BRONTE CREEK WATERSHED STUDY

Appendix 3

Aquatic Habitat Inventory and Assessment

Progreston Dam, Bronte Creek

Conservation Halton

March 2002

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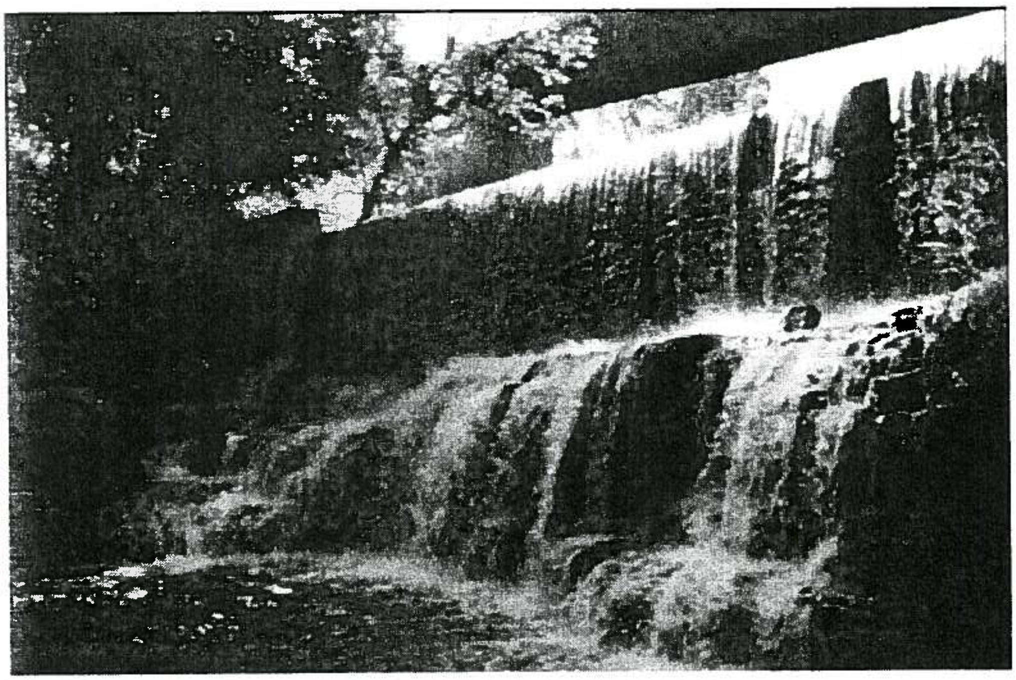
Appendix 3

Aquatic Habitat Inventory and Assessment

By: David Featherstone & Sherwin Watson-Leung
GIS Analyses and Mapping By: Jarold Holland-Hibbert



Progreston Dam, Bronte Creek

Conservation Halton

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March 2002

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CHAPTER 1: *INTRODUCTION*

The Bronte Creek watershed is located at the western end of Lake Ontario within the Regional Municipality of Halton, City of Hamilton (former Town of Flamborough) and Puslinch Township (Wellington County). Bronte Creek and most of its major tributaries arise from wetlands located on the limestone plain above the Niagara Escarpment which extend in an arc from Strabane to Morriston to Haltonville (Figure 1.1). The main branch of Bronte Creek plunges over the Escarpment at Progreston then flows through Lowville, Zimmerman and Bronte before entering Lake Ontario at Bronte Harbour. Crawford Lake is the only natural lake within the watershed. Mountsberg Reservoir, constructed by the Halton Region Conservation Authority (now Conservation Halton) in 1967, is the only other large impoundment within the watershed.

Bronte Creek is one of three major watersheds within the jurisdiction of Conservation Halton. Watershed studies have recently been completed for the Sixteen Mile Creek (1996) and Grindstone Creek (1998) watersheds. Bronte Creek is the only large watershed without a watershed plan and, to address this shortcoming, the Bronte Creek Watershed Study was initiated in 1999. The study summarizes the abiotic and biotic resources and cultural uses and their interrelationships within the watershed. The Bronte Creek Watershed Study describes a "watershed vision" which will ultimately allow the watershed community to care for its natural heritage and cultural resources within the context of existing and future municipal planning structures.

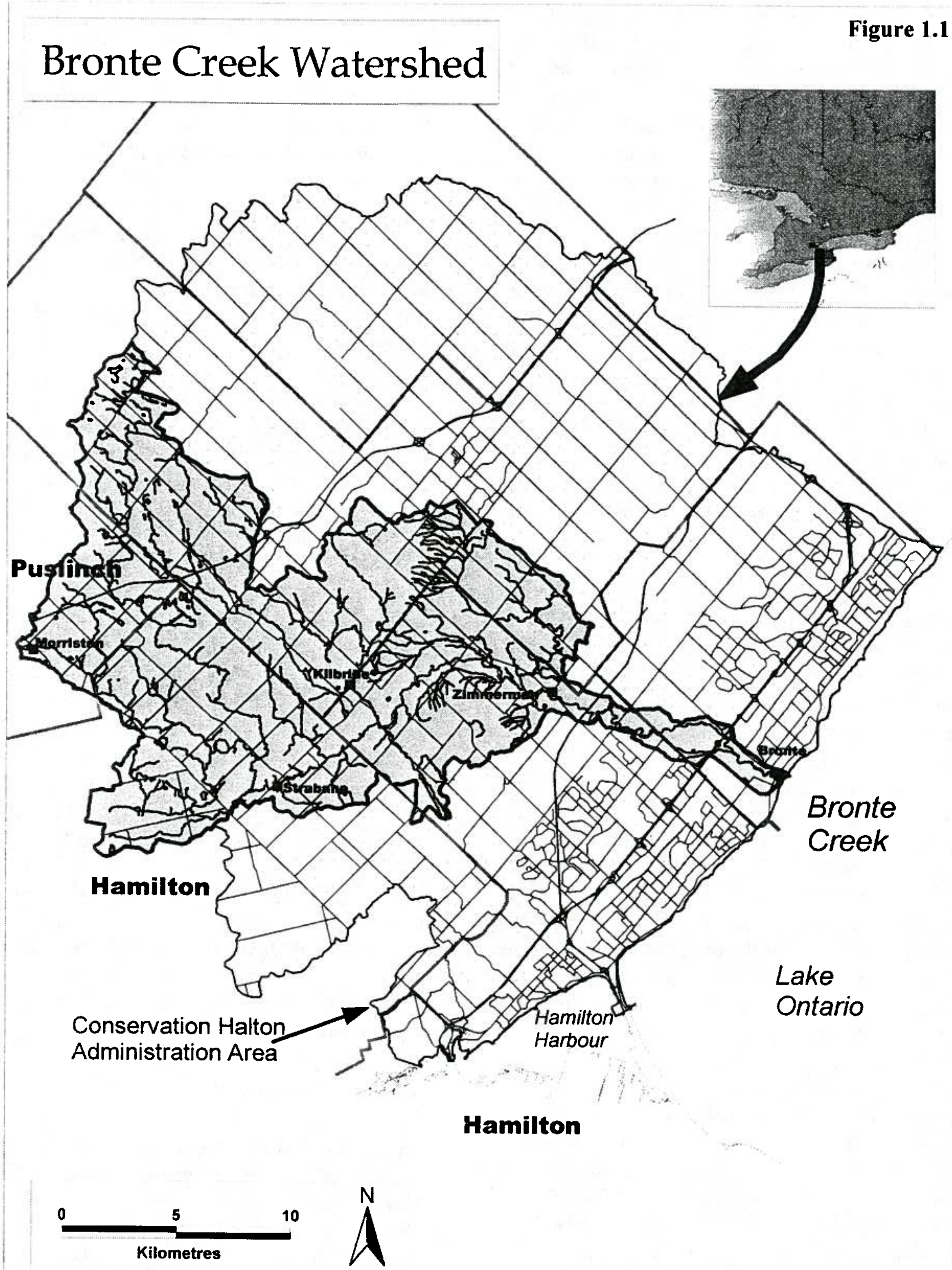
Appendix 3, Aquatic Habitat Inventory and Assessment, is one of five technical appendices which have been compiled in support of the Bronte Creek Watershed Study. This appendix provides a comprehensive description of existing aquatic habitat within the Bronte Creek watershed through an assessment of fish and benthic communities and associated water quality. The watercourses within the watershed are important since they act as the ultimate integrators of physiography and land use within the watershed. In recognition of this integration function, this appendix integrates other technical appendices produced as part of the Bronte Creek watershed study in an attempt to provide a holistic overview of aquatic resources and their relationship with physiography, natural heritage features, land use and anthropogenic management within the watershed.

The first section of the report provides a brief historical context of aquatic habitat and fisheries within the Bronte Creek watershed. This is followed by a summary of physiographic features and associated natural heritage features that provide a watershed context within which the aquatic resources are found. The next sections describe the study components that were used to provide indicators of aquatic health within the watershed. These indicators include benthic community sampling, instream temperature sampling and fish community sampling. The protocols, data assessment and findings associated with each component are presented and, where possible, compared with historical studies. The following section integrates the study components and provides a summary description of aquatic habitat and health for each subreach and tributary. The study concludes with recommended management strategies designed to maintain and enhance aquatic habitats within each subreach of the Bronte Creek watershed.

1.1 Previous Studies

Appendix 3 draws heavily on, and provides comparison to, three separate watershed-type studies that have previously been conducted within the Bronte Creek watershed. The first study, entitled *Twelve Mile Creek Conservation Report,* was completed in 1960 by the Department of Commerce and

Figure 1.1

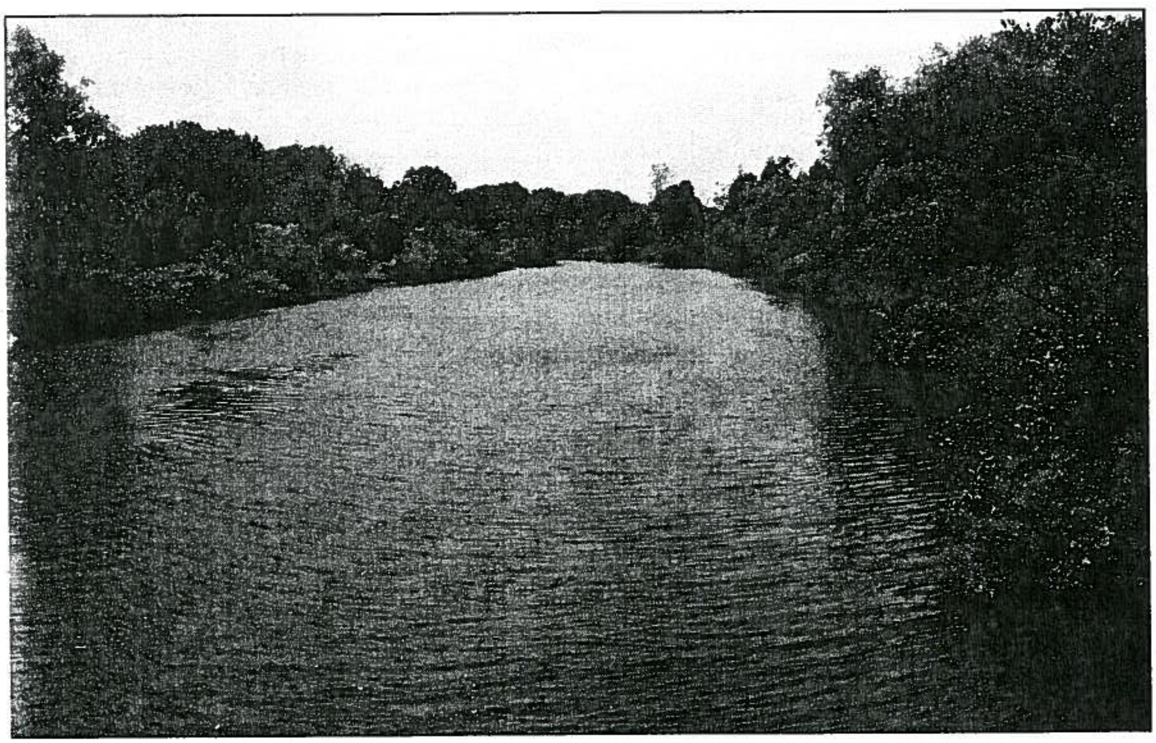

Bronte Creek Watershed
Puslinch
Morriston
Kilbride
Zimmerman
Strabane
Bronte
Bronte Creek
Hamilton
Lake Ontario
Conservation Halton Administration Area
Hamilton Harbour
Hamilton
0
5
10
Kilometres
N

Development. The Ministry of Natural Resources (C. Portt, author) published *An Assessment of the Bronte Creek Watershed* in 1981. Most recently, the Hamilton Naturalists' Club produced the *Hamilton-Wentworth Natural Areas Inventory* in 1993 and 1995. A brief summary of these keystone studies is provided.

The *Twelve Mile Creek Conservation Report* (TMCCR; Department of Commerce and Development, 1960) was prepared to appraise the conservation needs of the watershed and to outline the conservation measures that should be implemented. Survey work in support of the studies was grouped under five headings: land, forestry, water, wildlife and recreation. A history of the area provided a contextual perspective to conservation needs.

An Assessment of the Bronte Creek Watershed (ABCW; Portt, 1981) was prepared to provide an assessment of Bronte Creek and its tributaries and associated recommendations for the future management of the cold-water fisheries in the Bronte Creek watershed. Although focused on salmonid habitat and its future management, this report also defined important linkages between watershed physiography and fish habitat in Bronte Creek and its tributaries.

The *Hamilton-Wentworth Natural Areas Inventory* (HWNAI; Heagy, 1995) involved the inventory and evaluation of the biophysical attributes of 92 natural areas within the former Regional Municipality of Hamilton-Wentworth (now the City of Hamilton). Volume 1 of the study provided an overview of the physical, hydrological and biological features of Hamilton-Wentworth. Watershed summaries, including detailed water quality and fisheries information, were compiled for each watershed lying wholly or partly within the Region.



Bronte Creek at Centre Road, Carlisle

CHAPTER 2: *CULTURAL HISTORY*

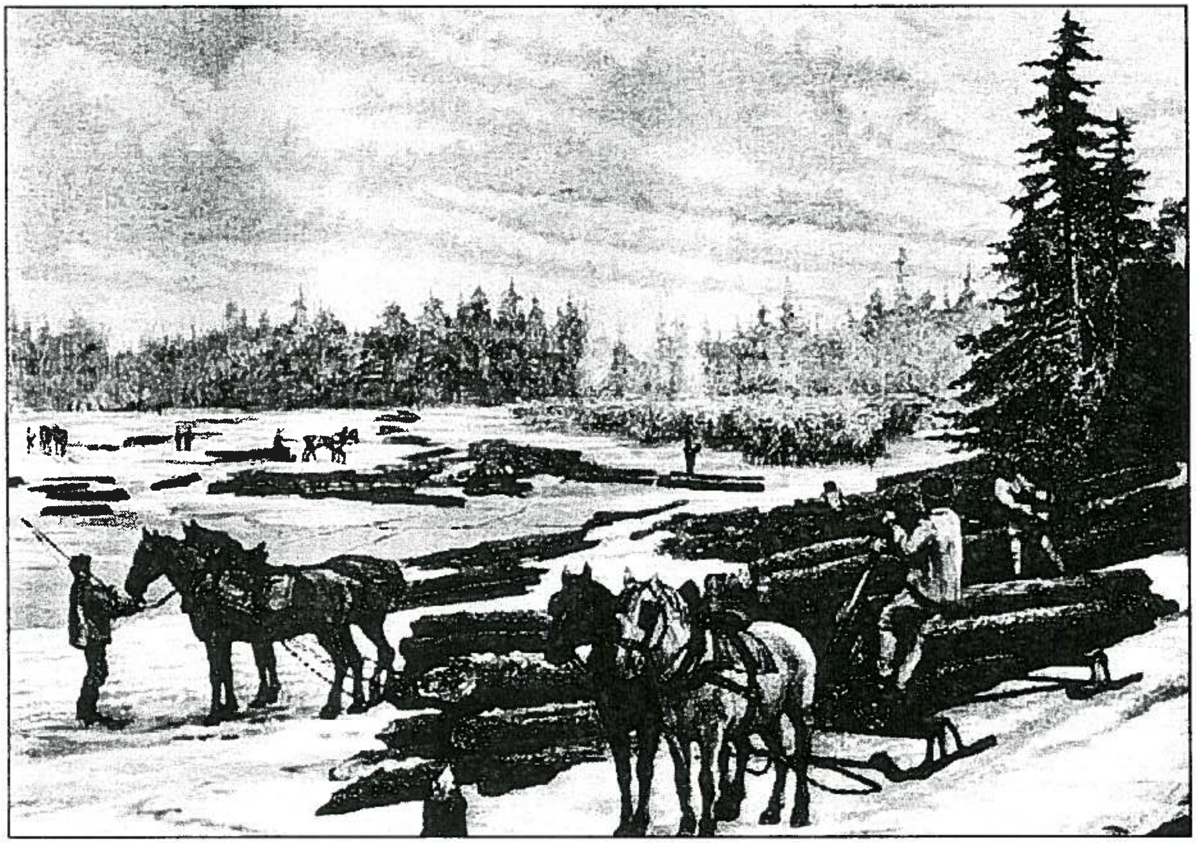
Prior to European settlement, the Bronte Creek watershed was inhabited by Iroquoian peoples of the Wendat and Attiwandaron confederacies. Both confederacies practiced slash and burn horticulture on a limited scale within the watershed, constructing small, palisaded villages which were abandoned when the fertility of the land and other natural resources were exhausted (Gale, 2001). In 1651, shortly after European contact, these confederacies were defeated by the Five-Nation Iroquois, also known as the Senecas. The Senecas maintained several hunting camps and temporary villages in the region until they were displaced by the Mississauga, a nomadic Algonquian tribe, in early 1700s (Gale, 2001). The Mississauga constructed two large encampments in the watershed near present-day Rebecca Street and the Queen Elizabeth Way. Until the end of the American War of Independence, European contact was largely limited to fur trapping and missionary work. Atlantic salmon and brook trout were plentiful within Bronte Creek and its tributaries while lake trout, whitefish and cisco were abundant at its confluence with Lake Ontario.

Following the end of the war, American colony "Loyalists" were persecuted and forced to abandon their homes, fleeing north into Canada. The British purchased property from the Mississauga to provide land for the Loyalists. To bolster Upper Canada against the Americans, the army constructed Dundas Street as a main military road which was completed through Burlington by 1800. Initially, settlement was slow; however, there was renewed interest in settlement following the War of 1812. Until this time, the fisheries resources of Bronte Creek were considered a mainstay for the Mississauga First Nation. In 1805, as part of a treaty which ceded First Nation lands to the Crown, the Mississauga reserved the sole right of the fisheries in the Twelve Mile Creek and the Sixteen Mile Creek (Dept. of Commerce and Development, 1960).

As the influx of settlers swelled in the early 1800s, forest clearing associated with agriculture grew as did the need for sawmills and grist mills. Nelson Township had three sawmills in 1817 and by 1850 this number had risen to 17. Four sawmills were constructed between Dundas Street and Lake Ontario. Some of these structures were very large. By 1827, William Crooks had constructed a sawmill/grist mill dam immediately north of Dundas Street which flooded Lot 3 and a portion of Lot 2 to a depth of 7 m (Langlands, 1972). These dams prevented fish species, such as Atlantic salmon, from reaching upstream spawning areas.

Forest clearing led to significant changes in the extent of forest cover within the watershed. Early clearing was carried out to create viable agricultural land. Timber that remained after the construction of cabins and barns was burned to produce potash. Commercial logging commenced in the late 1820s. Increasing population and expansion of local industries increased the domestic consumption of lumber. Cordwood was used for heating and cooking purposes, as well as house, barn and fence construction. Forests, which covered 85% of the watershed in 1800, declined to 50% coverage by 1880 and to less than 10% by 1900. This resulted in a significant change in the flow regime of Bronte Creek. More intense discharge was experienced during spring freshet and storms while reduced baseflow was evident during summer months. By 1850, the flows necessary for mill operation appeared to have been available only at certain times of the year.

The degradation of habitat associated with dam construction and deforestation, combined with overharvest, resulted in the decline of fisheries within Bronte Creek. Thousands of Atlantic salmon were caught by spearing and netting during spawning runs following the War of 1812. As early as 1820, loss of declining stocks of fish and game was noted as one of the factors forcing the Mississaugas to cede their hunting and fishing reserve at the mouth of Bronte Creek (Gale, 2001). The Atlantic salmon runs along the north shore of Lake Ontario were largely depleted by the 1840s (Langlands, 1972) and the species was extirpated from the Lake Ontario watershed by 1900.



Clearing the land

CHAPTER 3: *WATERCOURSE NOMENCLATURE*

There is considerable confusion pertaining to watercourse nomenclature within the Bronte Creek watershed. The Canada Gazeteer provides official names of geographical features such as watercourses; however, many of the Bronte Creek tributaries (Figure 3.1) are not listed in the gazetteer. Some tributaries have two or three names while others have none. This subsection attempts to standardize watercourse nomenclature which will be used throughout the remainder of the report.

Bronte Creek was officially referred to as Twelve Mile Creek (based on distance from the Burlington Beach lakehead) from 1796 until 1954 when the name was changed to avoid confusion with the Twelve Mile Creek in Port Dalhousie, Ontario (Conservation Halton, 2001; based on distance from the Niagara-on-the-Lake lakehead).

The Twelve Mile Creek Conservation Report (TMCCR) refers to all tributaries using alphabetical characters and avoids reference to any local names. The report "An Assessment of the Bronte Creek Watershed" (ABCW) provides better direction in this regard. For the purposes of this study, the tributaries are identified by the following names with following rationale and other common names in parentheses.

3.1 Reach and Subwatershed Descriptions

The main body of this report is divided into three sections that discuss instream temperatures, fish communities and benthic communities within Bronte Creek and its tributaries. The physical characteristics of the various subwatersheds within the Bronte Creek watershed and general descriptions of these watercourses, focusing on location, underlying physiography, adjacent natural features and land use are provided in Table 3.1.

3.1.1 Bronte Creek (Estuary)

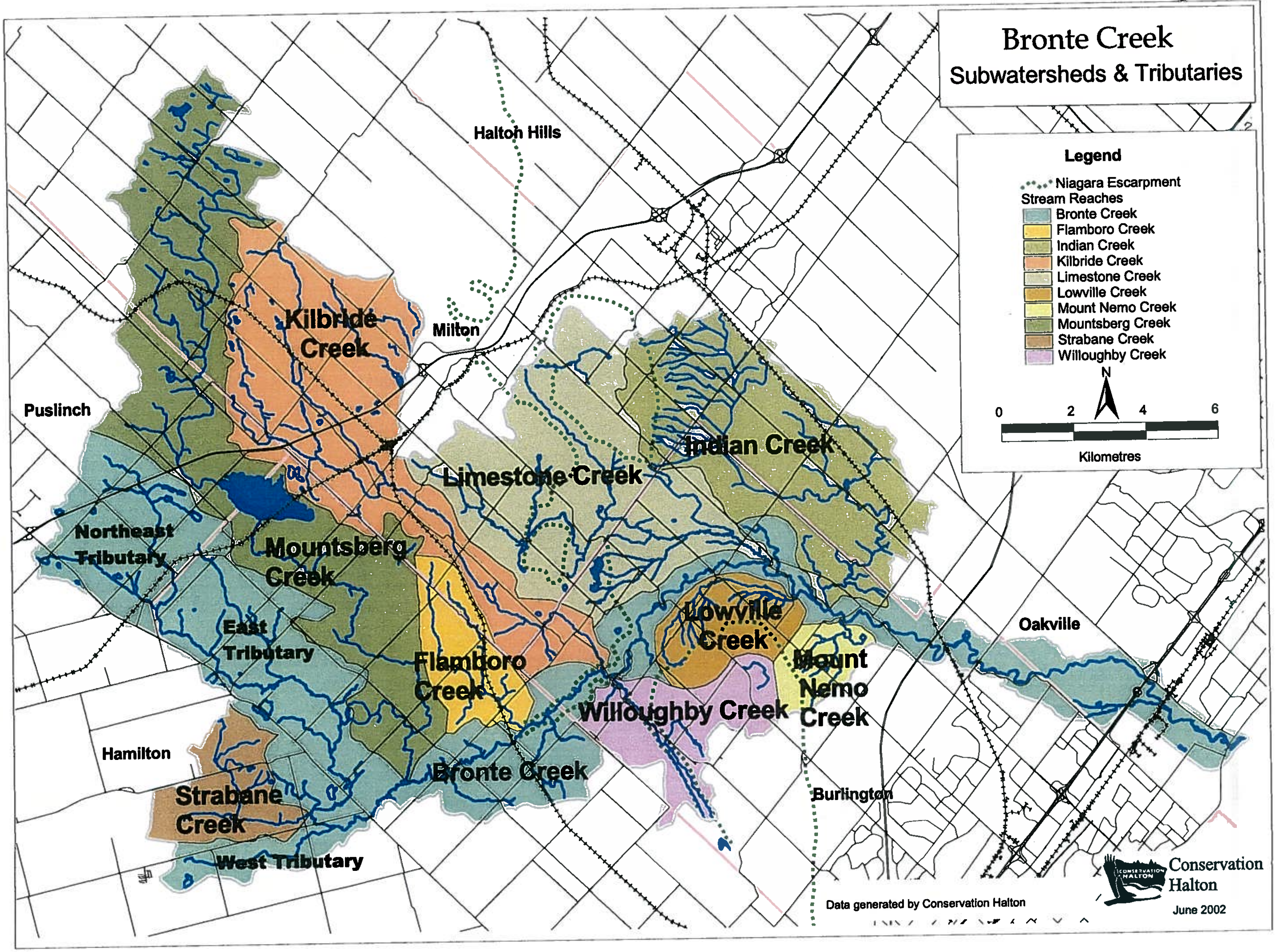
The estuarine area extends approximately from Rebecca Street downstream to Bronte Harbour. This low gradient reach, which meanders through urban Oakville, is strongly influenced by water levels in Lake Ontario. Downstream of Rebecca Street, the creek flows through the locally significant Bronte Marsh wetland prior to entering Bronte Harbour.

3.1.2 Bronte Creek (Estuary to Lowville)

This reach extends from Rebecca Street upstream to the Lowville Dam, which is the first barrier to fish passage upstream from Lake Ontario. Agriculture is the primary land use within this subwatershed downstream to Regional Road 5 (Dundas Street). With exception of Bronte Creek Provincial Park, urban and urbanizing lands are found from Regional Road 5 south to Rebecca Street. The park forms part of a provincially significant Area of Natural and Scientific Interest (ANSI)

Mount Nemo Creek	(new name; tributaries descend from Mount Nemo)
Indian Creek	(common name; referred to in ABCW)
Lowville Creek	(new name; flows along south side of Lowville village)
Limestone Creek	(common name; referred to in ABCW)
Willoughby Creek	(historical name (B. Christmas, pers.comm.); also known as Cedar Springs Creek, Kelly's Creek, Willow Brook)
Kilbride Creek	(common name; referred to in ABCW)
Flamboro Creek	(referred to in ABCW)
Mountsberg Creek	(common name; referred to in ABCW; also known as Badenoch Creek)
Strabane Creek	(common name; referred to in ABCW)

Figure 3.1



Bronte Creek
Subwatersheds & Tributaries
Legend
Niagara Escarpment
Stream Reaches
Bronte Creek
Flamboro Creek
Indian Creek
Kilbride Creek
Limestone Creek
Lowville Creek
Mount Nemo Creek
Mountsberg Creek
Strabane Creek
Willoughby Creek
N
0
2
4
6
Kilometres
Halton Hills
Milton
Puslinch
Kilbride Creek
Limestone Creek
Indian Creek
Northeast Tributary
Mountsberg Creek
East Tributary
Flamboro Creek
Lowville Creek
Mount Nemo Creek
Willoughby Creek
Oakville
Hamilton
Strabane Creek
Bronte Creek
Burlington
West Tributary
Data generated by Conservation Halton
Conservation Halton
June 2002

Table 3.1. Physical Characteristics of Subwatersheds within the Bronte Creek Watershed (modified from Portt, 1981).

Subwatershed	Watershed Area (km^2)	Forest Cover (%)	Average Gradient (%)
Main Bronte Creek			
Lower Bronte (Estuary to Lowville)	18.3	29	0.5
Middle Bronte (Lowville to Progreston)	13.7		1.0
Upper Bronte (Progreston to Headwaters)	52.0	25	0.3
Tributaries			
Mount Nemo Creek	6.4	30	2.3
Indian Creek	39.9	8	0.3
Lowville Creek	7.0	26	1.2
Limestone Creek	34.1	39	1.0
Willoughby Creek	12.1	25	1.3
Kilbride Creek	34.6	42	0.5
Flamboro Creek	8.7	48	0.5
Mountsberg Creek	46.7	33	0.3
Strabane Creek	11.1	34	0.4

and an Environmentally Sensitive Area (ESA). Several major tributaries enter the upstream portion of this reach: Limestone Creek, Lowville Creek, Indian Creek and Mount Nemo Creek. Downstream, the Trafalgar Moraine represents a drainage barrier and as a result, the watershed is constricted downstream to Lake Ontario.

3.1.3 Bronte Creek (Lowville to Progreston)

This reach extends from the Progreston Dam downstream to the Lowville Dam, flowing through a deep outwash valley which bisects the Niagara Escarpment. Land use is primarily agricultural/rural outside of the valley feature. The Cedar Springs Community is found within the valley itself, east of Cedar Springs Road. The valley system forms an extensive ESA/ANSI feature. Groundwater discharge is prevalent along valley walls and in Bronte Creek itself. Lowville Dam, Dakota Mills Dam and Progreston Dam are three significant barriers to fish passage in this reach. The Flamboro Creek, Kilbride Creek and Willoughby Creek tributaries enter the main branch through this reach.

3.1.4 Bronte Creek (Progreston to Headwaters)

The headwaters of Bronte Creek arise on the Flamborough Plain in the vicinity of Morriston. Outliers of the provincially significant Beverly Swamp Complex and several ESA's are found in this area. Significant groundwater discharge enters Bronte Creek east of Highway 6 at Maddaugh Road. Downstream of Highway 6, the watercourse flows through the Norfolk Sand Plain which also supports groundwater discharge. With the exception of Morriston and Carlisle, rural and agricultural land uses are predominant within the subwatershed. Mountsberg Creek and Strabane Creek enter Bronte Creek within this reach.

3.1.5 Mount Nemo Creek

The headwaters of Mount Nemo Creek emanate from the Escarpment slopes along the eastern edge of Mount Nemo (ESA/ANSI). Its tributaries flow through agricultural lands downstream of Walkers Line before coalescing and entering a large forested feature associated with the Bronte Creek Valley ESA to the south of No. 2 Sideroad.

3.1.6 Indian Creek

The headwaters of much of this subwatershed emanate from the slopes of the Niagara Escarpment (Crawford Lake/Rattlesnake Point Escarpment Woods ESA). The tributaries rapidly descend the Escarpment slopes to the Peel Plain south of Derry Road. The soils below the Escarpment are well-suited for agriculture. As a result, vegetation cover within the subwatershed is sparse and fields extend to the stream banks. Indian Creek discharges to Bronte Creek within the Sidrabene property located north of No. 2 Sideroad and west of Appleby Line.

3.1.7 Lowville Creek

The headwaters of Lowville Creek emanate from the Escarpment slopes along the northern edge of Mount Nemo (ESA/ANSI). Its tributaries flow through an area of rural/agricultural land use, coalescing upstream (west) of Walkers Line. Forest cover dissipates downstream of Walkers Line as the watercourse enters the Peel Plain. Lowville Creek discharges to Bronte Creek immediately downstream of No. 4 Sideroad.

3.1.8 Limestone Creek

The west branch of Limestone Creek arises within the Guelph Junction ESA on the Flamborough Plain south of No. 3 Sideroad. Downstream, this branch enters a glacial outwash valley associated with the Calcium Pits ESA/ANSI/Wetland Complex. The stream then descends over the Niagara Escarpment at Guelph Line, joining the east branch upstream of Derry Road. The west branch is characterized by significant forest cover and groundwater discharge with some adjacent agricultural activity.

The east branch arises within the Flamborough Plain feature associated with the Milton Heights outlier. Downstream, this branch enters a glacial outwash valley and provincially significant wetland associated with the Nassagaweya Canyon and the Crawford Lake/Rattlesnake Point Escarpment Woods ESA/ANSI. The stream joins the west branch upstream of Derry Road.

Significant groundwater discharge occurs in the area below the confluence to Derry Road (Holysh, 1995). Downstream of Derry Road, Limestone Creek bisects several agricultural properties and the Crosswinds Golf and Country Club within the Peel Plain. The watercourse discharges to Bronte Creek upstream of No. 4 Sideroad.

3.1.9 Willoughby Creek

The west branch emanates from the provincially significant Medad Valley wetland/ESA. Groundwater discharge and significant forest cover characterize the headwater area downstream to Colling Road. The east branch formerly originated on the lands currently owned and licensed by Nelson Aggregates. Existing flows are maintained by quarry pumping operations which discharges at Colling Road, immediately north of the Burlington Springs Golf and Country Club.

Downstream of the branches' confluence, Willoughby Creek flows north along Cedar Springs Road. Rural strip development extends downstream to a point approximately 500 m south of Britannia Road where Willoughby Creek enters a well-forested valley system (Lowville/Bronte Creek Escarpment ESA) which extends downstream to the Cedar Springs Community. A large dam structure is located on Willoughby Creek approximately 100 m upstream of its confluence with Bronte Creek.

3.1.10 Kilbride Creek

Kilbride Creek arises north of No. 10 Sideroad within the provincially significant Guelph Junction Wetland Complex which overlies the Flamborough Plain. Groundwater discharge

Willoughby Creek

from aquifers associated with the Moffat Moraine enters the watercourse in the vicinity of Highway 401. Kilbride Creek continues south through forests associated with the Guelph Junction Woods ESA, flowing over the Escarpment downstream of Kilbride at which point it enters the Bronte Creek Valley ESA/ANSI. With the exception of Kilbride, land use within the subwatershed is dominated by rural and agricultural activities. The waterfall located upstream (east) of Cedar Springs Road, associated with the Escarpment edge, is a natural barrier to fish passage. Kilbride Creek enters Bronte Creek immediately upstream of the Dakota Mills Dam.

3.1.11 Flamboro Creek

Flamboro Creek emanates from the locally significant Carlisle North Wetland Complex/ESA (Flamborough Plain). The watercourse enters a large on-line pond immediately upstream of Carlisle Road (Carlisle Golf and Country Club). Significant groundwater discharge occurs downstream of Carlisle Road where the Norfolk Sand Plain contacts the Bronte Creek outwash valley feature (ESA/ANSI). Several springs discharge into Flamboro Creek as it enters the well-defined valley prior to its confluence with Bronte Creek downstream of Progreston.

3.1.12 Mountsberg Creek

The headwaters of Mountsberg Creek arise within the provincially significant Badenoch-Moffat Swamp Complex/ESA on the Flamborough Plain. With the exception of the hamlet of Moffat, the subwatershed is dominated by rural and agricultural land use. The main branch flows westward from Guelph Line through Moffat. Five tributaries associated with Galt Moraine enter Mountsberg Creek between Town Line and Watson Road. Significant springs appear to be associated with these tributaries.

Mountsberg Creek enters the Mountsberg Reservoir (206.4 ha) downstream of Leslie Road. This wetland is considered provincially significant and has been designated as an ESA and ANSI. Downstream of the reservoir, the watercourse flows through the provincially significant Mountsberg East Wetlands complex/ESA. A large on-line pond is located near the Lawson Trailer Park downstream of 11^{th} Concession.

Downstream of Centre Road, the watercourse discharges to Bronte Creek through Courtcliffe Park.

3.1.13 Strabane Creek

The headwaters of Strabane Creek arise within the provincially significant Beverly Swamp Complex on the Flamborough Plain. With the exception of the hamlet of Strabane, land use within the subwatershed is characterized as rural/agricultural. Strabane Creek discharges to Bronte Creek downstream (east) of Brock Road.

CHAPTER 4: *PHYSIOGRAPHIC CONTEXT*

Local and regional physiography determines the physical extent of the Bronte Creek watershed and is intricately linked to its hydrology and hydrogeology. Physiography (Figure 4.1) is also the driving force which has dictated vegetation and land use patterns throughout the watershed. Poorly drained, rugged and rocky features within the watershed are not viable agricultural lands. As a result, forest cover and wetlands are often dominant features in these areas (Figures 4.2 and 4.3). Agricultural land uses generally predominate in areas characterized by gentle slopes and deep, well-drained soils.

The underlying bedrock within the watershed consists of three geological formations. The oldest unit is the Queenston formation, consisting of red shale, which forms the uppermost bedrock unit from Lake Ontario to the Niagara Escarpment and underlies the other formations. A thin sequence of sandstone, dolostone and shale units, known as the Cataract Group, overlies the Queenston shale and is exposed on the Escarpment slopes between the Queenston and Amabel formations. The Amabel formation consists of erosion resistant dolostone which overlies the other formations and extends from the Escarpment edge to the upstream boundary of the watershed. These formations were formed in an ocean environment approximately 400 to 500 million years ago.

The physiography of the watershed has also been prominently shaped by the Wisconsin Glaciation, that began to recede from southern Ontario 14, 000 years ago. Repeated advances and retreats of the glaciers resulted in the deposition of sediments over the bedrock. Sediments were either plastered over the bedrock as till or formed outwash deposits where meltwaters moved along the terminus of the glacier. The physiographic regions within the Bronte Creek watershed are described below.

4.1 Galt and Moffat Moraines

The Galt and Moffat moraines form part of a series of northeast-southwest trending bands of hummocky terrain which comprise the "Horseshoe Moraines" (Gartner Lee, 1986). Sand and gravel outwash deposits associated with the Galt Moraine overlie the relatively flat dolostone of the Flamborough Plain along the northern boundary of the Bronte Creek watershed. Although small in aerial extent within the watershed, these kame deposits form significant groundwater recharge/discharge areas which feed the headwaters of upper Bronte Creek, Mountsberg Creek and Kilbride Creek (Moffat Moraine). The kame deposits associated with the Galt Moraine north of Calfass Road between Town Line and Watson Road provide particularly strong areas of groundwater discharge and form the headwaters of significant coldwater tributaries of Mountsberg Creek.

4.2 Flamborough Plain

The Flamborough Plain, which tilts southward within the Bronte Creek watershed, consists of an uneven limestone plain above the Niagara Escarpment. This physiographic region is the dominant feature in the upper portion of the watershed and covers almost half of the watershed. The plain is generally overlain by shallow Wentworth Till (bouldery till, sand and gravel). Drumlin fields, outliers of the Guelph Drumlin field physiographic region, are found in the vicinity of Mountsberg, Freelton and Haltonville. Shallow, permeable soils combined with bedrock fractures and the presence of extensive wetland systems provide a significant groundwater recharge/discharge function within the watershed.

The Flamborough Plain is relatively uncultivated due to its predominantly shallow, stony and poorly-drained soils.

