Towards a Recovery Strategy for Species at Risk in the Ausable River:

Synthesis of Background Information

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Executive Summary

The Ausable River is one of the most biologically diverse basins of its size in Canada. Historically, the watershed supported at least 83 species of fishes, 24 species of freshwater mussels, and 21 species of reptiles. The aquatic community of the Ausable River includes 14 species listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC): seven fishes [pugnose shiner (END), eastern sand darter (THR), lake chubsucker (THR), black redhorse (THR), river redhorse (SC), greenside darter (SC), and bigmouth buffalo (SC)], four mussels [northern riffleshell (END), wavy-rayed lampmussel (END), snuffbox (END), and kidneyshell (END)] and three aquatic reptiles [eastern spiny softshell turtle (THR), queen snake (THR), and northern map turtle (SC)]. Several of these species at risk are declining within the basin and recovery actions are required.

Synthesis Objectives

The primary objective of this report is to relate the known physical and chemical characteristics of the Ausable River to trends in abundance and distribution of COSEWIC-listed species. A second objective is to assess and prioritize the threats to species at risk and identify appropriate mitigation measures. This report integrates information from four background reports completed for the Ausable River Recovery Team. These reports provided a synopsis of:

- physical characteristics of the Ausable River and Parkhill Creek basins, such as geology, physiography, and soils;
- current and historical changes (pre settlement to 2000) in land use;
- recent changes (1964 to 2002) in the physical and chemical water quality;
- habitat requirements and the historic and current distribution of aquatic species at risk.

Physical/ Chemical Environment of the Ausable River Basin

The Ausable River and its former tributary, Parkhill Creek, drain approximately 1600 km^2 of land in southern Ontario into Lake Huron. A channelized section, called the “Cut” was excavated from its current mouth in Port Franks to intercept the original Ausable River channel to the southeast. The remaining channel north of the “Cut” still receives water from Parkhill Creek, which flows parallel to the Ausable River for most of its length. A diversion channel was created in 1892 that directed the flow from Parkhill Creek into Lake Huron at Grand Bend. The Grand Bend diversion created a remnant channel between Grand Bend and Port Franks known as the Old Ausable Channel.

In the Ausable basin, there is typically a heavy accumulation of snow in the winter, increased precipitation in the spring and fall and episodic rainfall events in the summer. The Ausable River was historically known to have low summer base flows in the upper reaches and along some of its tributaries. The Ausable River has a natural tendency to carry a heavy load of silt and clay due to intense flows associated with spring snow melt and episodic summer rain events combined with the clay soils prevalent in the basin. Erosion of the streambed and banks during heavy flows contribute to a heavily silted river bottom.

Following European settlement, the land use and land cover changed significantly from natural cover to agriculture. Land use and land cover was compared between pre settlement mapping (Ontario Ministry of Culture, Tourism and Recreation) and 1983 land use systems mapping (Ontario Ministry of Agriculture and Food 1983). The pre settlement vegetation was comprised of predominantly upland forest cover (80.2 per cent), lowland (18.7 per cent), and lake and marsh (1.1 per cent). Major European settlement occurred following 1825, which led to the clearing of all but eight per cent of the forest cover by 1910.

By 1983, the land cover within the basin was dominated by row cropping systems (> 70 per cent), grain and hay systems (5.7 per cent), pasture systems (4.0 per cent), specialty agriculture (2.0 per cent), and woodland (13.5 per cent). Associated with the change in land use from natural cover to agriculture was the increase in artificial surface and sub-surface drainage. By 1983, approximately 71 per cent of the basin area was tile drained.

Over time, the significant changes to the channel, the construction of dams and reservoirs, the loss of forests and wetlands, the increase in agricultural land use and associated increase in the intensity of artificial drainage has affected the fluvial processes in the basin. Sediment erosion, delivery, and discharge as well as the frequency of summer low base flow events in the Ausable River have most certainly been affected because of these changes.

The main channel of the Ausable River has high suspended sediment and turbidity concentrations. Water quality data collected by the Ontario Ministry of the Environment and the Ausable Bayfield Conservation Authority (ABCA) found that the mean total suspended solid (TSS) concentration at the lower main Ausable Channel at “the Cut” was 114 mg/L (1982 to 1998). The European Inland Fisheries Advisory Committee reported that “good fisheries” could be maintained in waters that contain TSS at 25 to 80 mg/L. Thus, the mean TSS concentration in the lower Ausable River exceeds that required for “good fisheries”. Suspended solids and consequent sediment deposition may cover suitable habitat, clog gill membranes of fish and invertebrates, hinder predator/prey relationships, and limit light penetration required for aquatic vegetation. The turbid conditions of the Ausable River may be attributed to four main characteristics of the watershed:

- clay soils;
- lack of natural cover (less than 13 per cent forest cover);
- high potential for erosion in spring due to snow melt and heavy precipitation; and,
- altered flow regime (surface and subsurface drainage, channel alterations such as the “Cut”, and dams).

Nutrients, in particular, phosphorus (P) and nitrogen (N), are elevated in the Ausable and Parkhill basins. Phosphorus and N are nutrients that may promote aquatic plant production and may cause eutrophication in excessive amounts. Mean total phosphorus (TP) concentrations at seven Provincial Water Quality Monitoring Network stations in the Ausable (0.06 to 0.81 mg/L) and one station in Parkhill Creek (0.14 mg/L) were substantially higher than the Provincial Water Quality Objective for the protection of aquatic life (0.03 mg/L). At all sites, mean nitrate concentrations (3.48 to 5.61 mg/L) were also greater than the Canadian Council of Ministers of the Environment guideline for the protection of aquatic life (3.0 mg/L). Concentrations of un-ionized ammonia in tributaries of the Ausable River, Black and Decker creeks, on a few occasions were high enough to be considered toxic (i.e., > 0.2 mg/L), and therefore may limit the abundance and distribution of some aquatic organisms. Potential nutrient sources in the Ausable and Parkhill River include land management practices associated with agriculture, wastewater treatments plants and septic systems.

Species At Risk

Existing data from historical surveys were used to assess population trends of the 14 COSEWIC-listed species in the Ausable River. Minimal historical information on freshwater mussels exists prior to the 1990s. Surveys along the Ausable River in 1998 (eight sites) and 2002 (seven sites) yielded 3370 live mussels of 21 species (four COSEWIC-listed) with dead shells representing an additional three species. Fish distributions are largely based on records collected from 1929 to 2002 representing 2301 records of 83 species (seven COSEWIC-listed). Rigorous methods have not yet been used to sample for reptiles, and most species records in the basin have been through incidental observations indicating presence/absence rather than abundance. In total, 21 species of reptiles (11 COSEWIC-listed, 3 of which are primarily aquatic) have been identified from the Ausable River basin.

All twelve species at risk occur within the main channel of the Ausable River except the pugnose shiner and lake chubsucker, which only occur in the Old Ausable Channel. The Little Ausable River is the only tributary that harbors high priority species – both wavy-rayed lampmussel and black redhorse were confirmed in the lower reaches in 2002. While all three species of reptiles have only been found in the lower Ausable sub-basin, this is likely a result of limited basin-wide sampling efforts.

One species was found to be expanding its range (bigmouth buffalo), three species are apparently stable (kidneyshell, lake chubsucker, and greenside darter), three species are declining (pugnose shiner, northern riffleshell and wavy-rayed lampmussel), and three species may be extirpated from the Ausable River (snuffbox, eastern sand darter, and river redhorse). There was insufficient data to assess population trends for four species. These include all three species of reptiles (eastern spiny softshell turtle, queen snake, and northern map turtle), which are known from only a few records, and the black redhorse, which was previously unrecorded from the watershed, but collected at one site in 2002.

The majority of species at risk (ten) requires areas with firm gravel or sand bottoms with moderate to swift currents. Species that prefer gravel substrates include four mussels (kidneyshell, northern riffleshell, snuffbox, and wavy-rayed lampmussel), three fishes (black redhorse, river redhorse, and greenside darter) and the queen snake. The queen snake shows a preference for coarse substrates often found in calmer bays where it forages for crayfish. The eastern sand darter is very strongly associated with sand substrates.

The main threats affecting these species at risk appear to be related to turbidity, siltation and nutrient enrichment. Altered flow regime, toxic contaminants, thermal changes, and exotic species may also be important issues for populations of species at risk in the Ausable system.

The main causes of these threats appear to be linked to the change in land use from natural forest cover to agriculture. The associated loss of wetlands and increase in surface and subsurface drainage, intensive land use and changes to the drainage network (i.e., channel alterations including the "Cut" and dams) has likely contributed to increased sediment and nutrient loading. Nutrient enrichment concerns also arise from wastewater treatments plants and septic systems. High sediment and nutrient concentrations may limit the distribution and abundance of some freshwater mussel and fish species in the Ausable River.

Recommendations

Recommendations focused on four main areas: research and monitoring, stewardship/ habitat improvement, management, and public awareness. This report and recommendations will form the basis of a recovery strategy for aquatic species at risk in the Ausable River basin. While the focus of this Recovery Strategy will be on the identified COSEWIC-listed aquatic species at risk, numerous other terrestrial and semi-aquatic species at risk in the basin are expected to benefit from efforts that improve the ecological health across the entire basin.

<u>Research and monitoring</u>
Several important research and monitoring initiatives should be investigated:

- The relationship between species at risk and environmental variables such as, water quality, habitat, and pesticides and contaminants;
- Addition of water quality monitoring stations to the existing network;
- Continuation of monitoring changes in aquatic ecosystem health;
- Completion of additional aquatic species at risk surveys;
- Development of new species at risk monitoring protocols;
- Assess the current and future environment of the Old Ausable Channel including groundwater flow;
- Conduct a general fluvial geomorphic assessment of the entire basin to establish baseline conditions and develop a monitoring program;
- Characterize the extent, and assess the impacts, of tile drainage;
- Conduct a basin-wide dam assessment expanding on the 1991 ABCA study;
- Assess the impact of low base flows and precipitation patterns on habitat for riffle species;
- Develop a database for the recovery team;
- Complete and incorporate findings about potential fish hosts, and their distributions, for freshwater mussels from the Ausable River;
- Research alternative water management options, especially related to the low flow conditions in the basin; and,
- Assess the significance of any alterations to Hay Swamp to species at risk.

<u>Stewardship/ habitat improvement</u>
Stewardship/ habitat improvement efforts are critical to improving the overall quality of the ecosystem in the Ausable River basin. Projects that reduce sediment and nutrient loadings into

the basin should be encouraged. Efforts to increase stewardship/ habitat improvement projects in the basin include:

- Promoting existing stewardship programs aimed at improving water quality and aquatic habitat;
- Pursuing additional funds and partnerships;
- Evaluating potential habitat improvement projects; and,
- Researching urban stewardship initiatives.

Management

Dealing with species at risk issues require a coordinated approach to share information with agencies responsible for decisions that can affect species at risk, their habitat, and overall watershed health. Where possible, the recovery team should encourage:

- A coordinated approach to species at risk amongst the various responsible agencies within the basin (e.g., project review, drain maintenance activities);
- Wastewater treatment plant improvements; and,
- Investigate options for long-term habitat protection, including land acquisition.

Public awareness

Improving public awareness of the presence, importance, and sensitivity of species at risk in the Ausable River is critical to successful implementation of the recovery plan. The recovery team should encourage the:

- Development of a communications plan;
- Development of public awareness tools such as workshops, a website, and promotional materials;
- Promotion of stewardship activities and initiatives; and,
- Posting Conservation Areas and reservoir locations with signs regarding the risk of introducing exotic species.

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1.0 Introduction

The Ausable River drains approximately 1142 km^2 of agricultural land in southwestern Ontario. It empties into Lake Huron at Port Franks, a small village along Lake Huron's eastern shoreline (Figure 1.1). The Ausable River lies within the counties of Perth, Huron, Middlesex and Lambton. There are approximately 45,000 human inhabitants in the mainly rural basin.

