon, Sucker, Sculpin, Dace) with the presence of a warmwater fish (Pumpkinseed). The high species richness of fish species caught in the Soper Main subwatershed is representative of its high stream order. During 2007 and 2010 sampling, Round Goby was caught in the Soper Main subwatershed. Further monitoring will determine whether they are able to continue expanding their range.

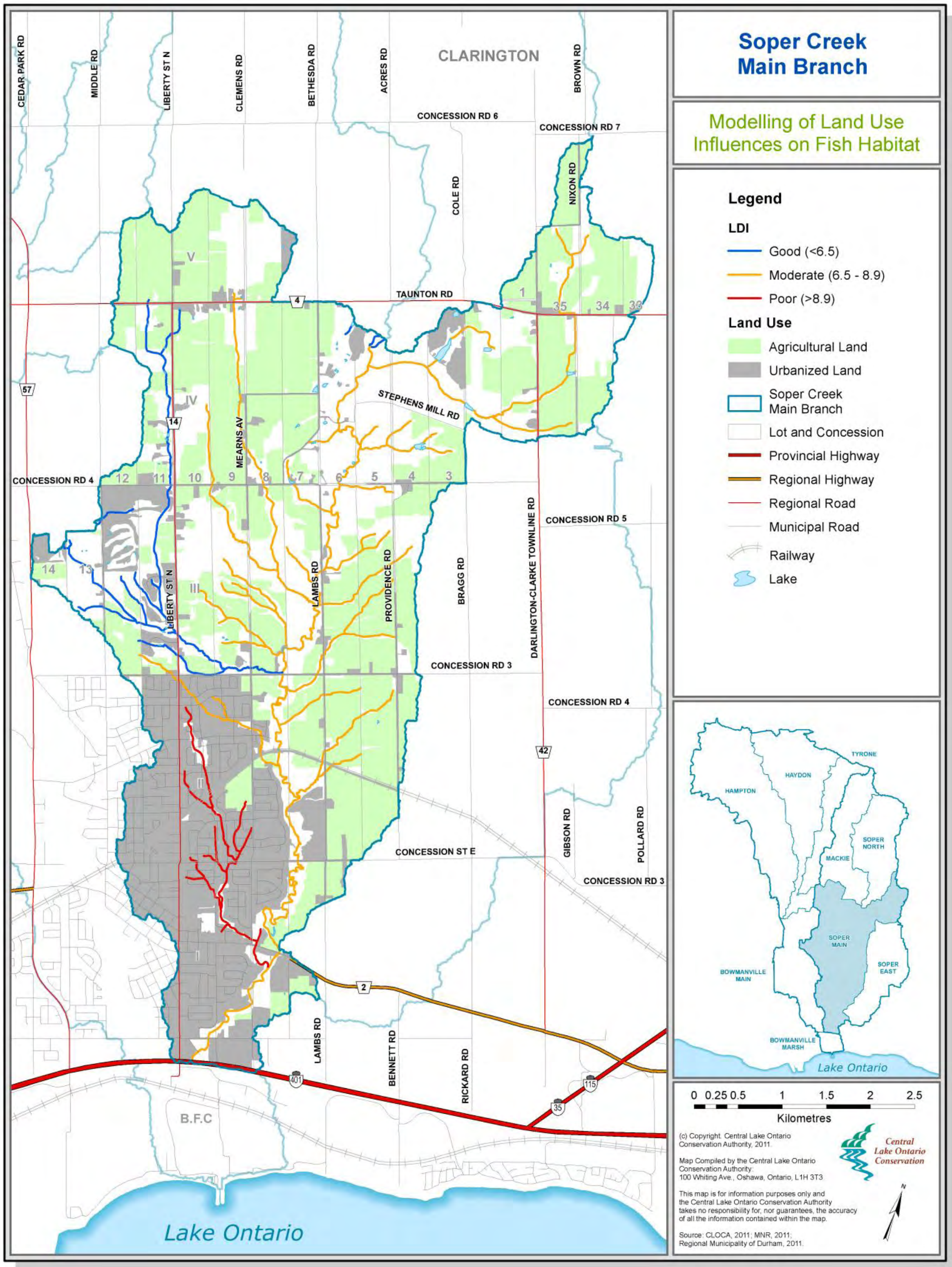


Figure 35: Modelled landscape disturbance on fish habitat in the Soper Main subwatershed