Figure 4.1

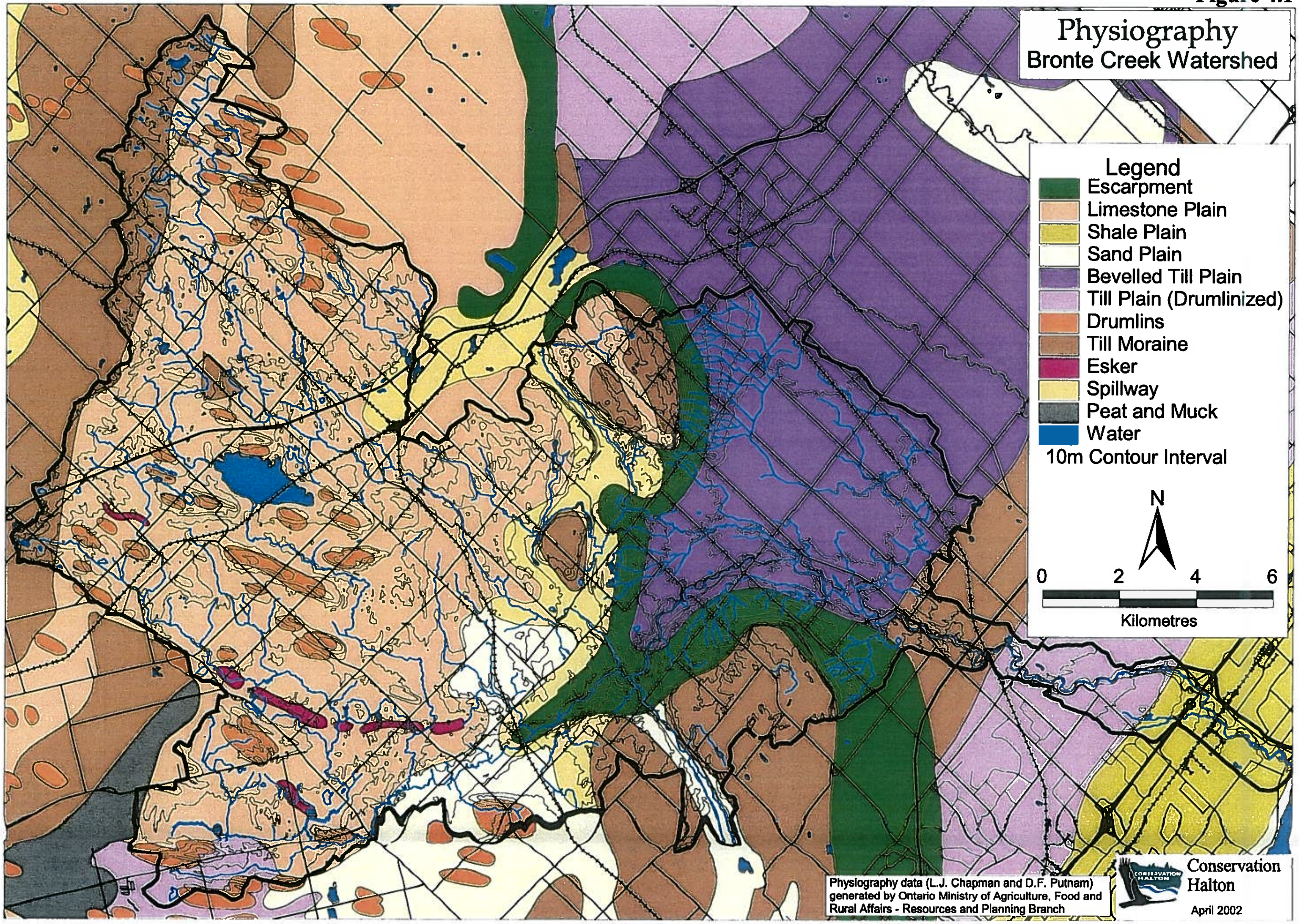

Physiography
Bronte Creek Watershed
Legend
Escarpment
Limestone Plain
Shale Plain
Sand Plain
Bevelled Till Plain
Till Plain (Drumlinized)
Drumlins
Till Moraine
Esker
Spillway
Peat and Muck
Water
10m Contour Interval
N
0
2
4
6
Kilometres
Physiography data (L.J. Chapman and D.F. Putnam) generated by Ontario Ministry of Agriculture, Food and Rural Affairs - Resources and Planning Branch
Conservation Halton
April 2002

Figure 4.2

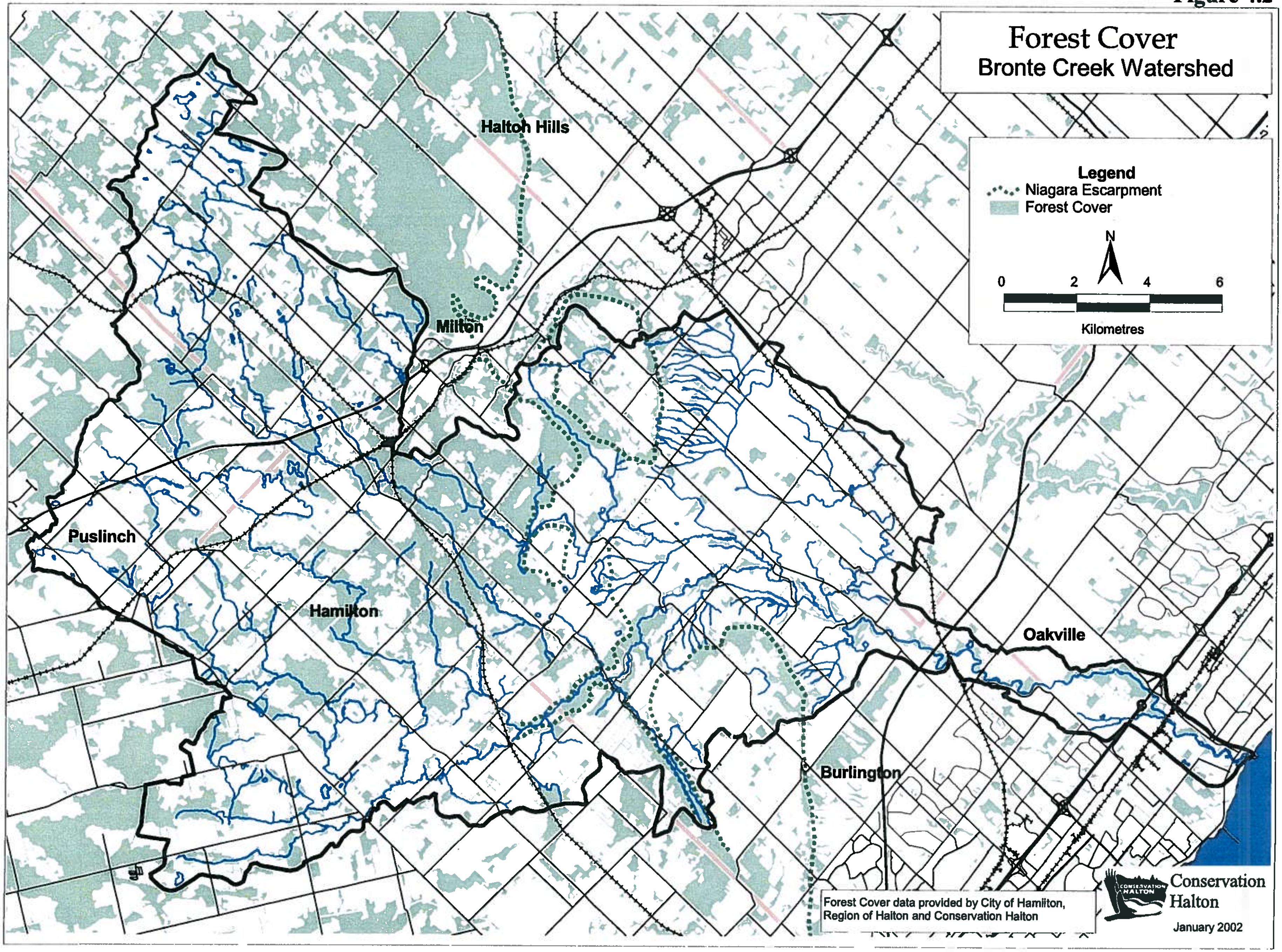
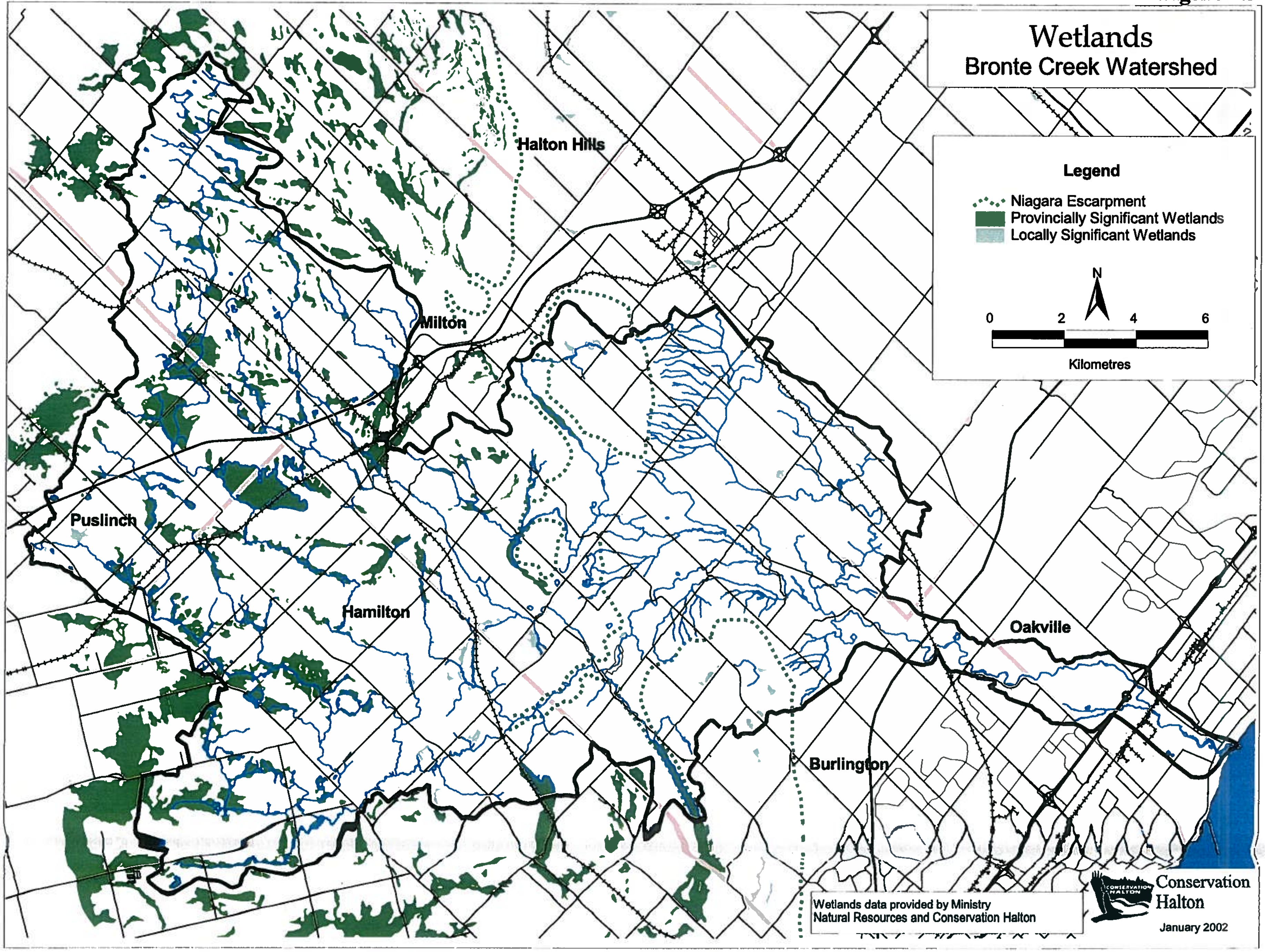

Forest Cover
Bronte Creek Watershed
Legend
Niagara Escarpment
Forest Cover
N
0
2
4
6
Kilometres
Halton Hills
Milton
Puslinch
Hamilton
Oakville
Burlington
Forest Cover data provided by City of Hamilton, Region of Halton and Conservation Halton
Conservation Halton
January 2002

Figure 4.3



Wetlands
Bronte Creek Watershed
Legend
Niagara Escarpment
Provincially Significant Wetlands
Locally Significant Wetlands
N
0
2
4
6
Kilometres
Halton Hills
Milton
Puslinch
Hamilton
Oakville
Burlington
Wetlands data provided by Ministry
Natural Resources and Conservation Halton
Conservation Halton
January 2002

Extensive forest cover is associated with Beverly Swamp, the Guelph Junction Wetland Complex, Badenoch-Moffat Swamp Complex, Mountsberg East Complex, North Progreston Marsh and contiguous upland areas. The headwaters of Flamboro Creek, Strabane Creek and Limestone Creek originate within the Flamborough Plain. These watercourses are generally characterized as low to moderate gradient streams with slopes less than 0.5% (Portt, 1981).

4.3 Norfolk Sand Plain

Bronte Creek passes through the Norfolk Sand Plain from Highway 6 downstream through Carlisle. Overlying the Flamborough Plain, the sands and silts of this feature originated as deltaic deposits in glacial Lake Whittlesey and Lake Warren (Heagy, 1993). Light soils and excellent drainage have resulted in extensive cultivation on this feature. Although a minor feature within the watershed, the well-drained, coarse soils of the Norfolk Sand Plain promote infiltration and groundwater recharge which contributes to coldwater habitat in Bronte Creek and Flamboro Creek. Watercourses within this feature generally exhibit a low gradient with slopes less than 0.5% (Portt, 1981).

4.4 Waterdown Moraine

The Waterdown Moraine consists of ridges of stoney till which were deposited at the edge of glacial Lake Warren by the Ontario ice lobe. Overlying the Flamborough Plain to the south of Mount Nemo and west of Medad Valley, the Waterdown Moraine is a headwater source for the eastern branch of Willoughby Creek and Mount Nemo Creek.

4.5 Niagara Escarpment and Spillways

The Niagara Escarpment is the most prominent physical feature within the Bronte Creek watershed. Formed by the differential erosion of the softer Queenston shale bedrock and the hard Amabel dolostone formation, the Escarpment bisects the watershed from north to south. The steep, rugged terrain of the Niagara Escarpment and its associated spillways is generally unsuited for agriculture or other development. Large tracts of provincially and regionally significant forest cover and wetlands are the dominant features within this physiographic region. Groundwater discharge emanating from the Escarpment slopes provides the headwater source for Indian Creek, Mount Nemo Creek and Lowville Creek.

The Nassagaweya Canyon and the Progreston-Lowville Valley contain deep sand and gravel deposits associated with deposition along glacial spillways. Groundwater discharge from these highly permeable aquifer systems feeds Bronte Creek, the downstream reaches of Willoughby Creek, Flamboro Creek and Kilbride Creek and the mid-reaches of Limestone Creek. The Medad Valley, which drains to both Grindstone Creek and Willoughby Creek, was likely formed as a result of local weathering associated with creek flow through a significant fracture in the Escarpment bedrock (Holysh, 1995). Watercourses along the Escarpment face and within the spillways are characterized by moderate to high gradients with slopes often in excess of 1.0% (Portt, 1981).

4.6 Peel Plain

A glacial lake that formed between the Trafalgar Moraine and an ice front to the north formed the Peel Plain. It consists of a large tract of clayey/silty soils that supports intensive agricultural activity. The characteristic fine-textured soils and extensive clearing of vegetation over this feature limit groundwater recharge. Groundwater discharge is generally insignificant. Much of Indian Creek and Bronte Creek (Lowville downstream to No. 2 Sideroad) as well as the downstream reaches of Lowville Creek and Limestone Creek flow through this feature. These watercourses are characterized by low to moderate gradients with slopes ranging from 0.3% to 0.5% (Portt, 1981).

4.7 Trafalgar Moraine

The Trafalgar Moraine consists of clay till with boulders and large quantities of Queenston shale. The moderately rugged terrain contrasts with the relatively flat Peel Plain to the north and the South Slope plain to the south. This bouldery till serves as a local recharge zone (Holysh, 1995) with groundwater moving downward through the moraine and emerging along its base. The rocky soils and hummocky topography have limited agricultural development along the moraine. As a result, the Trafalgar Moraine supports significant forest cover relative to other physiographic regions downslope of the Escarpment within the watershed.

The moraine acts as a drainage divide. Tributaries to the north flow to Bronte Creek which bisects the moraine at Zimmerman. To the south, a number of small streams originate along the base of the Trafalgar Moraine, discharging to Lake Ontario through Burlington and Oakville. As a result, the Bronte Creek watershed is constricted through, and downstream of, this feature which marks the downstream limit of major tributaries within the watershed.

4.8 South Slope

Within the Bronte Creek watershed, the South Slope physiographic region lies between the Trafalgar Moraine and the Lake Iroquois Plain. Topographic relief is generally low with soils dominated by clayey/silty Halton Till. The characteristic fine-textured soils and extensive clearing of vegetation over this feature limit groundwater recharge. Groundwater discharge is generally insignificant. The main branch of Bronte Creek (Highway 407 downstream to QEW) flows through this region.

4.9 Iroquois Plain

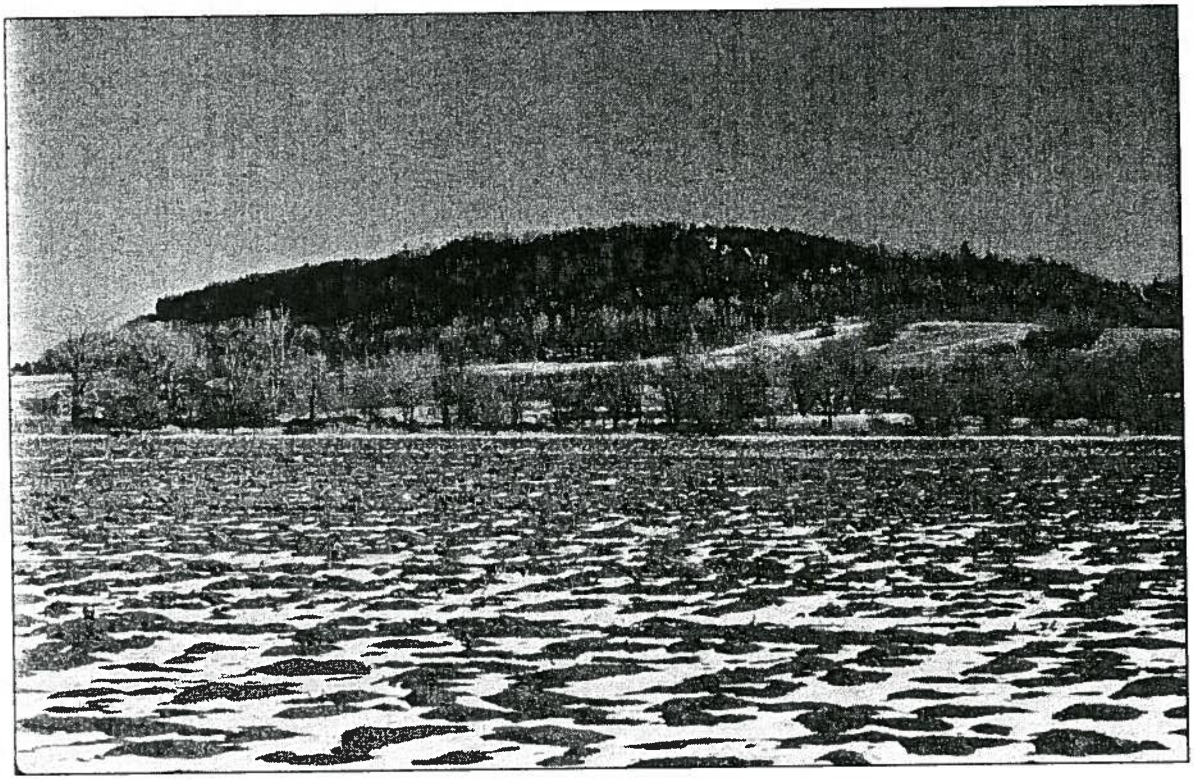
The Iroquois Plain was formed as a feature of the postglacial shoreline of Lake Ontario when water levels were significantly higher than present. This physiographic region consists of two subcomponents within the Bronte Creek watershed: a shale plain which extends from QEW downstream to Highway 2 and a narrow sand plain (barrier beach) which lies between Highway 2 to Lake Ontario. Agricultural land use dominated this feature in the past; however, much of this area has been converted to urban land use. Bronte Creek flows through this feature, displaying a low to moderate gradient.

4.10 Summary

Physiography within the watershed has a significant influence on hydrology, hydrogeology, land use and forest cover at a subwatershed level. A comparison of the Limestone Creek (34.1 ha) and Indian Creek (39.9 ha) subwatersheds illustrates the influences of differing physiography within two similar-sized catchments.

Limestone Creek originates within the Flamborough Plain and glacial outwash features along the Escarpment west of Rattlesnake Point. The rocky upland/slope features and poorly drained lowland areas have deterred agricultural activities throughout the upper portion of the watershed allowing the development of large tracts of forest cover. Significant groundwater recharge/discharge through the permeable overburden provides a relatively constant supply of coolwater to the watercourse. Vegetation on the landscape contributes to this system by moderating runoff during meltwater and storm events, providing infiltration pathways through root systems and by direct shading of the watercourse (minimizing heating during the summer months). Limestone Creek provides a constant source of baseflow with coolwater influences extending downstream through the Peel Plain to its confluence with Bronte Creek.

In contrast, most of the drainage area of Indian Creek lies within the Peel Plain. This relatively flat feature is characterized by deep, fertile soils and, as a result, has been largely cleared of vegetation to support agricultural activities. The fine-grained soils associated with the Peel Plain are relatively impermeable and groundwater discharge is negligible. Impermeable soils combined with a general lack of vegetation result in a very "flashy" runoff regime whereby intense peaks of storm runoff are followed by periods of low to intermittent baseflow.



Mount Nemo

CHAPTER 5: *FISH COMMUNITY STUDY*

5.1 Historical Sampling

Four watershed-wide fish community studies have been undertaken on Bronte Creek. The first study was undertaken in 1958 as a component of the TMCCR. The Department of Lands and Forests (now OMNR) conducted fish community surveys in the watershed in 1972 and 1974, respectively (Collins *et al.*, 1972; Cluet, 1974). The ABCW included sparse sampling in 1980 throughout the upper portion of the watershed. Most recently, fish community sampling occurred within the Hamilton-Wentworth portion of the watershed in 1991 as a component of the HWNAI. A brief summary of these studies is provided below.

Twelve Mile Creek Conservation Report, TMCCR (Dept. of Commerce and Development, 1960)

Fifty-four aquatic habitat stations were surveyed in 1958 as part of the TMCCR. Unfortunately, the total number and locations of stations sampled for fish is not known. A total of 27 species of fish were collected. Creek chub were the most common fish sampled and were present at 30 stations. Brook trout were the most common salmonid and were present at 16 stations. Brown trout were sampled in the main branch of Bronte Creek between Cedar Springs Road and Carlisle Road. Rainbow trout, now common in the watershed, were not sampled. With the exception of smallmouth bass and rock bass, both of which were sampled in Bronte Creek and its tributaries downstream of Lowville, no centrarchids (bass and sunfish) or esocids (i.e. northern pike) were sampled. Redside dace were relatively common and were sampled at 17 stations.

1972/1974 Department of Lands and Forests Studies (Collins et al., 1972; Cluet, 1974)

Twenty-six fish community stations were sampled in 1972 and 1974 by the Department of Lands and Forests. These stations provided a good coverage of the entire watershed from the estuary upstream to the headwaters. A total of 29 species of fish were collected. Creek chub and blacknose dace were the most common fish species sampled and were present at 19 and 18 stations, respectively. Brook trout were the most common salmonid and were present at 5 stations. Brown trout and rainbow trout were sampled in Limestone Creek. Centrarchids (pumpkinseed) were sampled for the first time in the upper portions of the watershed including Mountsberg Creek downstream of the Mountsberg Reservoir (constructed in 1967) and Strabane Creek. Redside dace were present at 6 stations.

An Assessment of the Bronte Creek Watershed with Recommendations for Salmonid Management, ABCW (Portt, 1981)

Nine stations were surveyed in 1980 as part of the 1981 OMNR study. These stations were confined to reaches known to support salmonids; however, the study did assess fisheries potential throughout the remainder of the watershed based on direct observation of fish habitat and correlation with physiographic features.

Hamilton-Wentworth Natural Areas Inventory, HWNAI (Heagy, 1993,1995)

Seven stations were surveyed in 1991 as part of the Natural Areas Inventory study. All stations were located within the Regional Municipality of Hamilton-Wentworth (now the City of Hamilton). Sampling was restricted to Bronte Creek (four stations) and Mountsberg Creek (two stations) upstream of Carlisle, with the exception of one station located downstream of Progreston. Twenty-two species of fish were sampled as part of this survey. White sucker were present at 5 of the 7 stations. No salmonids were sampled. Rock bass, pumpkinseed, bluegill and largemouth bass were sampled upstream of

Carlisle. Redside dace were present at 2 stations.

5.2 Fish Community Sampling Protocol

A watershed-scale assessment of fish communities has not been undertaken within the Bronte Creek watershed since 1981. Comprehensive fish community surveys have not been carried out since the 1972/1974 study. Since 1981, fish community sampling has been focused on specific reach studies associated with activities such as:

- monitoring of environmental impacts (i.e. Limestone Creek)
- salmonid productivity (Lake Ontario Fisheries Unit)
- lamprey assessment program (Department of Fisheries and Oceans)
- brown trout spawning surveys (Izaak Walton Fly Fisher's Club)
- OMNR fish community and spawning surveys
- ROM studies (silver shiner)
- HWNAI study (limited to Hamilton-Wentworth)

To address the need for additional fish community sampling to provide comprehensive watershed coverage, fish community sampling was carried out in support of the Bronte Creek Watershed Study in 1998, 1999, 2000 and 2001.

The sampling effort was generally directed toward the upper portions of the watershed in areas where inventories are incomplete or are more than 10 years old. Sampling was avoided in reaches were recent work has been completed (i.e. Limestone Creek at Derry Road, Bronte Creek at the Cedar Springs Community, lower Bronte Creek). Many stations were paired with benthic stations to allow for community comparisons.
Fish community sampling consisted of electrofishing using a backpack electrofisher and one or two netters. At each station, sampling progressed upstream in a systematic manner with an objective of sampling the full range of habitats available within a particular stream reach. Depending on stream size and habitat heterogeneity, the sampled reach varied from 50 m to over 300 m in length.

Electrofishing

The sampling program carried out on Bronte Creek and its tributaries was moderate in intensity. The program was not intended to provide quantitative fish community analyses or to define the ultimate extent of fish habitat within the watershed.

The purpose of the monitoring program was to qualitatively assess changes in fish community composition from the headwaters of watercourses to their confluence with the main branch of Bronte Creek and to assess changes in fish community over time. It should be noted that comparison of data from different surveys may be limited by differences in survey effort, methodology and timing of sampling.

Fish community sampling was conducted at 49 stations within the main branch and tributaries of Bronte Creek as part of the watershed study (Figure 5.1). Sampling results are provided in Appendix 2. Table 5.1 shows the distribution of sampling sites by subreach and tributary.

A Ministry of Natural Resources Field Collection Record form was completed for each station. Relevant data recorded on these forms include site location, station diagram, sample time, sample date, species captured (numbers and approximate sizes), substrate, cover and water and air temperature.

The following subsections attempt to describe the fish community and functions associated with the various reaches of Bronte Creek and its tributaries. Within each reach, the existing fish community is described and compared to past records (where available).

Table 5.1. Distribution of Fish Community Sampling Stations by Subreach and Tributary.

Tributary/Subreach	Stations
Bronte Creek: (Estuary to Lowville)	0
Bronte Creek: (Lowville to Progreston)	1
Bronte Creek: (Progreston to Headwaters)	7
Mount Nemo Creek	1
Indian Creek	3
Lowville Creek	6
Limestone Creek	3
Willoughby Creek	1
Kilbride Creek	3
Flamboro Creek	7
Mountsberg Creek	15
Strabane Creek	2

5.3 Subreach and Tributary Descriptions

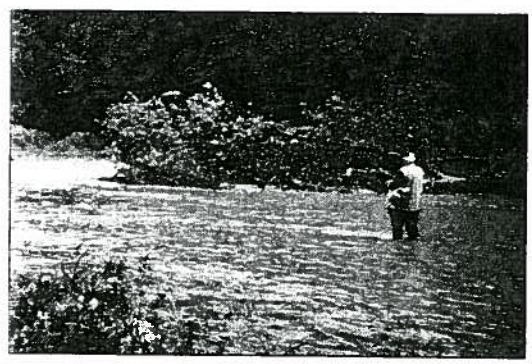
5.3.1 Bronte Creek (Estuary)

The fish community in this section of Bronte Creek reflects its close association with Lake Ontario. This reach acts as a significant staging area for salmonids (i.e. rainbow trout, brown trout and chinook salmon) which tend to hold in the deeper mid-channel areas before moving upstream in response to changes in stream temperatures and increased stream flows. Although studies have not been conducted to date, it is likely that the estuary provides suitable spawning habitat for lake-oriented species such as gizzard shad, alewife, carp, brown bullhead, logperch and northern pike. Smallmouth bass may overwinter in the deep, slow moving pools through this reach.

5.3.2 Bronte Creek (Estuary to Lowville)

This section of Bronte Creek supports a diverse array of resident warmwater fish species and provides a migratory corridor/spawning area for Lake Ontario salmonids. Lowville Dam (Figure 5.2) is the first barrier to fish passage on Bronte Creek upstream from Lake Ontario.

Large runs of rainbow trout occur from early to mid-spring while chinook salmon and brown trout migrate upstream through the fall. False runs of rainbow trout (adult fish that move upstream during the fall but which do not spawn until late winter/early spring) may also move upstream in the fall with fish dropping back to the lake or deeper pools to hold until the spring spawning season. Low water levels during the fall months can restrict much of the fall spawning runs to the lower portion of this reach (i.e. downstream of Regional Road 5).



Angling in Bronte Creek

Young-of-the-year rainbow trout have been observed through this section; however, the extent of production is not known. It is likely that high instream temperatures during the summer months limit nursery and juvenile habitat, particularly downstream of Britannia Road.

Following the rainbow trout and white sucker spawning runs, smallmouth bass move upstream to spawn in late spring. Smallmouth bass are present in the deeper pools in this

Figure 5.1

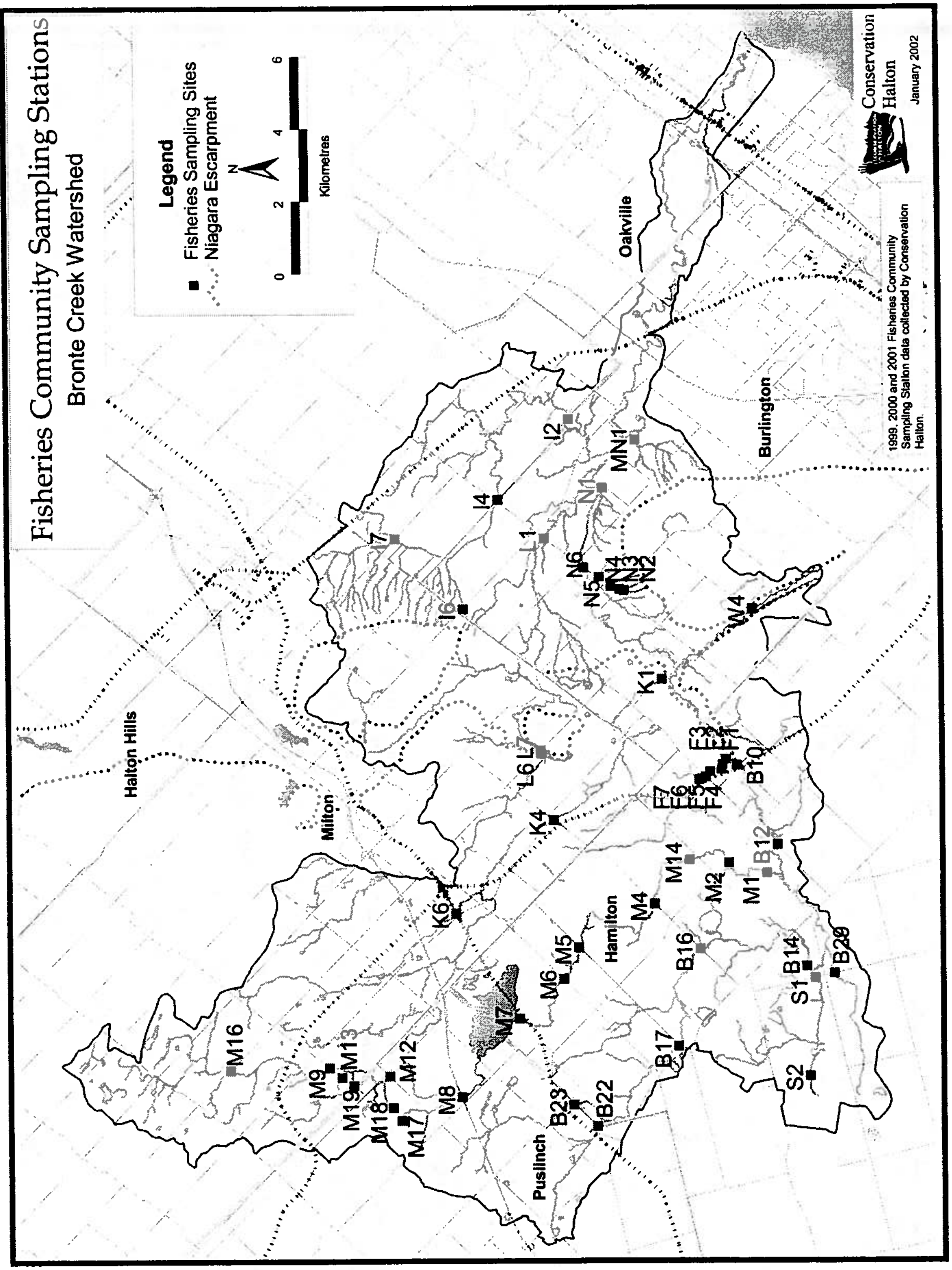
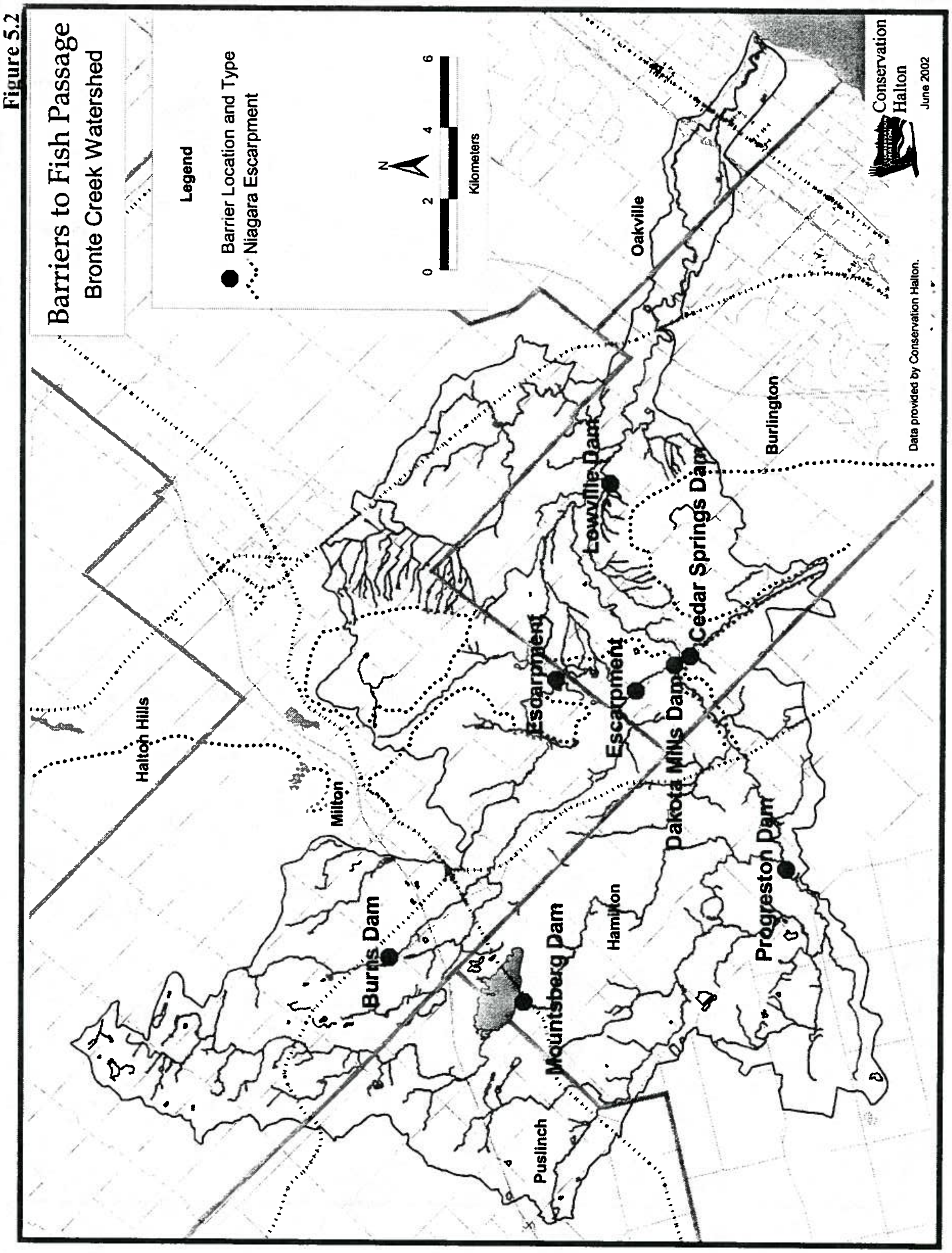

Fisheries Community Sampling Stations
Bronte Creek Watershed
Legend
Fisheries Sampling Sites
Niagara Escarpment
N
0
2
4
6
Kilometres
Oakville
Burlington
Milton
Halton Hills
Hamilton
Puslinch
I2
MN1
I4
N1
L1
I7
N6
N5
N4
N3
N2
I6
W4
K1
F3
F1
B10
L6
L7
F7
F6
F5
F4
K4
M14
M2
B12
M1
K6
M4
M5
B16
B14
B20
S1
M6
M7
B17
M16
M9
M13
M19
M12
M18
M17
M8
B23
B22
S2
Conservation Halton
January 2002
1999, 2000 and 2001 Fisheries Community Sampling Station data collected by Conservation Halton.

Figure 5.2


Barriers to Fish Passage
Bronte Creek Watershed
Legend
Barrier Location and Type
Niagara Escarpment
N
0 2 4 6
Kilometers
Oakville
Burlington
Lowville Dam
Cedar Springs Dam
Escarpment
Escarpment
Dakota Mills Dam
Progreston Dam
Hamilton
Mountsberg Dam
Burns Dam
Milton
Halton Hills
Puslinch
Conservation Halton
June 2002
Data provided by Conservation Halton.

section throughout the summer; however, lake-run fish may contribute significantly to this spawning run. The downstream portion of this reach displays a particularly high level of diversity with the stream fish assemblage merging, at times, with species from Lake

Ontario. In June 1998, 26 species of fish, including five species of shiners, were sampled from Petro Canada Park (Royal Ontario Museum, 1998). Common species include northern hog sucker, river chub, rock bass, pumpkinseed, common shiner, bluntnose minnow and creek chub. The silver shiner, a nationally and provincially vulnerable fish species, has been sampled from Petro Canada Park upstream to Zimmerman.

Since the TMCCR, the most significant change in species assemblage in this reach is the presence of rainbow trout, brown trout and chinook salmon which were first introduced in Bronte Creek by the Ministry of Natural Resources in the 1970s. These populations are largely maintained by annual stocking although natural recruitment of rainbow trout has been documented. Increased diversity recently observed toward the downstream end of this reach likely reflects seasonal changes in fish community (i.e. a combination of lake-run and resident species in late spring vs. residents only in mid-summer), differences in sampling techniques and possibly the presence of highly trained ichthyologists (ROM/DFO staff).

5.3.3 Bronte Creek (Lowville to Progreston)

This section lies within the glacial spillway which extends from the Progreston Dam downstream to the Lowville Dam. A third dam, at Dakota Mills (upstream of Cedar Springs Road), is also present in this reach. These dam structures (Figure 5.2) are barriers to fish passage. The Progreston Dam was constructed at the point where Bronte Creek descends over the Niagara Escarpment. The natural falls at this location likely constituted a barrier to fish passage prior to construction of the dam.

This reach supports a diverse coolwater fish community including brook trout, brown trout and rainbow trout as well as a variety of forage fish such as white sucker, northern hog sucker, blacknose dace, longnose dace, rainbow darter, fantail darter and creek chub. Brook trout are present in small numbers and are native to Bronte Creek. Brown trout are naturalized through this section and were originally stocked in the 1950s. The Izaak Walton Fly Fisher's Club has conducted annual brown trout spawning surveys from Lowville upstream to the Dakota Mills Dam since 1983.

The 1989 Cambridge District Fisheries Management Plan (OMNR, 1989) identified the Lowville Dam as a partition between the resident brown trout population upstream of the dam and the migratory rainbow trout population which can move upstream to the dam. However, significant numbers of rainbow trout have been known to move upstream of this dam to the Dakota Mills Dam following the removal of stop logs during the spring months (Conservation Halton, 1998). Large numbers of rainbow trout are produced in this reach when this occurs (OMNR, 2001).

Although the Dakota Mills Dam is a significant barrier to fish passage, a side channel circumventing the dam may provide upstream access, under favourable flow conditions, for adult rainbow trout (B. Christmas, pers. comm.). Rainbow trout juveniles have been sampled upstream of the Dakota Mills Dam in the main branch of Bronte Creek, Kilbride Creek and Flamboro Creek.

The reach from Lowville upstream to the Dakota Mills Dam was recently part of an Atlantic salmon research study carried out by the OMNR. In this study, young-of-the-year Atlantic salmon were stocked into a matrix of habitat types (cobble/boulder cover vs. woody cover) and competitive environments (rainbow trout vs. no rainbow trout) in tributaries along the north shore of Lake Ontario to assess survival rates and identify "best bet" habitats for future introductions. A report documenting the results of this study is anticipated in the near future (L. Stanfield, pers. comm.).

With the exception of rainbow trout and low numbers of centrarchids which are now present, the fish community assemblage through this reach does not appear to have changed significantly since the TMCCR.

5.3.4 Bronte Creek (Progreston to Headwaters)

Main Branch

From Progreston upstream through Courtcliffe Park, Bronte Creek supports a diverse warmwater fish community with remnant brook trout and brown trout populations associated with pockets of groundwater refugia. Native stream species are intermixed with a number of species more typical of lake environments. Largemouth bass, pumpkinseed, green sunfish, black crappie and northern pike are present through this section, reflecting the diffusion of these species downstream from Mountsberg Reservoir and other on-line ponds. Extensive channel alterations through the Carlisle Conservation Area and Courtcliffe Park have created lentic (lake-like) conditions that are suitable for these species as well as large numbers of carp.