The Ausable River is located on the northern fringe of the Carolinian Canada life zone. The Carolinian Canada life zone is a unique ecosystem that supports a wide variety of species, many of which are at the northernmost limits of their range. As a result, the Ausable River supports a diverse aquatic fauna. The Ausable River basin historically supported 83 species of fishes, 24 species of freshwater mussels and 21 species of reptiles (Appendix 3), making it one of the richest basins of its size in Canada. Its diverse aquatic community includes 14 species listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) including seven fishes, four mussels and three aquatic reptiles (Table 1.1). Several of these species are declining within the basin and recovery actions are required to prevent extirpations.

Table 1.1: Species at risk listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in the Ausable River and Parkhill Creek basins.

	Species	COSEWIC Status
Mussels	northern riffleshell (*Epioblasma torulosa rangiana*)	Endangered
	wavy-rayed lampmussel (*Lampsilis fasciola*)	Endangered
	snuffbox (*Epioblasma triquetra*)	Endangered
	kidneyshell (*Ptychobranchus fasciolaris*)	Endangered
Fishes	pugnose shiner (*Notropis anogenus*)	Endangered
	eastern sand darter (*Ammocrypta pellucida*)	Threatened
	lake chubsucker (*Erimyzon sucetta*)	Threatened
	black redhorse (*Moxostoma duquesnei*)	Threatened
	river redhorse (*Moxostoma carinatum*)	Special concern
	greenside darter (*Etheostoma blennioides*)	Special concern
	bigmouth buffalo (*Ictiobus cyprinellus*)	Special concern
Reptiles	eastern spiny softshell turtle (*Apalone spinifera spinifera*)	Threatened
	queen snake (*Regina septemvittata*)	Threatened
	northern map turtle (*Graptemys geographica*)	Special concern

The primary purpose of this report is to summarize existing information that has been assembled for the Ausable River Recovery Team. Therefore, this report will integrate the historical and present land use, fluvial geomorphology, water quality, and species at risk trends in the basin arising from the four background reports:

- species at risk (Ausable River Recovery Team 2003)
- water quality (Veliz 2003)
- land use (Dolmage and Nelson 2003)
- fluvial geomorphology (Dolmage 2003)

This report will also provide recommendations for future recovery efforts within the following categories: research and monitoring, stewardship and habitat improvement, management, and public awareness. This synthesis of information, along with discussions with landowners, stakeholder groups and other interested citizens, is anticipated to form the basis of a Recovery Strategy for aquatic species at risk in the Ausable River basin. The focus of this Recovery Strategy will be on the aquatic species at risk listed in Table 1.1; however, there are numerous other terrestrial and semi-aquatic species at risk that would benefit from recovery efforts targeting the improvement of ecological health across the entire basin.

1.1 Basin Overview - The Ausable River and Parkhill Creek basins

The original Ausable River drainage pattern was described as a *barbed fishing hook* (Department of Planning and Development 1949). The Ausable River arises near Staffa and flows in a south-westerly direction (Figure 1.1). East of Exeter, the river empties into the reservoir created by Morrison Dam (constructed in 1955). Several kilometres west of Exeter, the Ausable River is joined by Black Creek, which drains the wet sandy area known as Hay Swamp. As the river continues southward, it converges with the Little Ausable River and Nairn Creek. South of the Village of Nairn, the Ausable River makes a wide arc to the west. Near Arkona, the river makes an abrupt turn to the north and cuts a large gorge through the Wyoming Moraine. Once the river emerges from this gorge, it enters the Thedford Flats (clay plain). Before 1875, the river flowed north to Grand Bend and then made another sharp turn and flowed south to its outlet near Port Franks (Figure 1.1).

Several key alterations have affected the drainage pattern of the Ausable River. To help improve drainage in the Thedford Flats, a channel was excavated from Lambton County Road 18 straight west to Highway 21. Completed in 1875, this "Cut" diverted the flow of the Ausable River directly to Port Franks, (effectively removing the loop the river made through Grand Bend). Currently, the section of the former riverbed between Lambton County Road 18 and the confluence with Parkhill Creek no longer conducts flow. Parkhill Creek, a former tributary of the Ausable River, flows through this section of the former Ausable River bed. Parkhill Creek enters Lake Huron at Grand Bend via another channel excavated in 1892 and is now, technically no longer part of the original Ausable River drainage system. When the second diversion channel was constructed in Grand Bend, the portion of the Ausable River that flowed between Grand Bend and Port Franks was cut off from the main channel. This abandoned section is now more of a pond than a river, however, it maintains a small flow (Department of Planning and Development 1949, Dillon 1975). This section of the river is referred to as the 'Old Ausable Channel', and is contained largely within the boundaries of Pinery Provincial Park.

Another important feature of the original Ausable drainage pattern was former lakes Burwell, George, and Smith. It is believed that this lake complex was a shallow bay of the glacial lakes Algonquin and Nipissing, which were cut off by a sand bar during times of low water. The prevailing northwesterly winds shaped the sand bar into the sand dunes that are present along the current Lake Huron shoreline between Grand Bend and Port Franks. Glacial lake water was trapped behind the sand dunes and the shallow inland lake complex, surrounded by marsh and forested swamp, was created (Department of Planning and Development 1949, Dixon 1963). The "Cut" (1872-1875) drained lakes Burwell and George and left the remnant Lake Smith and lands available for agriculture. In 1955, Lake Smith was also drained. The muck soils of this region are now highly valued for vegetable production.

The Ausable River and Parkhill Creek basins were divided into sub-basins as determined by discharge characteristics, geology, land use, and dams (e.g., the Morrison Dam separates the Ausable Headwaters and the Upper Ausable) (Figure 1.1) (Snell and Cecile Environmental Research 1995 and Veliz 2001). The Ausable sub-basins include the Ausable Headwaters, Upper Ausable, Middle Ausable, and Lower Ausable. The Ausable tributary basins include Black Creek, Little Ausable, and Nairn Creek. The Parkhill basin was divided into Upper and Lower sub-basins. The 'Old Ausable Channel' is the smallest sub-basin and drains an area referred to as the 'Dunes'.

2.0 Fluvial Geomorphology

Two important functions of streams and rivers include the transportation of excess surface water and the gradual erosion of the Earth's surface through erosion, transportation, and deposition of material. These fluvial processes are influenced by climate, local soil and bedrock characteristics, and vegetation (Scott 1996).

2.1 Climate and Discharge

The Great Lakes region's weather differs considerably from other mid-continental regions in Canada and the United States. The prevailing westerly winds force alternating air masses of warm, humid air from the Gulf of Mexico and cold, dry air from the Arctic into the region. The weather in this region is due, in large part, to the moderating influence of the lakes on the air masses that pass over them. This is particularly evident in the summer and winter when thunderstorms and snow squalls descend quickly. Since the Ausable River and Parkhill Creek basins lie on the leeward shoreline (snow belt) of Lake Huron, they are subject to large accumulations of lake effect snow during the winter (Environment Canada 1995).

The Ausable Bayfield Conservation Authority (ABCA) maintains two precipitation stations located at Exeter and Springbank (Figure 1.1). Environment Canada has climate information for Exeter and Ilderton (close to the Springbank station) (Environment Canada 2002). Based on averaging the values for these two climate stations, the Ausable River and Parkhill Creek basins receive approximately 1002 mm of total precipitation in a given year and the mean annual temperature for the area is 7.75 ^{o}C (Appendix 2). Snowfall is highest in December and January, averaging 51.2 cm during these two months. Rainfall increases in the spring (April-May), and is highest during August and September. The increased rates of rainfall in spring and late summer result from a combination of rapidly moving air masses, and the thermal dynamics of Lake Huron. Relatively high precipitation rates occur during the summer months and are closely associated with the high number of thunderstorms occurring during these months (Appendix 2). These summer rainfall events are short-lived and episodic, producing large quantities of precipitation. These events are usually interspersed with periods of very dry conditions (Environment Canada 1995).

There are five stream discharge and water-level stations in the Ausable River and Parkhill Creek basins (Figure 1.1). On the Ausable River, the three stations are located just west of Exeter, at Springbank, and just south of the "Cut". The two stations in the Parkhill Creek basin are found east of the Parkhill Reservoir inlet and on the Ptsebe (or South Parkhill) Creek. Typically, rating curves are applied to water-level data to infer discharge rates. Rating curves cannot be applied to data collected at the "Cut" station because water level at this station is dependent on lake water levels and fluctuate accordingly.

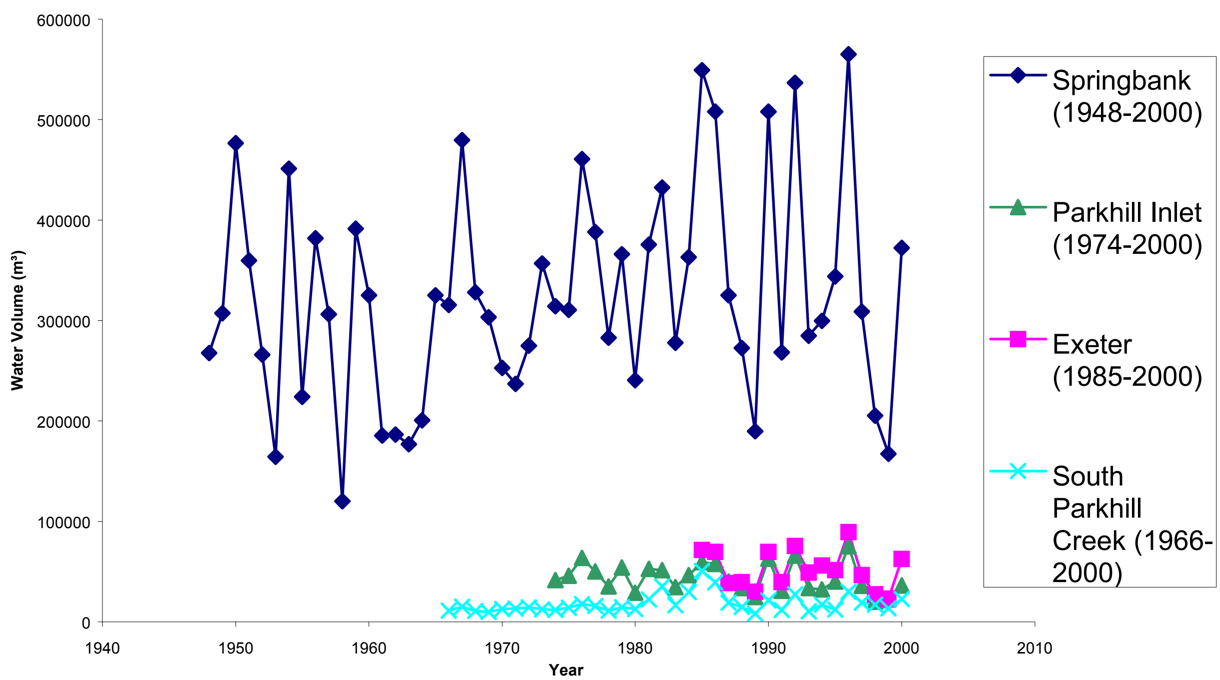

Figure 2.1: Mean annual water discharge (m^3) at four stations in the Ausable River and Parkhill Creek basins (Environment Canada 2000).

In the Ausable River and Parkhill Creek basins, mean annual stream discharge is highly dependent on precipitation (Figure 2.1). For example, in 1998 mean annual discharge (6.51 m^3/second) at the Springbank station was well below the 50-year mean annual discharge (10.3 m^3/second); and, annual precipitation (332.5 mm) was well below the 30-year climate normal at Ilderton (988.5mm) (Environment Canada 2002). In 1992, mean annual discharge (2.39 (m^3/second) at the Exeter station was well above the 20-year mean annual discharge (1.66

m^3/second); and, annual precipitation (877.25 mm) was higher than the 30-year climate normal (532.75 mm).

At all stations, mean monthly discharge is greatest in March and lowest in August (Figure 2.2). For example, at the Springbank station, mean monthly flows reach a maximum of 29.6 m^3/s in March and then gradually decline to 1.72 m^3/s in August. The mean monthly discharges peak in March and April and are associated with spring snowmelt. In summer, discharge patterns in the Ausable River and Parkhill Creek reflect the discontinuous pattern of precipitation associated with thunderstorms. Immediately following thunderstorms, discharge in the river increases dramatically but declines quickly to lower levels during intervals between thunderstorms. Summer discharge is further compromised by an increase in evaporation rates due to increased air temperatures and minimal groundwater influence.