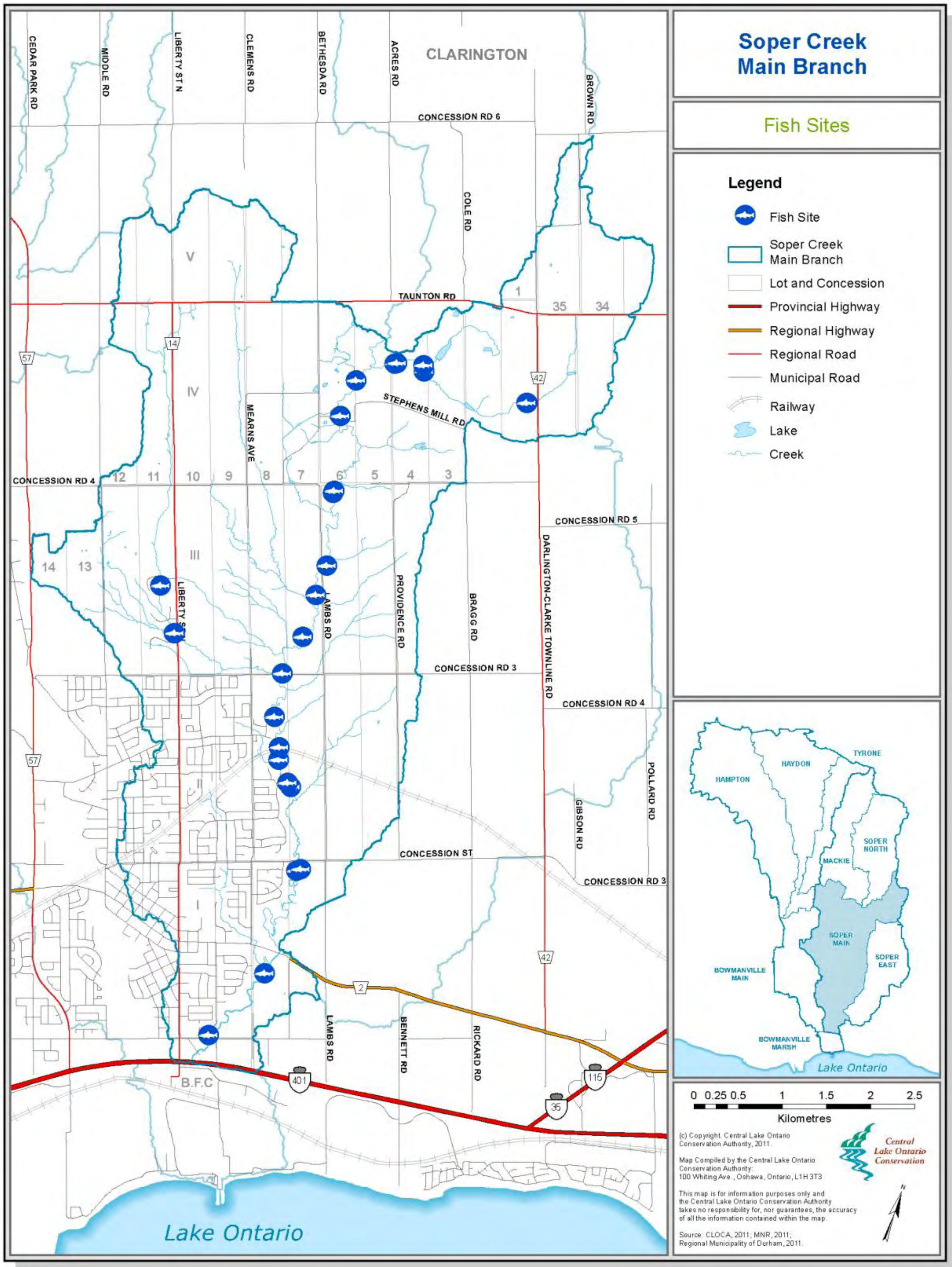


Figure 36: Fish sampling sites in the Soper Main subwatershed

4.2.9 Soper Creek Subwatershed (Soper East Subwatershed)

4.2.7.1 Aquatic Habitat

Strahler Stream Order

The Soper East subwatershed is comprised entirely of low-order streams (stream orders 1 through 3) with the exception of a 10m stretch of a fourth-order stream at the south end of the subwatershed (Table 26 and Figure 33). Subwatersheds with a greater proportion of low-order streams are more susceptible to environmental change than subwatersheds having larger proportions of high-order streams (EC, 2004). First order streams comprise 65% of the watercourses with the remainder being made up of second (14%), third (21%), and fourth-order (0.02%) streams. Most of these first order streams arise from the Iroquois Beach groundwater discharge, which is not as strong as the Oak Ridges Moraine and Till Plain regions in the north, meaning they are potentially more susceptible to environmental change.