Upstream of Courtcliffe Park, habitat conditions are generally less altered with fish communities dominated by native stream fishes such as creek chub, blacknose dace, pearl dace, brassy minnow, central mudminnow and brook stickleback. Brook trout appear to be present in pockets from Highway 6 upstream to 11th Concession, increasing in abundance to Maddaugh Road where they form the primary component of the fish community. Brook trout habitat extends upstream of Leslie Road on the main branch. Redside dace were once relatively common in this reach; however, recent sampling has confirmed their presence at two stations only (Highway 6-north crossing and 11th Concession).

Significant shifts in the fish community are associated with the diffusion of non-indigenous centrarchids and northern pike from Mountsberg Reservoir and other on-line ponds. These species were not present in 1958 but have become a significant component of the fish community, particularly where lentic (lake-like) habitats have been created (i.e. Courtcliffe Park and Carlisle Conservation Area). Redside dace, once well-distributed through this reach, appear to be restricted to section between Highway 6 (north crossing) and 11th Concession.

Northeast Tributary

A headwater tributary, originating east of the main branch upstream of Highway 401, enters the main branch downstream of Maddaugh Road. Although not sampled, the headwater branches of this tributary appear to support warmwater forage fish upstream to at least Calfass Road (Country Road 36). Permanent flow and coolwater conditions are present at Maddaugh Road and extend downstream to the Bronte Creek confluence. This lower reach supports a relatively diverse forage fish community including brassy minnow, pearl dace, white sucker, blacknose dace and creek chub. The northeast tributary likely supports brook trout near its confluence with the main branch.

East Tributary

A second tributary system enters Bronte Creek from the east at 12th Concession. Arising west of Mountsberg Reservoir, this tributary appears to be fed primarily by surface flow and is intermittent downstream to at least Mountsberg Road. Negligible flows were observed at this station in July 1998 (prior to the peak of the recent drought). Although not sampled, forage fish were observed in a standing pool at Mountsberg Road. Redside dace were sampled at this site in 1991 as part of the HWNAI study. The downstream reach of this tributary may support a wider range of fish species, particularly if significant groundwater discharge enters the channel prior to its confluence with Bronte Creek.

West Tributary

Further downstream, an un-named tributary to Bronte Creek emanating from Beverly Swamp discharges to Bronte Creek west of Highway 6 downstream of Brock Road. At Brock Road, this tributary supports a forage fish community consisting of brook stickleback, pearl dace, creek chub and blacknose dace. This tributary may become intermittent during extended periods of drought.

5.3.5 Mount Nemo Creek

One station was sampled on the downstream reach within the Mount Nemo Scout Camp in July 2000. The species assemblage at this station consisted of creek chub, blacknose dace, white sucker fathead minnow and pumpkinseed and is indicative of tolerant warmwater forage fish habitat. White suckers migrate into this system via Bronte Creek and Lake Ontario to spawn in the spring. It is likely that rainbow trout and possibly chinook salmon also enter Mount Nemo Creek to spawn; however, flashy discharge, intermittent flows and warm instream temperatures during the summer months appear to preclude significant salmonid production in this system. This characterization matches that provided in the ABCW. The TMCCR did not provide a fisheries assessment of this watercourse.

5.3.6 Indian Creek

Despite relatively degraded habitat conditions and intermittency of flows throughout much of this creek and its tributaries, Indian Creek continues to support a diverse warmwater fish community including low numbers of species which generally require relatively unimpaired water quality (i.e. smallmouth bass and rainbow darter). White sucker, rainbow trout, chinook salmon and possibly smallmouth bass ascend Indian Creek from Bronte Creek to spawn. Young-of-the-year rainbow trout have been observed in the creek at Appleby Line; however, juvenile production is limited by high instream temperatures and intermittent flows during the summer months. This assessment of the fish community is consistent with that provided in the ABCW. It is interesting to note that the TMCCR indicated that permanent coldwater conditions extended downstream from the Appleby Line tributaries to Britannia Road. The justification for this classification is unknown.

Indian Creek Tributary

5.3.7 Lowville Creek

Lowville Creek has been the subject of relatively intensive fish community sampling in conjunction with a Permit To Take Water application submitted by the Lowville Golf Course. Anecdotal reports indicate that brook trout and brown trout may have inhabited this tributary in the past; however, recent sampling indicates that Lowville Creek supports a tolerant forage fish community dominated by creek chub, blacknose dace, white sucker and fathead minnow. Largemouth bass are present in the on-line Lowville Golf Course pond. Rainbow trout and possibly chinook salmon migrate upstream into this system from Bronte Creek and YOY rainbow trout have been observed at No. 4 Sideroad; however, salmonid production appears to be limited by low/intermittent flows during the summer months. This assessment is consistent with that provided in the TMCCR and the ABCW.

5.3.8 Limestone Creek

Limestone Creek supports a diverse coldwater fish community highlighted by the presence of salmonids from its headwaters downstream to its confluence with Bronte Creek. Brook trout are common upstream of Walkers Line to the headwaters of the west branch and to the east branch dam. Rainbow trout and chinook salmon migrate upstream to the Escarpment on the west branch and to the east branch dam. A small population of resident brown trout appears to inhabit Limestone Creek downstream of Derry Road. Limestone Creek is noted as a significant producer of juvenile rainbow trout which eventually smolt and migrate downstream to Lake Ontario, returning to spawn as adults. Coho salmon have successfully reproduced here in the past (OMNR, 1993). A diverse array of forage fish including species such as rainbow darter, fantail darter, stonecat, common shiner, northern hog sucker, white sucker and creek chub are also present throughout the system. This fish community assessment closely matches that provided in the ABCW. Rainbow trout, chinook salmon and coho salmon were introduced to the watershed subsequent to the publication of the TMCCR.

A series of tributaries emanating in the vicinity of Islay Lake coalesces downstream of Guelph Line, entering Limestone Creek immediately east of Walkers Line. This tributary system supports a variety of forage fish species. Although most of the tributary branches are intermittent, one tributary, which crosses No. 8 Sideroad sustains permanent flow.

5.3.9 Willoughby Creek

Willoughby Creek supports a significant coldwater fish community from Cedar Springs Road downstream to the Bronte Creek confluence. The Cedar Springs Dam (Figure 5.2) acts as a barrier partitioning native brook trout from rainbow trout and brown trout which could otherwise move upstream from Bronte Creek. Brook trout are the dominant fish species throughout much of this system with forage fish such as blacknose dace and creek chub also present. Extensive spawning activity has been observed from the Cedar Springs Community upstream to the downstream terminus of the Cedar Springs Road ponds (Conservation Halton, 1998; OMNR, 1988). Significant groundwater discharge is present throughout this reach and is a key habitat component within this system. The fish community of Willoughby Creek was not assessed in the TMCCR or ABCW reports.

5.3.10 Kilbride Creek

Kilbride Creek provides coolwater habitat from the Bronte Creek confluence upstream to the Escarpment falls (between No. 8 Sideroad and Cedar Springs Road; Figure 5.2), for brook trout, brown trout and rainbow trout as well as several forage fish species such as rainbow darter, johnny darter, white sucker, creek chub and blacknose dace. Brook trout are native to the creek whereas brown trout are naturalized following stocking efforts in the main branch of Bronte Creek in the 1950s. The presence of juvenile rainbow trout in this reach (upstream of the Dakota Mills Dam) is somewhat confounding since it is unlikely that adult rainbow trout would be able to surmount this obstacle. However, it is possible that adult rainbow trout are moving upstream of the Dakota Mills Dam via an abandoned channel of Bronte Creek which flows south and west around the dam (B. Christmas, pers. comm.). Rainbow trout were first reported from this reach in 1980.

Fish community sampling confirms the presence of brook trout from the falls upstream past the CPR tracks. Brook trout habitat likely extends upstream past Highway 401. Brook trout spawning activity was observed upstream of the CPR tracks in Fall 2000. Although not sampled, there have been anecdotal reports of brown trout in the vicinity of Kilbride. It is unknown how brown trout could have gained access to the reaches upstream of the falls which act as a natural barrier to fish passage. This reach also supports a variety of forage fish species.

Burns Reservoir is located on Kilbride Creek immediately upstream of 10th Sideroad. This reservoir was constructed in 1967 for recreational purposes. Stocked with rainbow trout annually until the early 1990s, the reservoir supported a centrarchid fishery until 1999 when a significant winterkill event associated with low water levels, lack of inflow and heavy snow cover resulted in the near total loss of the reservoir fishery. In December 2000, the reservoir was restocked with approximately 4,000 fish (black crappie, pumpkinseed, largemouth bass) from the Milton Mill Pond.

Fish community sampling has not been undertaken upstream of Burns Reservoir. Upstream flows may become intermittent during periods of drought.

5.3.11 Flamboro Creek

The downstream reach of Flamboro Creek, from where it enters the Bronte Creek valley to the Bronte Creek confluence, supports brook trout, brown trout and rainbow trout. Brook trout are native to the creek whereas brown trout are naturalized following stocking efforts in the main branch of Bronte Creek in the 1950s. Like Kilbride Creek, the presence of juvenile rainbow trout in this reach (upstream of the Dakota Mills Dam) is somewhat confounding since it is unlikely that adult rainbow trout would be able to surmount this obstacle. However, it is possible that adult rainbow trout are moving upstream of the Dakota Mills Dam via an abandoned channel of Bronte Creek which flows south and west around the dam (B. Christmas, pers. comm.).

Upstream of the valley to Carlisle Road, Flamboro Creek supports a more tolerant warmwater forage fish community dominated by creek chub and blacknose dace. Pumpkinseed and yellow perch found in the deeper pools immediately downstream of Carlisle Road reflect the influence of the on-line Carlisle Golf and Country Club pond on downstream habitats. This large, dammed impoundment (Figure 5.2), located immediately upstream of Carlisle Road, provides warmwater habitat for species such as largemouth bass, pumpkinseed, yellow perch and carp.

The headwaters of Flamboro Creek, between the CPR tracks and 10th Concession, are supported by significant groundwater discharge which provides suitable coolwater habitat for brook trout. Although there are no sampling records for brook trout in this reach, anecdotal reports from knowledgeable local anglers (B. Christmas, pers. comm.) confirm its presence in the headwater area.

5.3.12 Mountsberg Creek

Downstream of Mountsberg Reservoir

Mountsberg Creek supports a diverse fish community from the Bronte Creek confluence upstream to the Mountsberg Reservoir. Native stream species are intermixed with a number of species more typical of lake environments. Largemouth bass, pumpkinseed, green sunfish, black crappie and northern pike are present through this section, reflecting the influence of Mountsberg Reservoir and other on-line ponds on the fish community. Despite extensive sampling efforts, only one salmonid was sampled in this reach as part of the watershed study (one brown trout at 11th Concession). Although small pockets of brook trout and brown trout may persist in this reach (anecdotal reports), it is likely that thermal impacts associated with the reservoir and other on-line ponds have resulted in a significant contraction of trout habitat in this section. It should be noted that the brown trout was sampled at one of the two stations where marginal coolwater/warmwater habitat was identified.

Mountsberg Reservoir

Mountsberg Reservoir, constructed in 1967, is an extensive marsh with a maximum depth of less than 3 m and an average depth of less than 2 m. The dam associated with the reservoir is a barrier to fish passage (Figure 5.2). Extensive beds of aquatic vegetation, a variety of substrate and the remnants of the drowned swamp (stumps, logs) provide excellent habitat for largemouth bass which were stocked in 1969 by the Department of Lands and Forests. Northern pike, which were illegally stocked in the 1980s (anecdotal reports) have also become established in the reservoir. Pumpkinseed, black crappie, bluegill and brown bullhead are also present in significant numbers.

Upstream of Mountsberg Reservoir

Coolwater habitat immediately upstream of the Mountsberg Reservoir supports brook trout and several forage fish species. The spring-fed tributaries emanating from the Badenoch Swamp (upstream of Calfass Road/Country Road 36) provide suitable conditions for brook trout. The main branch, arising east of Moffat, supports a forage fish community including species such as pearl dace, central mudminnow, brassy minnow, blacknose dace, creek chub and white sucker. Similar to the reaches downstream of the reservoir, the fish community in the upstream reaches (with the possible exception of spring sources) reflects the presence of fish species, particularly northern pike, which have colonized the stream from the reservoir. The presence of several year classes of northern pike indicates that pike may be migrating into the headwaters for spawning purposes. The extensive thicket marsh on the east branch downstream of Calfass Road (Country Road 36) is generally flooded during the early spring, providing large areas of flooded grasses which are preferred for pike spawning.

Summary

The fish community of Mountsberg Creek has changed dramatically since the TMCCR. Coolwater habitat downstream of the Mountsberg Reservoir is negligible and brook trout, which appeared to be abundant in 1958, appear to have been extirpated from this reach or are present in very low numbers. Similarly, redside dace are no longer present in this reach. Centrarchids and northern pike, not present in 1958, have become widespread upstream and downstream of the reservoir.

5.3.13 Strabane Creek

Strabane Creek supports a relatively diverse coolwater fish community downstream of Brock Road to the Bronte Creek confluence, with brook trout found in the deeper pools. Within Beverly Swamp, the headwaters wind through dense thickets and support species such as brook stickleback, blacknose dace and finescale dace. This assessment is consistent with those provided in the TMCCR and the ABCW.

5.3.14 Summary

The fish community within the Bronte Creek watershed has undergone significant changes since European settlement. A keystone species, the Atlantic salmon, has been extirpated from the watershed as a result of habitat degradation and overharvest. Lake trout, whitefish and cisco, which were commonly caught off the mouth of the river at the turn of the 20th century, have been extirpated from the western basin of Lake Ontario as a result of overfishing and sea lamprey predation. Once extirpated from the entire Lake Ontario basin, the lake trout has been the subject of an intensive reintroduction program in Ontario and New York. Although largely sustained by stocking, limited natural reproduction has been documented (OMNR, 2001).

Non-native salmonids have been introduced throughout much of the watershed. Brown trout have become naturalized in Bronte Creek and its tributaries from Lowville upstream to Carlisle. Rainbow trout have become naturalized and successfully reproduce in Limestone Creek and the main branch of Bronte Creek. Reproduction is also successful when access is provided upstream of the Lowville dam. Rainbow trout, chinook salmon and brown trout continue to be stocked on an annual basis by the Ministry of Natural Resources to support a recreational fishery.

The construction of the Mountsberg Reservoir and other on-line ponds has provided suitable habitat for a number of fish species which are native to Ontario but are not-native to the upper portions of the Bronte Creek watershed. Centrarchids and northern pike have diffused from these centres throughout the watershed. The creation of lentic environments through channel dredging and widening (Courtcliffe Park and Carlisle Conservation Area) have inadvertently created additional habitat opportunities for these species, possibly to the detriment of native stream fishes such as redside dace.

5.4 Notable Fish Species

It is recognized that several fish species within the Bronte Creek watershed are of special interest to the public from an ecological, natural heritage and recreational perspective. This subsection provides additional fish species information that may be of interest to anglers, naturalists and other groups.

5.4.1 Redside Dace

Redside dace has been designated as a nationally and provincially vulnerable species based on its limited distribution in Canada and Ontario. The range of this species, particularly in urban and urbanizing areas which form the core of its distribution, appears to be contracting. The redside dace is a sight feeder and is known to be sensitive to the effects of excessive turbidity. A Recovery Plan is currently in development for this species (Redside Dace Recovery Plan, 2001).

The TMCCR noted that redside dace was present at 17 stations and was one of the most common cyprinids sampled. Redside dace remained relatively common in the upper portions of the watershed as observed in fish community sampling in the early 1970s. Since this time, the redside dace population within the watershed appears to have contracted (Figure 5.3.1). Since 1990, only three records of redside dace are available for Bronte Creek, despite a concerted effort to resurvey former sites known to support redside dace in the past. Mountsberg Creek, a former stronghold, no longer appears to support this species. The present distribution of redside dace appears to be limited to the section of Bronte Creek bounded by Highway 6 (north crossing) and 11th Concession Road, as well as the tributary system which enters Bronte Creek from the northeast, downstream of Mountsberg Road. Very small numbers of redside dace were sampled at each site, indicating that this species is not abundant.

Urbanization and changes in vegetation cover have been postulated as potential causal factors for the decline of redside dace populations in southern Ontario (Redside Dace Recovery Plan, 2001). The construction of the Mountsberg Reservoir in 1967 may partially account for the demise of redside dace in Mountsberg Creek downstream of the reservoir since redside dace are known to prefer coolwater habitat conditions; however, it does not account for the loss of populations within the remainder of the upper watershed since land use in this area has not changed significantly over the past forty years.

Although land use and riparian cover have not changed significantly during this period, the fish community within the upper watershed has undergone significant changes. The construction of Mountsberg Reservoir has provided habitat conditions suitable for lake-oriented warmwater fish species such as largemouth bass, pumpkinseed, black crappie and northern pike which are not native to this portion of the watershed. These species were stocked (legally and illegally) and populations thrived. Over time, centrarchids and northern pike have spread upstream and downstream from the reservoir (and possibly other on-line ponds) and now form a significant component of the stream fish community. Construction of on-line ponds and channel dredging (i.e. Courtcliffe Park, Carlisle Conservation Area) have created additional lentic (lake-like) habitats that favour production of these non-indigenous fish species.

The introduction of exotic species into stable ecological communities (aquatic, wetland and terrestrial) is often at the expense of some component of the existing community. It is hypothesized that, faced with increased competition for a limited forage base and increased predation, the redside dace may be succumbing to significant fish community changes within the upper watershed.

5.4.2 Silver Shiner

The silver shiner has been designated as a nationally and provincially vulnerable species based on its limited distribution in Canada with populations restricted to southwestern Ontario. Its present distribution is limited to the Thames River and Grand River watersheds and lower Bronte Creek with a recent record within the Sixteen Mile Creek (Philips Planning and Engineering Ltd., 2000). The silver shiner is known to inhabit the deeper pools of medium to large streams with moderate to high gradients and is generally absent from smaller tributary streams and slow-moving river sections (Baldwin, 1986). It is at the northern edge of its range in Canada and should likely be considered a "Carolinian" species.

The silver shiner was first sampled in Bronte Creek at Zimmerman in 1983. Subsequent sampling undertaken by the Royal Ontario Museum in the 1990s (ROM, 1998) indicates that the silver shiner is restricted to the lower reaches of Bronte Creek between Zimmerman and the estuary (Figure 5.3.2). This distribution pattern is consistent with its habitat requirements, noted above. Significant numbers of silver shiner have been observed during sampling and it is likely that this population will remain stable provided that their deep pool habitat is maintained.

5.4.3 Brook Trout

Brook trout are the only native stream-dwelling salmonid within eastern North America. Native to the Bronte Creek watershed, brook trout were also stocked in Mountsberg Creek and Bronte Creek from 1951 to 1971 (Portt, 1981).

With the exception of Mountsberg Creek downstream of Mountsberg Reservoir, the distribution of resident brook trout is similar to that observed in 1958 (TMCCR; Figure 5.4.1). This reach of Mountsberg Creek, which historically supported coldwater fish habitat, was transformed into a warmwater system with marginal ability to support salmonid populations following construction of the reservoir. Brook trout have not been sampled downstream of the reservoir since 1958 although anecdotal reports persist. It should be noted that brook trout were stocked in Mountsberg Creek through the 1950s; however, it is likely, given the similarity of habitat conditions in adjacent Bronte Creek, that a native population would have been present in this area.

Throughout most of its range within the watershed, brook trout have had to adapt to the introduction of exotic and non-indigenous species. In Limestone Creek, downstream of the Escarpment, rainbow trout have become naturalized and now co-exist with the native brook trout population. On Bronte Creek, upstream of Lowville to Progreston, brook trout have had to adapt to the presence of naturalized brown trout and rainbow trout populations. Brook trout populations through this reach are low. It is unknown whether this is the result of interspecific competition or lack of preferred habitat.

Upstream of Progreston, centrarchids and northern pike have diffused from Mountsberg Reservoir and on-line ponds and are now present throughout much of the brook trout range in the upper watershed. Northern pike have a reputation for adversely affecting brook trout populations in southern Ontario either through competition or predation. Adult brook trout upstream of the Mountsberg Reservoir have been observed with bite marks that appear to be attributable to northern pike (D. Featherstone, pers. comm.).

5.4.4 Atlantic Salmon

Prior to European settlement, Atlantic salmon were abundant in Lake Ontario and its tributaries. Likely a relict population which colonized the present lake from the Atlantic coast during the immediate post-glacial period, Lake Ontario was the only Great Lake which supported this species. Atlantic salmon were abundant within the Bronte Creek watershed, with adults likely ascending Bronte Creek and its tributaries upstream to

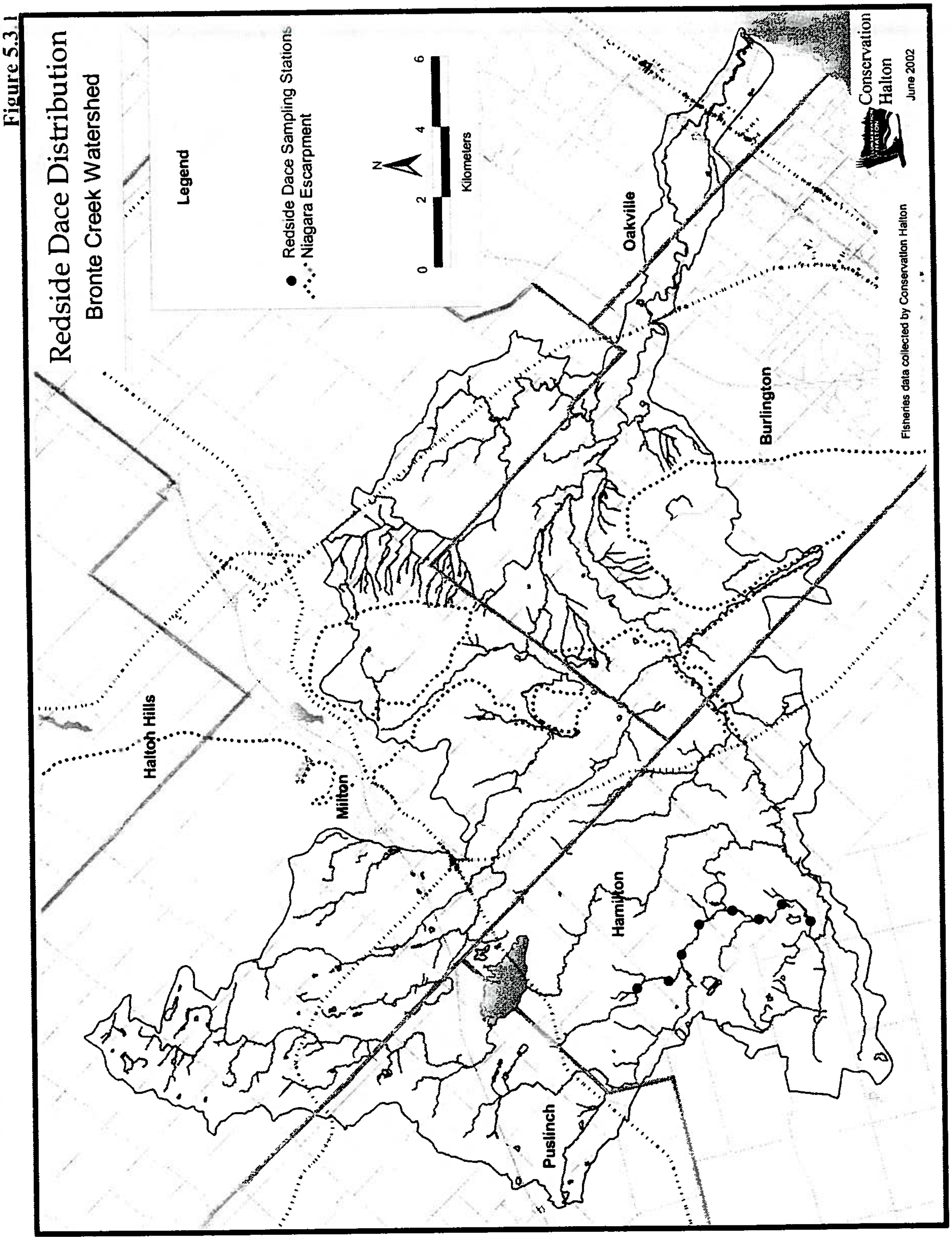
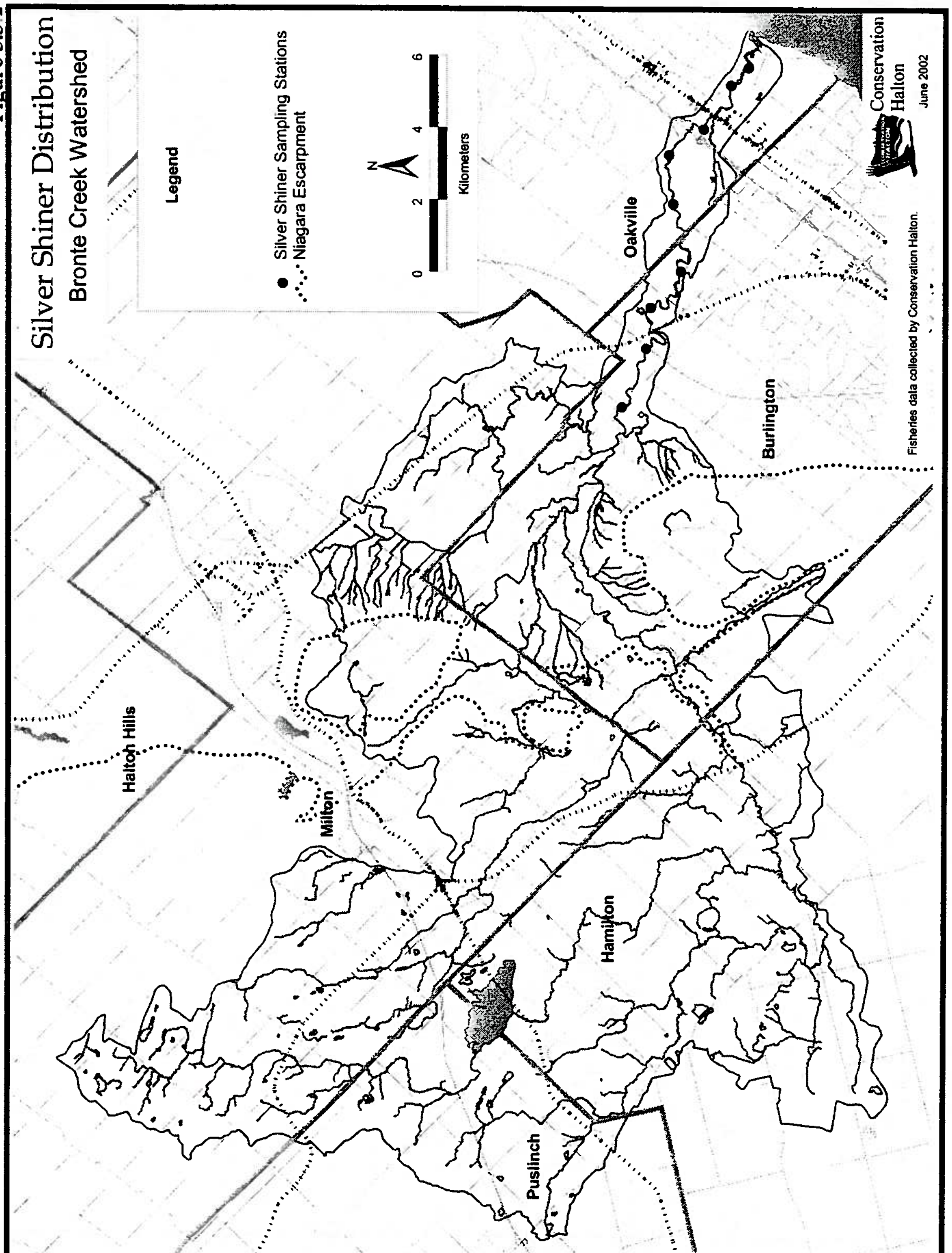

Redside Dace Distribution
Bronte Creek Watershed
Legend
Redside Dace Sampling Stations
Niagara Escarpment
N
0
2
4
6
Kilometers
Halton Hills
Milton
Oakville
Burlington
Hamilton
Puslinch
Conservation Halton
June 2002
Fisheries data collected by Conservation Halton

Figure 5.3.1

Figure 5.3.2


Silver Shiner Distribution
Bronte Creek Watershed
Legend
Silver Shiner Sampling Stations
Niagara Escarpment
N
0 2 4 6
Kilometers
Halton Hills
Milton
Oakville
Burlington
Hamilton
Puslinch
Conservation Halton
June 2002
Fisheries data collected by Conservation Halton.

Progreston during their spawning runs. Habitat destruction and overharvest led to the demise of the Atlantic salmon within the watershed by the mid 1800s and its eventual extirpation from Lake Ontario and its tributaries by the late 1800s.

Attempts to reintroduce Atlantic salmon to Lake Ontario have been ongoing since the late 1980s. In southern Ontario, stocking efforts have been focused on the Credit River and Wilmot Creek; however, with little success (OMNR, 1995). To better understand the habitat and competition requirements for juvenile Atlantic salmon survival (i.e. to ensure that Atlantic salmon are stocked at sites which optimize survival), the Ministry of Natural Resources recently completed a four year study on Lake Ontario tributaries. Within the Bronte Creek watershed, Atlantic salmon fry (7,600 to 20,500 fry/year) were stocked in Bronte Creek and Willoughby Creek upstream of Lowville (OMNR, 1997-2000). A review of study results is ongoing with findings anticipated to be published in the near future (OMNR, 2001). It is hoped that concerted stocking efforts supported by such research will ultimately result in the re-establishment of this heritage species within Lake Ontario and its tributaries (including Bronte Creek).

5.4.5 Brown Trout

Brown trout, native to Europe, were stocked in middle and upper reaches of Bronte Creek and Mountsberg Creek from 1953 to 1959 (Portt, 1981). As a result of this stocking effort, self-sustaining populations were established on the main branch of Bronte Creek from Lowville upstream to Carlisle (Figure 5.4.2). This population also appears to utilize the downstream reaches of Kilbride Creek and Flamboro Creek for spawning and nursery habitat. The capture of single specimens during recent sampling indicates that small populations of resident fish are also present in Mountsberg Creek and Limestone Creek.

Although brown trout spawning surveys undertaken by the Izaak Walton Fly Fisher's Club routinely show good numbers of spawning redds from Lowville upstream to Dakota Mills Dam, the brown trout fishery appears to be hampered by a lack of juvenile production (OMNR, 2000). It is not known whether this is associated with interspecific competition (rainbow trout), a lack of suitable spawning/nursery habitat, superimposition of rainbow trout redds over brown trout redds (Kocik and Taylor, 1991) or higher gradient conditions in this reach which may be more favourable for rainbow trout (Stoneman, 1996).

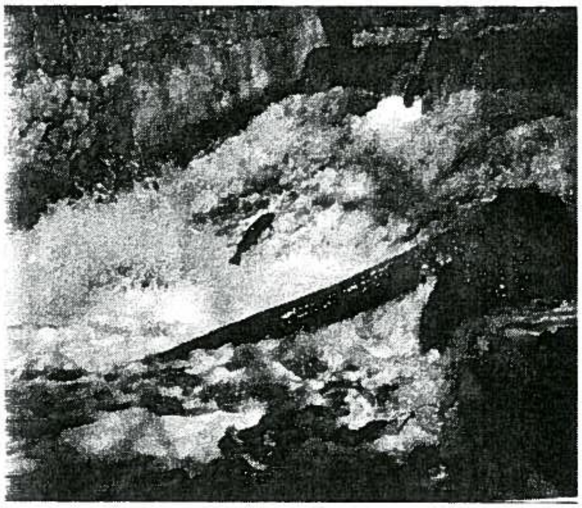
In contrast to the naturalized resident brown trout population, brown trout are stocked annually at Bronte Beach Park (15,000 to 16,000 yearlings/year; OMNR, 1997-2000) and contribute to the recreational fishery in Lake Ontario and Bronte Creek on a put-and-delayed take basis. The strain stocked in Lake Ontario does not have a strong migratory tendency (Bowlby, 1991) and fall spawning runs in Bronte Creek are generally restricted to the lower reaches downstream of Regional Road 5, although they may ascend upstream to Lowville under favourable flow conditions (Figure 5.4.2). No natural reproduction of lake-run brown trout has been documented in Bronte Creek.

5.4.6 Rainbow Trout

Rainbow trout, native to the west coast of North America, have been stocked throughout the world. The first stocking of rainbow trout in the Lake Ontario watershed was undertaken by New York State in 1878 with the first introductions in Ontario occurring in 1911 (MacCrimmon and Lowe-Gots, undated).

Rainbow trout were first stocked in the Bronte Creek watershed in 1927 and 1930 and again in 1954 (MacCrimmon and Lowe-Gots, undated); however, there is no evidence that self-sustaining populations developed from these stocking efforts. In the 1970s, stocking was carried out on Bronte Creek (Lowville, Cedar Springs Road, Progreston, Carlisle), Limestone Creek (Guelph Line), Kilbride Creek and Mountsberg Creek (Portt, 1981).

Although it is likely that strays from other stocking efforts may have occasionally entered the lower portions of Bronte Creek from Lake Ontario prior to this date; the first sampling record of rainbow trout in the watershed was reported in 1972 (Howell and Cox, 1972).



Rainbow Trout at the Lowville dam

Today, supplemented by annual stocking by the Ministry of Natural Resources (average 21,000 yearlings/year downstream of Lowville; OMNR, 1999-2001), Bronte Creek supports a migratory run of rainbow trout which moves from Lake Ontario into the system from mid-fall through early spring, spawning in Bronte Creek and its tributaries in March and April. Natural reproduction in Limestone Creek (downstream of the Escarpment) is significant with studies indicating that natural reproduction in this system may support a spawning run of 222 to 370 fish (OMNR, 1983).

Significant natural reproduction has also been observed from Lowville upstream to Dakota Mills Dam. The Lowville Dam acts as a partition between migratory salmonids and resident brook trout and brown trout but rainbow trout have been observed moving upstream of the dam when the stop logs are removed from the structure. Recent biomass surveys conducted by the Ministry of Natural Resources as part of the Atlantic salmon research program indicate that numbers of rainbow trout juveniles far surpass those of other salmonids throughout this reach. It is unknown whether this is a result of favourable habitat conditions for rainbow trout production relative to resident salmonids or whether a competitive factor is involved.

Rainbow trout juveniles have also been sampled upstream of the Dakota Mills Dam in the main branch of Bronte Creek, Kilbride Creek and Flamboro Creek. Although the Dakota Mills Dam is a significant barrier to fish passage, a side channel circumventing the dam may provide upstream access, under favourable flow conditions, for adult rainbow trout (B. Christmas, pers. comm.).

5.4.7 Chinook Salmon

Chinook salmon were first introduced into Lake Ontario in 1874 with stocking likely carried out in Bronte Creek between 1919 and 1925. During this period, spawning runs of thousands of adult fish were observed in the Credit River and Bronte Creek (Scott and Crossman, 1973); however, a self-sustaining population was not established as a result of this stocking effort.

Following the success of the coho salmon introduction program (initiated in 1969), chinook salmon were re-introduced into Bronte Creek in 1974 (Portt, 1981). Annual stocking commenced in the late 1970s. Chinook salmon eventually replaced coho salmon as the dominant anadromous salmonid in the Lake Ontario stocking program. Stocking levels within Lake Ontario peaked at 70,000 in 1992 (OMNR, 1993). From 1993 to 1996, stocking was cut by approximately 50% to 65% from 1992 stocking levels to reduce predator demand which appeared to be exceeding the sustainable supply of forage fish in Lake Ontario (OMNR, 1999). Following extensive public consultation, stocking was moderately increased in 1997. Since 1997, annual stocking in Bronte Creek has averaged 46,000 fingerlings (OMNR, 1998-2001; downstream of Lowville).

Natural reproduction of chinook salmon has

Figure 5.4.1

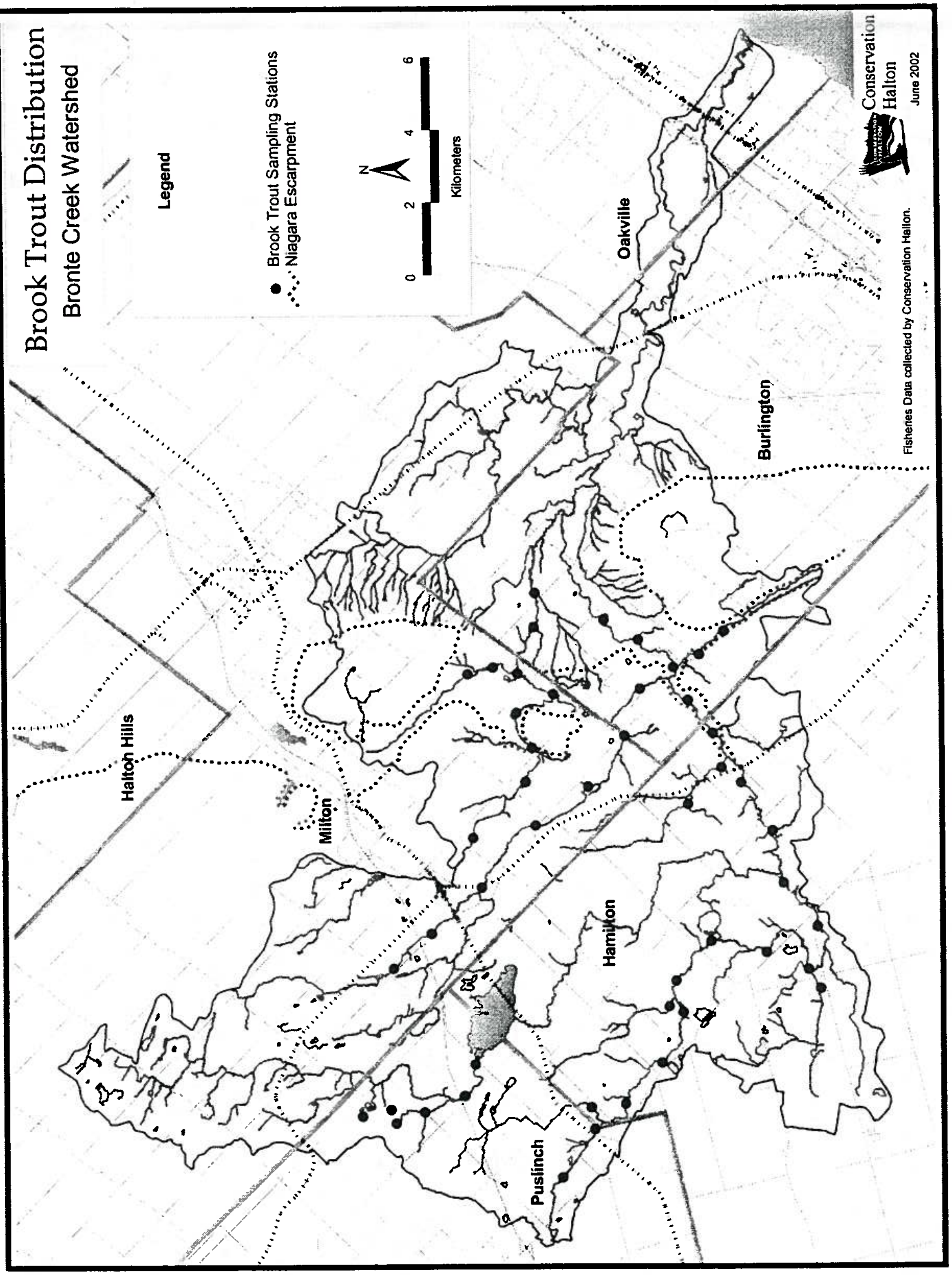
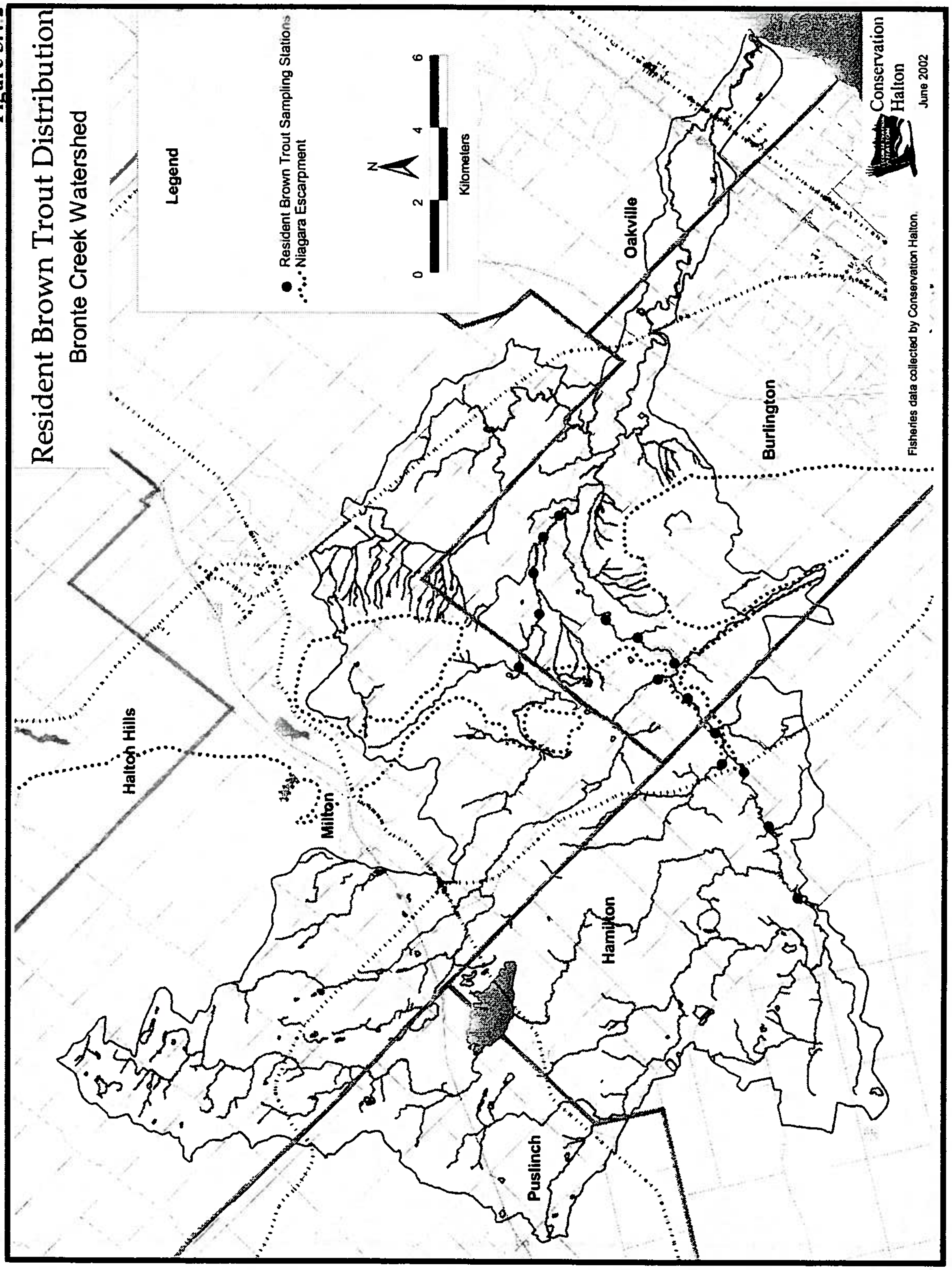

Brook Trout Distribution
Bronte Creek Watershed
Legend
Brook Trout Sampling Stations
Niagara Escarpment
0 2 4 6
Kilometers
N
Halton Hills
Milton
Oakville
Burlington
Hamilton
Puslinch
Conservation Halton
June 2002
Fisheries Data collected by Conservation Halton.