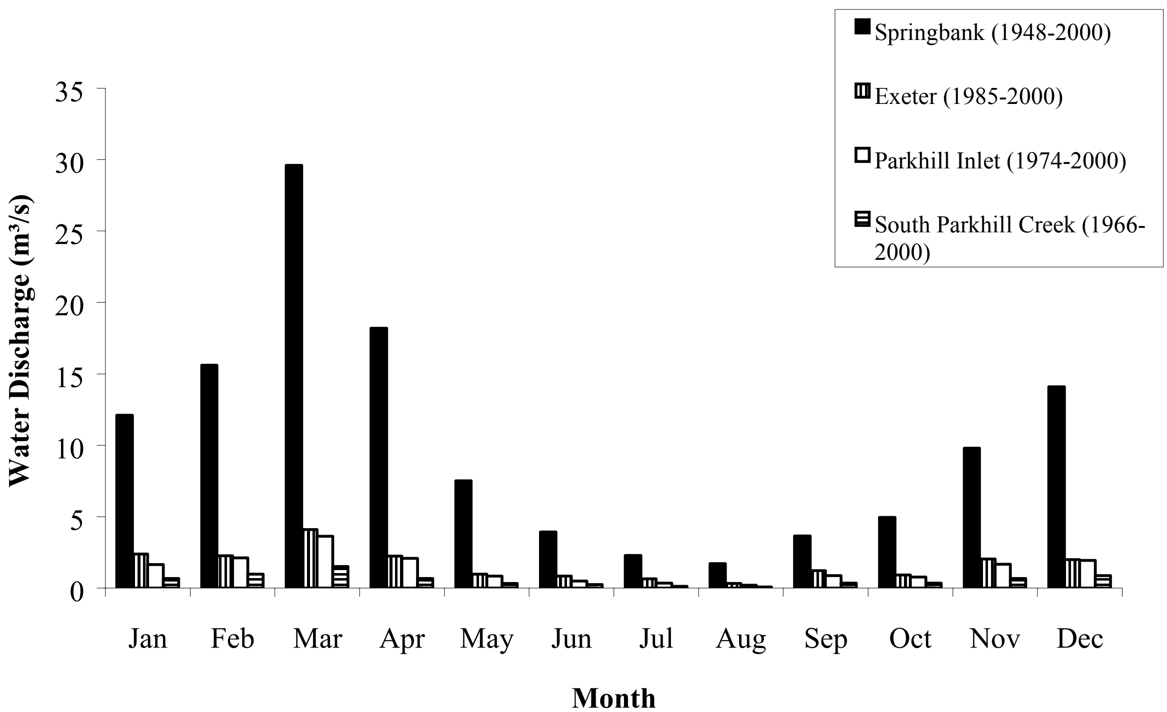

Figure 2.2: Mean monthly discharge (m^3) at four stations in the Ausable River and Parkhill Creek basins (Environment Canada 2000).

Environment Canada has collected suspended sediment (SS) samples periodically during the open-water season with a depth-integrated sampler at the Springbank station between 1970 and 1994. From the instantaneous measures of SS and stream discharge, sediment loads have been calculated. The sediment load in the Ausable River peaks in March (461.7 tonnes) and is at its lowest in August (25.2 tonnes). In the spring, during the snow melt and spring rains, large volumes of water enter the watercourses after having drained a predominantly till-based basin largely devoid of vegetation. Sediment loads are typically reduced in the summer months due to the increase in vegetation (i.e., crops) and the decrease in discharge (Figure 2.3).

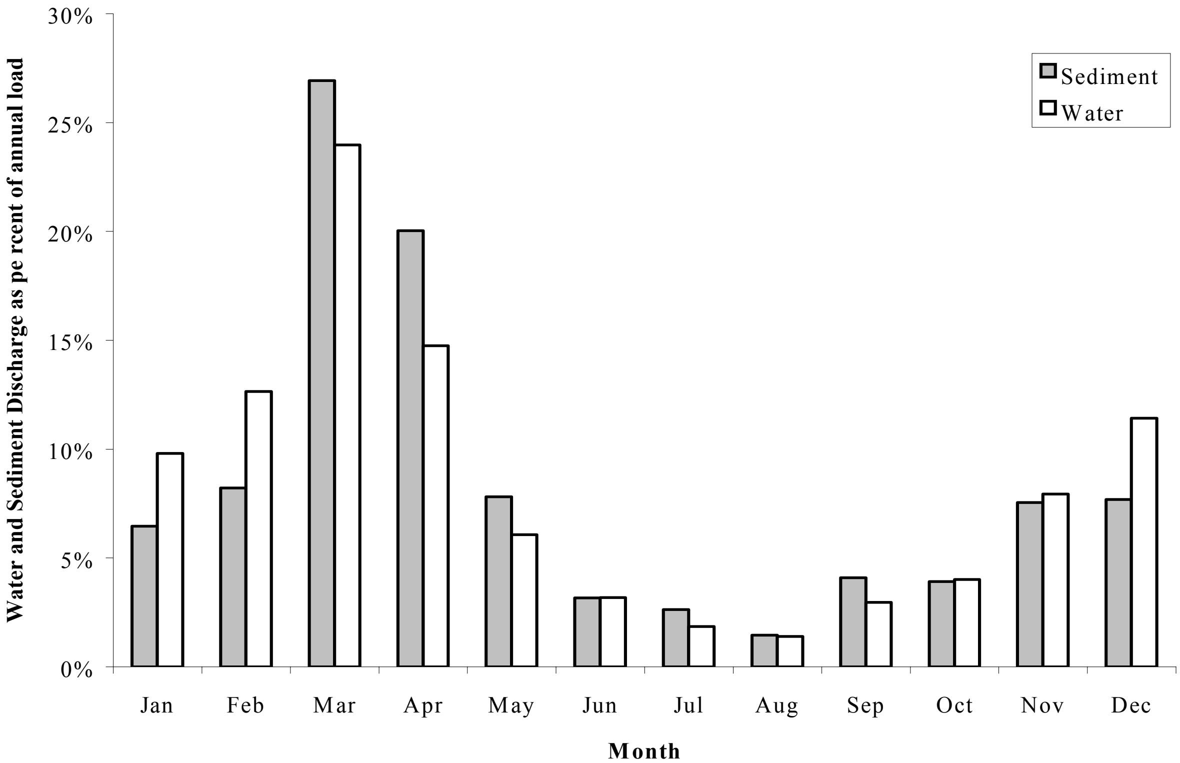

Figure 2.3: Water and sediment discharge as per cent of annual load for the Ausable River and the Springbank station from 1970 to 1994 (Environment Canada 2000).

2.2 Bedrock and Soil Characteristics

2.2.1 Bedrock Geology

A rock plain that dips to the southwest underlies much of southern Ontario. This rock plain is at its highest point near Collingwood (518 metres above sea level) and from this point falls approximately 3.8 metres per kilometre towards Kettle Point (182 metres above sea level). In the headwaters of the Ausable River near Staffa and Cromarty, this bedrock appears in the form of limestone sinkholes. The bedrock is also exposed near Arkona in the gorge created by the Ausable River (Department of Planning and Development 1949).

The bedrock of the area is characteristic of the Devonian period of the Palaeozoic era. It is of sedimentary origin and was formed when a sea advanced over part of the Great Lakes basin (Department of Planning and Development 1949, Dillon 1975). The bedrock in the Ausable River and Parkhill Creek basins can be divided into two formations. The northern portion of the basin is described as the Norfolk Formation – a grey and brown limestone, magnesium limestone, calcareous sandstone, chert, with small quantities of gypsum. The calcareous composition of the bedrock formation explains the neutral nature of local soils. The southern portion of the basin consists of the Hamilton Formation – a soft blue and grey shale and grey limestone. The erosive action of the glaciers on the shale of this formation resulted in the large number of clay deposits (Department of Planning and Development 1949).

2.2.2 Quaternary Geology and Physiography

Physiography describes the nature of the land features and quaternary geology describes the composition of the land features. Combined study of these features provides insight into natural characteristics of the basin. The physiography of the Ausable River basin is dominated by the presence of moraines, till plains and old shorelines (Figure 2.4). Three moraines in the basin (Lucan, Seaforth and Wyoming) control the drainage pattern of the main watercourses. The moraines were created in a north-south pattern while the general slope of the underlying geology is from northeast to southwest. As a result, the main river channels flow in a southwesterly pattern but are forced to follow the glacial spillways of the moraines. The tributaries drain the moraine slopes and enter the main channels at right angles (trellis pattern) (Chapman and Putnam 1984, Department of Planning and Development 1949).

Of the three moraines in the Ausable River basin, the Wyoming Moraine is the most pronounced. This moraine is composed of boulder clay (Figure 2.5) and forms a broad ridge south of Ailsa Craig. To the north of Ailsa Craig, the Wyoming Moraine is composed of two bands of material with a slight depression in between. Parkhill Creek is contained within this depression (Dillon 1975). The Ausable River occupies the large glacial spillway to the east of the Wyoming Moraine (Chapman and Putnam 1984). This valley drained the area of meltwater during the Port Huron advance approximately 13,000 years ago, resulting in numerous shallow deposits of sand and gravel (Cooper 1974A, Cooper 1974B, Cooper 1979).

Till plains are a flat surface feature that are also referred to as "ground moraines". They were created when the glacier retreated rapidly and deposited material underneath the ice (Scott 1996). In the Ausable River and Parkhill Creek basins, flat till plains are located between the moraine ridges and are composed mostly of Rannoch Till (clayey silt to silty till) or St. Joseph Till (clayey silt to silty clay) (Cooper 1979).

There are six major historic shorelines within the Ausable River basin. Listed from oldest to youngest they are: Lake Arkona, Lake Whittlesey, Lake Warren, Lake Grassmere, Lake Algonquin and Lake Nipissing (Cooper 1979). Lakes Warren, Nipissing and Algonquin had the greatest influence on the landscape of this area. The Lake Warren shoreline begins inland of the current shoreline and runs north-south along the westerly edge of the Wyoming Moraine and is quite pronounced in the Thedford area. To the west of this shoreline is a sand deposit associated with the beach of Lake Warren and two small sandy deltas are apparent where the Ausable and Bayfield Rivers emptied into Lake Huron (Figure 2.5) (Dillon 1975). The shorelines of Lakes Algonquin and Nipissing are close to the existing shoreline of Lake Huron and are not highly visible. It is believed that the Thedford Marsh/Klondyke area was once a shallow bay of Lakes Algonquin and Nipissing (Chapman and Putnam 1984).

2.2.3 Soils

The basins are dominated by clay and clay loam soils (Huron/Perth/Brookston) on the moraines and till plains (Dolmage 2003). These fine-textured soils with low permeability reflect the underlying sedimentary bedrock of the area. Pockets of other soil types are present and reflect other types of glacial deposition such as outwash and lacustrine deposits. For example, in the spillways associated with the moraines, glaciofluvial outwash deposits, consisting of sand and gravel, occur in response to glacial meltwaters (Land Resource Institute 1991). Another example exists southeast of Nairn, where a large clay plain is present. This clay plain of relatively impermeable clays is a glaciolacustrine deposit that was once part of the lakebed of glacial Lake Whittlesey (Cooper 1979, Land Resource Institute 1991).

The dominant soils in the Ausable basin are well to poorly drained. The influence of groundwater on such a relatively impermeable landscape is limited to areas underlain by porous bedrock (e.g., limestone and sandstone). For example, areas underlain by shale bedrock are usually poor aquifers due to the composition of the bedrock. Shales are composed of fine materials that have high water retention capabilities; therefore, they do not readily release nor absorb water. As a result, the Ausable River and Parkhill Creek experience flows largely derived from precipitation, and low base flows during the summer months are common (Department of Planning and Development 1949, Chapman and Putnam 1984).