Table 26: Soper East subwatershed Strahler stream order

Total stream length (km) and proportion of the total stream length (in parenthesis) by stream-order of the subwatershed (values calculated from the 2010 CLOCA drainage layer).

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
23.02	4.92	7.23	0.01	0.00	35.18
(65%)	(14%)	(21%)	(0%)	(0%)	(100%)

Instream Barriers

There are no potential instream barriers within the Soper East subwatershed.

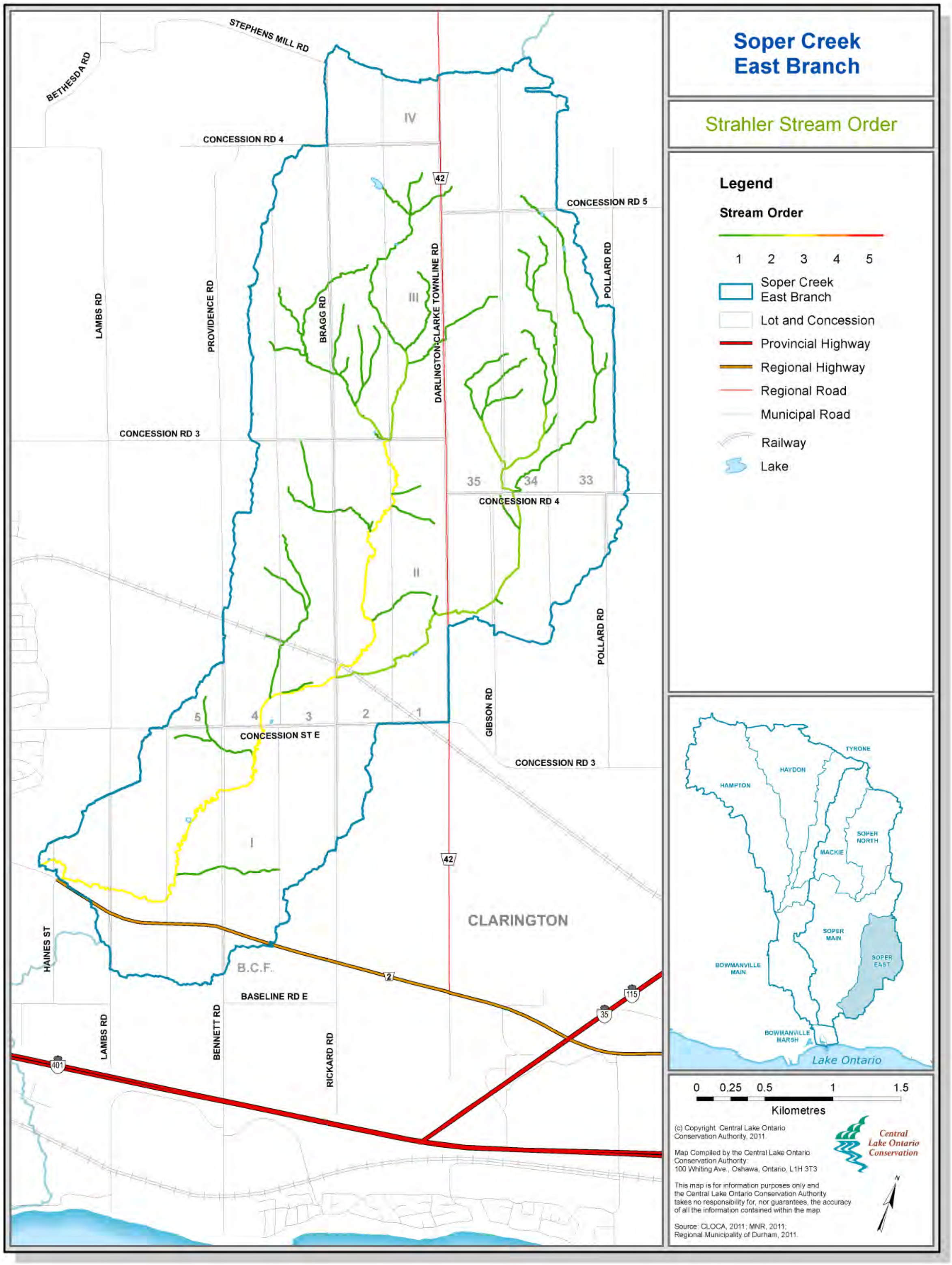


Figure 37: Strahler stream order of the Soper East subwatershed

Riparian Vegetation

The Soper East subwatershed has a total of 53% of its stream length intersecting natural riparian vegetation (Table 27). This is well below the watershed average of 73%, which likely can be attributed to the significant agricultural land cover in this subwatershed. By stream-order, the proportion of riparian cover is greatest along third (96%) and second order streams (59%), and lowest along first order (38%) streams. Riparian cover is especially important for low-order streams, which are more affected by environmental change than large-order streams (EC 2004). The Soper East subwatershed has the lowest scores for riparian coverage on both first and second order streams. This data supports the LDI categorization of poor health throughout the majority of the subwatershed.

Table 27: Status of riparian vegetation in the Soper East subwatershed
Total stream length (km) intersecting natural areas based on ELC (OMNR, 2007) communities and resulting percentage of total stream length with cover (in parenthesis) by stream-order. Highlighted columns represent lower order streams which benefit greatly from riparian cover and may be given priority when determining areas for restoration.