Figure 5.4.2


Resident Brown Trout Distribution
Bronte Creek Watershed
Legend
Resident Brown Trout Sampling Stations
Niagara Escarpment
N
0
2
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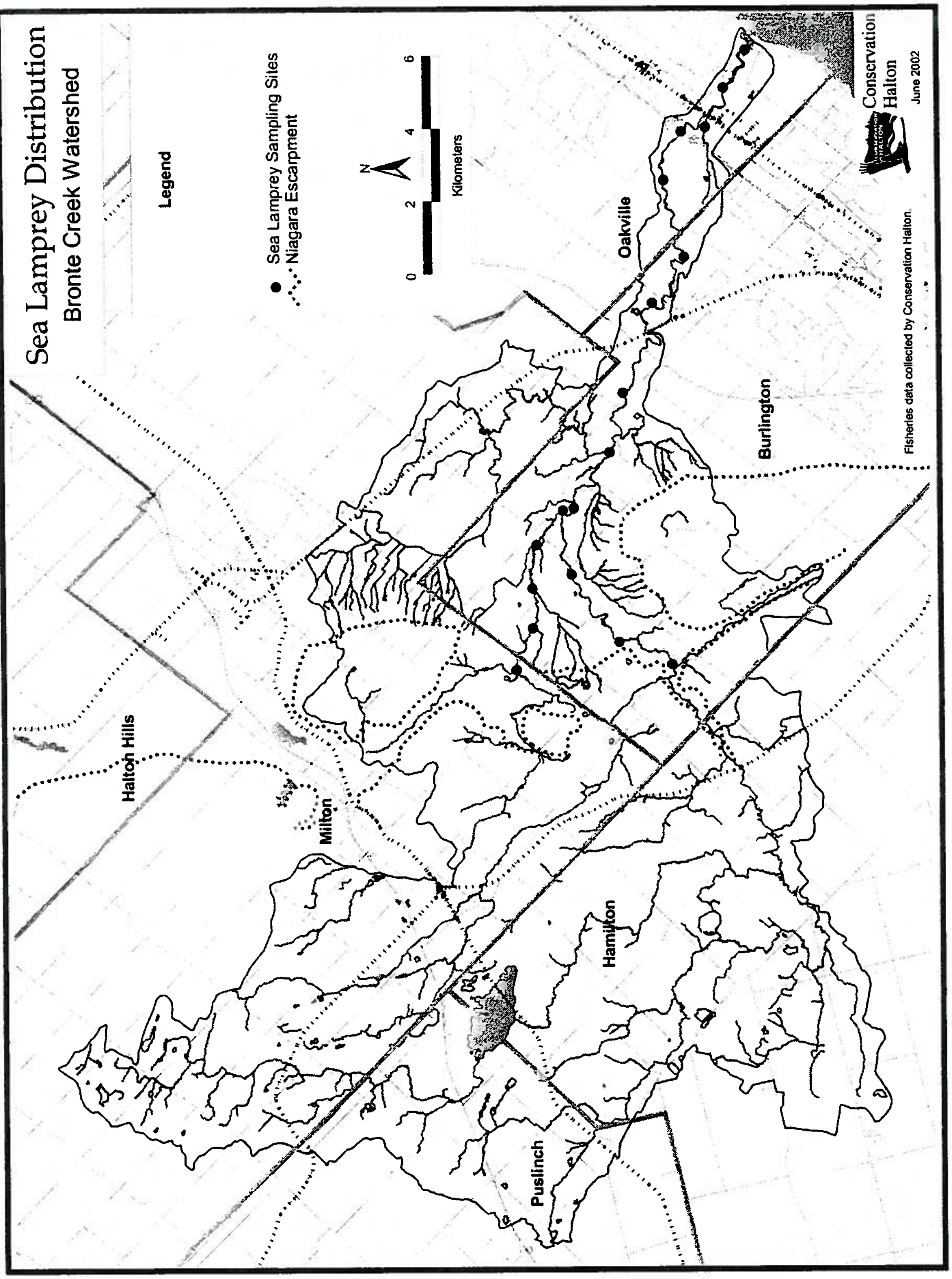
6
Kilometers
Halton Hills
Milton
Oakville
Burlington
Hamilton
Puslinch
Conservation Halton
June 2002
Fisheries data collected by Conservation Halton.

Figure 5.4.3


Sea Lamprey Distribution
Bronte Creek Watershed
Legend
Sea Lamprey Sampling Sites
Niagara Escarpment
N
0
2
4
6
Kilometers
Halton Hills
Milton
Oakville
Burlington
Hamilton
Puslinch
Conservation Halton
June 2002
Fisheries data collected by Conservation Halton.

been documented in Ontario tributaries of Lake Ontario, particularly in 1997 when estimates of wild chinook production closely matched stocking numbers (OMNR, 1998). Although the extent of natural production appears to vary significantly from year to year, recent reports suggest that natural reproduction is occurring in several tributaries (OMNR, 2001) and anecdotal evidence of natural reproduction persists in the lower reaches of Bronte Creek. Precipitation patterns may play a key role in determining reproductive success since access to upstream spawning areas may be hindered by low water levels during the early to mid-fall period.

5.4.8 Sea Lamprey

An anadromous fish species native to the Atlantic Ocean, the sea lamprey has adapted to an entirely freshwater existence in the Great Lakes. The origin of sea lamprey in Lake Ontario, where it has been known since 1835, is open to conjecture. One school of thought suggests that this species is indigenous (Christie, 1973) while another proposes entry via the Erie Barge Canal (Smith, 1995) which was completed in 1819. Although the Welland Canal was completed in 1829, it is suspected that modifications to the canal in the late 1800s provided access to the remaining Great Lakes (Mills *et al.*, 1999). Sea lamprey sightings were reported in Lake Erie in 1921 (Dymond, 1921) and Lakes Huron, Michigan and Superior in 1936, 1937 and 1946, respectively (Smith and Tibbles, 1980).

During the parasitic phase of its life cycle, the sea lamprey subsists on the blood and body fluids of fish, using its sucker mouth for attachment and a rasp-like tongue to penetrate the scales and skin of its chosen prey. In the Great Lakes, the sea lamprey attack a variety of fish species, including lake trout, rainbow trout, lake whitefish, yellow perch, walleye, suckers and burbot (Scott and Crossman, 1973). Approximately 60% of sea lamprey attacks on lake trout are fatal (Swink, 1993) and each lamprey destroys an average of 18 kg of fish during its parasitic adult phase. The colonization of sea lamprey in the upper Great Lakes was followed by a sharp, continuous decline in lake trout production (Smith and Tibbles, 1980). More recently, sea lamprey parasitism has been identified as a key factor hindering the rehabilitation of fish stocks in Lake Huron and Lake Michigan (GLFC, 2000).

Bronte Creek is known as one of the highest producers of lamprey larvae (ammocoetes) in the Great Lakes, proportional to its size (MNR, 1973). The spring migration of spawners into Bronte Creek is unhindered by barriers from Lake Ontario upstream to the Dakota Mills Dam (Figure 5.4.3). Although Lowville Dam is a barrier to salmonid migration, it does not constitute a significant barrier to sea lamprey (Paul Sullivan, DFO, pers. comm.). Spawning also occurs in Limestone Creek; however, larval distribution is variable and usually confined to the area downstream of Derry Road to the Bronte Creek confluence. In 1971, lampricide treatments using TFM (3-trifluormethyl-4-nitrophenol) were initiated on Bronte Creek and Limestone Creek. This lampricide, appropriately applied over a twelve-hour period, selectively kills sea lamprey larvae and has greatly reduced sea lamprey populations throughout most of the Great Lakes. Typically, Bronte Creek requires treatment once every three years, overlapping with the minimum duration of the larval phase of the life cycle when ammocoetes are burrowed in soft stream substrates.

The Department of Fisheries and Oceans is proposing the construction of a fixed-crest low-head barrier to be incorporated with the planned expansion of the QEW to block sea lamprey spawning migrations. Its purpose will be to eliminate or greatly reduce the need for future TFM treatments and, in doing so, reduce expenditures and risks associated with the perpetual use of TFM within the watershed. Similar in design to other low-head barriers within the Lake Ontario watershed, the Bronte Creek barrier will include a fishway to allow the unimpeded migration of other fish species while sea lamprey are trapped and removed. The project will be subject to a standard environment assessment process. If approved, work on this structure may begin as early as summer 2002 (A. Hallett, DFO, pers. comm.).

5.4.9 Northern Pike

Northern pike are indigenous to Lake Ontario and utilize coastal marshes for spawning and nursery habitat. Anecdotal evidence suggests that the estuarine marsh near the mouth of Bronte Creek supports a spring spawning run of northern pike. The magnitude of this population is unknown at present.

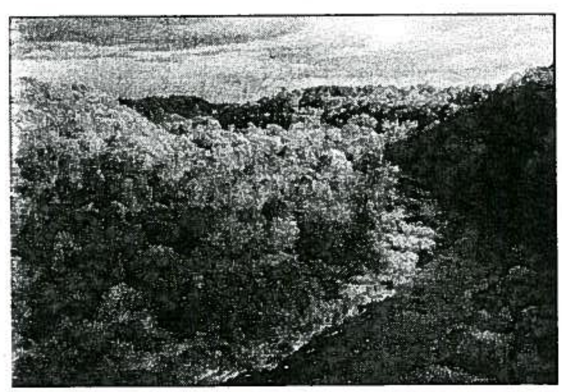
Northern pike appear to have been illegally stocked in Mountsberg Reservoir with first reports of angled specimens occurring in the late 1980s (B. Roelofson, pers. comm.). The population of northern pike within the reservoir appears to have increased steadily in the 1990s with anglers specifically targeting pike by the late 1990s. Recent sampling and observations indicate that northern pike have spread both upstream and downstream of the reservoir (Figure 5.5.1). Several year classes of northern pike have been sampled upstream of the reservoir, indicating that pike may be using upstream marshes as spawning and nursery areas. Adult northern pike have been observed in Bronte Creek from Courtcliffe Park downstream to the Cedar Springs Community.

Northern pike are not indigenous to the upper portion of the watershed. Unlike brook trout populations in northern Ontario, brook trout populations in headwater streams in southern Ontario have not co-evolved with northern pike and generally suffer as a result of introductions, either through competition or predation. The presence of northern pike may result in a reduction of brook trout populations, particularly in low gradient/altered reaches which are favourable for northern pike production.

5.4.10 Centrarchids (sunfish family)

Prior to 1960, smallmouth bass and rock bass were the only members of the centrarchid family reported from the Bronte Creek watershed. Their distribution was limited to Bronte Creek and its tributaries downstream of Lowville. Although likely indigenous to this portion of the watershed, smallmouth bass were also stocked downstream of Regional Road 5 through the 1950s. Resident smallmouth bass support a small recreational fishery downstream of Lowville through the summer months. Lake-run smallmouth bass may also migrate into the lower reaches of Bronte Creek to spawn from mid-spring through early summer.

Other members of the centrarchid family appear to have diffused through the watershed (Figure 5.5.2) following the construction of Mountsberg Reservoir in 1967. Largemouth bass were stocked in Mountsberg Reservoir in 1969 by the Department of Lands and Forests and quickly developed a self-sustaining population. Trophy-sized individuals in excess of 3 kg are angled annually from this impoundment. Largemouth bass are also abundant in lentic environments associated with Burns Reservoir, Courtcliffe Park and Carlisle Conservation Area. Black crappie, pumpkinseed, bluegill and green sunfish have also colonized and thrived in these areas.



Bronte Creek in Bronte Creek Provincial Park

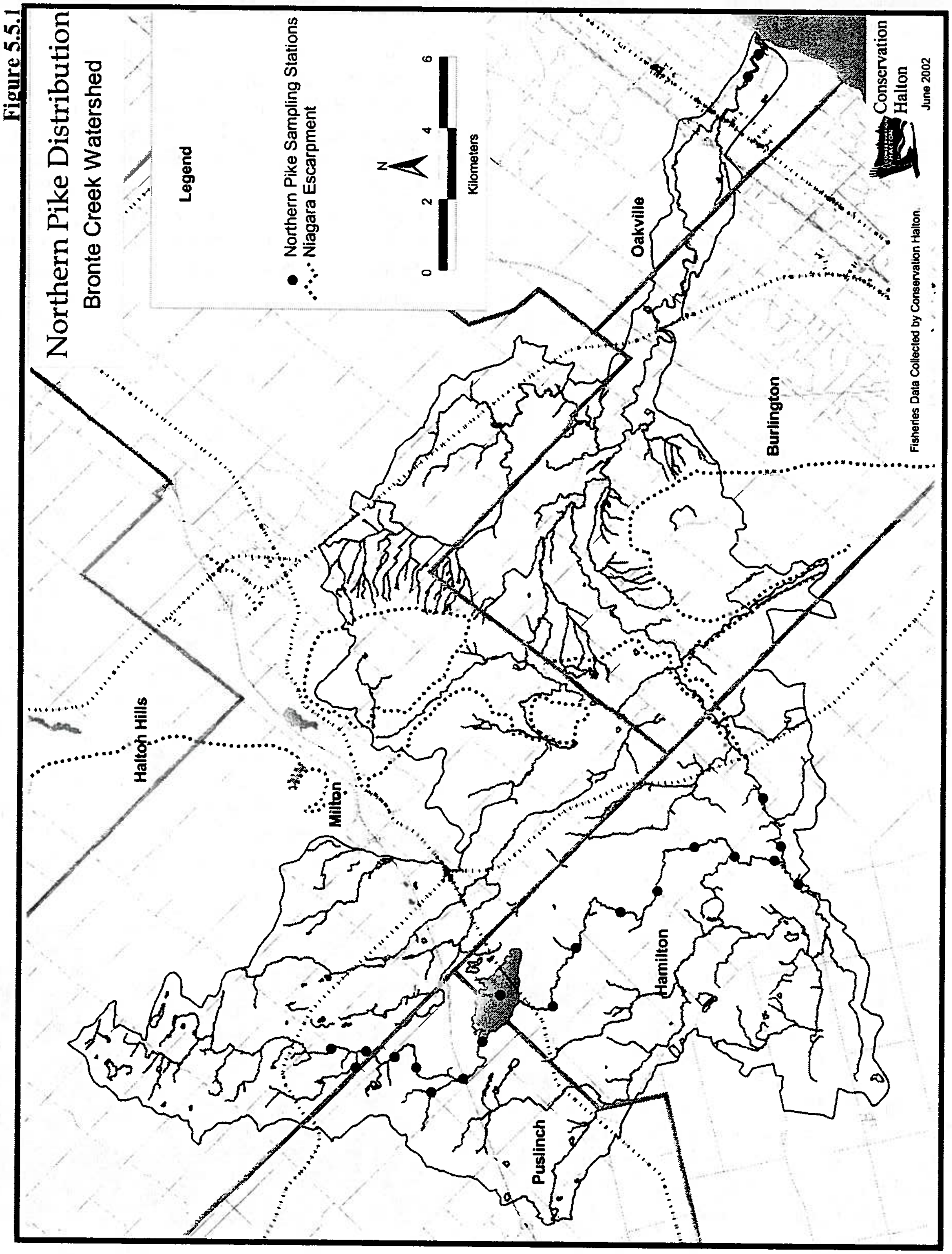
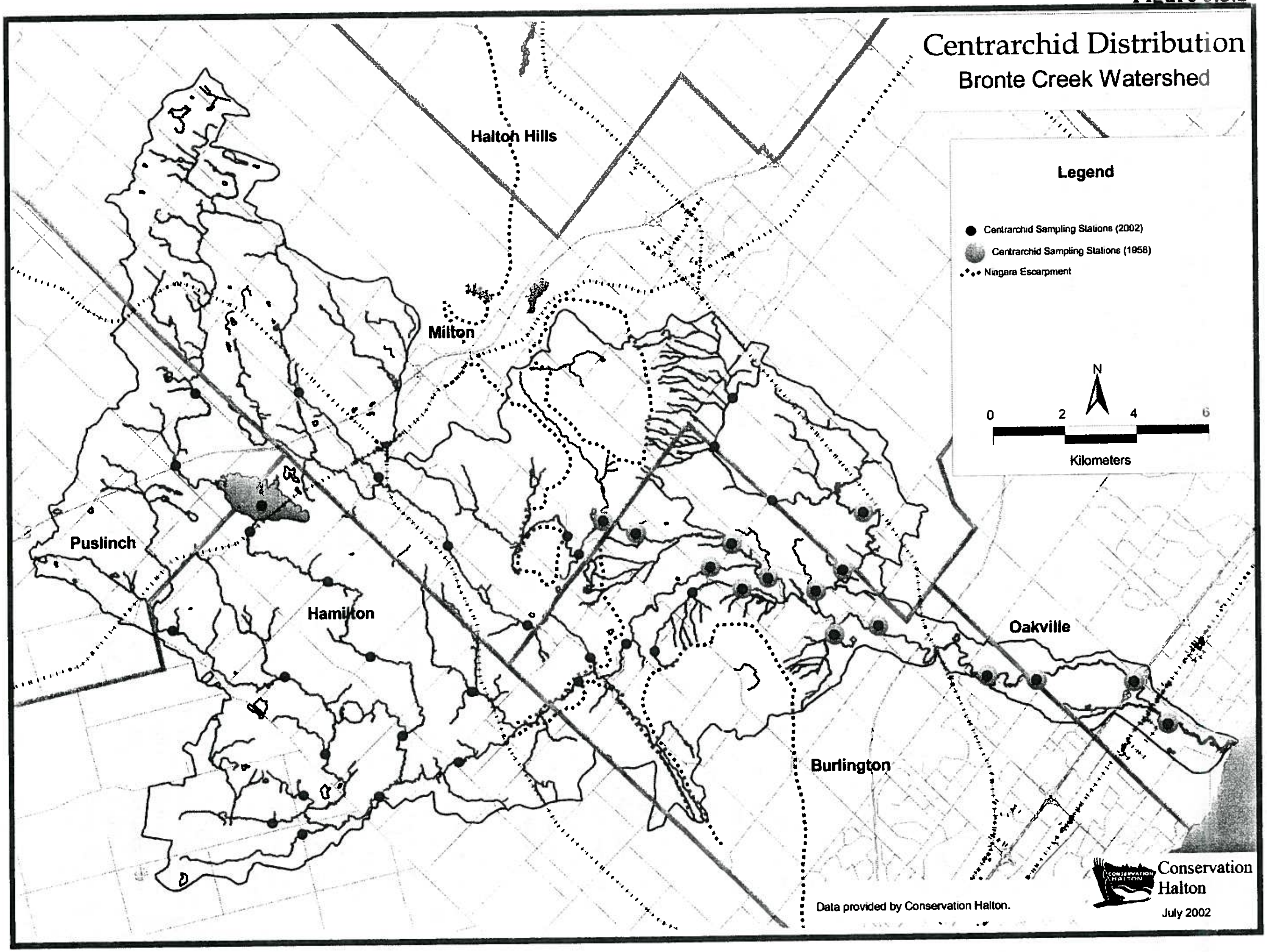

Northern Pike Distribution
Bronte Creek Watershed
Legend
Northern Pike Sampling Stations
Niagara Escarpment
N
0 2 4 6
Kilometers
Halton Hills
Milton
Oakville
Burlington
Hamilton
Puslinch
Fisheries Data Collected by Conservation Halton.
Conservation Halton
June 2002

Figure 5.5.1

Figure 5.5.2


Centrarchid Distribution
Bronte Creek Watershed
Legend
Centrarchid Sampling Stations (2002)
Centrarchid Sampling Stations (1958)
Niagara Escarpment
N
0
2
4
6
Kilometers
Halton Hills
Milton
Puslinch
Hamilton
Oakville
Burlington
Data provided by Conservation Halton.
Conservation Halton
July 2002

CHAPTER 6: *INSTREAM TEMPERATURE SURVEY*

6.1 Study Protocol

A formal instream temperature survey of the Bronte Creek watershed was conducted during the summers of 1998 to 2001 using the thermal stability methodology developed by Stoneman and Jones (1996). This methodology was developed to determine the presence and location of coldwater, coolwater and warmwater habitats in southern Ontario.

Following two to three days of relatively stable, warm weather (no precipitation, maximum air temperatures greater than 24.5°C), water temperatures were taken at easily accessible stations (typically roadsides and bridges) between 4:00 and 4:30 p.m. This measurement represented the maximum daily water temperature and was compared with the maximum daily air temperature (obtained from Pearson International Airport) using the nomogram designed for southern Ontario streams (Stoneman and Jones, 1996). Based on the protocol, coldwater sites ideal for brook trout and brown trout have an average daily maximum temperature of approximately 14°C. Coolwater sites average approximately 18°C and are ideal for rainbow trout while warmwater sites have average maximum daily water temperatures of approximately 23°C.

The thermal stability protocol provides a general depiction of instream thermal conditions within the watershed. However, it is limited in that it may not identify local areas of thermal refugia (groundwater upwellings, spring sources) which may support salmonids during periods of thermal stress in otherwise marginal coolwater and warmwater habitats.

Seventy-seven stations were sampled using this methodology in 1998, 1999 and 2000 (Figure 6.1). The distribution of instream temperature stations by tributary and subreach is provided in Table 6.1. Results of station sampling are provided in Appendix 1.

Observed thermal conditions were compared with historical descriptions of instream thermal regimes provided in the TMCCR and the ABCW. The instream temperature database was also used to identify and prioritize aquatic habitat restoration opportunities within the Bronte Creek watershed. It is anticipated that a combination of dam removal, natural channel design and riparian plantings could be undertaken to enhance aquatic habitat with an emphasis on restoring high quality habitats for sensitive native fish communities. The thermal regimes predicted by the protocol within Bronte Creek and its tributaries are illustrated in Figure 6.2.1 and are described in the following subsections.

Table 6.1. Distribution of Instream Temperature Stations by Subreach and Tributary.

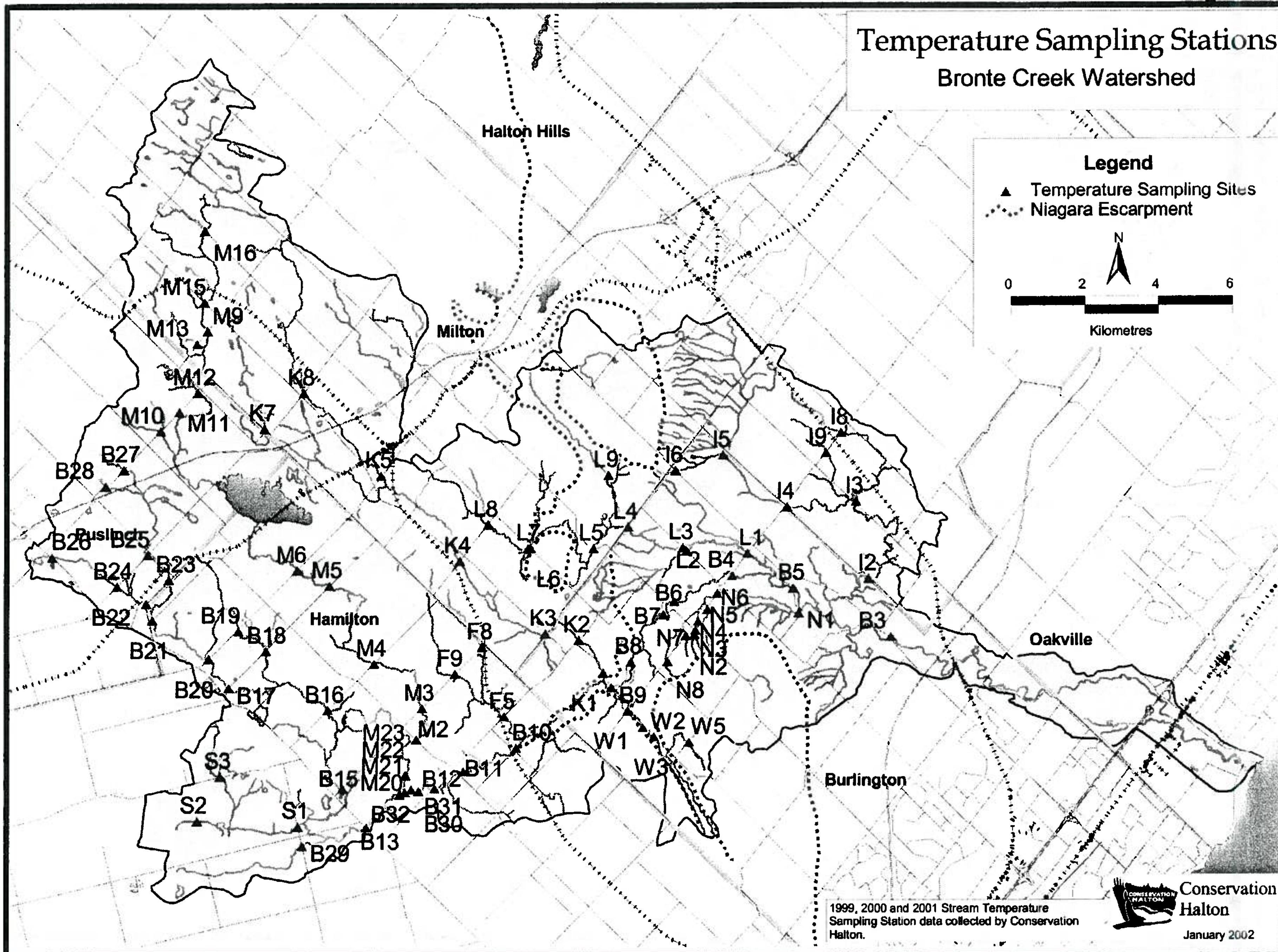
Tributary/Subreach	Stations
Bronte Creek: (Estuary to Lowville)	4
Bronte Creek: (Lowville to Progreston)	4
Bronte Creek: (Progreston to Headwaters)	19
Mount Nemo Creek	0
Indian Creek	7
Lowville Creek	8
Limestone Creek	9
Willoughby Creek	4
Kilbride Creek	7
Flamboro Creek	3
Mountsberg Creek	11
Strabane Creek	2

6.2 Subreach and Tributary Descriptions

6.2.1 Bronte Creek (Estuary)

Sampling was not conducted in this reach. Warmwater habitat is typically associated with

Figure 6.1


Temperature Sampling Stations
Bronte Creek Watershed
Legend
Temperature Sampling Sites
Niagara Escarpment
N
0 2 4 6
Kilometres
Halton Hills
Milton
Hamilton
Oakville
Burlington
Puslinch
M16
M15
M9
M13
M12
M10
M11
K8
K7
K5
B27
B28
B26
B25
B24
B23
B22
B21
B20
B19
B18
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B16
B15
B13
B29
S1
S2
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M6
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B30
B12
B11
B10
F5
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F9
K4
K3
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L8
L7
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L3
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I6
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I4
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B8
B9
B3
N1
N2
N3
N4
N5
N6
N7
N8
W1
W2
W3
W5
1999, 2000 and 2001 Stream Temperature Sampling Station data collected by Conservation Halton.
Conservation Halton
January 2002

Figure 6.2.1

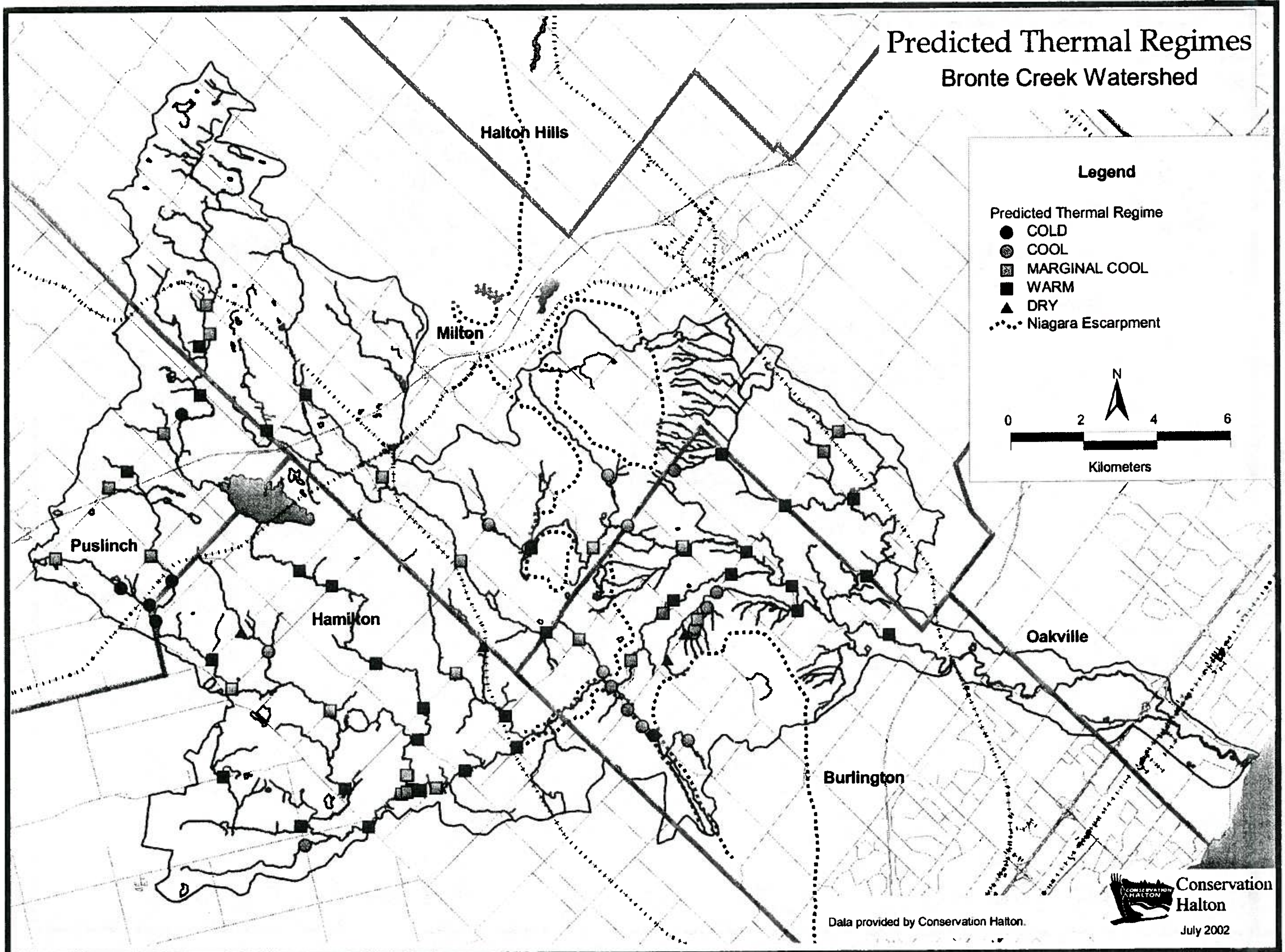
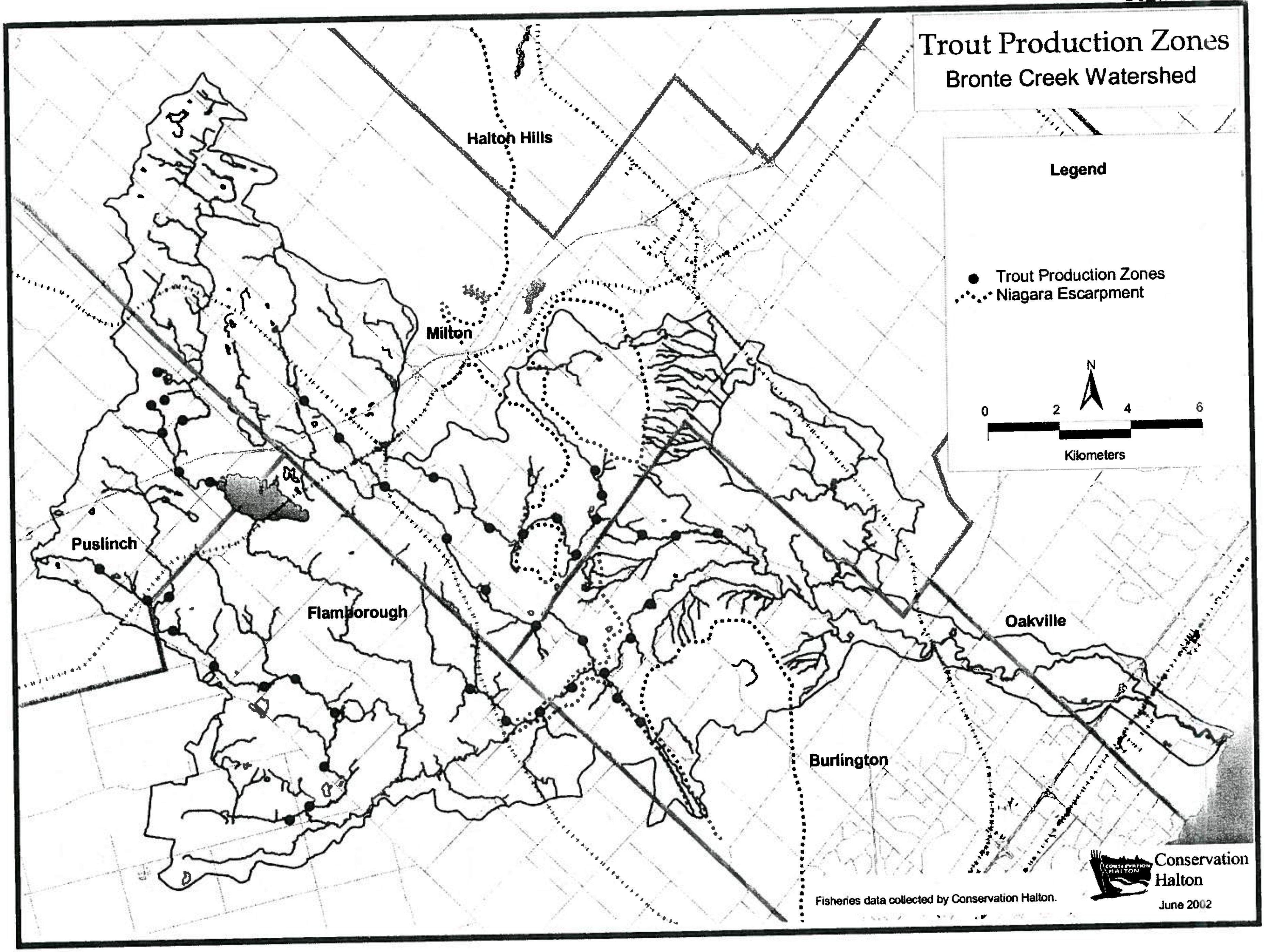

Predicted Thermal Regimes
Bronte Creek Watershed
Legend
Predicted Thermal Regime
COLD
COOL
MARGINAL COOL
WARM
DRY
Niagara Escarpment
N
0
2
4
6
Kilometers
Halton Hills
Milton
Puslinch
Hamilton
Oakville
Burlington
Data provided by Conservation Halton.
Conservation Halton
July 2002

Figure 6.2.2



Trout Production Zones
Bronte Creek Watershed
Legend
Trout Production Zones
Niagara Escarpment
N
0
2
4
6
Kilometers
Halton Hills
Milton
Puslinch
Flamborough
Oakville
Burlington
Fisheries data collected by Conservation Halton.
Conservation Halton
June 2002

this wide, exposed and low gradient reach. Lower portions of this reach may be periodically impacted by coldwater upwelling along the Lake Ontario shoreline during the summer months. This phenomenon is associated with sustained north/north-west winds which push warmer lake waters toward the New York shoreline, allowing cold, hypolimnetic waters to be exposed along the north/northwest shoreline of Lake Ontario.

6.2.2 Bronte Creek (Estuary to Lowville)

Four stations were sampled in this reach. From Lake Ontario upstream to the Lowville Dam, Bronte Creek provides warmwater habitat with significant warming observed between Lowville Park and Appleby Line. This is consistent with thermal impacts associated with the Lowville dam combined with a general lack of groundwater discharge and the relatively wide, exposed nature of the channel downstream of Lowville. This assessment is generally similar to the TMCCR and ABCW and corresponds well with the existing fish community. However, the TMCCR report did indicate that coolwater habitat persisted downstream of Lowville to Britannia Road.

6.2.3 Bronte Creek (Lowville to Progreston)

Four stations were sampled in this reach. Instream temperatures are indicative of coolwater and marginal coolwater/warmwater habitat. Spring-fed tributaries (Flamboro Creek, Kilbride Creek, Willoughby Creek and smaller systems) and areas of coldwater refugia associated with specific areas of groundwater upwelling (B. Christmas, pers. comm.) maintain pockets of viable coolwater habitat through otherwise marginal reaches. These significant areas of groundwater discharge are associated with groundwater movement into and through the sands and gravels of the glacial spillway and tend to moderate the thermal impacts associated with the Progreston and Dakota Mills dams. This description is consistent with the 1960 and 1980 reports and corresponds well to the existing fish community.

6.2.4 Bronte Creek (Progreston to Headwaters)

Main Branch

Twelve stations were sampled in this reach. Coldwater habitat is present on the main branch (downstream of Morriston) from Leslie Road downstream to an on-line pond located upstream of Campbellville Sideroad. Significant spring discharge at Maddaugh Road contributes to summer instream temperatures which do not rise above 10°C even under conditions of extreme heat and drought (i.e. Summer 1999). Coldwater conditions continue downstream past McRae Road; however, an on-line pond upstream of Campbellville Road appears to result in thermal impacts which adversely affect this significant coldwater resource (warmwater conditions at Campbellville Road).

Marginal coolwater/warmwater habitat extends from Mountsberg Road downstream to 10th Concession; however, brook trout continue to persist through portions of this reach. Downstream of 10th Concession, sections of poor riparian cover and extensive channel alterations through Courtcliffe Park and Carlisle Conservation Area contribute to an overall warming trend. However, groundwater discharge within the wetlands of the Flamborough Plain and from springs/upwellings associated with the Norfolk sand plain provide areas of coldwater refuge which continue to provide marginal salmonid habitat (brook trout and brown trout) through the summer months.
The 1960 and 1980 reports do not provide a similar level of instream temperature profiling on the main branch. The 1960 report indicated that coldwater habitat (with summer instream temperatures cooler than that observed downstream of Progreston) extended downstream to Centre Road while the 1980 report indicated that Bronte Creek and all of

its tributaries upstream of Progreston supported coolwater/coldwater habitat.