Stone and Saunderson (1992) interpreted existing long-term sediment and hydrometric data from six southern Ontario Rivers, including the Ausable River. Between 1970 and 1980, the annual range of median particle sizes transported in the Ausable River (Springbank station) was between 2 and 20μm while the overall range of particle sizes transported was < 2 to 2000 μm. This range of median particle sizes was similar to that of the Thames (2 to 10μm) and the Humber rivers (2 to 80 μm) while all six rivers transported a similar range of particle sizes (< 2 to 2000 μm). Stone and Saunderson (1992) attributed the narrow median particle size range transported in the Ausable River basin to its clay-rich soils. It was determined that between 40 and 50 per cent of the annual sediment load in the Ausable River was characterized by the ≤ 2 μm size fraction.

To address concerns about soil erosion and its impact on water quality and agricultural productivity, a soil erosion study was completed for the Ausable River (Giancola et al. 1983). The majority of the soils within the Ausable River and Parkhill Creek watersheds are not highly erodible. However, erodibility increases in areas under intense cultivation and in areas with steep gradients such as moraine slopes. The steepest slopes occur in the Middle and Lower Ausable sub-basins. In these sections of the river, the topography is more rolling due to the influence of the Wyoming Moraine to the north of the river and the Seaforth Moraine to the south. Therefore, this area of the watershed contains the largest area of high erosion potential. Only five per cent of the Ausable River basin is within the high erosion potential category. Over 50 per cent of the Ausable River basin displays a medium erosion potential due in large part to the intensive agricultural use of the land (Giancola et al. 1983).

2.3 Terrestrial Vegetation and Land Use

The change from a basin primarily covered in natural cover to an agricultural basin occurred rapidly between 1850 and 1890. The following sections of the report will be based on three time periods: Pre settlement to 1800s, 1800s to 1940s, and 1940s to 1986. The time periods were selected based on existing data sources.

2.3.1 Terrestrial Vegetation

Pre settlement to 1800s

Snell and Cecile Environmental Research (1995) interpreted pre-settlement maps of the Ausable River basin published by the Ontario Ministry of Culture, Recreation and Tourism (No date). With the assistance of the Ausable Bayfield Conservation Authority (ABCA), the maps were transferred into digital format and interpreted with a geographical information system (GIS). An interpretation of these maps overlaid with sub-basin boundaries forms the basis for the pre-settlement vegetation (Table 2.1). The Ausable River basin appears to have been left relatively uninfluenced by European settlers until the middle of the 19th century (Department of Planning and Development 1949). During this period, the Ausable River and Parkhill Creek basins were thickly covered with upland and lowland vegetation that was comprised primarily of species representative of the Deciduous Forest Region in the north and the Carolinian zone in the south (Figure 2.6).

Table 2.1: Pre-settlement vegetation in the Ausable River and Parkhill Creek basins (Ontario Ministry of Culture, Recreation and Tourism).
Representative upland species include maple, beech, hickory, birch, ironwood, hemlock, and white pine. Representative lowland species include silver maple, white elm, willow, black ash, cottonwood, white cedar, and tamarack.

Sub-basin	Upland (per cent)	Lowland (per cent)	Lake (per cent)	Marsh (per cent)
Ausable Headwaters	98.8	1.2		
Upper Ausable	86.8	13.2		
Middle Ausable	90.4	9.6		
Lower Ausable	83.5	10.9	4.1	1.5
Black Creek	66.4	33.6		
Little Ausable	97.6	2.4		
Nairn Creek	95.9	4.1		
Upper Parkhill	90.0	10.0		
Lower Parkhill	43.5	54.4	0.4	1.7
Dunes	*	*	*	*
Mean	80.2	18.7	0.6	0.5

*No data exist for the Dunes sub-basin from this period.

Over the entire Ausable River and Parkhill Creek basins, vegetation was comprised of upland (80.2 per cent) and lowland (18.7 per cent) communities. Dominant species in the upland category included maple and beech species, while subdominant species included hickory, birch, ironwood, hemlock, and white pine species (Department of Planning and Development 1949, Snell and Cecile Environmental Research 1995). The composition of the 'lowland' community was not defined in the Ministry of Culture and Tourism report. However, as Hay Swamp is predominantly located in the Black Creek sub-basin (33.6 per cent lowland) it is likely that wetlands, lowland forests, wet forests, and other associated wet habitats make up the defined vegetation type. Representative species in the 'lowland' category would include silver maple, white elm, willow, black ash, cottonwood, white cedar, and tamarack (Department of Planning and Development 1949, Snell and Cecile Environmental Research 1995).

Large amounts of lowland vegetation also were found within the lower Ausable River (10.9 per cent), Upper Parkhill Creek (10.0 per cent), and Lower Parkhill Creek (54.4 per cent) sub-basins. This vegetation occurred on the former glacial lakebed of lakes Algonquin and Nipissing, a very flat, poorly drained area composed of saturated clay and muck soils. The marsh (1.5 per cent) and lake (4.1 per cent) area present in the Lower Ausable and Lower Parkhill Creek (1.7 and 0.4 per cent) sub-basins were lakes Burwell, George, and Smith. There were also several pockets of lowland vegetation near the confluence of Nairn Creek and the Ausable River and the headwaters of the Lower Ausable River and the headwaters of Upper Parkhill Creek sub-basin.

1800s to 1940s

Settlement of the watershed in the mid-1800s resulted in a drastic decrease in forest cover throughout the basin. It was not until 1825, after the purchase of the land by the Canada Company from the Chippewas, that settlers began to penetrate the area in larger numbers. By 1910, the majority of the land had been cleared and the area was predominantly agricultural with a few urban areas (Department of Planning and Development 1949). During this period, forest cover is reported by township as per the Canadian Census as reported in the Department of Planning and Development (1949). There was a substantial decrease in forest cover across all townships between 1850 and 1910. In 1850, the proportion of woodland cover across all townships in the Ausable Bayfield Conservation Authority area was 42 per cent. By 1910, the proportion of woodland cover had dropped to just eight per cent (Department of Planning and Development 1949) and remained relatively constant until 1940. It is probable that the pattern and distribution of woodland in place by 1910 is very similar to what is present currently. However, strict comparisons are not appropriate as forest cover from this period is reported by township instead of by basin area.

1940s to 1986

An interpretation of Ontario Ministry of Natural Resources 1986 Ontario Base Map data indicated overall forest (13.1 per cent), wetland (2.45 per cent), and Environmentally Significant Area (0.03 per cent) within the Ausable River and Parkhill Creek basins (Table 2.2, Figure 2.7).

Table 2.2: Forests, Wetlands and Environmentally Significant Areas (ESA) in the Ausable River and Parkhill Creek basins (Ontario Ministry of Natural Resources 1986, Ausable Bayfield Conservation Authority 1995).

Sub-basin	Area (km^2)	Forest as per cent of basin area	Wetland as per cent of basin area	ESA as per cent of basin area
Ausable Headwaters	101.59	8.5	0.27	0.03
Upper Ausable	253.15	10.0	6.69	0.01
Middle Ausable	231.52	12.0	0.70	0.03
Lower Ausable	174.25	17.9	0.27	0.02
Black Creek	106.88	18.0	16.38	0.01
Little Ausable	159.44	5.7	0.14	0.02
Nairn Creek	134.42	8.7	0.45	0.02
Upper Parkhill	147.11	12.5	0.18	0.02
Lower Parkhill	309.62	13.5	0.64	0.07
Dunes	27.04	81.6	1.69	0.03
Entire basin	1644.94	13.1	2.45	0.03

The Dunes, Lower Ausable and Black Creek sub-basins had the highest proportion of forest cover in the Ausable River and Parkhill Creek basins in 1986. Predominant features within these sub-basins include the Pinery Provincial Park in the Dunes sub-basin, the Ausable Gorge area within the Lower Ausable River basin, and the Hay Swamp complex in the Black Creek basin. Across Ausable and Parkhill basins, forest cover is approximately 13 per cent, however, three of the sub-basins have less than nine per cent (i.e., Ausable Headwaters, Little Ausable, and Nairn Creek).

The area of forest cover in 1986 is greater than that recorded in 1940 (Department of Planning and Development 1949). It is clear that the majority of forest cover loss occurred in the basin between 1850 and 1910. A similar period and rate of forest loss occurred prior to the 1940s in other parts of southern Ontario (Riley and Mohr 1994).

With the exception of the Hay Swamp complex, which represents almost half of the total wetland area in the basin, few wetlands of significant size remain in the Ausable River and Parkhill Creek basins. Across all sub-basins, wetland cover is only 2.45 per cent. Seven of the sub-basins have less than 1 square kilometre of wetlands (Dolmage and Nelson 2003). The small area of wetlands in the Lower Ausable (0.27 km^2) and the Lower Parkhill Creek (0.64 km^2) sub-basins reflect the draining of lakes Burwell, George and Smith and its associated marsh area in 1875 by the Canada Company. The loss of wetland coverage in these sub-basins suggests that currently, aquatic systems do not benefit from the ecological functions that wetlands typically provide. Some of these ecological functions include: water retention, which reduces the potential for flooding; improved water quality, through reducing nutrient loadings, trapping sediment and pollutants and increasing oxygen content; and the protection of shorelines by reducing the potential for physical damage from waves (Lynch-Stewart 1983, Riley and Mohr 1994, Ontario Ministry of Natural Resources 1999, Mitsch and Gosselink 2000).

Environmentally Significant Areas (ESA) are sites which have been so designated because they support significant plant or animal species, serve important hydrological functions, and/or support remnant or threatened species of flora or fauna (Ausable Bayfield Conservation Authority 1995). The Ausable Bayfield Conservation Authority manages has 72 ESAs within the Ausable River basin, protecting over 50 square kilometres of land, of which 15.45 square kilometres are wetlands (Dolmage and Nelson 2003). Although the total ESA area across all sub-basins is very small (0.03 per cent), each ESA serves an important ecological role in a landscape dominated by agriculture.

The two major areas of environmental significance within the Ausable River basin include Hay Swamp, within the Black Creek sub-basin, and the Ausable River Valley, located within the Lower Ausable sub-basin. Hay Swamp is approximately 21.5 square kilometres and is covered with natural swamp forests, scrub, plantations, and pasture/grasslands (Schaus and Giancola 1984). The Ausable River Valley is a steep-sided gorge and valley that cuts through the surrounding bedrock and adjacent sand plain deposits to depths of up to 30 metres (Schaus and Giancola 1984). Encompassing an area of approximately 18 square kilometres, it has been designated by the Ontario Ministry of Natural Resources as a provincially significant Area of Natural and Scientific Interest (ANSI). The Pinery Park in the Dunes sub-basin contains much of the Oak Savanna remaining in North America. This area also supports Carolinian species such as Tulip tree, Sassafras, Black Oak and American chestnut trees.

In the Ausable River and Parkhill Creek basins riparian vegetation, particularly in the headwater areas, is lacking (Figure 2.7). High connectivity between forest patches through suitably sized corridors are necessary for species to move freely. Corridors also protect natural areas and species from adjacent land uses, predation and disturbances (Riley and Mohr 1994). If landscapes are not well connected, species diversity will decrease (Ontario Ministry of Natural Resources 1999). Riparian vegetation is an important type of forest corridor that provides connectivity across the terrestrial landscape while also providing benefits to aquatic habitat and water quality. Riparian cover may reduce the intensity and volume of runoff during storm events thereby, decreasing soil erosion, flooding, and turbidity (Vought et al. 1995). An active flood plain may also help to remove nutrients and sediments from surface water runoff, thereby protecting water quality (Skaggs et al. 1994). The shading provided by streamside trees and natural vegetation helps maintain cooler, more constant water temperatures in adjacent watercourses. Excessive temperatures and low water levels may reduce species diversity and abundance (Agriculture and Agri-Food Canada 1996, Ontario Ministry of Natural Resources 1999).

Interior forest habitat is important, particularly to certain area-sensitive bird species. Larger woodlands tend to contain a greater number of species due to the increased number of habitats available, and are less sensitive to the effects of surrounding land uses, tree blow-down, drought, disease, insect infestations and invasions by non-native species (Ontario Ministry of Natural Resources 1999). The forest cover in the Ausable basin consists mainly of small, unconnected woodlots with very little interior forest habitat. In 1986, the Ausable Headwaters, Little Ausable and Nairn Creek sub-basins all had less than ten per cent forest cover (Table 2.2) and virtually no interior forest habitat (Snell and Cecile Environmental Research 1995).