Strahler Stream Order					**Grand Total**
1	2	3	4	5	
8.65	2.89	6.95	0.01	0.00	18.50
(38%)	(59%)	(96%)	(100%)	N/A	(53%)

Landscape Influences

Land disturbance in the Soper East subwatershed is categorized as poor (high level of disturbance) in most reaches, with one good and one moderate reach (low to moderate level of disturbance) in the north end of the subwatershed (Figure 34). The good (low disturbance) reach is located in an area of the subwatershed that has adequate riparian buffer and groundwater inputs. The moderately disturbed branch located to the west of the good reach has some riparian buffers but not enough to fully mitigate adverse effects of the local land-use. The majority of the subwatershed has very limited riparian vegetation due in part to the significant proportion of agricultural and urban land uses. In combination with this subwatershed not having as much contribution from groundwater sources, particularly from the ORM, the overall health of the subwatershed suffers.

4.2.7.2 Fisheries

The Soper East subwatershed supports a moderately diverse fish community of 12 species from 5 families. Figure 35 depicts the fish sampling sites as part of the CLOCA aquatic monitoring programs within the subwatershed. The fish species caught in this subwatershed are representative of primarily cold/cool-water fish (Trout, Dace, Darters, Suckers) with the presence of a warmwater species (Bluntnose Minnow and Fathead Minnow). The moderate species richness of fish species caught in the Soper East subwatershed is representative of low stream order.