Northeast Tributary

A headwater tributary, originating upstream of Highway 401, enters the main branch downstream of Maddaugh Road. Four stations were sampled along this tributary. The west branch of this tributary emanates from a swamp upstream of Calfass Road, providing coolwater habitat which likely extends downstream of Highway 401. The east branch drains agricultural lands and is largely supported by tile drainage during periods of drought. Warmwater habitat extends downstream to its confluence with the west branch. The middle reach of this tributary system has been channelized and can be intermittent during periods of extended drought (Conservation Halton, 1998). Permanent flow and coolwater conditions become re-established upstream of Maddaugh Road and extend to the Bronte Creek confluence.

East Tributary

A second tributary system enters Bronte Creek at 12th Concession. Arising west of Mountsberg Reservoir, this tributary appears to be fed primarily by surface flow and is intermittent downstream to at least Mountsberg Road. Two stations were sampled; however, negligible flows were observed at this station in July 1998 (prior to the peak of the drought).

West Tributary

Further downstream, an un-named tributary of Bronte Creek was assessed at Brock Road immediately south of 8th Concession (West Flamborough). Similar to Strabane Creek, this tributary emanates from the Beverly Swamp. This tributary provides coolwater habitat; however, flows may be intermittent during extended periods of drought (CH, 2001).

6.2.5 Mount Nemo Creek

No stations were sampled on this creek; however, based on the physiographic similarities to Lowville Creek and anecdotal evidence of intermittent flows from adjacent landowners, Mount Nemo Creek is best characterized as a warmwater system with intermittent flows during periods of drought. This characterization matches that provided in the ABCW and corresponds well with the existing fish community. The TMCCR did not provide an assessment of this watercourse.

6.2.6 Indian Creek

Seven stations were sampled along Indian Creek. With the exception of a tributary in the vicinity of Appleby Line and Derry Road, Indian Creek and its tributaries provide warmwater habitat. On-line ponds, lack of riparian vegetation and lack of groundwater discharge contribute to warmwater conditions. This corresponds well to the instream temperature description provided in the ABCW and the existing fish community. It is interesting to note that the TMCCR indicated that permanent coldwater conditions extended downstream from the Appleby Line tributaries to Britannia Road. The justification for this classification is unknown. It is likely that land use within the watershed has remained relatively static (i.e. intensive agriculture) since the early 1900s.

Intermittent flow conditions on the main branch of Indian Creek downstream of Bell School Line to Bronte Creek have been observed during periods of extended drought (Conservation Halton, 1999, 2001) indicating that baseflow tends to infiltrate into the valley alluvium as the water table drops. Isolated pools provide areas of refuge for fish during these periods.

6.2.7 Lowville Creek

Eight stations were sampled along Lowville

Creek. With the exception of the Lowville Golf Course tributary, which is permanently fed by springs along the Escarpment the other tributaries arising from Mount Nemo are intermittent, particularly during drought conditions. The cold spring source has historically been impacted by an on-line pond at the Lowville Golf Course; however, recent works have resulted in the bypass of cool baseflows around the pond and back into the stream. Station sampling indicated that coolwater conditions extend downstream from Guelph Line to Walkers Line with significant warming occurring between Walkers Line and the Bronte Creek confluence. This assessment is consistent with that provided in the TMCCR. The existing fish community within Lowville Creek is more typical of a warmwater, possibly intermittent, watercourse. It is open to conjecture whether this community reflects true intermittent flow conditions or the extirpation of more sensitive species as a result of excessive water-taking during the recent drought.

Marginal/intermittent flow conditions have been observed throughout this system during periods of extended drought (Portt, 1981; Conservation Halton, 1999/2001). Baseflow appears to infiltrate into the valley alluvium downstream of Britannia Road as the water table drops. Recent changes in golf course water taking may increase the duration of flows in the system during periods of drought.

6.2.8 Limestone Creek

Nine stations were sampled along Limestone Creek. Fed by springs south of No. 3 Sideroad, the west branch of Limestone Creek provides coolwater habitat conditions downstream to its confluence with the east branch just north of Derry Road. The east branch and downstream portions of the west branch are fed by groundwater discharge from the deep sand and gravel aquifers associated with the Nassagaweya Canyon. Downstream of Derry Road, forest cover along Limestone Creek becomes less dense as agricultural land uses associated with the Peel Plain become dominant. Instream temperatures move toward the coolwater/warmwater margin as Limestone Creek approaches its confluence with Bronte Creek. The thermal stability profile of Limestone Creek closely resembles the descriptions provided in the TMCCR and ABCW. The coolwater habitat conditions upstream of Derry Road do not correspond with the healthy brook trout populations (coldwater habitat indicator) through these reaches.

A set of tributaries emanating downslope of Islay Lake coalesce and enter Limestone Creek immediately downstream of Walkers Line. With the exception of the tributary crossing No. 8 Sideroad, these tributaries are intermittent during the summer months. This minor system appears to support warmwater habitat.

6.2.9 Willoughby Creek

Four stations were sampled on this system. Willoughby Creek provides coolwater habitat from Cedar Springs Road downstream to its confluence with Bronte Creek. Groundwater inputs through the Medad Valley and from the Bronte Creek valley glacial spillway support steady baseflow and a coolwater temperature regime despite the presence of a number of on-line ponds along Cedar Springs Road. A portion of flow emanates from the Nelson Quarry; however, pumping is intermittent and is dependent on water levels within the quarry. The Burlington Springs Golf Course intercepts a portion of this flow. Coolwater conditions assessed through sampling are consistent with the ABCW. The TMCCR report treated Willoughby Creek as a minor tributary and no biophysical information was provided for this system. The coolwater temperature regime does not correspond with the healthy brook trout population (coldwater temperature regime indicator) in Willoughby Creek.

6.2.10 Kilbride Creek

Seven stations were sampled on Kilbride Creek. Although instream temperatures are warm downstream of Burns Reservoir, springs entering Kilbride Creek upstream of Highway

401 via the Moffat Moraine rapidly contribute to marginal coolwater/warmwater habitat conditions which extend downstream past Steeles Avenue. McClure's Lake, located within the Coral Park Campground downstream of Steeles Avenue, is a large, on-line pond complex which exerts a warming influence that extends downstream past Derry Road; however, groundwater discharge from Kilbride downstream to the Bronte Creek confluence regenerates coolwater habitat conditions. This description is generally consistent with the ABCW report. The TMCCR indicated that coolwater habitat did not extend upstream past the CPR tracks whereas this report contends that coolwater habitat extends north of Highway 401. The coolwater temperature regime does not correspond with the healthy brook trout populations (coldwater temperature regime indicator) which characterize much of Kilbride Creek.

Between Steeles Avenue and Kilbride, baseflow in the watercourse appears to infiltrate into the valley alluvium as the water table drops during drought conditions. Intermittent flow conditions were observed in the middle portion of this reach (centred at McNiven and Derry Road) during the fall of 1998 (Conservation Halton, 1998). Low baseflow was also observed during Summer 2001; however, intermittent flows were not observed. Groundwater discharge upstream of Kilbride Road results in a regeneration of instream flow with permanent flow conditions persisting downstream to the Bronte Creek confluence.

6.2.11 Flamboro Creek

Three stations were sampled on this system. The tributary crossing at 10th Concession immediately west of Milborough Town Line provides a source of permanent coolwater flow which extends downstream to the on-line pond on the Carlisle Golf Course Property. Warmwater habitat is present downstream of the pond; however, groundwater inputs, particularly the springs emanating from the valley slopes where Flamboro Creek cuts into the Bronte Creek Valley, allow coolwater habitat conditions to regenerate within the watercourse. This description is similar to that provided in the ABCW but differs from the TMCCR which noted that the creek was intermittent, supporting warmwater habitat only. The coolwater temperature regime upstream of the on-line pond does not correspond with the healthy brook trout population (coldwater temperature regime indicator) which inhabits this reach.

6.2.12 Mountsberg Creek

Downstream of Mountsberg Reservoir

Seven stations were sampled downstream of the reservoir. Historically, coolwater habitat conditions within Mountsberg Creek appear to have extended downstream from Badenoch Swamp to the Bronte Creek confluence (Department of Commerce and Development, 1960). However, thermal impacts associated with the Mountsberg Reservoir (constructed 1967) extend downstream to the 11th Concession where groundwater inputs mark a return toward marginal coolwater/warmwater habitat. Unfortunately, a large on-line pond/marsh downstream of 11th Concession (adjacent to Lawson Trailer Park) is responsible for further thermal impacts which extend downstream to Centre Road. Significant groundwater inputs appear to enter Mountsberg Creek between Centre Road and Courtcliffe Park (coolwater habitat); however, channel alterations within the park result in a shift to warmwater habitat in the short distance prior to its confluence with Bronte Creek.

The ABCW indicated that coolwater/coldwater habitat downstream of Mountsberg Reservoir was re-established downstream of a series of springs which coalesce and discharge to the creek upstream of 10th Concession. However, the contribution of these springs during periods of drought may be negligible since no discharge from these springs was observed during the summer of 1999. Based on this observation and downstream sampling, the extent of warmwater habitat downstream of Mountsberg

Reservoir is greater than that described in the ABCW. The warmwater regime corresponds well with the existing fish community.

Upstream of Mountsberg Reservoir

Four stations were sampled upstream of the reservoir. The watercourse supports a mix of marginal coolwater/warmwater and warmwater habitats from its source near Brookville downstream to Milborough Town Line. Intermittent flow has been observed in this reach during extended periods of drought (CH, 2001). A tributary fed by springs at the base of the Galt Moraine discharges to the main channel immediately upstream of Milborough Town Line, providing a source of permanent flow. Although sampling was not conducted on this tributary, coldwater functions may be impaired by lack of riparian habitat upstream of the Moffat Swamp.

Significant baseflow contributions, emanating from at least four spring sources along the Galt Moraine west of Town Line, enter Mountsberg Creek upstream of Regional Road 36. Voluminous spring discharge at one source (coldwater regime) occurs upstream of the Rainbow Ranch Fly Fishing Club ponds and within the ponds themselves; however, the on-line ponds result in thermal warming which is apparent at Regional Road 36. Two spring-fed tributaries flow through the Badenoch Swamp to the west of Rainbow Ranch, entering the main branch downstream of Regional Road 36. These coldwater tributaries contribute an overriding coolwater influence which extends downstream to Mountsberg Reservoir. Another spring-fed tributary located immediately west of Badenoch Swamp in the vicinity of Watson Road has been reported (R. Steele, pers.comm.); however, its significance is tempered by several on-line ponds at its source.

The TMCCR and ABCW reports do not provide a similar level of instream temperature profiling on Mountsberg Creek upstream of the reservoir. These reports indicated that Mountsberg Creek and all of its tributaries supported coolwater/coldwater habitat. The temperature regimes indicated by the protocol correspond well with the existing fish community.

6.2.13 Strabane Creek

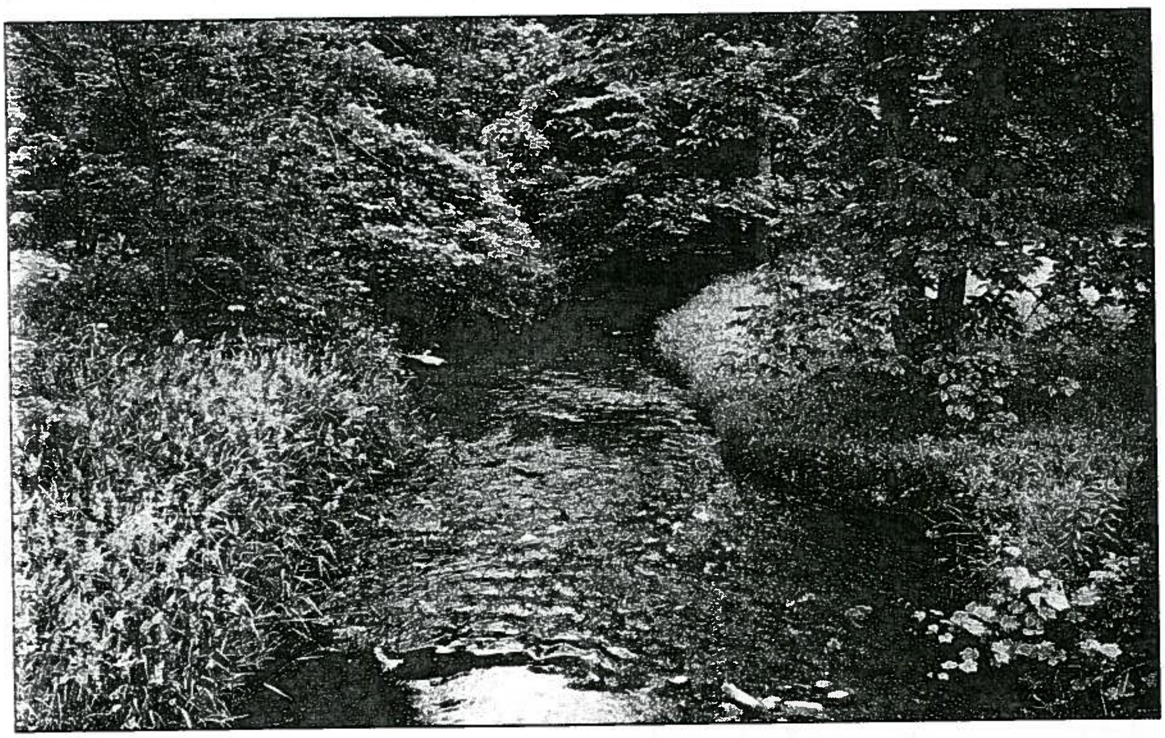
Two stations were sampled on Strabane Creek. Emanating from the Beverly Swamp, the headwaters of Strabane Creek appear to provide coolwater habitat. A large on-line pond located downstream of Middletown Road is associated with thermal impacts which appear to extend to Brock Road where marginal coolwater/warmwater habitat is present. Immediately downstream of Brock Road, active zones of groundwater discharge moderate summer temperatures providing coolwater conditions which extend downstream to Bronte Creek. A tributary which flows south into Strabane Creek from Highway 97 is intermittent during periods of drought and appears to convey warmwater discharge to the creek under typical flow conditions. This assessment is similar to descriptions provided in the TMCCR and ABCW. The coolwater temperature regime downstream of Brock Road does not correspond with the healthy brook trout population (coldwater temperature regime indicator) which inhabits this reach.

6.3 Summary

The instream temperature survey illustrates the over-riding influence of physiography within the watershed. Coldwater and coolwater habitat capable of supporting salmonids is typically associated with the well-vegetated, coarser-grained physiographic features along, or lying above, the Niagara Escarpment. Atypical areas of warmwater habitat within these features are generally associated with the construction of on-line ponds, channel dredging and the loss of riparian vegetation.

Warmwater habitat conditions are generally associated with the sparsely vegetated, finer-textured till plain features located below the Escarpment. Coolwater habitat conditions may persist some distance downstream of the Escarpment particularly where riparian cover is maintained along the banks of the watercourse.

According to the thermal stability protocol, there are few areas of prime coldwater habitat suitable for brook trout within the Bronte Creek watershed. Coolwater habitat suitable for brown trout and rainbow trout, while more abundant, is also fairly limited in distribution according to the protocol. A comparison of fish community data with the thermal habitats predicted by the thermal stability protocol (Figure 6.2.2) indicates that apparently healthy populations of all three trout species are found within a range of predicted thermal habitats including coldwater, coolwater and marginal coolwater/warmwater habitats. In some cases, the presence of these trout populations in otherwise unsuitable habitat may be associated with the presence of isolated coldwater refugia. However, the broad distribution of trout in marginal areas appears to indicate that trout populations in Bronte Creek have adapted to sub-optimal thermal habitats. It is interesting to note that the few coldwater stretches in the watershed support brook trout to the near total exclusion of other fish species. For the remainder of the report, to avoid confusion, all stream reaches which support salmonids will be deemed coldwater habitat while other reaches will be designated as warmwater habitat.



Limestone Creek at Britannia Road

CHAPTER 7: *BENTHIC COMMUNITY STUDY*

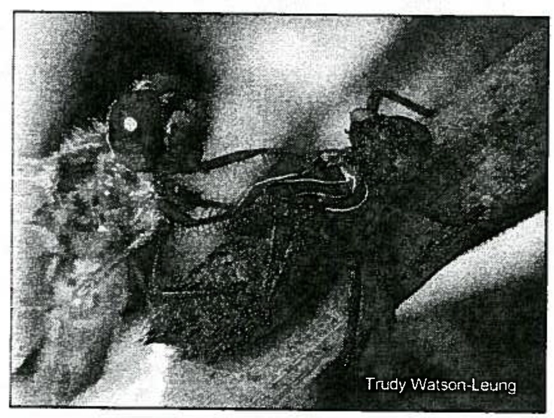
7.1 Introduction

Benthic macroinvertebrates are "bottom dwelling" organisms that are associated with the substrata of a watercourse or water body, for at least part of their life cycle. Representative groups include aquatic insects such as stonefly larvae, mayfly larvae, caddisfly larvae, beetles, true bugs, flies and other invertebrates including isopods, amphipods, crayfishes, mollusks and worms.

Benthic macroinvertebrates are widely used as bioindicators in the assessment of water quality because they are very abundant, easily sampled, continuously subject to local environmental stressors and show a wide range of tolerances to various degrees and types of pollution. Benthic macroinvertebrates are extremely beneficial in water quality assessments since they cannot avoid stressor-related events in the stream, which may be missed by traditional chemical analyses if not sampled during the event. Furthermore, the benthic community composition can provide a means to monitor changes in local ecosystems and water quality.

It is important to distinguish "water quality" as discussed in this section of the technical appendices, may differ from those in other sections. Our definition of water quality deals entirely with ecological water quality as it relates to physicochemical parameters and not water quality as it pertains to human health, although we recognize that both are intertwined.

Adjacent and upstream land use affects water quality in streams and rivers. Aquatic benthic communities downstream of urban environments are affected by urban stormwater runoff which may contain road salts, tars, oils, gasoline, metals, rubber tire derivative and elevated temperatures (Mackie, 1998). Urban land development can have a twofold effect on aquatic systems and benthic organisms due to increases in sediment loads during construction and increases in storm discharge due to development (increase in impervious area leading to reduced infiltration and increased surface runoff). Poor agricultural and animal husbandry practices can also adversely impact water quality. Animal access to streams can result in increased sediment loads, habitat destruction and organic enrichment. Runoff from fields can result in organic enrichment (fertilizers), increased sediment loading and the direct input of pesticides and herbicides into the stream (Mackie, 1998) if there is not an adequate buffer between the active field and the stream. Direct and indirect habitat loss, including the destruction of upstream wetlands, can also degrade water quality. Artificial impoundments such as dams, reservoirs and on-line ponds have detrimental effects on streams and rivers by imposing a lentic habitat within a lotic system (Mackie, 1998), disrupting stream dynamics and increasing stream temperatures.



Dragonfly adult emerging

7.2 Sampling, Lab Protocol and Analysis

To assess water quality within the Bronte Creek watershed on an ecological basis, 32 benthic macroinvertebrate stations were sampled from April to September during 1999 and 2000 (Figure 7.1, Table 7.1 and Appendix 3). Although benthic samples are ideally obtained during the early spring and late fall to ensure the collection of more mature insects, this was not feasible given the limited staff resources available during these time periods. The stations were selected to provide an overview of the benthic resources and water quality throughout the watershed, from the lower reaches to the upper headwaters. Stations in the smaller tributaries were chosen near their confluence with Bronte Creek to represent their contribution to water quality in the main branch of the creek.

Benthic sampling followed the BioMAP protocol (Griffiths, 1998), coinciding with Conservation Halton's evaluation of the BioMAP protocol. Two quantitative Surber samples (0.093 m^2 sampling area) were collected from riffle habitats and one qualitative D-Frame sweep sample was collected from representative habitats at each station. The quantitative samples were initially collected with a mesh size of 1000 *u*m, but was changed to 600 *u*m mesh in July 2000, to accommodate the collection of smaller macroinvertebrates. Each sample was live-sorted and preserved in 90% ethanol. Sample identification was performed in the lab using a standard dissecting microscope (up to 40x magnification). Specimens were identified to the "lowest practical taxonomic level" whenever possible. Some species or genera could not be identified to the lowest practical level due to magnification constraints.

Several biological indices were utilized to assess each site including: abundance, taxa richness, Shannon-Weaver Diversity Index (SDI), Hilsenhoff Biotic Index (HBI), Total number of Mayfly (Ephemeroptera), Stonefly (Plecoptera) and Caddisfly (Trichoptera) species (EPT) and BioMAP Water Quality Index (WQI). The distribution of taxa, trophic relationships and taxa dominance (>5 %) were also examined at each site.

It should be noted that the majority of biotic indices may produce inaccurate results for streams that deviate from the typical "ideal" stream continuum (i.e. low gradient and/or sand-based headwater stream). This factor was taken into account as part of our assessment of atypical stations (low gradient headwater streams with fine substrates and poorly developed riffle sections) with recommendations for future monitoring of these systems provided in Section 7.4.

A brief description of this study's water quality designation, the biological indices, their water quality associated scores and their biological standards (Table 7.2) are provided below.

Table 7.1. Distribution of Benthic Stations by Subreach and Tributary.

Tributary/Subreach	Stations
Bronte Creek: (Estuary to Lowville)	4
Bronte Creek: (Lowville to Progreston)	2
Bronte Creek: (Progreston to Headwaters)	5
Mount Nemo Creek	1
Indian Creek	4
Lowville Creek	1
Limestone Creek	3
Willoughby Creek	1
Kilbride Creek	3
Flamboro Creek	1
Mountsberg Creek	6
Strabane Creek	1

Benthic Sampling

Table 7.2. Summary of Water Quality Designations Associated with Various Benthic Index Ranges and Biological Standards.

Water Quality Designation	BioMAP	HBI Pollution	HBI	Richness	SDI	Biological Standard
Nonimpairment	Unimpaired	Excellent-organic pollution unlikely	0-3.5	>26	>4	Sensitive facultative and tolerant organisms generally represented. no species in excessively large numbers, best situation, balanced trophic structure, optimum community structure for stream size and habitat quality, habitat natural and free flowing
Slight impairment	Unimpaired/ gray	Very Good-possible slight organic pollution	3.51-4.50	19-26	3-4	Sensitive groups reduced in density or absent, facultative groups increasing in number, community structure less than expected, species richness may be less than expected due to intolerant form loss, habitat minimally impaired with limited human interference
Moderate impairment	Gray/Impaired	Good-Fair-some to fairly significant organic pollution	4.51-6.50	11-18	2-3	All sensitive species absent and facultative groups dominate or reduced/fewer species due to loss of intolerant forms, reduction in EPT, habitat impaired human interference prevelant
Substantial impairment	Impaired	Fair-FairlyPoor-fairly significant to significant organic pollution likely	5.51-7.5	4-10	<2	Facultative and tolerant species only or species insensitive to low oxygen present, few species present, dominated by one or two taxa, human impact severe
Severe impairment	Impaired	Poor-Very Poor-very significant to severe organic pollution	7.51-8.5	<4		Only most tolerant groups present, few species present, dominated by one or two taxa, human impact extremely severe
Severe impairment	Impaired	Poor-Very Poor severe organic pollution	8.51-10.00	0		No invertebrates

Abundance and Richness: Total number of individuals per sample and total number of taxa per sample respectively. Generally, this value increases with increasing water quality and habitat diversity. However, some pristine streams are naturally unproductive, such that the richness and abundance values are low. In these conditions organic enrichment may result in an increase of taxa and diversity. These indices are sensitive to various perturbations including toxic substances, severe temperature alterations, siltation and nutrient enrichment. Since the samples in this study were identified to the lowest practical level, the richness values may be underestimated. Mesh size of the sampling device also affects abundance and therefore richness values.

Shannon-Weaver Diversity Index (SDI): Combines richness with the distribution of individuals (evenness). An uneven community distribution can be an indicator of community instability. Impairment is often associated with changes in relative proportions of taxa and thus is reflected in the SDI. There are some naturally occurring environments where diversity is low, such as blackfly-dominated high gradient streams. The level of taxonomic identification affects SDI (i.e. scores may be underestimated at coarser levels of identification). SDI is calculated using the formula:

$$SDI = -\Sigma (n_i / N * \text{Log}_e\, n_i/N)$$

n_i = number of individuals of species *I*

N = total number of individuals

Hilsenhoff Biotic Index (HBI) (Hilsenhoff, 1987): Taxa are assigned "tolerance values" based on their tolerance to organic pollution. The HBI score is the mean tolerance value for all the taxa in a sample and scores range from 0 to 10. Scores increase as water quality decreases. Although designed for use in Wisconsin, modified versions are widely accepted. The index was developed as a means of detecting organic pollution in benthic communities in rock/gravel riffle streams and may be misleading in streams of different substrates. In this study the index was modified to reflect the taxonomic precision of the study and family index values were substituted for those groups that could not be identified to genus or species. Seasonal correction factors for the HBI were not used. The HBI rates streams or sites by the degree of organic pollution as reflected by the benthic community. HBI is calculated using the formula:

$$HBI = \Sigma (n_i * \text{tolerance}_i / N)$$

n_i = number of individuals in species *I*

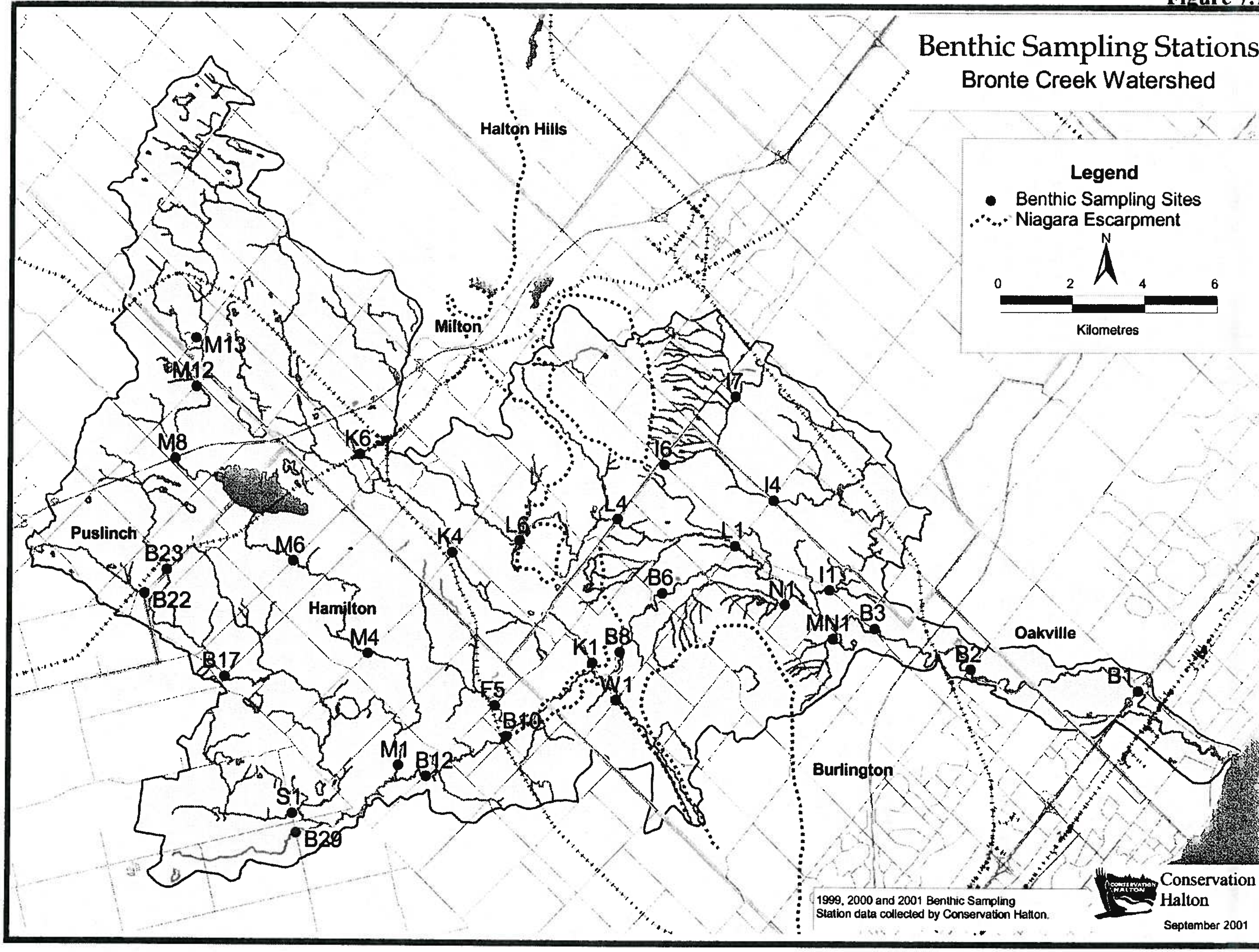
tolerance_i = tolerance value for species *I*

N = total number of individuals

Total number of Ephemeroptera, Plecoptera and Trichoptera species (EPT): A general indicator of stream quality based on the observance that these three orders are associated with cleaner water. Headwater streams that are naturally unproductive may experience an increased EPT in response to organic enrichment. This index is largely dependent on sampling season and maybe misleading since some species within these orders are pollution tolerant.

BioMAP WQI: Water quality index based on the vertical distribution of invertebrates along a watercourse from headwaters to lake. Taxa are assigned index values based on this vertical distribution in southern Ontario. WQI is sensitive to various perturbations within the stream such as organic pollution, temperature and oxygen concentration (Kilgour *et al.*, 2001). Sites are classified as "impaired" or "unimpaired" based on the index value and stream bankfull width. Water quality is unimpaired when the community of macroinvertebrates is not altered by human activities (Griffith, 1998). The BioMAP WQI is calculated using the formulae:

Figure 7.1


Benthic Sampling Stations
Bronte Creek Watershed
Legend
Benthic Sampling Sites
Niagara Escarpment
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Halton Hills
Milton
Puslinch
Hamilton
Oakville
Burlington
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MN1
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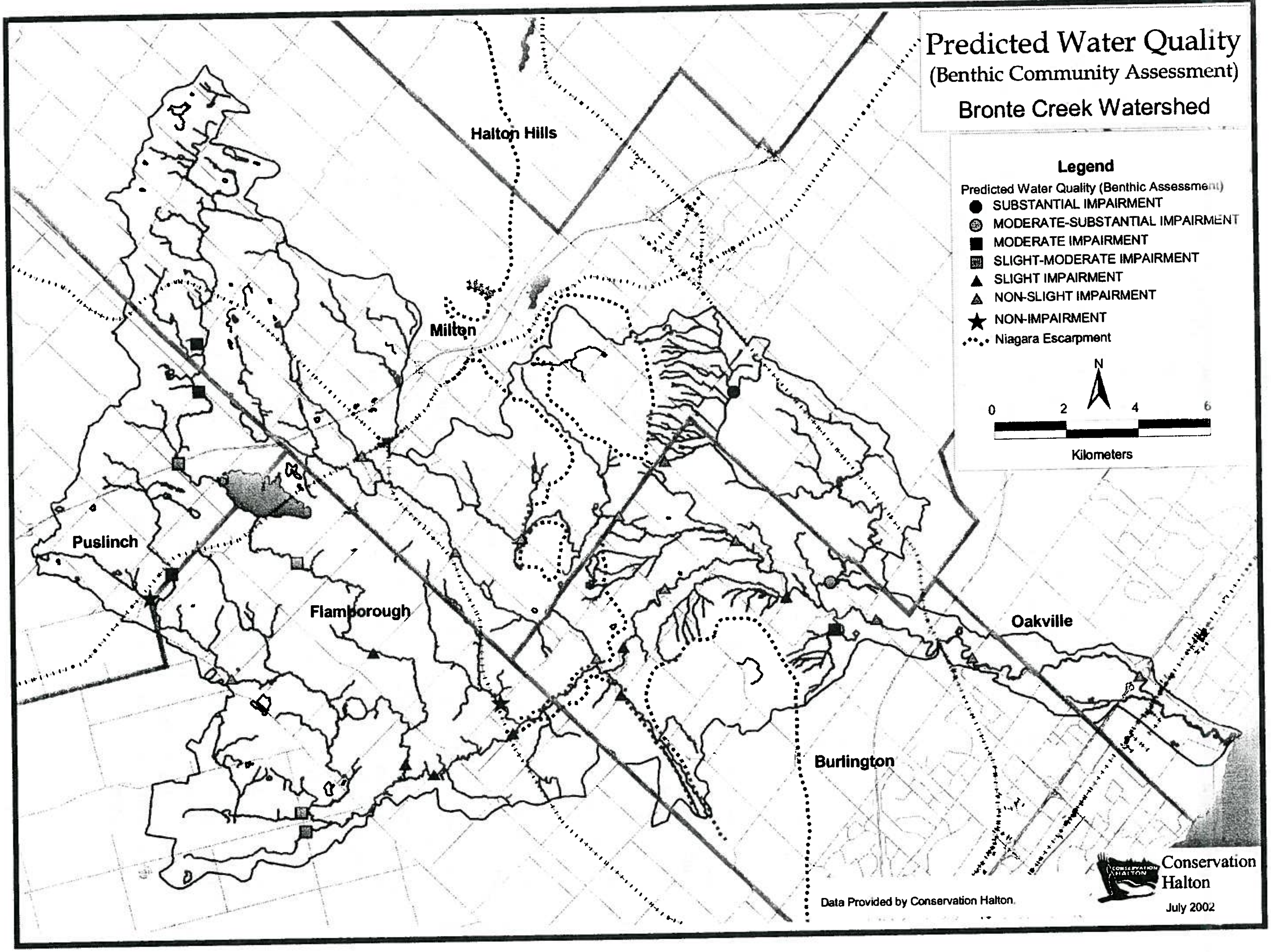
K1
B8
W1
B17
F5
B10
M1
B12
S1
B29
1999, 2000 and 2001 Benthic Sampling Station data collected by Conservation Halton.
Conservation Halton
September 2001

Figure 7.2


Predicted Water Quality
(Benthic Community Assessment)
Bronte Creek Watershed
Legend
Predicted Water Quality (Benthic Assessment)
SUBSTANTIAL IMPAIRMENT
MODERATE-SUBSTANTIAL IMPAIRMENT
MODERATE IMPAIRMENT
SLIGHT-MODERATE IMPAIRMENT
SLIGHT IMPAIRMENT
NON-SLIGHT IMPAIRMENT
NON-IMPAIRMENT
Niagara Escarpment
N
0
2
4
6
Kilometers
Halton Hills
Milton
Puslinch
Flamborough
Oakville
Burlington
Data Provided by Conservation Halton.
Conservation Halton
July 2002

WQI (quantitative samples):

WQI =
$[\Sigma (e^{SV_i} * Ln (x_i + 1))] \div [\Sigma Ln (x_i +1)]$

SV_i = sensitivity of the i^{th} taxon
x_i = density of the i^{th} taxon
n = total number of taxa per sample

WQI (qualitative):

WQI =
$1/k [\Sigma (SV_i]$, with k = integer (n/4), $k \leq 4$

SV_i = sensitivity of the i^{th} taxon ranked from highest to lowest
n = total number of taxa per sample

The water quality assessments at each station and reach were based quantitatively and qualitatively on the analyses of the benthic indices and biological criteria detailed in Table 7.2.

7.3 Results and Discussion

An overall summary of water quality of Bronte Creek and its tributaries, as determined through the analysis of multiple benthic indices, is presented in Figure 7.2. The following subsections provide a description of assessed conditions for each reach of Bronte Creek and its tributaries. A detailed analysis and description of each station can be found in Appendix 3 of this document.

7.3.1 Bronte Creek (Estuary)

Benthic sampling was not conducted in the estuary since standard stream indices could not be used in this lentic environment. This reach is also heavily influenced by Lake Ontario and a benthic assessment would not reflect water quality associated solely with Bronte Creek.

7.3.2 Bronte Creek (Estuary to Lowville)

Four stations were sampled within this reach. The water quality at these stations fell within the unimpaired and/or the slightly impaired categories (Table 7.2). The stations were characterized by benthic invertebrates typically found in mesotrophic conditions (elevated nutrient levels, moderate temperatures and moderate oxygenation levels), as would be expected for this reach of Bronte Creek (a third to fourth order stream). Filter feeders generally dominated the community.

Runoff from adjacent agricultural lands and contributions from the Indian Creek subwatershed likely contribute to nutrient loadings through this reach. Urbanization downstream of the QEW may have local effects on water quality via increased erosion potential and increased toxicants due to runoff. Locally significant groundwater discharge is known to occur within this reach which may enhance water quality in the vicinity of QEW.

7.3.3 Bronte Creek (Lowville to Progreston)

Two stations were sampled within the reach. Water quality at these stations fell within the slightly impaired category (Table 7.2). Elevated nutrient levels, low to moderate temperatures and high to moderate oxygen levels characterize this reach. The sites are characterized by a large number of filter feeders, predominately made up of the caddisfly *Hydropsyche* sp. The stream is likely adversely affected by the presence of significant dam structures and may also be impacted by residential land use through the Cedar Springs Community. Significant discharge of groundwater through the outwash deposits associated with the spillway counteract adverse impacts through this reach.

7.3.4 Bronte Creek (Progreston to Headwaters)

Five benthic stations were sampled throughout this reach (one on the west tributary, one on the northeast tributary, three on the main branch). Water quality within the stretch varied from nonimpairment to moderate impairment (Table 7.2). The west branch station, located in the village of Strabane, fell within the slight to moderate impairment categories, though this does not correspond to upstream land use. Intermittent flows, lack of suitable substrate and the low gradient of the site likely contributed to inaccurate results at this station. It is suggested that a suitable reference station be identified and used in comparison to this site (Section 7.4).

The station located on the main branch just downstream of the Mountsberg tributary fell into the slight impairment category, likely due to warming and ponding effects through Courtcliffe Park. The two stations further upstream on the main branch indicated nonimpairment. Significant groundwater discharge is associated with these stations.

The station on the northeast branch, indicated moderately impaired conditions, with significant organic pollution and elevated temperatures. This is most likely attributed to upstream channelization, poor agricultural practices and ponding. Major impacts within this reach are likely attributable to on-line ponds, channelization and removal of riparian cover. These impacts are partially counteracted by groundwater discharge and the presence of significant vegetation cover next to the watercourse.

7.3.5 Mount Nemo Creek

One station was sampled upstream of the Bronte Creek confluence. The water quality at the station was moderately impaired (Table 7.2), characterized by elevated nutrients and organic enrichment. The benthic community was dominated by isopods. The stream is likely intermittent during extended periods of drought. Air-photo analysis reveals upstream agricultural land use, upstream ponds and channelization, which may contribute to the observed organic pollution and elevated temperatures within Mount Nemo Creek.

7.3.6 Indian Creek

Four stations were sampled within this subwatershed. Water quality within the subwatershed was moderately to substantially impaired (Table 7.2), although one small, spring-fed tributary was classified as non-slightly impaired. Elevated nutrient levels, moderate to high temperatures and low oxygenation are indicative of the benthic community at the other three stations. Although intermittent flows may influence the results to some extent, it is likely that the results provide a true indication of poor water quality within the watershed. The major contributors to poor water quality appear to be lack of riparian cover, ponding, channelization and farm animal access to the creek.

7.3.7 Lowville Creek

One station was sampled near the mouth of the creek. The water quality at the station was slightly impaired (Table 7.2), with elevated nutrients and moderate oxygen levels. The stream exhibited intermittent flows during the drought years of 1998 and 1999, which may have influenced the results. Agricultural land use and upstream golf courses may contribute to moderate levels of organic pollution and elevated temperatures. Further sampling would aid in the classification of water quality in this tributary.

7.3.8 Limestone Creek

Three stations were sampled within this subwatershed. Water quality was non-impaired to slightly impaired (Table 7.2). The watershed is generally characterized by cold water temperatures and high to moderate oxygenation. The stream may be affected by nutrient inputs from an agricultural mushroom operation; however, any impacts appear to be offset by the significant amounts of groundwater discharge entering throughout the subwatershed upstream of Derry Road. Similar to other portions of the watershed upstream of the Escarpment, the upstream station in this subwatershed is a low gradient, non-gravel system. Since this system is atypical, the benthic indices used in the study may not be entirely applicable and it is suggested that a reference condition approach should be adopted for future monitoring of water quality conditions (Section 7.4).

7.3.9 Willoughby Creek

One station was sampled near the confluence with Bronte Creek. The water quality at the site was slightly impaired (Table 7.2), characterized by elevated nutrients, low to moderate temperatures and moderate oxygen levels. This slight impairment may be associated with the many manicured on-line ponds and possible septic inputs upstream of the site; however, significant groundwater discharge appears to counteract these impacts resulting in only minor impairment of water quality.

7.3.10 Kilbride Creek

Three stations were sampled within the subwatershed. Water quality within the subwatershed was generally non-impaired to slightly impaired (Table 7.2). The water was characterized by low to moderate temperatures, moderate to high oxygenation and mesotrophic conditions. Since much of the stream is a low gradient, non-gravel bottom type stream, the benthic indices used in the study may not be entirely applicable and it is suggested that a reference condition approach should be adopted for future monitoring purposes (Section 7.4).