2.3.2 Agriculture

The majority of the watershed is highly productive agricultural land (Snell and Cecile Environmental Research 1995) that provides many local families with their primary income. The pattern of land use for the area was assessed by the Ontario Ministry of Agriculture and Food (1983a) (See Dolmage and Nelson 2003). Snell and Cecile Environmental Research subsequently assessed results of this survey at the sub-basin level in 1995 (Table 2.3).

Table 2.3: Land use as a per cent of sub-basin area in the Ausable River and Parkhill Creek basins (Ontario Ministry of Agriculture and Food 1983a).
Row crop is a combination of corn system, mixed system and row crop categories. Built-up land and water categories have been excluded (See Dolmage and Nelson 2003).

Sub-basin	Row Crop (per cent)	Grain and Hay System (per cent)	Pasture System (per cent)	Specialty Agriculture (per cent)	Woodland (per cent)
Ausable Headwaters	79.2	6.2	2.4	0.6	9.9
Upper Ausable	71.6	4.8	5.7	1.9	9.8
Middle Ausable	70.9	7.4	6.3	0.2	12.7
Lower Ausable	61.3	5.0	1.0	8.1	18.5
Black Creek	71.9	1.4	2.8	1.6	19.4
Little Ausable	78.5	6.1	5.0	1.4	6.3
Nairn Creek	75.1	9.1	4.6	0.4	8.1
Upper Parkhill	69.9	7.2	4.4	0.6	11.3
Lower Parkhill	73.3	4.9	3.1	2.7	13.9
Dunes	0	0	0	0	88.3
Entire Basin	71.0	5.7	4.0	2.0	13.5

Except for the Dunes sub-basin, agriculture comprised the largest land use by area for each sub-basin in the study area. Across both the Ausable River and Parkhill Creek basins, 82.7 per cent of the 1983 land use was agricultural. The remaining land use within the basin included woodland (13.5 per cent), built-up/urban areas (2.3 per cent), idle agricultural land (0.9 per cent), water (0.2 per cent), and extraction from pits and quarries (0.1 per cent). Specialty agriculture, including vegetable farming, is most extensive in the Lower Ausable River (8.1 per cent) and Lower Parkhill Creek (2.7 per cent) sub-basins but is also prevalent in the Hay Swamp area (Black Creek and Upper Ausable River sub-basins). Vegetable farming is an intensive land use that requires irrigation, pesticide, and fertilizer inputs. The main sources of irrigation water are from the Ausable River, Black Creek and numerous pumped drainage ditches in the Thedford Flats/Klondyke area. Excessive irrigation may contribute to low flow situations in the basin.

Extensive drainage has occurred in the Thedford Flats/Klondyke area in the Lower Ausable and Lower Parkhill sub-basins. These areas contain highly productive agricultural land on the very fertile clay muck soils of former glacial lake plains. These soils are naturally poorly drained and require extensive drainage to control the excess water (Dillon 1975). In 1996, the growers within the Thedford Flats/Klondyke area commissioned a study that found that water table control and drainage issues were of utmost importance to growers in the area. Drainage ditches, pumps and control walls help growers to control water levels and prevent backflow during times of high flow within the Ausable River and Parkhill Creek channels. This area still floods during the spring but the extensive network of drainage ditches and pumps allows water to be drawn off the fields prior to spring planting. However, problems have arisen due to the intensive cultivation of the area (e.g., topsoil depletion). Loss of muck topsoil through oxidation, wind erosion and burning is extreme. Between 1971 and 1990, the Thedford Flats/Klondyke area lost, on average, 34 per cent of its topsoil. This has resulted in a number of drainage ditches not being deep enough to effectively drain water and increased pump maintenance costs due to sedimentation (MIG Engineering Ltd. 1996).

2.4 Land Use and Drainage Pattern Changes

2.4.1 Flooding

Flooding has been an ongoing issue in the lower reaches of the Ausable River and Parkhill Creek basins, especially in the Thedford Flats/Klondyke area. In the Thedford Flats/ Klondyke area, spring flooding was regarded as beneficial since the fertile silt that was deposited helped provide a rich agricultural landscape. However, the destruction of crops due to intense summer thunderstorms and associated flooding was not regarded as favourable (Department of Planning and Development 1949, Chapman and Putnam 1984).

Changes to the drainage pattern of both the Ausable River and Parkhill Creek systems has decreased flooding in some areas but increased it in others. For example, the creation of the "Cut" increased flooding hazards within the Village of Port Franks but decreased flooding events in the Thedford Flats/Klondyke Area.

Intense flows during flooding events on the Ausable River result in erosion of the streambed and banks and create heavy silting of the watercourse. Prior to the "Cut", this sediment was deposited in the Thedford Flats/Klondyke area (Department of Planning and Development 1949). Since the channel alterations, the majority of the sediment is deposited at the river mouth due to the reduction in velocity as the river enters the lake (Kilborn 1972). At the same time, the natural process of littoral drift continually deposits sand in the mouth of the Ausable River. This increases the amount of sediment located in the mouth of the channel and results in a reduction in channel capacity. Channel capacity is further reduced in the winter when ice from the lake piles up on the sandbars at the mouth causing ice jams (Dillon 1975, Department of Planning and Development 1949).

Richards (1990) examined 118 Great Lakes tributaries (i.e., 58 in the United States and 60 in Canada) and classified them based on their flow variability (event responsiveness). Event responsive rivers were classified as those with large increases in flow during runoff events following storms. Stable response rivers had smaller increases in flow. When determining event responsiveness, soil characteristics are a major factor. Event responsive rivers are characterized by drainage basins composed of fine-textured, heavy soils while stable responsive rivers are associated with soils having a looser, coarser texture and better infiltration capacity. The rivers were divided into four groups: event responsive, variable, stable and super-stable with event responsive being the most unstable. The Ausable River was identified as being event responsive. Surrounding watersheds such as the Sydenham, Thames and Maitland were all listed as being variable in nature. These classifications were attributed to the predominantly heavy soil types and intensive agricultural land use of these four watersheds (Richards 1990).

Dams and dam/reservoir structures also manage flooding in the Ausable River and Parkhill Creek basins. In 1991, the ABCA completed a dam and reservoir assessment that identified 21 dams within the Ausable River and Parkhill Creek basins. Only those dams having a reservoir capacity exceeding 0.1 hectare were included in the assessment. Two major dam structures are present in the basin: one on the Ausable River at Exeter (Morrison Dam) and one on the Parkhill Creek (Parkhill Creek Dam) at Parkhill. The Morrison Dam and reservoir was constructed in 1955 for flow augmentation and to supply water for a canning factory in Exeter, but also serves as a flood control structure. The surface area of the reservoir at normal summer holding level is approximately eight hectares. The Parkhill Creek Dam and reservoir were constructed in 1969, immediately north of Parkhill. The surface area of the reservoir at normal summer holding level is approximately 81 hectares. This dam was built to control the annual flooding in the Klondyke Flats marsh area (Dillon 1975).

Reservoirs act as sediment sinks for suspended material within a river system. This can have implications on the downstream watercourse (e.g., increased erosion). Dobbs (1987) described the deposition of sediments from the Parkhill Dam and predicted impairment of the flow augmentation and recreational functions of the reservoir. A similar assessment is not available for the Morrison Dam. Dams and other water impoundments can prevent fish migration, increase stream temperatures, act as a potential foothold for the establishment of zebra mussels and other exotic species, and affect the sediment budget downstream through increased sediment retention upstream and increased scouring immediately downstream.

2.4.2 Drainage

Twenty-three per cent of the 68 million hectares of cropland in Canada require improved drainage for efficient agricultural production (Skaggs et al. 1994). Agricultural drainage is installed to: (1) provide trafficable conditions so that seedbed preparation, planting, harvesting and other field operations occur in a timely manner; (2) protect the plant from excessive soil water conditions; and, (3) control salinity in irrigated arid and semi-arid areas (Skaggs et al. 1994). Due to the low permeability of the fine-textured soils of the Ausable River and Parkhill Creek basins, artificial surface and subsurface drainage is required to conduct agricultural practices throughout much of the basin (Department of Planning and Development 1949, Experimental Farm Service 1956, Soil Research Institute 1977, Land Resource Institute 1979, Land Resource Institute 1991).

Drainage may be provided by surface or sub-surface modifications. Municipal drains are an example of surface drainages. These drains are created by straightening and grading existing stream channels or by excavating new channels. Across the entire basin, municipal drains account for the majority of surface watercourse types. From the 1999/2000 survey of aquatic habitat at 1141 open surface watercourse-road intersections in the ABCA jurisdiction, 795 were channelized municipal drains. Since habitat assessments were conducted primarily in the upper stream reaches, the natural main channel(s) of the Ausable and tributaries may be under-represented. Nevertheless, the watercourse-road intersection surveys indicated the prevalence of surface drainage in the Ausable River basin.

Sub-surface drainage occurs via buried drainage tiles. In 1983, approximately 71 per cent of the entire watershed area had either systematic or random sub-surface tile drainage (Snell and Cecile Environmental Research 1995). Subsurface drainage covers greater than 50 per cent of sub-basin area in seven of ten sub-basins (Table 2.4). The rate of transformation of open surface drains to closed, tiled drains from 1975 to 1999 in Nairn Creek suggest that the proportion of lands tile drained presented in Table 2.4 may be underestimated. No equivalent information exists on the distribution of artificial drainage in the basin since 1983.

The transformation from open, surface drains to closed, tiled drains is occurring in the ABCA jurisdiction. Drain closures between 1975 and 1999 were examined in the Nairn Creek sub-basin. The total length of open watercourses in 1975 was determined from the 1975 enlargements (1:5 000) of aerial photographs (1:20 000). The length of closed, tiled drains in 1999 was determined from the 1999 (1:15 000) aerial photographs. The length of watercourse that no longer appeared in 1999 was assumed closed and tiled. The findings from this preliminary survey suggested that between 1975 and 1999, 14 per cent of open watercourses in the Nairn Creek sub-basin had been transformed to closed, tiled drains (Veliz 2001).

Table 2.4: Tiled land in the Ausable River and Parkhill Creek basins (Ontario Ministry of Agriculture and Food 1983b).
Tiled land includes both systematic and random tile drainage methods.

Sub-basin	Tiled Area by basin (km^2)	Tiled land as a per cent of basin area
Ausable Headwaters	71.8	73.0
Upper Ausable	174	68.6
Middle Ausable	109	47.7
Lower Ausable	92.9	46.5
Black Creek	68.4	64.0
Little Ausable	121	79.0
Nairn Creek	64.6	50.0
Upper Parkhill	100	68.0
Lower Parkhill	209	67.4
Dunes	0	0
Entire basin	1010	71.2

The conversion from natural drainage to surface or subsurface drainage has typically resulted in increased peak runoff rates (Skaggs et al. 1994). However, the magnitude of the increase in outflow rates from artificially drained lands will depend on such factors as soil moisture, rainfall intensity and the location of drainage improvements in relation to the point of assessment. Low summer base flow is an important issue for aquatic communities in tributaries of the ABCA basin, and further examination of artificial drainage and hydrology may be warranted. A regional flood frequency analysis identified the Ausable River as being one of the most susceptible rivers in southern Ontario to repeated low base flow events (Scott, A., Ausable Bayfield Conservation Authority, pers. comm., July 2003).

The overall effects of artificial surface drainage on the hydrology, sediment budgets, and ecology of watercourses is inconclusive. Increased sediment and nutrient (nitrogen and phosphorus) loadings are associated with artificial drainage (Skaggs et al. 1994). The increase in sediment loss may be temporarily due to construction, but in most of the reviewed studies the increase was attributed to increased runoff rates. The artificial drainage of lands through agricultural practices results in increases in mainly nitrate-nitrogen and phosphorus loadings (Skaggs et al. 1994). This increase in nutrient loading was, in part, expected because drainage improvements allow for agricultural production (i.e., associated fertilizer and animal manure usage) where it did not occur previously. The magnitude and duration of increased nutrient losses varied widely among the studies reviewed resulting from the wide range of land use changes (e.g., natural areas or from pasture lands), drainage methods employed, crops planted, soil characteristics and fertilizer amounts applied (Skaggs et al. 1994).