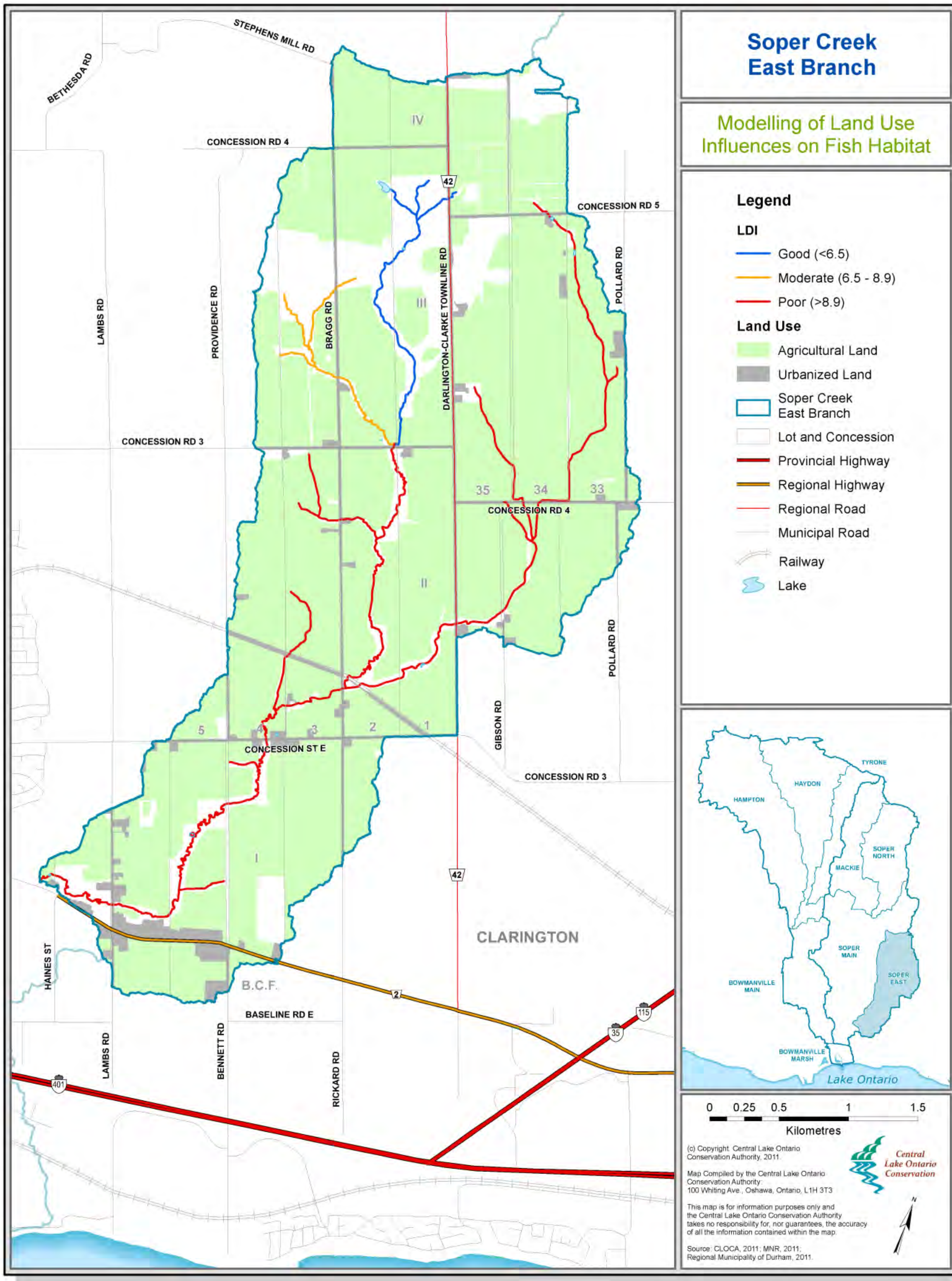


Figure 38: Modelled landscape disturbance on fish habitat in the Soper East subwatershed