7.3.11 Flamboro Creek

One benthic station was sampled upstream of the Flamboro creek and Bronte Creek confluence. The water quality at this station was non-impaired (Table 7.2) and was characterized by elevated nutrients, low temperatures and moderate oxygen levels. Several sensitive species were sampled at this site. The results were as expected since this reach of the creek flows through a forested valley with significant groundwater inputs which appears to counteract the effects of a large on-line pond associated with an upstream golf course.

7.3.12 Mountsberg Creek

Downstream of Mountsberg Reservoir

Three stations were sampled in the reaches downstream of the Mountsberg Reservoir. Water quality within the stretch is generally slightly impaired (Table 7.2). Mesotrophic conditions, moderate to high oxygenation and low to moderate temperatures characterize much of the subwatershed. Impacts associated with the Mountsberg Reservoir (nutrients, increased temperatures) appear to decrease downstream. The species assemblage changes from one dominated by filter feeders to a more balanced trophic group distribution which would be more typical of a second or third order stream.

Upstream of Mountsberg Reservoir

Two stations were sampled upstream of the Mountsberg Reservoir. Water quality in the reach is slightly impaired to moderately impaired (Table 7.2). Mesotrophic conditions, moderate oxygenation and moderate temperatures characterize much of the reach. Low gradients through the headwater wetlands may have influenced results at these stations; however, on-line ponds and agricultural practices within the subwatershed may be adversely impacting water quality. Further investigation of the water quality at the site is recommended using the reference condition approach (Section 7.4).

7.3.13 Strabane Creek

One station was sampled upstream of the Bronte Creek confluence. Water quality at this station is slightly to moderately impaired (Table 7.2) with elevated nutrients, moderate oxygenation and moderate temperatures. The low gradients through the wetlands upstream of the site may influence the community composition. A large upstream pond may be contributing to water quality degradation and elevated temperatures. Further investigation of the water quality at the site is recommended using the reference condition approach (Section 7.4).

7.4 Recommendations

The results of the benthic study correlated well with the instream temperature and fish community studies. Healthy, diverse fish communities were generally associated with reaches characterized by non-impaired or slightly impaired water quality. There were two significant exceptions noted as part of this assessment. The benthic community downstream of Mountsberg Reservoir is indicative of slightly impaired water quality and low to moderate temperatures whereas the fish community and instream temperature data consistently indicate warmwater habitat conditions. In Indian Creek, moderate to substantial impairment of water quality is indicated; however, the fish community is reasonably diverse. These exceptions illustrate the potential danger of using only one parameter to assess aquatic ecosystem health. It is important to investigate and integrate a suite of parameters to develop a holistic perspective on aquatic ecosystem health.

It is recommended that benthic monitoring be continued within the Bronte Creek watershed to assess water quality in conjunction with other monitoring efforts. Taxonomic resolution may be reduced to family level identification for most sites. Environmental criteria, including physical and chemical attributes, should also be adopted to aid in benthic stream assessments. Such attributes could include sediment embeddedness, substrate classification, stream side vegetation, overhead canopy, consolidation, temperature, dissolved oxygen, pH and nutrients levels.

As noted in Section 7.3, several stream reaches within the Bronte Creek watershed are considered atypical in that their characteristics do not match those typically associated with headwater stream systems. These reaches are generally associated with wetland complexes above the Niagara Escarpment and are characterized by low gradients, poor riffle development and fine substrates. Since most index scores are at least somewhat based on benthic organisms found in riffle areas, it is not surprising that at stations where riffles are weak or not present most indices will tend to indicate poor water quality when, in reality, they are reflecting available substrate and gradient at that particular station.

Future monitoring efforts in atypical reaches should adopt a "reference condition" approach to assess benthic communities. The reference condition approach uses data from relatively pristine sites with similar biological, chemical and physical characteristics as a baseline condition. Once the reference condition has been established, any site suspected of being impacted can be assessed through comparison to the reference condition.

CHAPTER 8: *AQUATIC ECOSYSTEM HEALTH*

An assessment of aquatic ecosystem health requires an assessment of the parameters that contribute to healthy aquatic ecosystems. These parameters are often studied in isolation; however, since they are closely intertwined in nature, an integration of these individual studies is required to form a holistic perspective on aquatic ecosystem health. This section integrates the results of stream corridor analyses from the following technical studies prepared in support of the Bronte Creek Watershed Study to provide an assessment of aquatic ecosystem health within the Bronte Creek watershed:

- Appendix 3 Aquatic Habitat Inventory and Assessment
- Appendix 4 Natural Heritage Report
- Appendix 5 Water Quality Report
- Appendix 6 Hydrology and Stream Morphology

Aquatic ecosystem health was defined as high, moderate and poor on a reach-by-reach basis through an assessment of the following parameters: water quality, benthic community, fish community, instream temperature regime, instream habitat and riparian cover. Table 8.1 provides a description of these parameters and their relationships to aquatic ecosystem health.

Table 8.1. Aquatic Ecosystem Health Parameters

Parameter	High Aquatic Ecosystem Health	Moderate Aquatic Ecosystem Health	Low Aquatic Ecosystem Health
Water Quality	Most parameters regularly meet PWQO*	Some parameters occasionally do not meet PWQO	Several parameters regularly do not meet PWQO
Benthic Community	Unimpaired	Moderate impairment	Impaired
Fish Community	Expected community based on stream order** and physiography	Moderate diversity, absence of expected species, presence of some non-indigenous species	Expected community not present (i.e. poor diversity, expected species absent, non-indigenous species abundant)
Instream Temperature Regime	Appropriate based on stream order and physiography	Marginal based on stream order and physiography (i.e. marginal coldwater habitat on Flamborough Plain)	Inappropriate based on stream order and physiography (i.e. warmwater habitat on Flamborough Plain)
Instream Habitat	Natural channel	Some alteration of aquatic habitat	Altered channel (on-line ponds, dredging, barrier to fish passage, livestock/farm animal access, urbanization)
Riparian Cover	Well buffered	Patchy/sporadic buffering	Absent/sparse buffering

*Provincial Water Quality Objectives

**Stream order is a method of ranking stream segments in a drainage basin in which larger (downstream) segments are given higher order numbers. Headwater tributaries are assigned order 1; where two order 1 streams combine, the next (downstream) segment becomes order 2; where two order 2 segments combine, the next (downstream) segment becomes order 3, etc. (Newbury and Gaboury, 1993).

Stream reaches characterized by high aquatic ecosystem health would have most, if not all, parameters within the high health category. Conversely, reaches characterized by low aquatic ecosystem health would have most parameters falling within the low health category. Aquatic ecosystem health within the Bronte Creek watershed is illustrated in Figure 8.1. It should be noted that this map does not necessarily correlate with regeneration priorities within the watershed. The following subsections provide a summary of aquatic health for each subreach/tributary within the Bronte Creek watershed.

8.1 Bronte Creek (Estuary)

The lentic environments and influence of Lake Ontario on this reach of Bronte Creek are not conducive to the types of sampling undertaken in the remainder of the watershed. Water quality sampling in the estuary indicated that most parameters regularly meet Provincial Water Quality Objectives (PWQO). The fish community is likely moderately impaired with large numbers of carp entering the marsh during the spring to spawn. Habitat alterations are associated with Bronte Harbour. Periodic dredging and maintenance of docking facilities is required to maintain the function of the harbour area. Riparian cover is good within the marsh but negligible within the harbour. Aquatic ecosystem health is high within Bronte Marsh but moderate to poor within Bronte Harbour.

8.2 Bronte Creek (Estuary to Lowville)

Benthic sampling indicates that water quality within this reach is generally unimpaired to slightly impaired while standard water quality sampling indicates that most water quality parameters regularly meet PWQO. Warmwater fish community and temperature regimes are consistent with expectations for a third or fourth order stream flowing through fine till plain features; however, Lowville Dam appears to constrain the downstream extent of coldwater habitat in Bronte Creek. With the exception of Lowville Dam and a partial barrier through the Sidrabene Community, no channel alterations are present through this reach. Riparian cover is patchy from Lowville downstream to No. 2 Sideroad but is extensive from No. 2 Sideroad downstream to the estuary. With the exception of the reach immediately downstream of Lowville, this section of Bronte Creek is considered to have high aquatic ecosystem health.

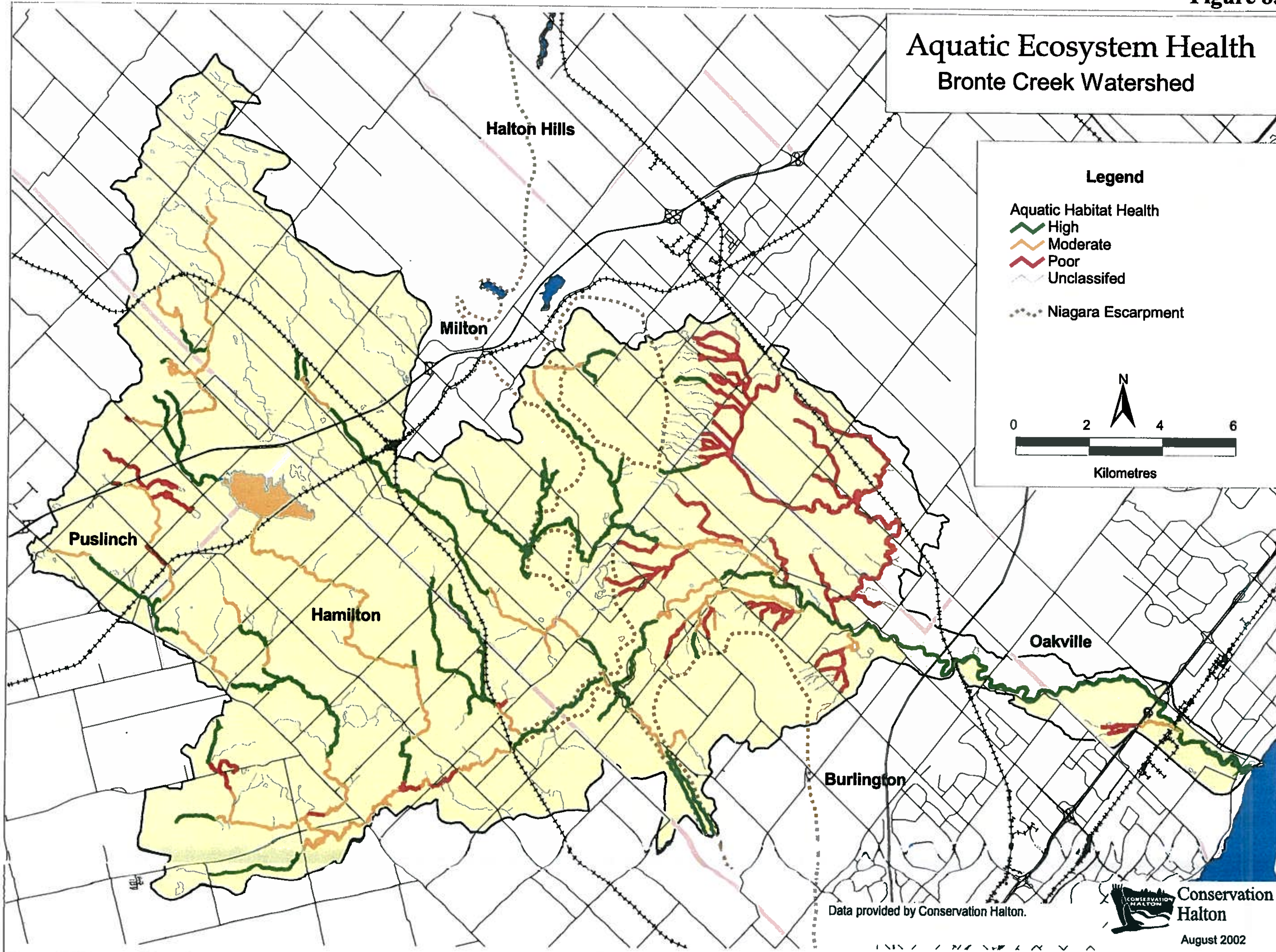
8.3 Bronte Creek (Lowville to Progreston)

Benthic sampling indicates that water quality in this reach is generally slightly impaired while standard water quality sampling indicates that most water quality parameters regularly meet PWQO. Temperature regimes are marginal for a third order stream flowing through a coarse outwash valley feature; however, this reach does support a productive coldwater fish community. The Progreston Dam and Dakota Mills Dam contribute to downstream warming and act as barriers to fish passage within this reach. With the exception of the Cedar Springs Community, the watercourse is generally well-buffered. Aquatic ecosystem health is rated as high with moderate health indicated immediately upstream of the Dakota Mills Dam.

8.4 Bronte Creek (Progreston to Headwaters)

Benthic sampling indicates that water quality within this reach varies from nonimpairment to moderate impairment while standard water quality sampling indicates that most water quality parameters regularly meet PWQO. Variable riparian cover, on-line ponds and other channel alterations result in a wide range of fish community and temperature regime conditions including those which are not consistent with the physiographic features (sand and limestone plains) and stream orders (first and second order streams) found in this portion of the watershed. High ratings of aquatic ecosystem health are generally

Figure 8.1



Aquatic Ecosystem Health
Bronte Creek Watershed
Legend
Aquatic Habitat Health
High
Moderate
Poor
Unclassifed
Niagara Escarpment
N
0
2
4
6
Kilometres
Halton Hills
Milton
Puslinch
Hamilton
Oakville
Burlington
Data provided by Conservation Halton.
Conservation Halton
August 2002

associated with unaltered reaches flowing through headwater swamps. Moderate ratings are associated with sections adversely impacted by poor riparian cover or channel alterations. Poor ratings are associated with altered stream sections with minimal riparian cover and altered fish communities (i.e. Carlisle Conservation Area and Courtcliffe Park).

8.5 Indian Creek

Benthic sampling indicates that water quality within this subwatershed is moderately to substantially impaired while standard water quality sampling indicates that several water quality parameters regularly do not meet PWQO. The warmwater fish community and temperature regimes on the main branch are consistent with expectations for a second or third order stream flowing through fine till plain features; however, on-line ponds on the tributaries do impact coldwater spring sources along the Escarpment. Most of the tributaries of Indian Creek have been channelized (ditched) and on-line ponds are ubiquitous. Livestock and other farm animal access contributes to habitat alterations within this subwatershed. Riparian cover is generally sparse or absent along many of the watercourses. With the exception of a tributary near Appleby Line and Derry Road, this subwatershed is characterized by poor aquatic ecosystem health.

8.6 Mount Nemo Creek

Benthic sampling indicates that water quality within this subwatershed is moderately impaired. Standard water quality and instream temperature sampling was not conducted on Mount Nemo Creek. The warmwater fish community is consistent with expectations for a first or second order stream flowing through fine till plain features; however, on-line ponds on the tributaries do impact coldwater spring sources along the Escarpment. Upstream of the Bronte Creek Valley ESA, most of the tributaries of Mount Nemo Creek have been channelized (ditched) and riparian cover is sparse or absent. The downstream portion of the stream within the Bronte Creek Valley ESA is well-buffered with riparian vegetation. This reach is characterized by moderate aquatic ecosystem health whereas the upstream reaches are considered to have poor aquatic ecosystem health.

8.7 Lowville Creek

Benthic sampling indicates that water quality within this subwatershed is slightly impaired. Standard water quality sampling was not conducted on Lowville Creek. The warmwater fish community is not consistent with the coolwater temperature regime indicated in sampling. The fish community may reflect a natural intermittent flow regime or may reflect the loss of diversity/salmonids associated with past water-taking in the upstream portion of the subwatershed. The Lowville Creek tributaries arising along the east face of Mount Nemo have been channelized. Riparian cover is patchy along most of the main branch of Lowville Creek. In general, Lowville Creek is characterized by moderate aquatic ecosystem health.

8.8 Limestone Creek

Benthic sampling indicates that water quality within Limestone Creek is generally unimpaired to slightly impaired while standard water quality sampling indicates that most water quality parameters regularly meet PWQO. The coldwater fish community and temperature regimes are consistent with expectations for first and second order streams flowing through coarse limestone plain and glacial spillway features. However, lack of riparian cover downstream of Derry Road appears to constrain the downstream extent of coldwater habitat in Limestone Creek. Upstream of Derry Road, occasional on-line ponds represent the only channel alterations and riparian habitat generally provides extensive buffering. However, patchy riparian cover and localized livestock access impact ecosystem health downstream of Derry Road.

Aquatic ecosystem health from Derry Road upstream is rated as high with moderate health exhibited downstream of Derry Road to the Bronte Creek confluence.

The east and west tributaries of Limestone Creek, which flow through a fine till plain south of Derry Road, have been channelized and are characterized by sparse riparian cover. These systems exhibit poor aquatic ecosystem health for much of their length with moderate health indicated in the better-buffered riparian zones near their confluence with the main creek.

8.9 Willoughby Creek

Benthic sampling indicates that water quality within Willoughby Creek is slightly impaired while standard water quality sampling indicates that most water quality parameters regularly meet PWQO. Coldwater fish community and temperature regimes are consistent with expectations for first and second order streams flowing through glacial spillway features. A dam structure near the confluence with Bronte Creek is a barrier to fish passage. A number of on-line ponds along Cedar Springs Road upstream of Britannia Road adversely affect channel form, contribute to instream warming and may partially obstruct fish passage. Riparian cover along this section is generally sparse. Flow alterations associated with water taking on the east branch of Willoughby Creek may also be impacting channel function and aquatic habitat. Extensive groundwater inputs along Cedar Springs Road appear to counteract the adverse impacts associated with these combined disturbances. Aquatic ecosystem health through the Medad Valley swamp and from Britannia Road downstream to the Bronte confluence is rated as high with moderate health exhibited along the residential strip upstream of Britannia Road.

8.10 Kilbride Creek

Benthic sampling indicates that water quality within Kilbride Creek is non-impaired to slightly impaired while standard water quality sampling indicates that most water quality parameters regularly meet PWQO. Coldwater fish community and temperature regimes throughout most of the subwatershed are consistent with expectations for first and second order streams flowing through the limestone plain and glacial spillway features of the Bronte Creek watershed. A dam structure associated with the Burns Conservation Area is a barrier to fish passage. On-line ponds associated with Burns Conservation Area and the Coral Park Campground contribute to localized downstream warming. Channel alterations are also present downstream of Coral Park. Riparian cover within the subwatershed generally provides excellent watercourse buffering. With the exception of a short section between Derry Road and Steeles Avenue and a short section downstream of Burns Conservation Area, aquatic ecosystem health is rated as high with moderate health exhibited through the aforementioned sections. Additional data is required to rate the upstream tributaries on this system.

8.11 Flamboro Creek

Benthic sampling indicates that water quality within Flamboro Creek (near its confluence with Bronte Creek) is non-impaired while standard water quality sampling at Carlisle Road indicates that most water quality parameters regularly meet PWQO. With the exception of a warmwater fish community downstream of the Carlisle Golf and Country Club pond, coldwater fish community and temperature regimes throughout most of the subwatershed are consistent with expectations for first and second order streams flowing through the limestone plain and glacial spillway features. The dam structure associated with the on-line pond is a barrier to fish passage and contributes to downstream warming. Riparian cover within the subwatershed generally provides excellent watercourse buffering. With the exception of a short section downstream of the on-line pond (moderate health), aquatic ecosystem health is rated as high.

8.12 Mountsberg Creek

Downstream of the Mountsberg Reservoir

Benthic sampling indicates that water quality downstream of the Mountsberg Reservoir is slightly impaired with impairment decreasing downstream of the reservoir. Standard water quality sampling at Campbellville Road indicates that most water quality parameters regularly meet PWQO. However, the Mountsberg Reservoir contributes to a downstream temperature regime which is not typically associated with watercourses on the limestone plain. Productive coldwater fish communities associated with second and third order streams on the limestone plain are not present. Non-indigenous species associated with the reservoir have colonized downstream habitats and may be impacting the native fish community. Riparian cover, though sparse in some areas, generally provides excellent buffering downstream to Courtcliffe Park. The aquatic ecosystem through most of this reach is characterized moderately healthy.

Upstream of the Mountsberg Reservoir

Benthic sampling indicates that water quality within Mountsberg Creek upstream of the Mountsberg Reservoir is slightly to moderately impaired while standard water quality sampling at Highway 401 indicates that most water quality parameters regularly meet PWQO. On-line ponds associated with the Rainbow Ranch Fishing Club are barriers to fish passage and contribute to downstream warming. Non-indigenous species associated with the Mountsberg Reservoir have moved upstream into the headwaters and may be impacting the native fish community. However, native fish assemblages have resisted colonization in the cold, spring-fed headwaters. Upstream of 15th Sideroad, fish community and temperature regimes are marginal for first and second order streams flowing through a limestone plain feature within the Bronte Creek watershed. Riparian cover provides excellent buffering downstream of 15th Sideroad; however, riparian cover is highly variable upstream of this crossing. High aquatic ecosystem health is generally restricted to cold headwater tributaries with the remainder of the subwatershed characterized as moderately healthy.

8.13 Strabane Creek

Benthic sampling indicates that water quality within Strabane Creek (near its confluence with Bronte Creek) is slightly to moderately impaired while standard water quality sampling at Carlisle Road indicates that most water quality parameters regularly meet PWQO. A large, on-line pond contributes to instream warming and marginal coldwater habitat upstream of Brock Road indicating some impairment of the coldwater temperature and habitat regimes expected for first and second order streams flowing through the limestone plain. Riparian cover within the subwatershed generally provides excellent watercourse buffering. With the exception of the section downstream of the on-line pond (moderate health), aquatic ecosystem health is rated as high.

CHAPTER 9: *RECOMMENDATIONS*

The aquatic studies, data analyses and stakeholders' process undertaken in support of the Bronte Creek Watershed Study have generated a number of recommendations to maintain and enhance aquatic habitats within the watershed. Some recommendations pertain to the entire watershed while other recommendations are more site-specific in nature. Watershed-wide recommendations are outlined in Section 9.1 while site-specific recommendations are provided in Section 9.2.

9.1 Watershed Recommendations

9.1.1 On-line Pond Inventory

On-line ponds/reservoirs are ubiquitous throughout the watershed. These on-line features have been constructed to provide a variety of uses including: flood control, low flow augmentation, wildlife habitat, fish habitat, recreation and site aesthetics. Although these ponds may provide localized benefits, their individual and cumulative effects adversely impact watercourses in the following ways:

- contribution to downstream warming
- reduced summer baseflow (increased evaporation)
- reductions in bedload transport (larger particles settle out in ponds instead of continuing to move downstream)
- increases in downstream erosion (as the watercourse attempts to regain its natural bedload)
- creation of lentic (lake-like) habitats which support non-indigenous species which may colonize upstream and downstream reaches to the detriment of native fish communities
- creation of barriers to fish passage

Although the locations of many ponds are known, there is not a full inventory of on-line ponds within the Bronte Creek watershed. Additional work should be undertaken to inventory the location of all on-line ponds/dams within the watershed. This inventory could then be compared to other databases (i.e. fish community and instream temperature databases) to develop a priority list for potential removal/alteration of these structures. The inventory should also be part of a comprehensive water allocation strategy to assess the current water usage to determine the basis for future water taking and conservation efforts. Removal/retrofitting of on-line ponds will restore natural stream function within the watershed and enhance aquatic ecosystem health. MNR staff note that "the age and deteriorating condition of many dams in Ontario as well as the legal responsibilities of dam owners may have implications on the fate of dams in the Bronte Creek watershed." (Timmerman, 2001).

9.1.2 Riparian Enhancement

Riparian buffers are essential to the health of watercourses and watersheds. These treed and/or marshy areas along the banks of watercourses contribute to ecosystem health in the following ways:

- shading maintains cooler stream temperatures during the summer months
- tree rooting systems provide bank stability and reduce bank erosion
- the network of rooting systems reduce/slow surface runoff and allow for sediment deposition and nutrient absorption (reducing flooding peaks and enhancing water quality)
- overhanging branches, fallen logs and tree roots provide excellent instream cover
- natural riparian buffers provide terrestrial food sources to the creek (insects)
- decaying leaves in the stream provide an important food source for micro-organisms and benthic invertebrates which, in turn, provide food for fish, amphibians and birds
- riparian buffers can provide important linkages between core natural areas within a watershed

Riparian cover within the Bronte Creek watershed is highly variable. Extensive headwater swamps and deep valley systems support significant riparian cover; however, stream reaches outside of these features often exhibit sparse or patchy riparian cover. An assessment of riparian cover by reach/tributary within the Bronte Creek watershed is provided in Table 9.1. Riparian habitat targets have been established for the Great Lakes Areas of Concern (AOC; Environment Canada *et al.*, 1996). Although the Bronte Creek watershed does not lie within an AOC, the habitat targets are generally applicable to all watersheds in southern Ontario. Based on these targets, at least 75% of stream length along first to third order streams within a watershed should support riparian habitat to maintain high stream integrity. Further, at least 75% of stream length along first to third order streams should support 30 m vegetated buffers on both sides of the creek to maintain high water quality. Although several reaches/tributaries come close to the AOC buffer targets, none meet the targets and several fall well short. As an extreme example, riparian cover within the Indian Creek subwatershed is only 11% with reaches supporting 30 m buffer zones accounting for less than 8% of total stream length.

To meet riparian habitat targets within the Bronte Creek watershed, stewardship opportunities to increase riparian cover along watercourses on private and public lands should be identified and developed. The Hamilton Halton Watershed Stewardship Program, Courtcliffe Park Steering Committee, the Izaak Walton Fly Fisher's Club, the Credit River Anglers' Association and private landowners are examples of groups/individuals who have shown an active interest in riparian regeneration. It is hoped that successful partnerships will continue to be forged to increase riparian cover and enhance aquatic habitat within the watershed.

Although riparian enhancement is an important component of aquatic habitat restoration within the Bronte Creek watershed, opportunities must be assessed in concert with other natural area objectives. For example, interspersion of habitats may be essential to wetland function. In some cases, creation of forest habitats may reduce interspersion and wetland function. As another example, redside dace do not appear to thrive in heavily forested environments. Increased forest cover may hinder recovery plans for this species in the Bronte Creek watershed.

Table 9.1. Riparian Cover Within the Bronte Creek Watershed.

Tributary/Subreach	Riparian Cover (%)	Riparian Cover Extending 30 m From Both Banks (%)
Bronte Creek: (Estuary to Progreston)	73	68
Bronte Creek: (Progreston to Headwaters)	59	48
Mount Nemo Creek	34	26
Indian Creek	11	8
Lowville Creek	37	9
Limestone Creek	54	43
Willoughby Creek	58	44
Kilbride Creek	70	61
Flamboro Creek	71	69
Mountsberg Creek	60	56
Strabane Creek	66	60
Bronte Creek Watershed	**52**	**44**

9.1.3 Fisheries Management

Fisheries management is a concern within the watershed. An updated fisheries management plan, similar to that developed for the Credit River and Grand River, is needed to address current recreational angling issues in the middle and lower reaches of Bronte Creek and to address issues associated with the introduction of non-indigenous species upstream of Progreston. Sea lamprey control remains a high priority downstream of the Escarpment. It is recommended that the OMNR, the agency responsible for fisheries management in Ontario, update the existing fisheries management plan for Bronte Creek, based on the results of this document. Some additional biological information may be required to make informed fisheries management decisions within the watershed. A brief summary of major issues is provided below.

Recreational Angling Issues

The 1989 Cambridge District Fisheries Management Plan (OMNR, 1989) identified the Lowville Dam as a partition between the resident brown trout and brook trout populations upstream of the dam and the migratory rainbow trout population which can move upstream to the dam. This partition was deemed necessary to protect resident trout populations from potential adverse impacts associated with rainbow trout competition. Since this plan was developed, there has been heated debate within the scientific and angling communities regarding the competitive advantages and disadvantages of the different trout species in stream environments and the need, or lack thereof, to maintain population partitions. The fisheries management plan would have to address this issue and provide appropriate management strategies based on the plan's recommendations.

Introduction of Non-indigenous Species Upstream of Progreston

Significant fish community shifts are associated with the diffusion of non-indigenous centrarchids and northern pike from Mountsberg Reservoir and other on-line ponds. These species were not present in 1958 but have become a significant component of the fish community, particularly where lentic (lake-like) habitats have been created (i.e. Mountsberg Reservoir, Courtcliffe Park and Carlisle Conservation Area). Redside dace, once well-distributed through upper Bronte Creek and Mountsberg Creek, appear to be restricted to a short reach on Bronte Creek between Highway 6 (north crossing) and 11th Concession and appear to have been extirpated from the Mountsberg Creek subwatershed. Anecdotal evidence indicates that the diffusion of northern pike upstream of Mountsberg Reservoir may be impacting the native brook trout population.

Further assessment of potential impacts associated with these introductions is required to assess whether species-specific management is required to maintain native species assemblages within the upper Bronte Creek and Mountsberg Creek subwatersheds.

9.1.4 Monitoring

Long-term monitoring is an important component of watershed planning and management. Conservation Halton is preparing a long-term monitoring strategy which will involve regular monitoring of a number of watercourse stations strategically placed within the Bronte Creek watershed. Monitoring will include fluvial geomorphic, fish community, benthic and water quality assessment. The frequency of monitoring will be determined by proposed land use. Where land use is anticipated to remain static, monitoring will be carried out at ten year intervals. Where significant land use change is anticipated (i.e. developing areas), stations will be monitored at two year intervals. Results of monitoring and recommendations for future management will be presented in regular reports which will be timed to coincide with other agency planning initiatives (i.e. Official Plan review) to provide a mechanism to incorporate monitoring recommendations into other planning initiatives.

9.2 Site Specific Recommendations

9.2.1 Bronte Creek (Estuary)

Aside from its use as a staging area for migratory fish in the early spring and fall, little is known about the aquatic habitat function of the estuary. A spring fish community survey (spawning survey and trap net survey) would assist in determining fish habitat utilization in this area. The results of this study could be used to assist the Town of Oakville in evaluating their management plan for the Bronte Creek marsh.

9.2.2 Bronte Creek (Estuary to Lowville)

Riparian coverage in the valley upstream of Zimmerman is patchy. Stewardship initiatives targeted at riparian enhancement would improve water quality and enhance fish habitat in this reach.

The magnitude of natural chinook salmon reproduction in Bronte Creek is not known. This should be investigated to assist in validating fisheries management and fish habitat management decisions in this reach.

Lamprey control remains a high priority on Bronte Creek given the high productive capacity of this system for sea lamprey. DFO is considering the construction of a fixed-crest weir underneath the QEW bridge to reduce expenditures and risks associated with TFM use. This weir would block upstream access for sea lamprey and minimize requirements for future TFM use. The weir should incorporate design elements which minimize effects on the upstream ANSI/ESA and which allow free passage of all other fish species within this reach.

9.2.3 Bronte Creek (Lowville to Progreston)

Riparian cover within the Cedar Springs Community is very sparse. Stewardship initiatives targeted at riparian enhancement, possibly incorporating low, aesthetically pleasing shrub cover, would improve water quality and enhance fish habitat through this community.

Recreational fisheries management is an issue in this reach (Section 9.1.3). Development of an updated fisheries management plan would have significant implications for future activities in this reach, in particular, the ultimate fate of the Lowville Dam and the Dakota Mills Dam. Each of these structures is acting as, or could be used as, a species partition. However, these structures also impede sediment and bedload transport through the system and increase downstream water temperatures during the summer months.

The Progreston Dam is currently being used to power a small hydroelectric facility. Excessive water taking has occurred on several occasions in the past resulting in the dewatering of the channel downstream of the dam to the facility outflow. Although these incidents have been documented and reported to the appropriate federal and provincial agencies, no action has been taken. It is recommended that one of these agencies take appropriate action to ensure that this does not reoccur in the future. Consideration should be given to removing the dam structure should the hydroelectric facility cease operation.

Two small tributaries enter Bronte Creek from the north and south immediately downstream of the Flamboro Creek confluence. The function of these tributaries is unknown and should be investigated further.

9.2.4 Bronte Creek (Progreston to Headwaters)

Main Branch

Extensive channel alterations through the Carlisle Conservation Area and Courtcliffe Park have created lentic (lake-like) conditions that have resulted in significant instream warming. These habitats favour non-indigenous species and restrict the distribution and abundance of native stream fishes. Extensive restoration efforts are required to return these systems to a more lotic (stream-like) condition. These restoration efforts are proceeding as part of a community-driven initiative in Courtcliffe Park. A similar restoration effort should be undertaken within the Carlisle Conservation Area.

Riparian cover upstream of Courtcliffe Park is patchy with large areas of wooded swamp separated by areas of intensive agricultural activity. Riparian enhancements would reduce thermal impacts and enhance instream cover in this reach. On-line ponds have significant impacts on instream water temperatures. Efforts should be made to contact these landowners and discuss potential options to minimize/eliminate the adverse impacts of on-line ponds in this important coldwater reach.

Northeast Tributary

Significant agricultural impacts (cattle access, channelization, on-line ponds) are evident in the upstream reaches of this tributary. Cattle fencing and riparian enhancement would improve water quality and aquatic habitat on this system.

East Tributary

The downstream portions of this tributary support redside dace. Riparian cover along some reaches (i.e. upstream of Campbellville Road, downstream of Mountsberg Road) is patchy with small areas of wooded swamp separated by areas of intensive agricultural activity. Riparian enhancements would reduce thermal impacts and enhance instream cover in this reach. On-line ponds may have significant impacts on instream water temperatures in the vicinity of Campbellville Road. Efforts should be made to contact these landowners and discuss potential options to minimize/eliminate the adverse impacts of these structures.

West Tributary

This tributary may become intermittent during extended periods of drought. Riparian cover downstream of Brock Road is sparse. Riparian plantings would reduce thermal impacts and enhance instream cover and water quality in this reach.

9.2.5 Mount Nemo Creek

Stewardship activities should focus on working with the agricultural community to address the concerns pertaining to degraded water quality and aquatic habitat. Buffer zones along the tributaries of Mount Nemo Creek should be left to regenerate naturally or planted with trees and shrubs to provide watercourse shading and an uptake area to capture sediment and nutrients running off adjacent fields. Where feasible, farmers should be encouraged to allow altered stream sections to renaturalize instead of re-dredging the channels on a continuous basis.

9.2.6 Indian Creek

Stewardship activities should focus on working with the agricultural community to address the concerns pertaining to degraded water quality and aquatic habitat. Buffer zones along the tributaries and main branch of Indian Creek should be left to regenerate naturally or planted with trees and shrubs to provide watercourse shading and an uptake area to capture sediment and nutrients running off adjacent fields. Fencing should be utilized to restrict livestock access to specific watering areas. Where feasible, farmers should be encouraged to allow altered stream sections to renaturalize instead of re-dredging the channels on a continuous basis.

On-line ponds on permanently flowing coolwater tributaries may have significant impacts on instream water temperatures. Efforts should be made to contact landowners with such ponds and discuss potential options to minimize/eliminate adverse impacts to possibly regenerate coolwater habitat within Indian Creek. The feasibility of dam removal at Camp Sidrabene should also be investigated.

Significant development including the CN intermodal facility and the Milton Phase 2 and 3 expansion is proposed within the northeast portion of the Indian Creek subwatershed. Provided that appropriate stormwater controls are implemented, there may be an opportunity to enhance degraded tributaries in this area as part of an overall development plan which would include the dedication and planting of riparian corridors adjacent to the watercourse.

9.2.7 Lowville Creek

Agency staff should continue to work with the Lowville Golf Course to ensure that baseflow from the spring tributary is released downstream of the irrigation pond. Monitoring of summer baseflows and instream temperatures should be conducted to determine the feasibility of re-introducing resident trout species which reportedly inhabited Lowville Creek in the past. Stewardship efforts should focus on encouraging Lowville and Indian Wells Golf Courses to obtain Audubon certification and minimizing the impacts of the golf courses on the natural environment by optimizing pesticide and fertilizer use, retrofitting on-line ponds and managing water taking in a sustainable manner to provide sufficient downstream flows to maintain aquatic life and protect downstream riparian rights.

9.2.8 Limestone Creek

Landowners with on-line ponds on the east and west branches should be contacted to discuss potential options to minimize/eliminate adverse impacts associated with these structures. Removal of on-line ponds would enhance existing brook trout habitat.

Additional riparian plantings are recommended in several sections downstream of Derry Road to assist in maintaining coolwater habitat conditions downstream to the Bronte Creek confluence. Riparian buffers would also stabilize stream banks, reduce sediment and nutrient loadings, provide instream habitat and provide terrestrial-based energy sources (insects, fallen leaves, logs) to the creek system.

The Sherman sand and gravel pit operation offers an opportunity to work in conjunction with Sherman Sand and Gravel to rehabilitate and naturalize the existing operations approaching and following decommissioning. This effort should focus on enhancing riparian buffers and forest linkages and maintaining and enhancing coldwater habitats. It is also suggested that the on-line pond be removed to improve water quality and improve fish passage and habitat.

9.2.9 Willoughby Creek

In the short-term, water-taking on the east branch of Willoughby Creek needs to be managed in a sustainable manner which provides sufficient downstream flows to sustain aquatic life as well as a water supply for the Burlington Springs Golf and Country Club. In the long-term, Nelson Quarry does not plan to continue pumping to the east branch following the termination of quarry operations. The quarry closure and rehabilitation plans should be reviewed to determine potential effects on Willoughby Creek and to identify potential opportunities to improve water quality and baseflow.

Landowners with on-line ponds along Cedar Springs Road should be contacted to discuss potential options to minimize/eliminate adverse impacts associated with these structures. Removal/retrofitting of on-line ponds, combined with riparian plantings along this reach, would enhance degraded coolwater habitat and provide conditions more suitable for brook trout.

9.2.10 Kilbride Creek

Riparian plantings and possibly natural channel design, through the altered channel section within the Serbian Orthodox Diocese property upstream of Derry Road would enhance degraded coolwater habitat within Kilbride Creek. The property owners of Coral Park Campground south of Steeles Avenue should be contacted to discuss potential options to minimize/eliminate adverse impacts associated with their on-line ponds. Removal/reconfiguration of these on-line ponds would enhance coolwater habitat in this reach.

A temperature study should be conducted within Burns Reservoir to assess the potential benefits of installing a bottom-draw outlet. The feasibility of constructing a bottom draw structure should be investigated if results indicate that significant downstream cooling could be realized.

9.2.11 Flamboro Creek

Although generally well-buffered, riparian cover along some reaches (i.e. upstream of 10th Concession) is patchy. Riparian enhancements would reduce thermal impacts and enhance instream cover in this reach. On-line ponds upstream and immediately downstream of 10th Concession may have significant impacts on instream water temperatures. Efforts should be made to contact these landowners and discuss potential options to minimize/eliminate the adverse impacts of these structures.

Carlisle Golf and Country Club should continue to sustain downstream baseflow from their on-line pond to Flamboro Creek as per their Permit To Take Water to protect downstream aquatic habitat and the riparian rights of downstream landowners.

9.2.12 Mountsberg Creek

Riparian cover upstream of 15th Sideroad is patchy. Downstream of the Mountsberg Reservoir, riparian cover within the Romanian Park (10th Concession) and Courtcliffe Park is similarly sparse. Riparian plantings throughout the subwatershed would reduce thermal impacts, enhance instream cover and improve water quality.

The Mountsberg Reservoir has a significant impact on downstream temperatures. A temperature study should be conducted within Mountsberg Reservoir to assess the potential benefits of installing a bottom-draw outlet. The feasibility of constructing a bottom draw structure should be investigated if results indicate that significant downstream cooling could be realized. Riparian plantings surrounding the reservoir should also be enhanced.

On-line ponds throughout the subwatershed appear to have a significant impact on instream water temperatures. Efforts should be made to contact these landowners and discuss potential options to minimize/eliminate the adverse impacts of these structures.

Fisheries management in this subwatershed should consider the impacts of non-indigenous species (i.e. northern pike and centrarchids) on native fish communities.

9.2.13 Strabane Creek

The landowner with the large on-line pond at the east end of Beverly Swamp should be contacted to discuss potential options to minimize/eliminate adverse impacts associated with this structure. Removal of the on-line pond would enhance degraded coolwater habitat downstream of the pond and provide temperature conditions more suitable for brook trout.

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APPENDIX 1

SAMPLING STATION SUMMARY AND INSTREAM TEMPERATURE SURVEY DATA

Table 1. Summary of Conservation Halton Temperature, Fisheries and Benthic Sampling Sites, UTM Coordinates (NAD27).