Stone and Krishnappan (1997) explored the physical and chemical characteristics of tile drain sediments from an agricultural watershed (Thames River) in Ontario. They showed that tile drain sediments have a tendency to form lumps and soil masses when being discharged into a watercourse. Depending on the flow characteristics of the stream these sediments will either settle to the bottom or be carried in suspension. Sediments in tile drain discharge were depleted in silicon, aluminum, potassium, iron and phosphorus but enriched in calcium and magnesium (Stone and Krishnappan 1997). The authors suggested that fine-grained surface materials are selectively transported through soil macropores into tile drains, which are then re-suspended during rainfall events and transported directly into surface water. As this influx of fine-grained sediment does not have the opportunity to be contained, absorbed or filtered though buffer zones or strips, it may have a serious impact on many geomorphologic aspects of the stream corridor (Parish 2000). Elevated levels of nitrate were found within tile drain sediments, and were attributed to the leaching of the chemical fertilizers and liquid manure applied to soils.

The combination of a predominantly agricultural land use, areas of river with erodible materials including clay and silts, and a high percentage of artificial drainage raise concern about the potential effect of tile drainage on sediment distribution within the watershed. Subsurface drainage in approximately 47 to 79 per cent of the land base suggests that during storm events, water may reach the river more quickly. This will result in flashier runoff events and more extreme flood conditions (Stone and Krishnappan 1997, Parish 2000). Associated with the higher peak flows are potentially higher rates of soil erosion and increased sediment and nutrient loadings. The impact of tile drainage on the sediment delivery and discharge, contaminant movement, and impacts to water quality for the Ausable River watershed is currently not well understood.

2.5 Fluvial Geomorphology Summary

The moraines of the watersheds control the drainage pattern of the Ausable River and Parkhill Creek watersheds. The moraines were created in a north-south pattern while the general slope of the underlying geology is to the southwest. Therefore, the main channels flow in a southwesterly pattern but are forced to follow the glacial spillways of the moraines until they find a weak spot where they can break through the moraine. The tributaries drain the moraine slopes and enter the main channels at right angles (Chapman and Putnam 1984, Department of Planning and Development 1949).

Stream discharge and sediment load can vary greatly between river systems due to local climate, bedrock conditions, physiography, soil and groundwater influences, gradient and other factors. The water carried by a stream comes from a variety of sources, with the largest being precipitation (Scott 1996). In the Ausable basin, there is typically a heavy accumulation of snow in the winter, increased precipitation in the spring and fall and episodic rainfall events in the summer. Thus, discharge peaks in the spring and is low during the summer. The Ausable River was historically known to have low summer base flows in the upper reaches and along some of its tributaries. For example, it has been stated that the Little Ausable River at Highway 4 was "tee-total dry" in 1843 (Department of Planning and Development 1949). Low summer base flows may have been further impacted by the loss of upland and lowland forests and wetlands and the amount of artificial drainage that has occurred. As a result, a large number of low order streams dry up completely in the summer (Department of Planning and Development 1949).

The Ausable River has a natural tendency to carry a heavy load of silt and clay due to intense flows associated with spring snow melt and precipitation and episodic summer rain events combined with clay soils that dominate the basin. Furthermore, erosion of the streambed and banks during the heavy flows ensure that the river bottom is heavily silted (Department of Planning and Development 1949). Over time, the significant changes to the channel due to alterations in the Klondyke Flats area and at Grand Bend, the construction of dams and reservoirs, the loss of forests and wetlands, the change in land use activities and associated increase in the intensity of artificial drainage has affected the fluvial processes in the basin. Sediment erosion, delivery, and discharge in the Ausable River have most certainly been affected because of these changes. The relationship between sediment transport and contaminant movement and impacts to water quality and the biota in the Ausable River basin is currently not well understood.

3.0 Water Quality and Biological Monitoring

Nutrient (nitrogen - N and phosphorus - P) concentrations, water clarity, suspended solids, and dissolved oxygen concentrations are well-known water quality characteristics that may limit populations of aquatic life. This section of the report is a summary of the spatial and temporal trends of total phosphorus, un-ionized ammonia, nitrate, turbidity, suspended solids and dissolved oxygen (section 3.1). Discussion of potential pollution sources is presented. The Ausable River benthic invertebrate monitoring program is also summarized (section 3.2).

3.1 Water Quality

3.1.1 Water Quality Methods

Since 1965, water samples have been collected from 20 stations located in the Ausable River and Parkhill Creek as part of the Provincial Water Quality Monitoring Network (PWQMN). This project is a joint effort by the ABCA and the Ontario Ministry of Environment (MOE). Water samples were typically collected monthly during the open-water season. Water sampling was suspended between 1995 and 2000, except at the Lower Ausable station where the river was sampled until 1998. Dissolved oxygen concentrations have not been monitored since 2000.

Of the 10 sub-basins in the Ausable River and Parkhill Creek basins, PWQMN stations were found in only six of them. Unfortunately, no long-term PWQMN station was situated in the Middle Ausable, the Lower Parkhill, or Nairn Creek sub-basins. As mentioned in section 2.1, suspended sediment samples were collected and interpreted from the Springbank station in the Middle Ausable sub-basin (operated by Environment Canada). As methodologies differ for the collection of suspended materials between the Environment Canada and PWQMN sites, these are not directly comparable values.

Eight PWQMN stations were selected to represent headwater, main channel, or tributary water quality in the six sub-basins (Figure 3.1). Two stations were selected in the Ausable Headwater sub-basin – Staff and Morrison. The Staffa station represents a small, second order agricultural stream; a creamery was present upstream of this station until 1971. As the Morrison station is located within the Morrison Dam reservoir, it is expected to have different water quality than that found upstream. The Lower Ausable and Decker Creek stations represent water quality in the Lower Ausable sub-basin. Decker Creek has been sampled at the Thedford Brick Yard and downstream of the Thedford Municipal Wastewater Treatment Plant (WTP) prior to 1995. Since 2000, sampling has occurred about 1.5 km further downstream of the WTP. Of the eight PWQMN stations in this study, five are downstream of a WTP (Figure 3.1). Only the Ausable Headwater stations (Staffa and Morrison) and the Lower Ausable station are not immediately downstream of a WTP.

The PWQMN long-term data were analyzed with a one-way analysis of variance (ANOVA) followed by Tukey's post-hoc tests to examine differences among sites. Regression analyses were completed to determine the relationship between year and the following indicators: TP, nitrate and total suspended solid concentrations. Regression analyses were completed for each station and for the combined data from the Ausable River stations. Regression analyses were completed only on continuous data. Due to the suspension of sampling between 1995 and 2000, data collected between 2000 and 2002 were omitted. ANOVA and regression analyses were performed with Minitab (release 11.1, Minitab Inc. 1996). Summary data in Table 3.1 are presented as averages, ranges and 90^{th} percentile values. The 90^{th} percentile is shown as an example of a typical high value for each water quality indicator.

Table 3.1: Summary of water quality data from eight stations in the Ausable River and Parkhill Creek basins.

Station	TP (mg/L)	NH_3 (mg/L)	$N0_3$ (mg/L)	Turbidity (FTU)	SS (mg/L)	D.O. (mg/L)
Ausable Headwaters - Staffa (1965 - 1975)						
n	132	130	133	127	127	136
Mean (±1SE)	0.94 (0.24)	0.005 (0.002)	3.99 (0.27)	9.06 (1.91)	45.87 (8.52)	9.38 (0.17)
Range	0.01 - 18	0.0007 - 0.21	0.01- 30.10	1.20-32.00	5.00-840.00	4.00-15.00
90th Percentile	1.65	0.005	6.4	23.00	89.60	
Ausable Headwaters - Morrison (1974, 1980-1995)						
n	189	186	188	101	128	35
Mean (±1SE)	0.06 (0.01)	0.004 (0.0004)	5.49 (0.01)	7.62 (2.33)	8.06 (1.11)	9.17 (0.49)
Range	0.01 - 0.54	<0.0001 - 0.04	0.002-15.70	0.06-230.00	0.10-131.00	4.50-18.00
90th Percentile	0.10	0.007	9.10	14.20	15.84	
Upper Ausable (1980 – 1995 and 2000 - 2002)						
n	192	190	191	133	189	168
Mean (±1SE)	0.11 (0.02)	0.003 (0.0003)	5.38 (0.24)	8.08 (1.71)	10.99 (1.32)	9.36 (0.24)
Range	0.01 -3.10	<0.0001-0.04	0.06 - 14.9	1.55-190	0.10-128.00	3.00-17.50
90th Percentile	0.21	0.007	9.3	15.68	25.08	
Lower Ausable (1982 – 1998 and 2000 - 2002)						
n	837	220	700	92	824	131
Mean (±1SE)	0.16 (0.01)	0.002 (0.0001)	5.61 (0.28)	76.83 (17.71)	113.59 (7.06)	9.01 (0.24)
Range	0.002 - 2.72	<0.0001-0.02	0.01-6.82	3.70-1300.00	1.60-2434.00	2.50-17.50
90th Percentile	0.35	0.005	9.11	153.40	256.10	
Black Creek (1966 – 1995 and 2000 - 2002)						
n	381	381	322	216	373	356
Mean (±1SE)	0.81 (0.16)	0.03 (0.004)	5.40 (0.19)	5.71 (0.82)	22.45 (2.95)	8.87 (0.19)
Range	0.01 - 32.62	0.00002 -0.65	0.01-30.10	0.40-115	0.10-709.00	2.00-18.50
90th Percentile	1.4	0.05	9.05	12.85	37.90	
Little Ausable River (1969 – 1995 and 2000 - 2002)						
n	323	323	323	207	318	293
Mean (±1SE)	0.08 (0.01)	0.002 (0.0001)	5.11 (0.21)	11.10 (1.79)	17.97 (2.25)	10.14 (0.18)
Range	0.01 - 1.10	<0.0001-0.01	0.005-7.51	0.65-204.00	0.50-504.60	3.00-19.00
90th Percentile	0.18	0.005	9.70	23.44	31.76	
Decker Creek (1966 – 1995 and 2000 – 2002)						
n	372	375	316	208	376	353
Mean (±1SE)	0.42	0.02 (0.002)	3.48 (0.17)	39.03 (6.48)	48.56 (4.63)	9.52 (0.16)
Range	0.02 -5.30	<0.0001-0.41	0.01-16.8	2.40-1110.00	0.50-950.00	2.00-21.00
90th Percentile	0.96	0.03	7.26	68.90	85.00	
Parkhill Creek (1972 – 1975 and 1980 - 1995)						
n	223	223	223	141	217	221
Mean (±1SE)	0.14 (0.004)	0.001 (0.0001)	4.83 (0.65)	41.14 (2.49)	39.62 (2.37)	8.74 (0.18)
Range	0.05-0.44	<0.0001-0.01	0.002-16.2	2.10-170.00	1.00-272.00	3.00-15.50
90th Percentile	0.21	0.003	8.83	79.00	78.18	

*The interim Provincial Water Quality Objective for total phosphorus (TP) is 0.03 mg/L (Ontario Ministry of Environment and Energy 1994); the draft Canadian Water Quality Guidelines for the protection of aquatic life (CWQG) for un-ionized ammonia (NH_3) is 0.02 mg/L, 3.0 mg/L for nitrate (NO_3) and 6.0 mg/L for dissolved oxygen (DO) for warm water freshwater biota (Canadian Council of Ministers of the Environment 2001 and 2002).

3.1.2 Water Quality Results

Phosphorus

Total phosphorus (TP) includes dissolved phosphorus and forms bound to organic and inorganic material in water. In many fresh water aquatic systems, phosphorus is the nutrient limiting primary production (plant growth). When phosphorus is added, the first response is increased primary productivity. Although this may be an aesthetic concern, increased productivity may be beneficial to aquatic life. Excessive enrichment may lead to detrimental effects.