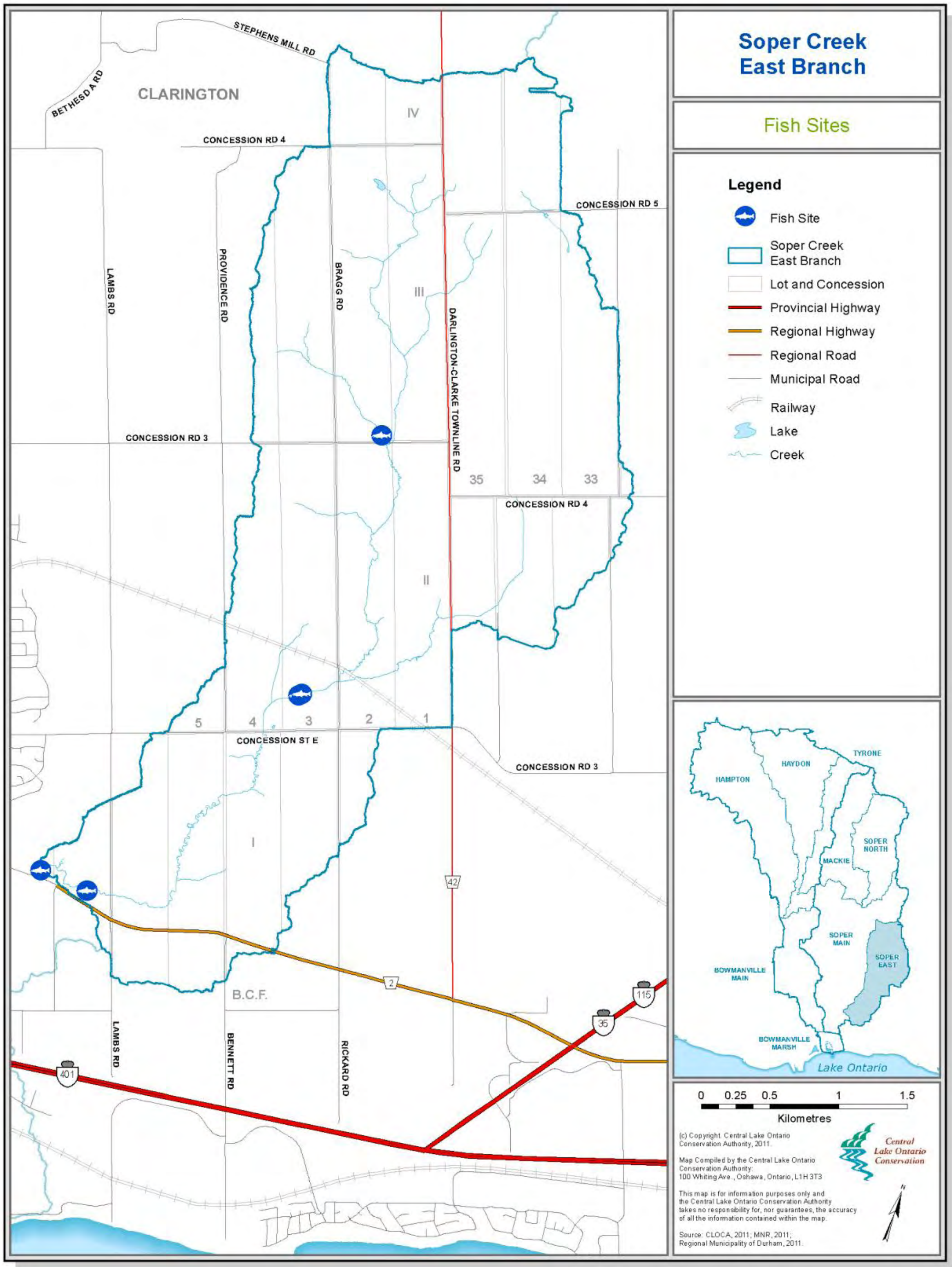


Figure 39: Fish sampling sites in the Soper East subwatershed

5.0 CONCLUSIONS

The Bowmanville/Soper Creek watershed supports a strong fishery through healthy aquatic habitat which in part can be attributed to the relatively high amounts of natural cover, riparian buffers and groundwater input. This watershed supports a high diversity of fish including sensitive fish species, such as, Brook Trout, Brown Trout and Pacific Salmon. That being said, the Bowmanville/Soper Creeks and their respective tributaries face many environmental stressors including impacts from existing intensive agriculture and continued urban growth. This is manifested through water quality degradation, increased stream temperatures and ultimately impacts to aquatic life. Many opportunities exist for restoration in the watershed which has the potential to improve aquatic habitat and overall watershed health. These opportunities include riparian restoration and enhanced stormwater management. Through restoration and protection of natural areas, the Bowmanville/Soper Creek watershed should maintain a healthy and diverse aquatic ecosystem.

WHAT WE DO ON THE LAND IS MIRRORED IN THE WATER

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7.0 GLOSSARY ADDITIONS

Anadromous - Refers to an organism that lives in the sea as an adult and returns to fresh water to spawn in the spring. May also refer to organisms that live in lakes and returns to creeks/tributaries to spawn.

BioMAP - A measure of environmental stress (biological water quality) using tolerance values developed for Southern Ontario

Biomass - The total weight of organisms per unit area at any given moment in time.

Dendritic - Descriptive of the resemblance to the pattern made by the branches of a tree or veins of a leaf

Extirpated - Any indigenous species no longer existing in the wild in a particular location but existing elsewhere.

Fish - Section 2 of the Federal Fisheries Act defines fish to include "parts of fish, shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals".

Fish Habitat - Section 34(1) of the Federal Fisheries Act defines fish habitat as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly to carry out their life processes".

Hilsenhoff Biotic Index (HBI) - A qualitative measure of water quality using tolerance values to weigh abundance in an estimate of organic pollution

Invasive species - Alien species (species that have been moved from an area to which they were native to areas where they did not naturally live and evolve, either intentionally or unintentionally) whose introduction and spread threatens the environment and the economy.

Morphometric - Descriptive of physical characteristics of a water body such as depth, surface area, and shape

Riparian - Terrestrial areas bordering aquatic zones showing an influence of water that is not normally found in adjacent uplands.