Station	UTM Easting	UTM Northing	Temperature Sampling Date	Fisheries Sampling Date	Benthic Sampling Date
B1	601859	4806755			Fall 1999
B2	597217	4807338			Fall 1999
B3	594541	4808453	July 14 1998		July 26 2000
B4	590200	4810111	July 3 1998		
B5	591878	4809770	July 14 1999		
B6	588604	4809411	June 29 1998		July 19 2000
B7	588313	4809055	June 29 1998		
B8	587418	4807784	June 29 1998		August 1 2000
B9	586878	4807086	July 13 1998		
B10	584262	4805436	July 15 1998	August 26 1999	July 13 2000
B16	579114	4806459	July 20 1998	August 29 2000	
B18	577412	4808057	July 20 1998, October 30 1998		
B19	576672	4808598	July 13 1998, October 30 1998		
B11	582822	4804795	July 15 1998		
B12	582033	4804327	July 15 1998	August 26 1999	August 21 2000
B13	580164	4803280	August 18 1999		
B14	578617	4803525		August 1999, August 31 2000	
B15	579525	4804326	July 20 1998		
B17	576403	4807061	August 18 1999	August 1999, August 26 2000	August 2000
B20	575856	4807846	July 13 1998, October 30 1998		
B21	574327	4808901	August 18 1999		
B22	574152	4809338	August 18 1999	August 24 1999	July 12 2000
B24	573365	4809804	July 20 1998		
B26	571587	4810606	August 18 1999		
B23	574768	4809994	August 24 1999	August 31 2000	August 11 2000
B25	574201	4810662	July 20 1998, October 30 1998		
B27	573546	4812966	July 20 1998, October 30 1998		
B28	573049	4812515	October 30 1998, August 18 1999		
B30	581594	4804247	July 27 2001		
B31	581590	4804268	July 27 2001		
B32	581078	4804169	July 27 2001		
B29	578421	4802777	August 31 2000	August 31 2000	August 2 2000
MN1	593366	4808168		August 10 2000	July 6 2000
I1	593265	4809503			Fall 1999
I2	593936	4810030	July 15 1998	August 9 2000	
I3	593586	4812118	July 15 1998		
I4	591699	4811964	July 3 1998	August 9 2000	July 27 2000
I5	589940	4813368	July 20 1998		
I6	588640	4812945	July 14/1999	August 10 2000	July 24 2000
I7	590610	4814821		August 15 2000	July 18, 21 2000
I8	593171	4813970	July 20 1998		
I9	592767	4813428	July 3 1998		
L1	590621	4810710	July 3 1998	August 1999, July 20 2000	Fall 1999, June 2 2000
L2	588952	4810773	July 15 1998		
L3	588844	4810872	July 3 1998		
L4	587335	4811441	July 3 1998		July 11 2000
L5	586382	4810845	July 13 1998		

Table 1 continued. Summary of Conservation Halton Temperature, Fisheries and Benthic Sampling Sites, UTM Coordinates (NAD27).

Station	UTM Easting	UTM Northing	Temperature Sampling Date	Fisheries Sampling Date	Benthic Sampling Date
L6	584589	4810839	August 24 1999	August 1999, August 17 2000	
L7	584664	4810852	July 3 1998	August 1999	August 17 2000
L8	583490	4811492	July 3 1998, October 30 1998		
L9	586792	4812827	July 3 1998		
N1	592023	4809097	July 14 1998, July 14 1999	August 5 1999	Fall 1999
N2	589159	4808513	July 14 1999	August 4 1999	
N3	589180	4808637	July 14 1999	August 5 1999	
N4	589262	4808888	July 3 1998, July 14 1999	August 5 1999	
N5	589523	4809201	July 15 1998	August 5 1999	
N6	589791	4809628	July 14 1999	August 5 1999	
N7	588925	4808491	July 3 1998		
N8	588429	4807794	July 3 1998		
K1	586655	4807488	July 13 1998, July 29 1999	July 27 1999,	Fall 1999
K2	585996	4808363	July 13 1998, September 24 1998		
K3	585076	4808543	July 13 1998, September 24 1998		
K4	582722	4810500	July 13 1998, September 24 1998	August 23 1999	July 25 2000
K5	580563	4812795	July 13 1998		
K6	580123	4813198		August 1999, Sept 1 2000	August 18 2000
K7	577383	4814072	July 20 1998, October 30 1998		
K8	578447	4815037	July 20 1998, October 30 1998		
W1	587326	4806456	June 29 1998		Fall 1999
W2	587742	4806000	June 29 1998		
W3	588048	4805746	June 29 1998		
W4	588631	4804972		September 1 2000	
W5	589002	4805607	June 29 1998		
F1	584415	4805733		August 1999	
F2	584270	4805830		August 1999	
F3	584126	4805852		August 1999	
F4	584073	4806175		August 1999	
F5	583938	4806289	July 15 1998	August 1999	Fall 1999
F6	583880	4806386		August 1999	
F7	583844	4806480		August 1999	
F8	583324	4808172	July 15 1998		
F9	582585	4807443	July 15 1998		
M1	581243	4804622		May 26 2000	May 26 2000
M2	581534	4805660	July 15 1998	July 31 1998	
M3	581683	4806516	July 15 1998		
M4	580371	4807719	July 20 1998	August 4 1998	July 25 2000
M5	579160	4809834	July 20 1998	August 4 1998	
M6	578272	4810250	July 13 1998	August 4 1998	August 22 2000

Table 1 continued. Summary of Conservation Halton Temperature, Fisheries and Benthic Sampling Sites, UTM Coordinates (NAD27).

Station	UTM Easting	UTM Northing	Temperature Sampling Date	Fisheries Sampling Date	Benthic Sampling Date
M7	577170	4811465		August 6 1998	
M8	574982	4813060		August 23 1999	August 8 2000
M9	575818	4816723	August 31 2000	August 23 1999	
M10	574558	4814008	July 20 1998, October 30 1998, August 31 2000		
M11	575055	4814525	October 30 1998		
M12	575563	4815046	July 20 1998, October 30 1998, August 31 2000	August 24 2000	July 31 2000
M13			August 31 2000	August 2000	August 3 2000
M14				August 1999, August 2000	
M15	575737	4817508	August 8 1998		
M16	575745	4819450	August 31 2000	August 28 2000	
M17	574331	4814735		September 9 2001	
M18	574693	4814957		September 9 2001	
M19	575297	4816043		September 9 2001	
M20	581393	4804299	July 27 2001		
M21	581222	4804225	July 27 2001		
M22	581255	4804670	July 27 2001		
M23	581216	4804685	July 27 2001		
S1	578295	4803307	July 20 1998, October 30 1998	August 31 2000	July 2 2000
S2	575558	4803458	August 31 2000	August 31 2000	
S3	576177	4804655	July 20 1998, October 30 1998		

Table 2. Summary of Conservation Halton Instream Temperature Study (1998-200).

Station	Date	Temperature		Status	Comments
		Water	Air		
B3	July 14/98	27.8	31.0	warm	
B4	July 3/98	25.0	29.5	warm	Atlantic salmon stocking site
B5	July 14/99	24.8	28.6	warm	smallmouth bass observed, successional old field riparian
B6	June 29/98	25.3	31.0	warm	Atlantic salmon stocking site, at downstream walkbridge
B7	June 29/98	24.8	31.0	warm (c)	Atlantic salmon stocking site, upstream of dam
B8	June 29/98	24.8	31.0	warm (c)	Atlantic salmon stocking site, swimming pond in upstream
B9	July 13/98	22.0	29.2	cool	good riparian cover, high gradient
B10	July 15/98	26.5/26	31.8	warm	above and below of Progreston dam, springs downstream
B11	July 15/98	26.0	31.8	warm	ponded, canopy cover absent
B12	July 15/98	25.0	31.8	warm (c)	ponded upstream but good canopy cover
B13	Aug 18/99	23.0	25.1	warm	moderate gradient, successional old field riparian
B15	July 20/98	26.3	30.0	warm	good riparian cover, low gradient upstream
B16	July 20/98	24.0	30.0	warm (c)	good riparian cover, low gradient upstream
B17	Aug 18/99	20.5	25.1	warm (c)	lowland forest, good instream cover
B18	July 20/98	20.5	30.0	cool	standing pool at culvert (no flow), fish observed
B18	Oct 30/98				no flow
B19	July 13/98	NA	29.2		no flow
B19	Oct 30/98				no flow
B20	July 13/98	24.8	29.2	warm	fish observed, canopy cover absent, manicured lawn (DS)
B20	Oct 30/98				flow observed
B21	Aug 18/99	14.0	25.1	cold	low gradient, choked with vegetation, tall shrub thicket
B22	Aug 18/99	15.0	25.1	cold	upstream of springs, cedar forest, watercress
B22	Aug 18/99	10.5	25.1	cold	downstream of springs, cedar forest, watercress
B23	Aug 24/99	20.0	27.1	cool	East trib., fish observed, successional old field
B24	July 20/98	15.0	30.0	cold	frogs, good instream cover (swamp)
B24	Oct 30/98				flow observed, 2/3 brook trout redds downstream
B24	Aug-99				no flow observed
B25	July 20/98	23.3	30.0	warm(c)	duckweed, pond upstream?
B25	Oct 30/98				dry, channelized
B26	Aug 18/99	19/20	25.1	cool(w)	residential (US; long culverts), riparian marsh (DS)
B27	July 20/98	28.5	30.0	warm	fish observed, corn field downstream, side branch
B27	Oct 30/98				flow observed, algae
B28	Oct 30/98				flow observed in tributary to the west, cattle pasture DS
B28	Aug 18/99	20.0	25.1	cool(w)	pasture impacts (DS), swamp/cattail marsh (US)
B28	Aug 24/99	20.0	27.1	cool	fish observed
B29	Aug 31/2000	21.0	28.0	cool	un-named tributary, wet meadow US, pond DS
B30	Jul 27/2001	26.0	30.0	warm	
B31	Jul 27/2001	24.5	30.0	warm	
B32	Jul 27/2001	23.5	30.0	cool(w)	
I2	July 15/98	31.5	31.8	warm	low flow, algae, fish observed
I3	July 15/98	27.0	31.8	warm	turbid, low flow, grass in channel, fish observed
I4	July 3/98	27.0	29.5	warm	very murky water
I5	July 20/98	27.0	30.0	warm	low gradient, turbid, flows through farm fields
I6	July 14/99	18.0	28.6	cool	moderate gradient, fish observed, wooded riparian
I8	July 20/98	23.0	30.0	warm(c)	remnant pool under culvert (no flow)
I9	July 3/98	22.0	29.5	cool (w)	remnant pool under culvert (no flow)
N1	July 14/98	28.0	31.0	warm	fish observed, silt/cobble substrate
N1	July 14/99	N/A	28.6		no flow, standing pool at upstream bend
N2	July 14/99	19.5	28.6	cool	rip rap/wetland upstream of culvert
N3	July 14/99	19.5	28.6	cool	fish observed, green frogs
N4	July 3/98	23.0	29.5	cool-warm	Pool under bridge
N4	July 14/99	21.5	28.6	cool	standing pool upstream of culvert, no flow
N5	July 15/98	23.5	31.8	cool	good canopy cover, muck substrate
N6	July 14/99	N/A	28.6		no flow, standing pool at upstream bend
N7	July 3/98		29.5		no flow
N8	July 3/98		29.5		no flow

Table 2 continued. Summary of Conservation Halton Instream Temperature Study (1998-2000).

Station	Date	Temperature		Status	Comments
		Water	Air		
L1	July 3/98	25.0	29.5	warm	Fast-flowing; very little tree cover
L3	July 3/98	23.5	29.5	warm (c)	no shade; muddy bottom
L2	July 15/98	25.8	31.8	warm	tributary south of main creek; fish observed
L4	July 3/98	20.0	29.5	cool	little-partial shade
L5	July 13/98	23.0	29.2	cool-warm	partial shade, waterfall, filamentous algae, fish observed
L7	July 3/98	25.5	29.5	warm	little flow beneath road; ponded (Calcium Pits)
L6	Aug 24/99	18.0	27.1	cool	north of Calcium Pits, wooded riparian, sand (DS)
L8	July 3/98	19.0	29.5	cool	partial shade
L8	Oct 30/98				flow observed, fish, wetland
L9	July 3/98	21.0	29.5	cool	shady
W1	June 29/98	21.0	31.0	cool	full shade across road; little shade at test site
W2	June 29/98	22.0	31.0	cool	very little shade; grass cut to edge of stream; fish visible
W3	June 29/98	12.0	31.0	cold	dried up spring meets creek
W5	June 29/98	22.0	31.0	cool	from Nelson Quarry discharge; partial shade
K1	July 13/98	21.8	29.2	cool	good riparian cover, shading
K1	July 29/99	22.5	31.0	cool	wooded riparian zone
K2	July 13/98	23.0	29.2	cool-warm	US/DS channel alterations but good shading
K2	Sept 24/98				flow observed
K3	July 13/98	23.8	29.2	warm	good riparian cover, shading
K3	Sept 24/98				no flow
K4	July 3/98	22.5	29.5	cool (w)	full-partial shade
K4	Sept 24/98				flow observed
K5	July 13/98	23.3	29.2	warm (c)	low gradient, aquatic vegetation
K7	July 20/98	25.0	30.0	warm	fish, good riparian cover
K7	Oct 30/98				flow observed
K8	July 20/98	26.0	30.0	warm	fish, cobble substrate, good riparian cover
K8	Oct 30/98				no flow, fish in standing pool under culvert (Burns trib.)
F5	July 15/98	25.0	31.8	warm	bottom draw discharge from golf club pond
F8	July 15/98	NA	31.8		dry
F9	July 15/98	24.8	31.8	warm (c)	spring through swamp wetland
M2	July 15/98	27.0	31.8	warm	good canopy cover, ponded downstream
M3	July 15/98	28.0	31.8	warm	ponded wetland upstream, canopy cover absent
M4	July 20/98	24.5	30.0	warm	good riparian cover
M5	July 20/98	26.0	30.0	warm	marsh upstream, swamp downstream
M6	July 13/98	27.5	29.2	warm	fish observed, sand substrate
M9	Aug 31/2000	22.0	28.0	cool/warm	Silver maple swamp, low gradient
M10	July 20/98	22.0	30.0	cool(w)	wetland upstream, fish observed
M10	Oct 30/98				low gradient, flow observed
M10	Aug 31/2000	20.0	28.0	cool(w)	fish observed, water crest, south side of road
M11	Oct 30/98				immed. E of M6, flow observed, brook trout DS
M12	July 20/98	26.5	30.0	warm	pool upstream, good riparian cover downstream
M12	Oct 30/98				flow observed
M12	Aug 31/2000	24.0	28.0	warm	
M13	Aug 31/2000	24.0	28.0	warm	pond upstream, succesion old field
M15	Aug 31/2000	21.0	28.0	cool(w)	wet meadow, riparian, downstream pond
M16	Aug 31/2000	23.0	28.0	warm	very low water, riparian meadow upstream, downstream cedar forest, flow has decreased
M20	Jul 27/2001	25.0	warm	30	
M21	Jul 27/2001	25.0	cool(w)	30	
M22	Jul 27/2001	23.0	cool(w)	30	
M23	Jul 27/2001	23.5	cool(w)	30	
S1	July 20/98	24.3	30.0	warm	ponded upstream, heavy algae
S1	Oct 30/98				flow observed
S3	July 20/98	28.0	30.0	warm	pond/cattle pasture upstream
S3	Oct 30/98				no flow

APPENDIX 2

FISHERIES SUMMARY

Table 1. Fish Community Summary (various data sources). 1990-present.

Common Name	Creek / Scientific Name	Lower Bronte Creek	Middle Bronte Creek	Upper Bronte, East Branch	Upper Bronte, Main Branch	Upper Bronte, North-East Branch	Upper Bronte, West Branch	Bronte Harbour	Flamboro	Indian	Kilbride, downstream of escarpment	Kilbride, upstream of escarpment	Limestone, downstream of escarpment	Limestone, upstream of escarpment	Lowville	Mount Nemo	Mountsberg, upstream of Reservoir	Mountsberg, downstream of reservoir	Mountsberg Reservoir	Strabane	Willoughby
American Brook Lamprey	*Lampetra appendix*		X																		
Sea Lamprey	*Petromyzon marinus*	X																			
Alewife	*Alosa pseudoharengus*	X						X													
Coho Salmon	*Oncorhynchus kisutch*	X						X					X								
Chinook Salmon	*Oncorhynchus tshawytscha*	X						X													
Rainbow Trout	*Oncorhynchus mykiss*	X	X					X	X		X		X								X
Atlantic Salmon	*Salmo salar*	X	X																		X
Brown Trout	*Salmo trutta*	X	X					X	X			X	X					X			X
Brook Trout	*Salvelinus fontalis*		X		X				X		X	X	X	X			X			X	X
Rainbow Smelt	*Osmerus mordax*							X													
Central Mudminnow	*Umbra limi*			X	X	X	X		X		X	X	X	X			X	X		X	
Northern Pike	*Esox lucius*							X									X	X			
Northern Redbelly Dace	*Phoxinos eos*			X	X	X				X		X		X				X		X	
Finescale Dace	*Phoxinos neogaeus*																			X	
Redside Dace	*Clinostomus elongatus*			X	X																
Spotfin Shiner	*Cyprinella spiloptera*	X																			
Carp	*Cyprinus carpio*	X						X		X			X								
Brassy Minnow	*Hybognathus hankinsoni*			X		X						X					X	X			
Hornyhead Chub	*Nocomis biguttstus*	X																			
River Chub	*Nocomis micropogon*	X																			
Golden Shiner	*Notemigonus crysoleocas*							X		X											
unknown Chub	*Nocomis spp.*	X																			
Striped Shiner	*Luxilus chrysocephalus*	X																			
Common Shiner	*Luxilus cornutus*	X	X	X	X			X		X		X	X			X		X			
Gizzard Shad	*Notemigonus crysoleucas*	X																X			
Emerald Shiner	*Notropis atherinoides*	X						X													
Blacknose Shiner	*Notropis heterolepis*																	X		X	
Spottail Shiner	*Notropis hudsonius*	X						X													
Silver Shiner	*Notropis photogenis*	X																			
Rosyface Shiner	*Notropis rubellus*	X			X													X			
Spotfin Shiner	*Notropis spilopterus*	X																			
Mimic Shiner	*Notropis volucellus*								X												
Bluntnose Minnow	*Pimephales notatus*	X	X	X	X				X	X		X	X					X			X
Fathead Minnow	*Pimephales promelas*	X			X		X		X	X		X	X		X	X	X	X			
Blacknose Dace	*Rhinichthys atratulus*	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X		X	X
Longnose Dace	*Rhinichthys cataractae*	X	X		X					X	X		X					X			X
Creek Chub	*Semotilus atromaculatus*	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X
Pearl Dace	*Margariscus margarita*			X	X	X	X					X					X	X		X	
White Sucker	*Catostomus commersoni*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 1 continued. Fish Community Summary (various data sources). 1990-present.

Common Name	Creek Scientific Name	Lower Bronte Creek	Middle Bronte Creek	Upper Bronte, East Branch	Upper Bronte, Main Branch	Upper Bronte, North-East Branch	Upper Bronte, West Branch	Bronte Harbour	Flamboro	Indian	Kilbride, downstream of escarpment	Kilbride, upstream of escarpment	Limestone, downstream of escarpment	Limestone, upstream of escarpment	Lowville	Mount Nemo	Mountsberg, upstream of Reservoir	Mountsberg, downstream of reservoir	Mountsberg Reservoir	Strabane	Willoughby
Northern Hog Sucker	***Hypentelium nigricans***	X	X		X						X	X	X				X	X		X	X
Shorthead Redhorse	***Moxostoma macrolepidotum***	X														X					
Brown Bullhead	***Amelurus nebulosus***	X		X	X			X					X			X		X	X		
Stone Cat	***Noturus flavus***	X											X								
Tadpole Madtom	***Noturus gyrinus***	X																			
Trout Perch	***Percopsis omiscomaycus***	X																			
American Eel	***Anguilla rostrata***							X					X			X					
Brook Stickleback	***Culea inconstans***	X	X	X	X	X	X			X		X		X		X	X			X	X
Threespine Stickleback	***Gasterosteus aculeatus***	X						X								X					
White Perch	***Morone americana***							X								X					
Rock Bass	***Ambloplites rupestris***	X		X	X			X		X						X		X	X	X	
Sunfish	***Lepomis***							X								X					
Green Sunfish	***Lepomis cyanellus***	X														X		X	X	X	
Pumpkinseed	***Lepomis gibbosus***	X	X	X	X			X	X	X		X				X	X	X	X	X	
Bluegill	***Lepomis macrochirus***	X														X		X	X		
Small Mouth Bass	***Micropterus dolomieu***	X			X			X		X						X			X		
Large Mouth Bass	***Micropterus salmoides***	X	X	X	X			X		X			X			X	X	X	X		X
Black Crapple	***Poxomis nigromaculatus***							X								X		X	X		
Yellow Perch	***Perca flavescens***	X						X	X							X					
Rainbow Darter	***Etheostoma caeruleum***	X	X		X					X	X		X								X
Iowa Darter	***Etheostoma exile***													X		X					
Fantail Darter	***Etheostoma flabellare***	X	X							X	X	X	X								X
Johnny Darter	***Etheostoma nigrum***	X	X	X	X			X		X	X		X					X		X	X
Log Perch	***Percina caprodes***	X						X								X					
Blackside Darter	***Percina maculata***				X								X			X					X
Freshwater Drum	***Aplodinotus grunniens***							X								X					
Molted Sculpin	***Cottus bairdi***															X					
Slimy Sculpin	***Cottus cognatus***							X								X					
unknown Cyprenid	***Unknown Cyprenid***					X										X				X	

Table 2. Summary of Fish Community Sampling (Conservation Halton). 1998-2001.

Scientific Name	Common Name	Station B10	B12	B14	B16	B17	B22	B23	B29	MN1	I2	I4	I6	I7	L1	L6	L7	N1	N2	N3	N4	N5	N6	F7	S1	S2
Poxomis nigromaculatus	Black Crappie																									
Rhinichthys atratulus	Blacknose Dace	X	X	X	X	X		X		X	X	X		X	X	X	X				X	X	X		X	
Notropis heterolepis	Blacknose Shiner																								X	
Pimephales notatus	Bluntnose Minnow	X	X	X	X						X	X		X	X											
Hybognathus hankinsoni	Brassy Minnow				X			X																		
Culea inconstans	Brook Stickleback				X	X		X	X			X		X		X	X								X	X
Salvelinus fontalis	Brook Trout			X		X	X									X									X	
Amelurus nebulosus	Brown Bullhead				X																					
Salmo trutta	Brown Trout	X																								
Umbra limi	Central Mudminnow			X	X	X			X							X	X							X	X	X
Luxilus cornutus	Common Shiner	X	X	X	X	X				X		X		X	X											
Semotilus atromaculatus	Creek Chub	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X			X	X	X	X		X	
Etheostoma flabellare	Fantail Darter	X										X	X		X											
Pimephales promelas	Fathead Minnow		X						X	X		X		X	X						X			X		
Phoxinos neogaeus	Finescale Dace																									X
Notemigonus crysoleocas	Golden Shiner										X															
Lepomis cyanellus	Green Sunfish																								X	
Etheostoma exile	Iowa Darter															X										
Etheostoma nigrum	Johnny Darter	X	X	X	X	X						X			X										X	
Micropterus salmoides	Large Mouth Bass		X		X	X								X												
Rhinichthys cataractae	Longnose Dace	X	X								X				X											
Notropis volucellus	Mimic Shiner																									
Hypentelium nigricans	Northern Hog Sucker	X	X												X										X	
Esox lucius	Northern Pike																									
Phoxinos eos	Northern Redbelly Dace											X		X		X									X	
Margariscus margarita	Pearl Dace				X	X		X	X																X	
Lepomis gibbosus	Pumpkinseed	X	X	X	X	X				X	X	X		X										X	X	
Etheostoma caeruleum	Rainbow Darter	X									X	X			X											
Oncorhynchus mykiss	Rainbow Trout	X													X											
Ambloplites rupestris	Rock Bass		X		X	X					X	X	X												X	
Notropis rubellus	Rosyface Shiner																									
Micropterus dolomieu	Small Mouth Bass										X															
Catostomus commersoni	White Sucker	X	X	X	X	X		X	X	X	X	X		X	X	X	X				X		X		X	
Perca flavescens	Yellow Perch																									

Table 2. Summary of Fish Community Sampling (Conservation Halton). 1998-2001.

		Station																								
Scientific Name	Common Name	K1	K4	K6	W4	F1	F2	F3	F4	F5	F6	M1	M2	M4	M5	M6	M7	M8	M9	M12	M13	M14	M16	M17	M18	M19
Poxomis nigromaculatus	Black Crappie											X	X				X									
Rhinichthys atratulus	Blacknose Dace	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X		X	X			
Notropis heterolepis	Blacknose Shiner											X		X												
Pimephales notatus	Bluntnose Minnow		X							X		X	X		X	X						X				
Hybognathus hankinsoni	Brassy Minnow		X	X								X										X	X			
Culea inconstans	Brook Stickleback		X	X	X																		X		X	X
Salvelinus fontalis	Brook Trout	X	X	X		X	X											X		X				X	X	
Amelurus nebulosus	Brown Bullhead											X					X									
Salmo trutta	Brown Trout					X	X	X						X												
Umbra limi	Central Mudminnow	X	X	X								X	X		X		X	X	X	X	X	X				X
Luxilus cornutus	Common Shiner		X									X	X	X	X	X						X				
Semotilus atromaculatus	Creek Chub	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
Etheostoma flabellare	Fantail Darter	X	X	X																						
Pimephales promelas	Fathead Minnow		X	X						X	X	X		X		X						X	X			
Phoxinos neogaeus	Finescale Dace																									
Notemigonus crysoleocas	Golden Shiner											X														
Lepomis cyanellus	Green Sunfish											X										X				
Etheostoma exile	Iowa Darter																									
Etheostoma nigrum	Johnny Darter	X										X	X	X	X	X						X				
Micropterus salmoides	Large Mouth Bass											X				X	X	X		X		X				
Rhinichthys cataractae	Longnose Dace	X										X	X	X								X				
Notropis volucellus	Mimic Shiner										X															
Hypentelium nigricans	Northern Hog Sucker	X										X	X	X	X				X			X				
Esox lucius	Northern Pike																	X			X	X				X
Phoxinos eos	Northern Redbelly Dace		X	X										X		X										
Margariscus margarita	Pearl Dace			X																X		X	X			
Lepomis gibbosus	Pumpkinseed			X		X	X			X	X	X	X		X	X	X	X	X			X	X			
Etheostoma caeruleum	Rainbow Darter	X																								
Oncorhynchus mykiss	Rainbow Trout	X				X	X	X																		
Ambloplites rupestris	Rock Bass											X	X		X		X					X				
Notropis rubellus	Rosyface Shiner													X												
Micropterus dolomieu	Small Mouth Bass																									
Catostomus commersoni	White Sucker	X	X	X							X	X	X	X	X	X	X	X	X	X	X	X	X			
Perca flavescens	Yellow Perch										X															

APPENDIX 3

BENTHIC MACROINVERTEBRATE STUDY

Bronte Creek

Bronte Creek: Estuary to Lowville

Station B1-QEW

The density, taxa richness and diversity of the samples were within the expected range for the site. EPT values were high. BioMAP WQI indicated unimpaired conditions. HBI classified the water quality under the slight organic pollution category. The site was dominated by *Dannella* sp., *Ameletus* sp., Chironominae, *Stenelmis* sp., *Cheumatopsyche* sp., *Bezzia* sp., Naididae and *Helicopsyche* sp.

Ameletus sp. and *Dannella* sp. were likely misidentified, since they are not found in this type of habitat. The samples could not be verified. The site was generally dominated by facultative organisms, usually found in mesotrophic, mesothermal and mesoxyphilous conditions. Some sensitive intolerant species were also present. The water quality at the site is classified within the nonimpairment to slight impairment categories (Table 7.2), with elevated temperatures, nutrients and decreased oxygen levels. The site is the most downstream station in the study and it is expected to contain at least some organic enrichment and mid-range oxygen and thermal conditions. Open exposure and lack of canopy often inherent to lower reaches may account for some temperature elevation. Sampling of the site was affected by the larger mesh size used such that smaller body forms would not have been captured efficiently and may have effected various biotic measures.

Station B2-Hwy. #5

The density, taxa richness and diversity of the samples were within the expected range for this site. EPT values were high. BioMAP WQI indicated unimpaired conditions and HBI indicated slight organic pollution. The site was dominated by Naididae, Chironominae, *Stenelmis* sp. *Attenella* sp. and *Ameletus* sp. *Ameletus* sp. identification could not be verified due to sample loss. The remaining dominant taxa at the site generally are facultative organisms, found in mesotrophic, mesothermal and mesoxyphilous conditions. Some sensitive intolerant species were also present. The water quality at the site is classified within the nonimpairment to slight impairment categories (Table 7.2), with slightly elevated temperatures and nutrient levels and decreased oxygen levels. The site is expected to contain at least some organic enrichment, mid-range temperature and oxygen levels since it is found in the lower reaches of the watershed. Open exposure and lack of canopy often inherent to lower reaches may account for some temperature elevation. Sampling of the site was likely affected by the larger mesh size used such that smaller forms were not captured efficiently.

Station B3-Appleby Line

Only the quantitative sample data was available for this site. The density and taxa richness were within the expected range for this site. SDI values were lower than expected. EPT values were high. BioMAP WQI indicated unimpaired conditions and HBI indicated some organic pollution. The site was dominated by *Cricotopus* sp., *Isonychia* sp., *Caenis anceps*, *Hydropsyche bronta*, *Cheumatopsyche* sp. and *Polypedilum scalaenum*.

The dominant taxa at the site generally are facultative organisms, found in mesotrophic, mesothermal and mesoxyphilous conditions. Some sensitive intolerant species were also present. The community was similar to communities affected by nutrient additions and non-point sources from Bode *et al.*, 1996. The water quality at the site is classified within the nonimpairment to slight impairment categories (Table 7.2), with slightly elevated temperatures, nutrients and decreased oxygen levels. The site is expected to contain at least some organic enrichment, mid-range temperature and oxygen levels since it is found in the lower reaches of the watershed. Open exposure and lack of canopy often inherent to lower reaches may account for some temperature elevation.

Station B6-Lowville Park

Only the quantitative sample data was available for this site. The density and taxa richness were within the expected range for this site. SDI values were lower than expected. EPT values were high. BioMAP WQI indicated unimpaired conditions and HBI indicated slight organic pollution. The site was dominated by *Hydropsyche morosa*, *Chimarra* sp., *Baetis flavistriga*, *Caenis anceps*, *Tricorythodes* sp. and *Cheumatopsyche* sp.

The dominant taxa at the site generally are facultative organisms, found in mesotrophic, mesothermal and mesoxyphilous conditions. The community was similar to communities affected by nutrient additions and non-point sources from Bode *et al*., 1996. Some sensitive intolerant species were also present. The water quality at the site is classified within the nonimpairment to slight impairment categories (Table 7.2), with slightly elevated temperatures and nutrients and high to moderate oxygen levels. Ponding as a result of the Lowville Dam would likely account for some warming and oxygenation of the water.

Bronte Creek: Lowville Dam to Progreston Dam

Station B8-Cedar Springs Community

The density, taxa richness and diversity of the samples were within the expected range for this site. EPT values were high. BioMAP WQI indicated unimpaired conditions and HBI indicated slight organic pollution. The site was dominated by *Hydropsyche* sp., *Isonychia* sp., *Baetis tricaudatus* and Chironomidae.

The dominant taxa at the site are generally facultative or saprophobic organisms, found in mesotrophic, clear, well oxygenated to oxygen-saturated waters, at low to mid-range temperatures. The community was similar to communities affected by nutrient additions and non-point sources from Bode *et al*., 1996. Some sensitive intolerant species were also present. The water quality at the site is classified within the slight impairment category (Table 7.2), with slightly elevated nutrients, low to moderate temperatures and high to mid-range oxygen levels. Some effects are expected in these mid-reaches and the Dakota Mills dam upstream. There may also be septic issues in this reach. Groundwater discharge improves water quality in the area. Sampling of the site was likely affected by the larger mesh size used such that smaller forms were not captured efficiently.

Station B10-Progreston

The density, taxa richness and diversity of the samples were within the expected range for the site. EPT values were high. BioMAP WQI indicated unimpaired conditions and HBI indicated the presence moderate organic pollution. The site was dominated by *Hydropsyche* sp. *Heptagenia* sp., *Stenelmis* sp., *Cheumatopsyche* sp., *Isonychia* sp., *Stenonema vicarium*, *Psephenus* sp. and Chironomidae.

The dominant taxa at the site are facultative or saprophobic, found in mesotrophic, well oxygenated, clear water, at mid to high temperatures. The community was similar to communities affected by nutrient additions and non-point sources and downstream of impoundments from Bode *et al*., 1996. Some sensitive intolerant species were also present. The water quality at the site is classified within the slight impairment category (Table 7.2), with slightly elevated nutrients and temperatures and high to moderate oxygen levels. Groundwater discharge and an oxygenation effect at the outfall are influencing water quality at this site. Sampling of the site was likely affected by the larger mesh size used such that smaller forms were not captured efficiently.

Bronte Creek: Upstream of Progreston Dam/ Headwaters

Station B12-Carlisle Road

The density, taxa richness and diversity of the samples were within the expected range. EPT values were moderate. BioMAP WQI indicated unimpaired conditions and HBI indicated slight organic pollution. The site was dominated by *Hydropsyche* sp., *Cheumatopsyche* sp., Chironomidae and *Stenelmis* sp.

The dominant organisms at the site are facultative, generally found in mesotrophic, mid-range temperature and well-oxygenated conditions. The community was similar to communities affected by nutrient additions and non-point sources and impoundment from Bode *et al.*, 1996. Generally the community was skewed and dominated by Hydropsychidae. Some sensitive intolerant species were also present. The water quality at the site is classified within the slight impairment category (Table 7.2), with slightly elevated nutrient and temperature levels and moderate oxygen levels. Some warming effects and enrichment can be attributed to the on-line ponds in Courtcliffe Park upstream. Additionally, a confluence effect upstream, where Mountsberg Creek enters the Bronte Creek may affect the benthic community at this site.

Station B17-Mountsberg Road

The density, taxa richness and diversity of the samples were within the expected range. EPT values were high. BioMAP WQI indicated unimpaired conditions. HBI indicated mixed results ranging from excellent conditions to some organic pollution. The site was dominated by *Serratella* sp., Chironomidae, *Cheumatopsyche* sp., *Hydropsyche* sp., *Stenelmis* sp., *Promoresia* sp. and *Chimarra* sp. The dominant organisms at the site were mostly facultative organisms found in mesotrophic, mid-range to high oxygen concentrations and low to moderate temperatures. The community was similar to natural communities from Bode *et al.*, 1996. Numerous sensitive intolerant species were also present. The water quality at the site is non-impaired (Table 7.2), with slightly elevated nutrients and high to moderate oxygen levels and low water temperatures. There is a high amount of filter feeders at the site, possibly reflecting the upstream wetland.

Station B22-Maddaugh Road West Crossing

The density was as expected, but taxa richness and diversity were lower than the expected range. EPT values were low. BioMAP WQI indicated unimpaired conditions and HBI indicated slight organic pollution. The site was dominated by Empididae, Simuliidae, *Leuctra* sp., *Rhyacophila* sp., *Stenelmis crenata*, *Pagastia* sp., *Baetis tricaudatus* and *Lepidostoma* sp.

Many of the dominant taxa are typical of smaller headwater streams. A number of these organisms are pollution intolerant and are characteristic of cold water systems. Low richness and EPT scores are not uncommon in headwater streams. The community was similar to natural communities from Bode *et al.*, 1996. The water quality at the site is nonimpaired (Table 7.2), with low to moderate nutrient levels, cold water temperatures and high to moderate oxygen levels. The site is a known area of ground water discharge and an artesian well is located at the site. Brook trout are also known to be present.

Station B23-Madduagh Road East Crossing (Bronte North-East Branch)

The density and taxa richness was as expected but diversity was lower than the expected range. EPT values were low. BioMAP WQI indicated impaired conditions and HBI indicated significant organic pollution. The site was dominated by *Hydroptila* sp., *Dubiraphia quadrinotata, Microtendipes* sp., *Simuliidae, Hyalella* sp., *Helobdella stagnalis, Caecidotea* sp. *and Cragonyx* sp.

The dominant organisms at the site are saproxenous or facultative organisms that are generally found in mesotrophic, eutrophic, mesoxyphilous and mesothermal systems. Large numbers of isopods such as Caecidotea are often an indication of organic enrichment (Kellogg 1994). The number of intolerant species was reduced. The community was similar to communities effected by nutrient additions and non-point sources from Bode *et al.*, 1996. The water quality at the site is classified within the moderate impairment category (Table 7.2), with significant organic pollution, elevated temperatures and high to moderate oxygen levels. The benthic community does not reflect a typical benthic community that would be expected for this size and type of stream. 100 m upstream of the site, the stream briefly disappears under bedrock for several metres. Orthophotography analysis indicates upstream channelization, agricultural landuse and ponding that likely contribute to the poor water quality observed at this site.

Station B29-Brock Road South (Bronte West Branch)

The density of the first quantitative sample was within the expected range, but the second was very low for the site. Species richness and diversity indices at the site were lower than the expected for an unimpaired stream. EPT values were also low, indicating possible impairment. BioMAP WQI indicated impaired conditions, while HBI indicated very significant organic pollution. The site was dominated by *Neureclipsis* sp., *Caecidotea* sp., Chironomini and *Hyalella azteca.*

Caecidotea sp. is facultative and is often found in eutrophic-mesotrophic conditions, is tolerant of low oxygen concentrations and is associated with mesothermal conditions (15-30 °C). *Neureclipsis* sp. is often found in lotic erosional habitats on vascular hydrophytes; while some species are reported to be intolerant to organic pollution. Chironomini is a sub-tribe of Chironomidae that can be found along a wide gradient of organic pollution. *Hyalella azteca* has a wide range of tolerance to organic pollution, can be found in eutrophic and mesotrophic conditions, tolerant of warm water conditions and characteristics of generally clear water. Overall the water quality at the site shows slight to moderate impairment (Table 7.2) that does not coincide with the known upstream land use. These results may be erroneous and likely reflect the lack of suitable substrate and low gradient at the sampling site. The benthic indices are often inappropriate for low gradient streams, lacking suitable riffle habitat. Upstream land use consists of the low gradient Beverly Swamp that could contribute nutrients to the watercourse. The landowner of the adjacent property also stated that the stream was intermittent during the drought season of 1998 and 1999, which may explain the impairment at the site. Further investigation of the benthic invertebrates at this site is suggested using a reference site comparison.

Mount Nemo Creek

Station MN1-Boy Scout Camp

The densities of the samples were within the expected range for an unimpaired stream. Species richness and diversity indices at the site were lower than the expected for an unimpaired stream. EPT values were also low indicating impairment. BioMAP WQI indicated impaired conditions. HBI indicated the presence of significant organic pollution. The site was dominated by *Caecidotea* sp., *Hydropsyche* sp., Simuliidae, *Stenelmis* sp. and Chironomidae.

The dominant benthic organisms at the site were facultative, generally found in mesotrophic or eutrophic systems, at mid to high range temperatures. Additionally, the percentage of insects at the site was low and dominated by Isopoda further indicating community impairment and organic enrichment. The community was similar to communities effected by nutrient additions and non-point sources and impoundment from Bode *et al.*, 1996. Sensitive intolerant species were predominantly absent. The water quality at the site is within the moderate impairment category (Table 7.2), with elevated nutrients and organic enrichment. The stream was known to be intermittent in the drought years of 1998 and 1999. Air-photo analysis reveals upstream agricultural land use, a large upstream pond and channelization, which are likely the major contributors to the organic pollution and elevated temperatures. The sampling area was located within a well-forested area, which likely improved the water quality compared to upstream.

Indian Creek

Station I1-Appleby Line

The species richness, density and diversity indices at the site were lower than the expected values for an unimpaired stream. EPT values were low indicating potentially poor water quality. BioMAP WQI indicated an impaired site. HBI indicated the presence of slight to fairly significant organic pollution at the site. The site was dominated by the *Perlesta* sp., *Caecidotea* sp., *Stenelmis* sp. and Chironomidae.

The dominant groups are facultative or tolerant in relation to organic pollution, often found in eutrophic-mesotrophic conditions mid to low oxygen concentrations and are associated with mesothermal conditions. The low density, richness, diversity and lack of EPT species are a distinct indicator of ecosystem impairment. One sensitive intolerant species *Paraleptophlebia* sp. was identified but is likely an identification error. Samples were not available for verification. The water quality at the site is classified as within the moderate to substantial impairment categories (Table 7.2), with elevated nutrients, low oxygen levels and moderate to high temperatures. The site is affected by surrounding and upstream agricultural land use. Cattle have been observed upstream of the site. Sampling of the site was likely affected by the larger mesh size used at the site such that smaller body forms would not have been captured efficiently.

Station I6-Appleby Line & Derry Road

The density at the station was as expected, while the species richness and diversity indices at the site were lower than the expected. EPT values were low. BioMAP WQI indicated an unimpaired site. The HBI indicated some organic pollution likely at the site. The site was dominated by Simuliidae, *Paraleuctra* sp., *Leuctra* sp., *Baetis tricaudatus*, *Dicranato* sp. and *Acentrella* sp.

The dominant groups at the site vary from facultative to intolerant organisms, found in oligotrophic and mesotrophic conditions of well oxygenated sites. The community was not similar to any communities from Bode *et al.*, 1996. Various sensitive intolerant species were also present. The water quality at the site is not impaired to slightly impaired (Table 7.2), with low to moderate nutrients, oxygen saturation and some indication of low water temperatures. The higher gradient at the site may influence the diversity, richness and EPT. The site represents one of the better quality sites of Indian Creek. Sampling of the site was likely affected by the larger mesh size used at the site such that smaller body forms would not have been captured efficiently.