The mean TP concentrations at all PWQMN sites were greater than the Provincial Water Quality Objective (PWQO) of 0.03 mg/L (Ontario Ministry of Environment and Energy 1994) (Table 3.1). Highest mean TP concentrations were found in the tributaries, notably at the headwaters of the Ausable River, Black Creek and Decker Creek. Mean TP concentrations at the headwaters of the Ausable River were very high before the 1971 closing of a creamery in Staffa (1.37 ± 3.30 mg/L from 1966 to 1971; 0.06 ± 0.01 mg/L from 1972 to 1975). The mean TP concentration at the headwaters of the Ausable after the creamery closed was still twice the PWQO. Currently, the Ausable River at Staffa is a second-order, small (0.5-m wide) and clear stream draining pasture lands. Phosphorus concentrations in the Ausable headwaters at Staffa may, in part, reflect the pastoral activity in proximate lands but may also indicate that background concentrations are relatively high. Elevated TP concentrations at Black Creek and Decker Creek may, in part, be the result of effluents from municipal WTPs. The high TP concentrations from the 1960s and 1970s inflate the overall mean TP concentrations at these sites.

Between 1966 and 2002, TP concentrations have marginally decreased in the Ausable River (Figure 3.2). The decrease is mostly attributed to the slight reduction in TP at a few stations (i.e., Lower Ausable, Black Creek and Decker Creek) (see Table 3.2 or Table A1 in Veliz 2003a). The TP concentrations in Black and Decker creeks, in the 1960s and 1970s were very high. Subsequent reductions in TP at these sites appear to account for an overall decrease in the Ausable River.

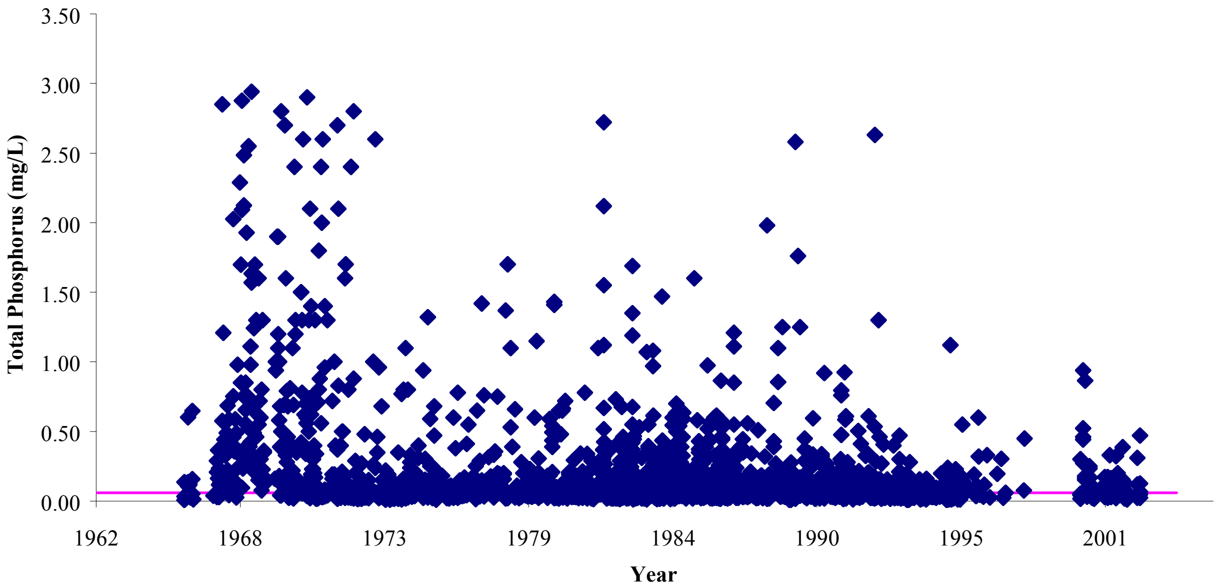

Figure 3.2: Total phosphorus concentrations (mg/L) at seven stations in the Ausable River (n=2393). Concentrations > 5 mg/L were removed from the graph (n=20). The Provincial Water Quality Objective of 0.03 mg/L is indicated as a horizontal line (Ontario Ministry of Environment and Energy 1994).

Table 3.2: Summary table of results of regression analyses for the relationship between water quality indicators (total phosphorus, nitrate and total suspended solids) and year at the Provincial Water Quality Monitoring Network stations in the Ausable River and Parkhill Creek basins.

Data analyses were completed only on continuous time intervals as noted for each station. (no change —; increase⇑; decrease ⇓).

Sub-basin and station	Total Phosphorus	Nitrate	Suspended Solids
Ausable Headwaters (Staffa) (1965 - 1975)	—	⇑	—
Ausable Headwaters (Morrison) (1980 - 1995)	—	—	—
Upper Ausable (1980 - 1995)	—	—	—
Lower Ausable (1982 - 1998)	⇓	—	⇓
Black Creek (1966 – 1995 for TP and SS; 1966 – 1984 for N)	⇓	⇑	⇓
Little Ausable (1970 - 1995)	—	⇑	⇓
Decker Creek (1966 - 1995 for TP and SS; 1966 – 1984 for N)	⇓	⇑	⇓
Parkhill Creek (1980 - 1995)	—	—	—
Entire Ausable River except Parkhill Creek (years are as stated above)	⇓	⇑	—

Efforts to reduce phosphorus in WTP effluents may have contributed to the reduced TP concentrations observed across the entire Ausable River. For example, batch dosing with aluminum sulphate started in 1971 at the Hensall WTP, which discharges to Black Creek (Rick Turnbull, pers. comm., October 29, 2002). Further reductions were realized with the addition of primary coagulates. In a recent study of surface water quality in Huron County (the Upper Ausable and Black Creek sub-basins), Bonte-Gelok and Joy (1999) also found that TP concentrations had decreased over time. The time trend of decreasing phosphorus discharge from WTPs has been reported nationally, as well. Phosphorus discharge from municipal WTPs decreased 37 per cent from 1983 to 1996 in Canada (Chambers et al. 2001). Reduced TP in surface water may also be the result of government restrictions on phosphorus detergents in the 1970s and increased public awareness and efforts to reduce phosphorus loadings, including rural pollution abatement programs.

At all of the PWQMN stations, a significant proportion of TP is in dissolved form. Total dissolved phosphorus (TDP) as a percentage of TP ranged from 30 per cent at the Lower Ausable site to 58 per cent at Black Creek (Table 3.3). The high proportion of TP that is in the dissolved fraction in the Ausable River and Parkhill Creek suggests that loadings from WTPs, livestock operations, and private septic systems may be important.

Table 3.3: Mean (±1SE) proportion of total phosphorus (TP) as total dissolved phosphorus (TDP) in the Provincial Water Quality Monitoring Network (PWQMN) stations in the Ausable River and Parkhill Creek basins.

Sub-basin and station	Mean (±1SE) proportion of TP as TDP
Ausable Headwater (Staffa)	0.42 (0.02)
Ausable Headwater (Morrison)	0.32 (0.03)
Upper Ausable	0.42 (0.02)
Lower Ausable	0.30 (0.01)
Black Creek	0.58 (0.03)
Little Ausable	0.46 (0.02)
Decker Creek	0.51 (0.01)
Parkhill Creek	0.44 (0.02)

Un-ionized ammonia

Un-ionized ammonia (NH_3) may be toxic to aquatic animals if concentrations (measured as N) exceed the PWQO of 0.02 mg/L (Ontario Ministry of Environment and Energy 1994). The concentration of un-ionized ammonia depends on the total ammonia, water pH, and water temperature. During the summer months, diurnal increases in river pH and temperature can shift the ammonia into the toxic, un-ionized form. Fish kills are possible when un-ionized ammonia rises above 0.2 mg/L (Canadian Council of Ministers of the Environment 1991). The guideline concentration (0.02 mg/L) is derived from chronic exposure studies on native Canadian species multiplied by a safety factor of 0.1 (Canadian Council of Ministers of the Environment 1991).

Throughout most of the Ausable River, concentrations of un-ionized ammonia were well below the PWQO. The Hensall station on Black Creek however, recorded the highest mean concentration (0.027 mg/L, $F_{7, 2020}$= 15.77 P<0.001) compared to the seven other PWQMN stations. In addition, concentrations from this station regularly exceeded guideline levels prior to 1971 (Figure 3.3). Ammonia concentrations were also high at the Decker Creek station (90th percentile: 0.034 mg/L). High levels of ammonia in these Ausable tributaries were likely due to both WTP effluents and agricultural runoff. Since monitoring resumed in 2000, un-ionized ammonia concentrations were greater than 0.02 mg/L in Black Creek on three dates (May 9, 2000, June 13, 2000 and August 13, 2000) (Figure 3.3). The highest concentration (0.2 mg/L) was recorded on May 9, 2000. This finding is consistent with the Hensall WTP discharge dates (April/May and November) indicated by the Clean Water Agency (Bev Mollard, pers. comm., October 22, 2002). The Village of Hensall has submitted a proposal to improve the current sewage treatment process. However, elevated concentrations of un-ionized ammonia in June and August of 2000 indicated that other sources of nitrogen are also important to water quality in Black Creek.

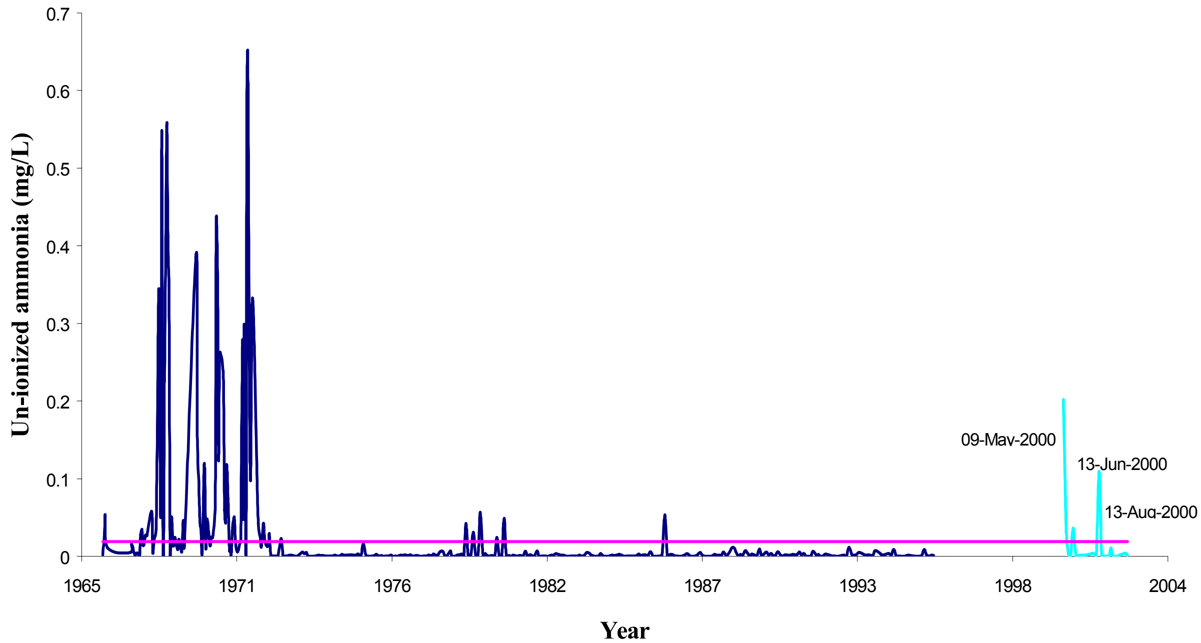

Figure 3.3: Un-ionized ammonia (NH_3) concentrations (mg/L) in Black Creek from 1966 to 1995 and 2000 to 2002. The Provincial Water Quality Objective of 0.020 mg/L is indicated as a horizontal line (Ontario Ministry of Environment and Energy 1994). The Hensall wastewater treatment plant is located immediately upstream of this station. On three dates since 2000 the concentrations have surpassed the 0.020 mg/L objective. Fish kills are possible at concentrations > 0.2 mg/L.

Nitrate

Nitrate is the primary source of nitrogen for aquatic plants. All forms of inorganic nitrogen (nitrite and ammonia) have the potential to undergo nitrification to nitrate. In well-oxygenated systems, increasing concentrations of inorganic nitrogen increase the risk of algal blooms and eutrophication. Furthermore, nitrate may also be directly toxic to aquatic organisms. There are two guidelines recommended by the Canadian Council of Ministers of the Environment (CCME) (2002): the first to prevent eutrophication (0.9 mg/L), and the second for the protection of aquatic life from direct toxic effects (3.0 mg/L). Elevated nitrate concentrations are considered to contribute to eutrophication and its undesirable effects, such as algae and macrophyte blooms, shortened food chains, and changes in the aquatic community (CCME 2002).