Station I7-Tremaine Road & Derry Road

The species richness, density and diversity indices at the site were lower than the expected values for an unimpaired stream. EPT values were low indicating poor water quality. BioMAP WQI indicated an impaired site. HBI indicated some organic pollution to very significant organic pollution at the site. The site was dominated by *Physella integra*, *Neoporus* sp. and the Chironomidae tribe Tanypodinae.

The dominant groups are facultative or tolerant organisms. *Physella integra* made up a large proportion of the community and are often found in lentic systems, facultative-tolerant to organic pollution, they are associated with eutrophic-mesotrophic waters, tolerant of low oxygen and mesothermal conditions. *Neoporus (Hydroporus)* sp. are common in both polluted and non-polluted waters, typically in mesotrophic waters. Chironomidae can be found in most habitats but high densities can often be associated with organic enrichment. The percentage of insects is lower than expected and the amount of snails is much higher than expected for a stream of this size and type, further indicating site impairment. The site is affected by surrounding and upstream agricultural land use and channelization. No sensitive intolerant species were present. The water quality at the site is substantially impaired (Table 7.2), with elevated nutrients, temperatures, low oxygen levels and siltation.

This site was impacted by channelization and alteration, lack of riparian areas, erosion and agricultural runoff. Improved agricultural practices such as an increase in riparian areas would drastically improve the water quality within this stretch and downstream.

Lowville Creek

Station N1-#4 SR

The density of the first quantitative sample was within the expected range, but the second sample was very low. Species richness and diversity indices at the site were lower than the expected for an unimpaired stream. EPT values were also low indicating poor water quality. BioMAP WQI indicated unimpaired conditions in the first quantitative and qualitative samples. BioMAP WQI indicated impaired conditions in the second quantitative sample, but the results are erroneous due to the low densities. HBI indicated some organic pollution in the quantitative samples. The site was dominated by *Perlesta* sp., Naididae, Chironominae, *Stenelmis* sp. and *Caecidotea* sp. The low density in the second quantitative sample would likely affect the benthic indices and is therefore unreliable.

The dominant organisms at the site are facultative, some are associated with eutrophic-mesotrophic conditions, are tolerant of low oxygen concentrations and are associated with mesothermal conditions. Some sensitive intolerant species were also present. The water quality at the site is likely slightly impaired (Table 7.2), with elevated nutrients and moderate oxygen levels. The stream was known to be intermittent in the drought years of 1998 and 1999, which may have influenced the results. Agricultural land use and a golf course are found upstream, which likely are the major contributors to the organic pollution and elevated temperatures. Further sampling would aid in the classification of water quality in this tributary.

Limestone Creek

Station L1-Britannia Road

The density of the samples were within the expected range. Species richness and diversity were within the expected range in the first sample, but low in the second. EPT values indicated good water quality, BioMAP WQI indicated unimpaired conditions and HBI indicated excellent water quality, with possible slight organic enrichment. The site was dominated by *Antocha* sp., Simuliidae, *Helicopsyhe* sp., *Psychomyia* sp., *Cheumatopsyche* sp., Lumbriculidae, *Stenelmis* sp. and *Drunella* sp.

Antocha sp. and *Helicopsyche* sp. are both saproxenous organisms, are characteristic of clean water habitats, generally mesotrophic, but also are tolerant of organic enrichment if dissolved oxygen, pH and water temperature are not adversely altered. *Psychomia* sp. and *Drunella* sp. are generally intolerant of organic waste. Blackflies are typically found in faster flowing waters and may be associated with colder, non-polluted streams, oligotrophic streams. *Stenelmis* sp. and *Cheumatopsyche* sp. are facultative and found in warm streams and rivers, in mesotrophic waters, with moderate oxygen. Some pollution intolerant species are present at the site, although they are not dominant. The water quality at the site is non-impaired to slightly impaired (Table 7.2), with elevated nutrients possibly as a result of some upstream agriculture and mushroom operation.

Station L4-Derry Road

The density of the first quantitative sample was within the expected range, but the second sample was low. Species richness was low in the samples, but high for the site. The diversity index was low in the quantitative samples. EPT values indicated good water quality, BioMAP WQI indicated unimpaired conditions and HBI indicated slight to some organic enrichment. The low density in the second site may lead to erroneous results. The site was dominated by *Hydropscyhe* sp. and to a lesser extent the Chironomidae and *Rhyacophila* sp, *Dicranota* sp., *Baetis tricaudat*us, *Isonychia* sp. and *Glossosoma* sp.

The benthic community at the site is dominated by facultative or saprophobic organisms, generally found in oligotrophic and mesotrophic systems, in moderate to saturated oxygen conditions and low to moderate temperatures. The community is not similar to Bode *et al.*'s (1996) stream communities. The dominance of *Hydropsyche* sp. at the site indicates potential community instability, although some pollution intolerant species are present. The water quality at the site is non-impaired to slightly impaired (Table 7.2), with elevated nutrients, low temperatures and high oxygen levels. An upstream mushroom operation may contribute to the organic enrichment and is known to contain a higher salt concentration. There are numerous areas of groundwater discharge in the low gradient forested area upstream that must be retained to ensure the higher water quality.

Station L6-Twiss Road

The density and SDI of the samples were within the expected range. EPT values indicated good water quality, BioMAP WQI indicated unimpaired conditions and the HBI indicated slight to some organic enrichment. The site was dominated by *Hydropscyhe* sp. and to a lesser extent *Baetis brunneicolor*, *Optioservus* sp., *Glossosoma* sp. and Brachycentridae.

Hydropsyche sp. exhibit a wide range of tolerances to organic pollution, typical of mesotrophic waters, with moderate oxygen concentrations and generally clear waters. *Optioservus* sp. are characteristic of clean, cold water habitats but are also tolerant of organic enrichment if oxygenation is adequate. *Glossosoma* sp. is found in headwater streams. *Baetis brunneicolor* is usually found in second order streams and its pollution tolerance is moderate. The benthic community was very skewed, as exhibited by the extremely low SDI, which likely reflected the *Hydropsyche* sp. dominance. The water quality at the site is non-slightly impaired (Table 7.2), with elevated nutrients, lower instream temperatures and moderate oxygen levels. Since the site is a low gradient, non-gravel bottom type stream, the benthic indices used in the study may not be entirely applicable and it is suggested that a reference condition approach should be adopted in the future.

Flamboro Creek

Station F5-Bronte Confluence

The density of the samples were within the expected range. Species richness and diversity indices at the site were lower than the expected for an unimpaired stream. EPT values were also low. BioMAP WQI indicated unimpaired conditions and HBI indicated slight organic pollution in the qualitative samples and little to no organic pollution in the quantitative samples. The site was dominated by *Diplectrona* sp., *Cheumatopsyche* sp., *Ephemerella* sp., *Optioservus* sp., Lumbriculidae and Orthocladiinae. The larger 1000 *u*m mesh size used failed to capture the smaller size classes.

Diplectrona sp., *Optioservus* sp. and Lumbriculidae are generally characteristic of unpolluted headwater streams, although *Optioservus* sp is tolerant of organic enrichment when oxygen concentrations are high. The remaining dominant taxa are facultative organisms, found in mesotrophic, mesothermal and mesoxyphilous waters. This site is characterized by numerous intolerant species. The water quality at the site is non-impaired (Table 7.2), with elevated nutrients, low temperatures and moderate oxygen levels. The results were as expected since the creek flows through a forested valley, with ground water input.

Willoughby Creek

Station W1-Britannia Road

The density of the samples were within the expected range for the site. Species richness and diversity indices at the site were lower than expected for an unimpaired stream. EPT values were also low, indicating possible impairment. BioMAP WQI indicated unimpaired conditions and HBI indicated excellent water quality. The site was dominated by *Dolophilodes* sp., *Hydropsyche* sp., *Ephemerella* sp., *Promoresia* sp., *Ectopria* sp. *and Stenelmis* sp. The larger 1000 m mesh size used failed to capture the smaller size classes.

Dolophilodes sp. and *Promoresia* sp. are typically found in unpolluted headwater streams. *Ectopria* sp., *Hydropsyche* sp., *Ephemerella* sp. and *Stenelmis* sp. exhibit a wide range of tolerances to organic pollution and are typical of mesotrophic waters, with moderate oxygen concentrations. The water quality at the site is likely slightly impaired (Table 7.2), with elevated nutrients, low to moderate temperatures and moderate oxygen levels. There are many manicured on-line ponds upstream of the site and possible septic issues at this site, though it appears that there is sufficient groundwater input to maintain water quality.

Strabane Creek

Station S2-Brock Road North

The density and richness at the station was as expected and diversity was lower than the expected for an unimpaired stream. EPT values were low indicating poor water quality. BioMAP WQI indicated an impaired site. HBI indicated some organic pollution likely at the site. The site was dominated by *Cheumatopsyche* sp., *Diphetor hageni*, *Cricotopus* sp., *Hyalella* sp., *Caecidotea* sp., *Tricladida* sp. and *Stenelmis crenata*.

The majority of the dominant organisms at the site are facultative and generally found in mesotrophic, mesothermal and mesoxyphilous systems. The dominance of the isopod *Caecidotea* sp. is often an indicator of organic enrichment. Only once sensitive species was present in the samples. Based on the indices and community at the site, the water quality at the site is slightly to moderately impaired (Table 7.2), with increased nutrients, moderate oxygenation and moderate temperatures. The low gradient upstream of the site may influence the community composition. There is some agriculture upstream of the site, but there is a fairly wide riparian zone that likely minimize the impacts. Large upstream ponds may contribute to some water quality degradation and elevated temperatures. Further investigation of the water quality at the site is recommended using the reference condition approach.

Kilbride Creek

Station K1-Cedar Springs Road

The density of the second quantitative sample was within the expected range, but the first was very low. Species richness and diversity indices at the site were lower than the expected for an unimpaired stream. EPT values were also low. BioMAP WQI indicated unimpaired conditions and HBI indicated slight organic pollution. The site was dominated by Simuliidae, Chironomidae, *Suwallia* sp., *Hydropsyche* sp., Naididae, *Isonychia* sp. and *Leuctra* sp. Sampling of the site was likely affected by the larger mesh size used at the site such that smaller body forms would not have been captured efficiently.

The dominant taxa at the site includes *Leuctra* sp. and *Isonychia* sp. which are intolerant to organic pollution and require high oxygen saturation. Numerous intolerant and sensitive species were present at the site. The other dominant taxa are generally facultative organisms. Overall the benthic indices indicate that the water quality is nonimpaired to slightly impaired (Table 7.2), with some slight organic enrichment, high to moderate oxygenation and low to moderate temperatures. The site is known to be in a high gradient area, below a small waterfall, in an area of ground water discharge.

Station K4-Steeles Ave.

The density and species richness of the samples were within the expected range for the site. SDI at the site was lower than the expected for an unimpaired stream. EPT values were as expected. BioMAP WQI indicated unimpaired conditions and HBI indicated some to slight organic pollution. The site was dominated by *Cheumatopsyche* sp., *Leuctra* sp., *Nigronia* sp., *Stenelmis* sp., *Optioservus* sp. and the Chironomid tribes Chironomini and Tanytarsini.

Leuctra sp. and *Nigronia* sp. are relatively intolerant organisms and are characteristic of non-impacted headwater streams. *Optioservus* sp. is characteristic of clean water habitats but are also tolerant of organic enrichment if oxygenation is adequate. Some sensitive species are present at the site. The remaining dominant organisms are facultative. The community is similar to natural communities of Bode *et al.*, 1996. Overall the benthic indices indicate that the water quality is nonimpaired to slightly impaired (Table 7.2), with some slight organic enrichment, cool to moderate temperatures and high to moderate oxygenation. The stream is likely affected by an upstream on-line pond, but is also known to contain areas of ground water discharge, which may compensate in part for the effects of the pond. Sampling of the site was affected by the larger mesh size used at the site such that smaller body forms would not have been captured efficiently.

Station K6-McNiven Road/CPR Tracks

The density and species richness of the samples were within the expected range for the site. SDI at the site was lower than the expected for an unimpaired stream. EPT values were as expected. BioMAP WQI indicated unimpaired conditions and HBI indicated some to mid-range organic pollution. The site was dominated by *Rheotanytarsus* sp., *Polpedilum aviceps*, *Cricotopus* sp., *Cheumatopsyche* sp., *Optioservus trivittatus*, *Stenelmis crenata* and *Hydropsyche bettenis*.

The site is dominated by facultative organisms, most of which are found in mesotrophic nutrient conditions. The dominant species are typical of metathermal and oligothermal conditions indicating that water temperature is fairly cold. Some intolerant species are also present at the site, but do not dominate the population. The community is similar to natural communities of Bode *et al.*, 1996. The indices indicate that the benthic community is nonimpaired to slightly impaired (Table 7.2) although there is some organic enrichment, low to moderate temperatures and moderate oxygenation. The area upstream of the site appears to have sufficient riparian cover, although Hwy 401 upstream may contribute some detriment to the system. A sand and gravel operations' pit/pond upstream does not appear to be connected to the stream.

Mountsberg Creek

Mountsberg Creek: Bronte Confluence to Reservoir

Station M1-Courtcliffe Park

The density of the samples were low, but within the expected range for the site. Taxa richness and diversity of the samples were also within the expected range. EPT values were high. BioMAP WQI indicated unimpaired conditions and HBI indicated excellent to very good water quality. The site was dominated by *Helicopsyche* sp., *Paraleptophlebia* sp. *Stenonema vicarium*, *Drunella* sp., Chironomidae, *Cheumatopsyche* sp., *Hydropsyche* sp., *Stenelmis* sp., *Caecidotea* sp. and *Chimarra* sp. The site is generally dominated by saproxenous or facultative organisms. Most of the groups are found in mesotrophic conditions, over a range of oxygen levels and temperatures. Various sensitive, intolerant species are present at the site. The community is similar to natural communities of Bode *et al.*, 1996. Overall the benthic indices indicate that the water quality is slightly impaired (Table 7.2), with some organic enrichment and moderate to high oxygenation. Although the dominant species tend to prefer moderate to higher temperatures (mesothermal and euthermal), the presence of cool oligothermal and metathermal species such as *Helicopsyche* sp. suggests some upwelling may be occurring in the area. The water quality at this site was expected to be lower due to the presence of on-line ponds, agriculture and channel alteration upstream. It is possible that increased forest cover and groundwater input upstream improve the water quality. Downstream of this site, there is extensive ponding and channel alteration that are expected to degrade the stream quality significantly. Sampling at the site was affected by larger mesh size of the surber sampler.

Station M5-Mountsberg Road

The density, taxa richness and diversity of the samples were also within the expected range for the site. EPT values were high. BioMAP WQI indicated unimpaired and transitional (in the second quantitative sample) conditions. HBI indicated excellent to good water quality. The site was dominated by *Hydropsyche* sp., *Cheumatopsyche* sp., *Sphaerium* sp., *Chimarra* sp., *Stenonema terminatum*, *Nigronia* sp., Chironomidae, *Stenelmis* sp. and *Baetis flavistriga*.

The dominant taxa are facultative organisms that are typical of mesotrophic, mesothermal waters, with moderate oxygen concentrations. Some sensitive, intolerant species are present at the site although their numbers are reduced. The community is similar to natural, impoundment related, or nutrient effected communities of Bode *et al.*, 1996. Overall the water quality is slightly impaired (Table 7.2), with mesotrophic conditions, moderate oxygenation and moderate temperatures. The water quality is likely affected by the upstream low gradient wetland system and on-line pond.

Station M6-Campbellville Road

The density was low in the second quantitative sample. Taxa richness and diversity of the samples were within the expected range for the site. EPT values were moderate to low at the site. BioMAP WQI indicated unimpaired conditions. HBI indicated the presence of some organic pollution. The site was dominated by *Hydropsyche* sp., *Cheumatopsyche* sp., *Stenelmis* sp., *Oecetis* sp., *Antocha* sp. and *Psephenus* sp.

Antocha sp. and *Psephenus* sp. are characteristic of clean water habitats, but also are tolerant of organic enrichment if dissolved oxygen, pH and water temperature are not adversely altered. *Oecetis* sp., *Hydropsyche* sp., *Cheumatopsyche* sp. and *Stenelmis* sp. are facultative and characteristic of mesotrophic conditions over a range of temperatures. Some sensitive, intolerant species are present at the site, though their numbers are reduced. The community is similar to natural, impoundment related, or nutrient effected communities of Bode *et al.*, 1996. Overall the water quality impairment at the site is slight to moderate (Table 7.2), with mesotrophic conditions, moderate oxygenation and moderate to high temperatures. The site is largely affected by the large upstream reservoir.

Mountsberg Creek: Upstream of Reservoir

Station M8-Hwy 401

The density, taxa richness and EPT at the station were within the expected range. SDI values were low. BioMAP WQI indicated inconclusive conditions in the quantitative samples. The HBI indicated fairly significant

organic pollution in both of the quantitative samples. The site was dominated by *Stenelmis crenata*, *Cheumatopsyche* sp., *Hydropsyche bettenis*, *Micropsectra* sp., Simuliidae, *Hydroptila* sp., *Stenonema vicarium*, *Paraleptophlebia* sp. and *Hyalella* sp.
The dominant taxa at the site are generally facultative organisms, found in meso/ eurythermal (warm water conditions) and mesotrophic nutrient conditions. Some sensitive, intolerant species are present at the site although their numbers are reduced. The community is similar to impoundment related communities of Bode *et al.*, 1996. Overall the water quality impairment at the site is slight to moderate (Table 7.2), with mesotrophic conditions, moderate oxygenation and moderate to high temperatures. Though the upstream landuse is dominated by a forested plantation, the presence of on-line ponds and poor agricultural practices upstream contribute to decreased water quality in this reach. Additionally, runoff from the Highway 401 may contribute to decreased water quality downstream.

Station M12-R.R. 36

The density and taxa richness at the station were within the expected range. SDI and EPT values were moderate to low at the site, indicating possible impairment. BioMAP WQI indicated impaired conditions in the quantitative samples and unimpaired conditions in the qualitative sample. HBI indicated fairly significant organic pollution in both the quantitative samples. The site was dominated by Simuliidae, *Cheumatopsyche* sp., *Acerpenna* sp., *Dubiraphia* sp. and *Hyalella azteca*.

The dominant taxa at the site are facultative organisms. Some sensitive, intolerant species are present at the site, though their numbers are drastically reduced. The community is similar to impoundment effected communities of Bode *et al.*, 1996. Overall the water quality is moderately impaired (Table 7.2), with mesotrophic conditions, moderate oxygenation and moderate temperatures. The site is most affected by increased nutrient loading associated with the commercial on-line fishing ponds located upstream.

Station M13# 15 S.R.

The density, diversity and taxa richness was within the expected range at the site. EPT values were low, indicating possible impairment. BioMAP WQI indicated impaired conditions in the quantitative samples and transitional conditions in the qualitative sample. HBI indicated significant organic pollution. The site was dominated by Simuliidae, *Erpobdella* sp., Chironomidae, *Stenelmis* sp and *Hyalella azteca*.

The majority of the dominant taxa at the site are facultative organisms. *Erpobdella* sp. is common in both polluted and clean waters, but is often characteristic of organically enriched eutrophic systems. No intolerant species are present at the site. Overall the water quality impairment is moderate (Table 7.2), with mesotrophic to eutrophic conditions, moderate oxygenation and moderate temperatures. The site is likely affected by upstream agriculture.

Table 1. Summary of Water Quality Designation at each Benthic Station.

Major Reach or Tributary	BCWS Station ID	BCWS Designation
Bronte Creek	B1	Non-Slight Impairment
	B2	Non-Slight Impairment
	B3	Non-Slight Impairment
	B6	Non-Slight Impairment
	B8	Slight Impariment
	B10	Slight Impariment
	B12	Slight Impariment
	B17	Non-Slight Impairment
	B22	Nonimpariment
	B23	Moderate Impariment
	B29	Slight-Moderate Impariment
Mount Nemo Creek	MN1	Moderate Impariment
Indian	I1	Moderate-Substantial Impariment
	I6	Non-Slight Impairment
	I7	Substantial Impairment
Lowville	N1	Slight Impariment
Limestone	L1	Non-Slight Impairment
	L4	Non-Slight Impairment
	L6	Non-Slight Impairment
Willoughby	W1	Slight Impariment
Kilbride	K1	Non-Slight Impairment
	K4	Non-Slight Impairment
	K6	Non-Slight Impairment
Flamboro	F5	Nonimpariment
Mountsberg	M1	Slight Impariment
	M5	Slight Impariment
	M6	Slight-Moderate Impariment
	M8	Slight-Moderate Impariment
	M12	Moderate Impariment
	M13	Moderate Impariment
Strabane	S1	Slight-Moderate Impariment

Glossary of Definitions

Euoxyphilous- water having high oxygen concentration
Eurythermal- occurring over a temperature range of 15 °C or greater
Euthermal- warm water, occurring at temperatures greater than 30 °C
Eutrophic- high nutrient concentrations
Facultative- wide range of tolerance to organic pollution, common in both polluted and clean waters
Mesothermal- usually occurring between 15 to 30 °C
Mesotrophic- moderate nutrient concentrations
Mesoxyphilous- water having moderate oxygen concentration
Metathermal- occurring over a range of 5 to 15 °C
Oligothermal- usually occurring between 0 to 15 °C
Oligotrophic- low nutrient concentrations
Oligoxyphilous- water having low oxygen concentration
Saprophilic- occurring usually in polluted waters accompanied by periods of dissolved oxygen concentrations below 5 mg/L, pH changes of up to 2 units and temperatures exceeding 25 °C, but also present in limited numbers in clean water (United States Department of Agriculture, 1991)
Saprophobic- restricted to waters that have not been exposed to pollutants
Saproxenous- characteristic of clean water habitats, but also tolerant of organic enrichment if the dissolved oxygen concentration remains high and pH and water temperature not adversely altered

Table 2. Summary of Benthic Water Quality Data

Sampling Date	Fall 1999			Fall 1999			July 26 2000		
Station ID	B1			B2			B3		
Water Quality Parameters	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative
	D1	S2	S1	D1	S2	S1	D1	S2	S1
Density (per Water Quality Parameters)	512	231	78	773	218	139		353	413
Richness (per Water Quality Parameters)	40	30	24	36	29	27		32	36
Richness (per site)	53			54			46		
Shannon-Weaver Index		4	4		3	4		3	3
SDI Water Quality (SDI)		Good	Good		Good	Good		Poor	Poor
BioMAP WQI (Q or D)	3	11	12	3	14	17		14	15
BioMAP Water Quality	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired		Unimpaired	Unimpaired
Hillsenhoff Biotic Index (HBI)		4	4		5	5		4	4
Hilsenhoff Water Quality		Very Good	Very Good		Good	Very Good		Very Good	Very Good
EPT	29	12	11	35	16	13		17	21
EPT Water Quality	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent		Excellent	Excellent
% Insects	87	73	95	87	90	83		99	100
% Chironomids	19	22	22	16	39	31		8	14
% Crustaceans	0	0	0	0	0	0		0	0
% Isopods	0	0	0	0	0	0		0	0
% Snails	6	2	1	1	1	1		0	0
% Bivalves	0	0	0	0	0	0		0	0
% Annelids	3	24	3	2	6	14		1	0
% Tubeficids	0	0	0	0	0	0			
% Flatworms	0	0	0	0	0	0		0	0
% Shredders	3	1	5	2	3	4		3	7
% Filter Feeders	14	28	26	13	40	36		45	43
% Collectors or Gatherers	64	54	62	76	78	73		97	93
% Scrapers	59	32	32	63	23	26		29	27

Table 2 continued. Summary of Benthic Water Quality Data

Sampling Date	July 19 2000			Aug. 1 2000			July 13 2000		
Station ID	B6			B8			B10		
Water Quality Parameters	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative
	D1	S2	S1	D1	S2	S1	D1	S2	S1
Density (per Water Quality Parameters)		309	472	105	114	76	195	103	107
Richness (per Water Quality Parameters)		35	33	32	25	18	32	26	30
Richness (per site)	46			44			49		
Shannon-Weaver Index		3	3		4	3		4	4
SDI Water Quality (SDI)		Good	Poor		Good	Good		Good	Excellent
BioMAP WQI (Q or D)		14	16	4	18	19	4	15	16
BioMAP Water Quality		Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired
Hillsenhoff Biotic Index (HBI)		5	5		5	5		4	4
Hilsenhoff Water Quality		Good	Good		Good	Good		Very Good	Very Good
EPT		16	16	14	11	9	23	15	17
EPT Water Quality		Excellent	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent
% Insects		95	98	84	99	100	91	92	93
% Chironomids		32	12	6	20	22	7	3	7
% Crustaceans		0	0	3	0	0	0	0	4
% Isopods		0	0	0	0	0	0	0	2
% Snails		0	0	13	1	0	3	0	0
% Bivalves		0	0	0	0	0	5	8	3
% Annelids		5	1	0	0	0	1	0	1
% Tubeficids				0	0	0	0	0	0
% Flatworms		0	0	0	0	0	0	0	0
% Shredders		22	10	5	2	1	1	2	2
% Filter Feeders		49	43	20	54	51	73	60	38
% Collectors or Gatherers		89	95	39	79	79	85	76	69
% Scrapers		34	39	30	31	14	18	19	33

Table 2 continued. Summary of Benthic Water Quality Data

Sampling Date	August 21 2000			August 2000			July 12 2000		
Station ID	B12			B17			B22		
Water Quality Parameters	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative
	D1	S2	S1	D1	S2	S1	D1	S2	S1
Density (per Water Quality Parameters)	179	243	866	205	742	495		126	59
Richness (per Water Quality Parameters)	38	25	28	40	34	38		14	16
Richness (per site)	53			68			22		
Shannon-Weaver Index		3	3		4	4		2	2
SDI Water Quality (SDI)		Good	Poor		Good	Excellent		Very Poor	Poor
BioMAP WQI (Q or D)	4	13	16	3	18	13		31	25
BioMAP Water Quality	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired		Unimpaired	Unimpaired
Hillsenhoff Biotic Index (HBI)		5	5		5	5		4	4
Hilsenhoff Water Quality		Good	Good		Good	Good		Very Good	Very Good
EPT	23	9	8	23	17	16		8	6
EPT Water Quality	Excellent	Good	Good	Excellent	Excellent	Excellent		Good	Good
% Insects	74	99	99	44	99	95		97	100
% Chironomids	13	16	17	7	22	18		13	5
% Crustaceans	8	0	0	53	1	5		3	0
% Isopods	7	0	0	44	0	1		0	0
% Snails	15	0	0	1	0	0		0	0
% Bivalves	2	0	0	1	0	0		0	0
% Annelids	0	0	0	0	0	0		0	0
% Tubeficids	0	0	0	0	0	0			
% Flatworms	0	0	0	0	0	0		0	0
% Shredders	3	0	0	5	2	3		14	15
% Filter Feeders	22	69	71	11	53	21		27	36
% Collectors or Gatherers	49	91	94	20	83	62		48	32
% Scrapers	46	18	20	7	19	23		2	20

Table 2 continued. Summary of Benthic Water Quality Data

Sampling Date	August 11 2000			August 2 2000			July 6 2000		
Station ID	B23			B29			MN1		
Water Quality Parameters	Qualitative	Quantitative	Quantitative	Qualitative(site total)	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative
	D1	S2	S1	D1	S2	S1	D1	S2	S1
Density (per Water Quality Parameters)		110	151	81	40	194	125	121	129
Richness (per Water Quality Parameters)		21	24	15	7	15	25	16	14
Richness (per site)				26			33		
Shannon-Weaver Index		2	3		2	1		2	2
SDI Water Quality (SDI)		Poor	Poor		Very Poor	Very Poor		Poor	Poor
BioMAP WQI (Q or D)		7	9	3	5	9	3	8	6
BioMAP Water Quality		Impaired	Impaired	Unimpaired	Imparied	Imparied	Imparied	Imparied	Imparied
Hillsenhoff Biotic Index (HBI)		7	6		8	8		7	7
Hilsenhoff Water Quality		Fairly Poor	Fair		Poor	Poor		Fairly Poor	Fairly Poor
EPT		6	6	6	1	4	7	5	4
EPT Water Quality		Good	Good	Good	Very Poor	Poor	Good	Poor	Poor
% Insects		31	81	15	28	13	61	32	43
% Chironomids		5	22	2	20	1	34	8	12
% Crustaceans		51	15	68	70	86	34	62	57
% Isopods		15	1	64	53	79	33	62	56
% Snails		5	1	16	0	0	3	2	0
% Bivalves		0	0	1	0	1	0	0	0
% Annelids		14	3	0	3	0	1	1	0
% Tubeficids				0	0	0	0	0	0
% Flatworms		0	0	0	0	0	0	0	0
% Shredders		1	7	2	0	7	0	1	0
% Filter Feeders		10	42	1	0	2	22	10	27
% Collectors or Gatherers		13	24	2	20	9	45	13	40
% Scrapers		15	15	19	3	2	22	6	12

Table 2 continued. Summary of Benthic Water Quality Data

Sampling Date	Fall 1999			July 24 2000			July 18, 21 2000		
Station ID	I1			I6			I7		
Water Quality Parameters	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative
	D1	S2	S1	D1	S2	S1	D1	S2	S1
Density (per Water Quality Parameters)	335	70	75	23	209	143	179	115	109
Richness (per Water Quality Parameters)	17	10	10	11	12	14	15	13	13
Richness (per site)	26			23			31		
Shannon-Weaver Index		3	2		1	2		3	2
SDI Water Quality (SDI)		Poor	Poor		Very Poor	Poor		Poor	Very Poor
BioMAP WQI (Q or D)	3	6	8	4	25	25	2	4	3
BioMAP Water Quality	Imparied	Imparied	Imparied	Unimpaired	Unimpaired	Unimpaired	Imparied	Imparied	Imparied
Hillsenhoff Biotic Index (HBI)		5	6		5	5		6	6
Hilsenhoff Water Quality		Good	Fair		Good	Good		Fair	Fair
EPT	6	2	4	6	4	5	1	1	0
EPT Water Quality	Good	Poor	Poor	Good	Poor	Poor	Very Poor	Very Poor	Very Poor
% Insects	59	73	49	96	100	100	21	72	20
% Chironomids	1	10	20	17	4	13	0	10	11
% Crustaceans	35	11	48	0	0	0	4	3	1
% Isopods	35	11	48	0	0	0	0	0	0
% Snails	6	6	0	4	0	0	74	24	72
% Bivalves	0	0	0	0	0	0	0	0	2
% Annelids	0	10	1	0	0	0	0	0	6
% Tubeficids	0	0	0	0	0	0	0	0	0
% Flatworms	0	0	0	0	0	0	0	0	0
% Shredders	1	1	5	9	5	0	0	1	2
% Filter Feeders	1	10	21	35	79	59	0	3	3
% Collectors or Gatherers	5	70	48	52	91	73	1	3	3
% Scrapers	8	36	8	22	10	6	74	24	72

Table 2 continued. Summary of Benthic Water Quality Data

Sampling Date	June 2 2000			July 11 2000			August 17 2001		
Station ID	L1			L4			L6		
Water Quality Parameters	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative
	D1	S2	S1	D1	S2	S1	D1	S2	S1
Density (per Water Quality Parameters)	178	106	58	32	42	140	95	70	207
Richness (per Water Quality Parameters)	25	13	20	21	13	16	24	14	20
Richness (per site)	37			37			39		
Shannon-Weaver Index		3	4		3	2		3	2
SDI Water Quality (SDI)		Poor	Excellent		Poor	Very Poor		Poor	Very Poor
BioMAP WQI (Q or D)	4	22	20	4	38	25	4	37	24
BioMAP Water Quality	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired
Hillsenhoff Biotic Index (HBI)		3	4		4	5		4	5
Hilsenhoff Water Quality		Excellent	Very Good		Very Good	Good		Very Good	Good
EPT	14	7	7	15	6	8	18	7	10
EPT Water Quality	Excellent	Good	Good	Excellent	Good	Good	Excellent	Good	Excellent
% Insects	95	100	91	91	100	98	94	100	100
% Chironomids	3	5	10	0	12	6	20	0	1
% Crustaceans	2	0	0	6	0	0	5	0	0
% Isopods	0	0	0	3	0	0	3	0	0
% Snails	0	0	0	3	0	2	0	0	0
% Bivalves	2	0	3	0	0	0	0	0	0
% Annelids	0	0	5	0	0	0	1	0	0
% Tubeficids	0	0	0	0	0	0	0	0	0
% Flatworms	0	0	0	0	0	0	0	0	0
% Shredders	1	0	0	9	2	0	8	4	2
% Filter Feeders	74	26	22	16	52	77	35	40	76
% Collectors or Gatherers	74	71	59	44	74	88	47	70	88
% Scrapers	3	44	33	28	29	13	21	36	15

Table 2 continued. Summary of Benthic Water Quality Data

Sampling Date	Fall 1999			Fall 1999			July 25 2000		
Station ID	N1			K1			K4		
Water Quality Parameters	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative
	D1	S2	S1	D1	S2	S1	D1	S2	S1
Density (per Water Quality Parameters)	95	40	167	70	144	43	65	212	176
Richness (per Water Quality Parameters)	16	12	14	10	23	11	27	28	20
Richness (per site)	27			35			43		
Shannon-Weaver Index		3	3		4	3		4	3
SDI Water Quality (SDI)		Poor	Poor		Good	Poor		Good	Poor
BioMAP WQI (Q or D)	3	8	14	4	29	28	3	16	15
BioMAP Water Quality	Unimpaired	Imparied	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired
Hillsenhoff Biotic Index (HBI)		5	5		4	5		4	5
Hilsenhoff Water Quality		Good	Good		Very Good	Good		Very Good	Good
EPT	5	2	4	16	11	2	11	6	6
EPT Water Quality	Poor	Poor	Poor	Excellent	Excellent	Poor	Excellent	Good	Good
% Insects	72	73	78	100	84	88	86	99	99
% Chironomids	7	35	19	31	3	51	22	31	21
% Crustaceans	13	0	10	0	0	0	2	1	0
% Isopods	12	0	10	0	0	0	0	0	0
% Snails	2	0	1	0	1	0	6	0	1
% Bivalves	0	0	0	0	0	0	6	0	0
% Annelids	14	25	11	0	14	12	0	0	0
% Tubeficids	0	0	0	0	0	0	0	0	0
% Flatworms	0	0	0	0	0	0	0	0	0
% Shredders	0	0	0	1	13	2	6	7	3
% Filter Feeders	8	33	19	27	54	63	23	48	40
% Collectors or Gatherers	23	63	77	36	68	65	42	71	85
% Scrapers	16	25	38	7	10	2	20	21	30

Table 2 continued. Summary of Benthic Water Quality Data

Sampling Date	July 25 2000			Fall 1999			Fall 1999		
Station ID	K6			W1			F5		
Water Quality Parameters	Qualitative(site total)	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative
	D1	S2	S1	D1	S2	S1	D1	S2	S1
Density (per Water Quality Parameters)		74	675	140	118	515	31	85	109
Richness (per Water Quality Parameters)		18	24	28	14	18	12	18	17
Richness (per site)	31		32	38			31		
Shannon-Weaver Index		2	2		2	2		3	3
SDI Water Quality (SDI)		Poor	Very Poor		Poor	Poor		Poor	Good
BioMAP WQI (Q or D)		15	15	4	22	29	3	27	25
BioMAP Water Quality		Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired	Unimpaired
Hillsenhoff Biotic Index (HBI)		5	6		3	3		3	3
Hilsenhoff Water Quality		Good	Fair		Excellent	Excellent		Excellent	Excellent
EPT		9	10	11	6	8	12	8	7
EPT Water Quality		Good	Excellent	Excellent	Good	Good	Excellent	Good	Good
% Insects		100	98	94	96	99	94	42	72
% Chironomids		27	79	1	2	0	3	1	10
% Crustaceans		0	2	1	0	0	0	1	0
% Isopods		0	0	1	0	0	0	0	0
% Snails		0	0	1	3	0	3	1	0
% Bivalves		0	0	1	1	0	0	0	0
% Annelids		0	0	3	1	0	3	55	28
% Tubeficids				0	0	0	0	0	0
% Flatworms		0	0	0	0	0	0	0	0
% Shredders		9	38	7	0	1	0	4	5
% Filter Feeders		54	71	5	11	33	3	13	32
% Collectors or Gatherers		81	56	73	70	89	13	32	58
% Scrapers		27	21	64	63	56	6	19	24

Table 2 continued. Summary of Benthic Water Quality Data

Sampling Date	May 26 2000			July 25 2000			August 22 2000		
Station ID	M1			M5			M6		
Water Quality Parameters	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative
	D1	S2	S1	D1	S2	S1	D1	S2	S1
Density (per Water Quality Parameters)	152	68	44	35	199	187	31	34	267
Richness (per Water Quality Parameters)	35	26	22	15	27	26	18	16	26
Richness (per site)	59			44			40		
Shannon-Weaver Index		4	4		4	4		3	3
SDI Water Quality (SDI)		Good	Excellent		Excellent	Good		Good	Poor
BioMAP WQI (Q or D)	4	14	22	3	11	14	3	12	13
BioMAP Water Quality	Unimpaired	Unimpaired	Unimpaired	Unimpaired	"gray"	Unimpaired	Unimpaired	Unimpaired	Unimpaired
Hillsenhoff Biotic Index (HBI)		5	3		5	5		5	5
Hilsenhoff Water Quality		Good	Excellent		Good	Very Good		Good	Good
EPT	26	12	10	15	10	8	12	2	8
EPT Water Quality	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Poor	Good
% Insects	47	79	93	63	87	94	94	85	98
% Chironomids	13	13	7	3	21	12	3	6	4
% Crustaceans	34	16	2	14	0	1	6	0	0
% Isopods	24	16	2	0	0	1	0	0	0
% Snails	3	0	0	17	0	0	0	0	0
% Bivalves	16	1	2	6	13	6	0	6	1
% Annelids	0	0	2	0	0	0	0	0	0
% Tubeficids	0	0	0	0	0	0	0	0	0
% Flatworms	0	3	0	0	0	0	0	0	0
% Shredders	9	7	30	17	1	4	3	9	5
% Filter Feeders	22	10	14	6	53	55	26	9	71
% Collectors or Gatherers	22	31	45	14	61	67	48	53	86
% Scrapers	22	54	30	23	16	18	23	41	20

Table 2 continued. Summary of Benthic Water Quality Data

Sampling Date	August 8 2000			July 31 2000			August 3 2000		
Station ID	M8			M12			M13		
Water Quality Parameters	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative	Qualitative	Quantitative	Quantitative
	D1	S2	S1	D1	S2	S1	D1	S2	S1
Density (per Water Quality Parameters)		216	852	59	216	108	177	258	277
Richness (per Water Quality Parameters)		30	42	25	23	18	17	21	23
Richness (per site)	48			43			38		
Shannon-Weaver Index		3	2		3	3		2	3
SDI Water Quality (SDI)		Poor	Poor		Poor	Poor		Poor	Good
BioMAP WQI (Q or D)		11	10	3	9	7	2	5	5
BioMAP Water Quality		"Gray"	"Gray"	Unimpaired	Imparied	Imparied	"gray"	Imparied	Imparied
Hillsenhoff Biotic Index (HBI)		5	6		7	6		7	6
Hilsenhoff Water Quality		Good	Fair		Fair	Fair		Fair	Fair
EPT		14	20	11	7	6	8	2	5
EPT Water Quality		Excellent	Excellent	Excellent	Good	Good	Good	Poor	Poor
% Insects		69	78	58	50	60	83	84	82
% Chironomids		22	25	5	6	6	5	24	25
% Crustaceans		31	22	31	47	40	8	6	8
% Isopods		0	0	5	1	1	5	2	3
% Snails		0	0	3	0	0	5	1	3
% Bivalves		0	0	2	0	0	0	0	0
% Annelids		0	0	7	1	0	4	9	7
% Tubeficids				0	0	0	0	0	0
% Flatworms		0	0	0	0	0	0	0	0
% Shredders		8	3	2	0	1	0	0	1
% Filter Feeders		23	33	15	33	37	73	74	55
% Collectors or Gatherers		54	61	24	47	52	76	76	74
% Scrapers		26	14	7	6	10	9	2	19

Table 2 continued. Summary of Benthic Water Quality Data

Sampling Date	August 2 2000		
Station ID	**S1**		
Water Quality Parameters	Qualitative	Quantitative	Quantitative
	D1	**S2**	**S1**
Density (per Water Quality Parameters)		353	150
Richness (per Water Quality Parameters)		27	16
Richness (per site)	31		
Shannon-Weaver Index		2	2
SDI Water Quality (SDI)		Poor	Very Poor
BioMAP WQI (Q or D)		13	10
BioMAP Water Quality		Impaired	Impaired
Hillsenhoff Biotic Index (HBI)		5	5
Hilsenhoff Water Quality		Good	Good
EPT		13	7
EPT Water Quality		Excellent	Good
% Insects		78	52
% Chironomids		5	9
% Crustaceans		13	35
% Isopods		13	30
% Snails		0	1
% Bivalves		2	0
% Annelids		0	0
% Tubeficids			
% Flatworms		7	12
% Shredders		4	8
% Filter Feeders		51	31
% Collectors or Gatherers		73	45
% Scrapers		12	7