Mean nitrate concentrations at all stations in the Ausable River and Parkhill Creek systems exceeded the water quality guideline for the prevention of eutrophication (0.9 mg/L) and for the protection of aquatic life from direct toxic effects (3.0 mg/L) (CCME 2002). However, nitrate in the Parkhill and Ausable systems was not sufficiently elevated to suggest a toxic impact, which would be expected at concentrations above 30 mg/L (Canadian Council of Ministers of the Environment 1991). The guideline concentration (3.0 mg/L) is derived from chronic exposure studies on native Canadian species multiplied by a safety factor of 0.1 (Canadian Council of Ministers of the Environment 1991).

Nitrate concentrations show a slight increasing trend in the Ausable River between 1966 and 2002 (Figure 3.4). However, this trend is not consistent at all PWQMN stations (Table 3.2 and Table A2 in Veliz 2003a). Nitrate concentrations appeared to increase over time in the Ausable Headwaters at Staffa, Black Creek, Little Ausable, and Decker Creek stations. No significant changes in nitrate concentrations were observed in the main channel PWQMN stations or at the Parkhill Creek PWQMN station. This may be a result of dilution at the main channel stations.

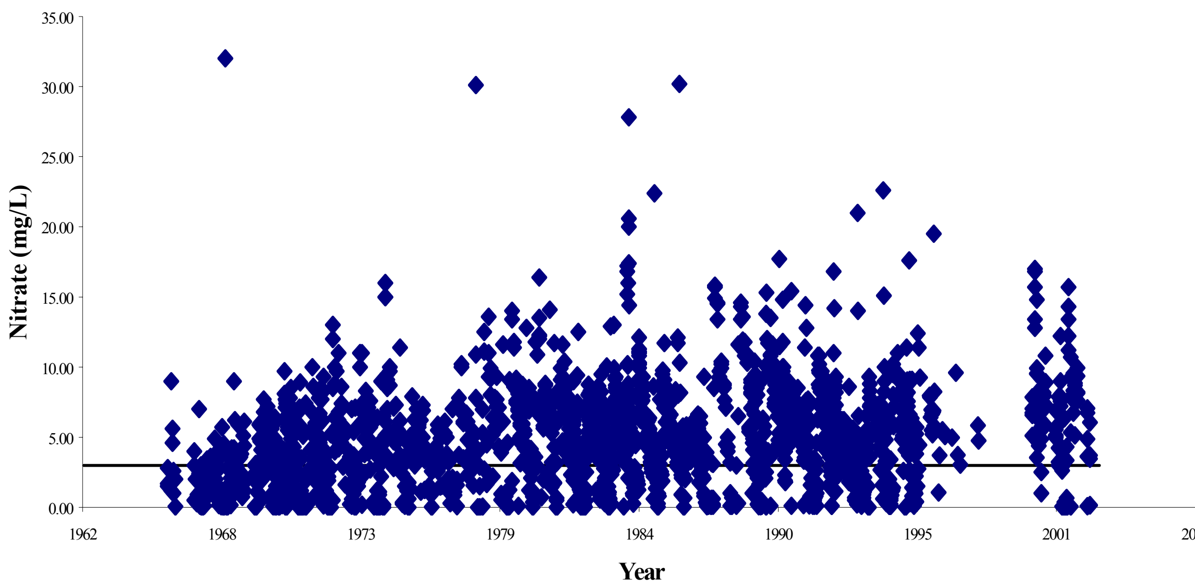

Figure 3.4: Nitrate concentrations (mg/L) at seven Provincial Water Quality Monitoring Network (PWQMN) stations on the Ausable River from 1966 to 2002 (n=2172). One nitrate value (x=178 mg/L) was removed from the graph. For collection time periods at specific sites refer to Veliz (2003). The 3.0 mg/L guideline for the protection of aquatic life from direct toxic effects (Canadian Council of Ministers of the Environment 2002) is indicated.

Increasing nitrate concentrations in surface water are also being observed on a regional and national scale. Bonte-Gelok and Joy (1999) noted an increasing concentration of nitrate over time at the Huron County PWQMN stations. Nitrogen removal is not generally employed at Canadian WTPs because of the high infrastructure costs of the treatment technology. Thus, nitrogen loading from WTPs to Canadian surface waters has increased in response to population increases; across Canadian waters it was 17 per cent higher in 1996 than in 1983 (Chambers et al. 2001). The human population in urban centers served by WTPs discharging to the Ausable River has for the most part, increased since the 1970s (Table B1 in Veliz 2003a). Thus, wastewater from increasing human populations in the Ausable River is likely contributing to increasing nitrate concentrations at the PWQMN stations. The human contribution of nitrate in the Ausable system is an obvious source, as most of the PWQMN that showed an increase in nitrate concentrations were downstream of WTPs. However, the application of manure and fertilizers on agricultural land is another important source of nitrates that should not be overlooked.

Turbidity and Suspended Solids

Turbidity and TSS are different parameters that provide complementary information about water quality. Turbidity is a measurement based on optical properties that quantifies the amount of light that is scattered and absorbed rather than transmitted. Total suspended solids (TSS) is a main component of turbidity, however, it is a measure of material suspended in the water column such as microorganisms, phytoplankton, detritus, clay and other mineral substances.

The highest mean concentrations of TSS (114 ± 7 mg/L) and turbidity were found on the main Ausable channel at the Lower Ausable station from 1982 to 1998 and 2000 to 2002 (Table 3.1, Figure 3.5). The relatively high TSS and turbidity values at this station are not unexpected results as the re-suspension of fine material in the lower portion of a river is a common fluvial process. Increased TSS concentrations were also found at Decker Creek, compared to the other stations in the northern part of the basin (i.e., Morrison, Upper Ausable, and Little Ausable). As previously discussed (section 2.2), the watercourses in southern portion of the Ausable River basin drain more erodible clay soils, which may contribute to the elevated turbidity and TSS noted at these stations.

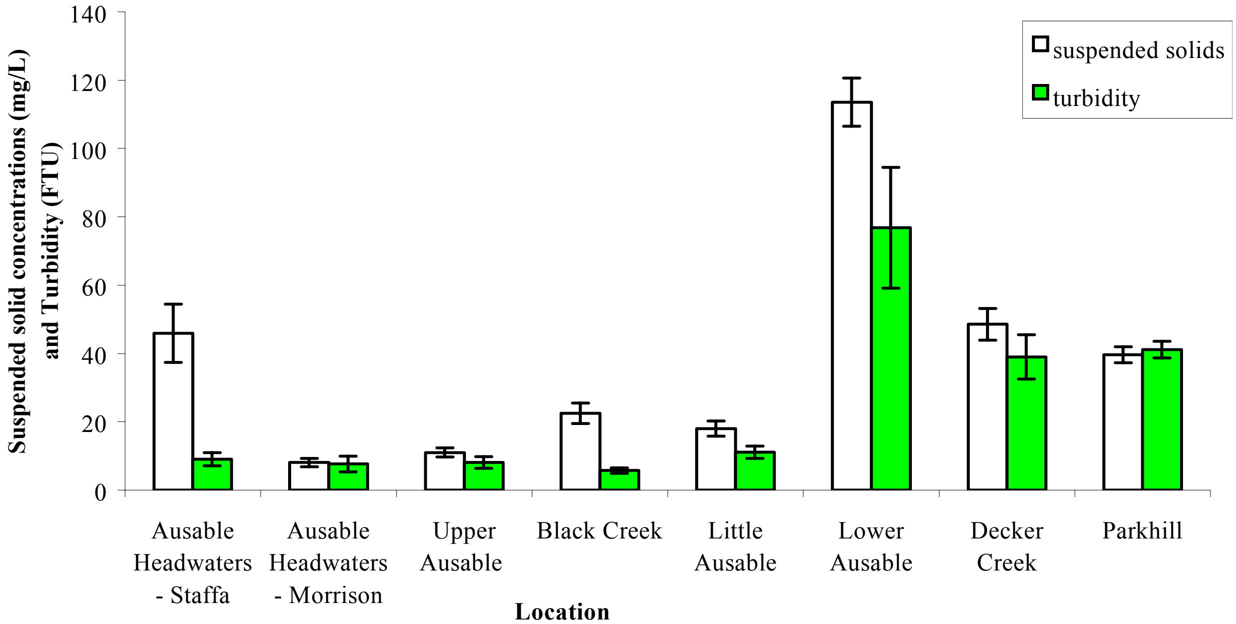

Figure 3.5: Mean total suspended solids (mg/L) and turbidity (FTU) ±1 SE at eight Provincial Water Quality Monitoring Network (PWQMN) stations in the Ausable River and Parkhill Creek.

Reduced light penetration due to turbidity may reduce or eliminate the growth of aquatic plants by blocking the sunlight needed to drive plant photosynthesis. The vegetation provides fish habitat and phytoplankton to help support an aquatic food base. Smith (1971, *In* Kerr 1995) indicated that populations of bigeye shiner (*Notropis boops*), bigeye chub (*Notropis amblops*) and the pugnose minnow (*Oosopoeodus emiliae*) have been decimated in Illinois streams because of the disappearance of aquatic vegetation and the invertebrates associated with this vegetation. The loss of the aquatic plants was attributed to high turbidity.

It is difficult to set guidelines for the concentration of suspended material since there are many site specific conditions affecting the response of aquatic organisms and that standards are set for various reasons. In Canada, many agencies recommend that suspended matter should not be added to surface water in concentrations that will change the background level by more than 10 per cent (CCME 2001). In Ontario, 30 mg/L is the maximum standard for suspended material permitted in effluent discharged to surface water. The European Inland Fisheries Advisory Committee (EIFAC 1965 *In* Kerr 1995) reported that there was no evidence that TSS concentrations less than 25 mg/L have any harmful effects on fisheries. Good fisheries can be maintained in waters between 25 to 80 mg/L, whereas between 80 and 400 mg/L are considered unlikely to support good fisheries, and only poor fisheries are likely to be found above 400 mg/L (EIFAC 1965 *In* Kerr 1995). At most PWQMN stations in the Ausable River and Parkhill Creek, except the Lower Ausable and Springbank stations, TSS levels were in the 25 to 80 mg/L range and therefore, TSS would not be considered a limiting factor for "good fisheries". However, these concentrations may still impact sensitive species.

Over time, there has been no change in TSS concentrations from the combined data from seven PWQMN stations in the Ausable River (Table A3 in Veliz 2003a, Figure 3.6 and Table 3.2). This trend was not consistent at all PWQMN stations as a decrease was observed at the Lower Ausable, Little Ausable, Black, Decker, and Parkhill creek stations. The reduction in suspended solid concentrations at some stations may be related to changes in point-source discharge patterns. For example, the improvements at the Hensall WTP may have resulted in a decrease in suspended solid concentration in Black Creek. However, decreased TSS concentrations were also observed at the Lower Ausable station, a station not directly downstream of a WTP. The reduction in TSS concentrations at this main channel location may be important for aquatic biota susceptible to effects of turbidity and sedimentation. Further examination of this trend was therefore, completed.

Figure 3.6: Total suspended solid concentrations (mg/L) at seven Provincial Water Quality Monitoring Network (PWQMN) stations in the Ausable River (n = 2336). For collection time periods at specific stations sites refer to Veliz (2003).

The number of TSS samples with concentrations that exceeded 80 mg/L was determined on an annual basis between 1982 and 1996 for the Lower Ausable station. The percentage of samples that exceeded 80 mg/L decreased between 1982 and 1996 (Figure 3.7) (Fewer than 10 samples were collected annually between 1997 and 2002 and therefore these years were excluded). The decrease in TSS concentrations at the Lower Ausable station might indicate that landscape level activities, such as tree planting, resulted in decreased suspended solid concentrations in the main channel of the Ausable River. However, results from the Springbank station (Middle Ausable sub-basin) indicated no change in suspended sediment concentrations between 1970 and 1993 (Figure 3.8). Due to the low number of samples collected annually, analysis of the number of suspended solid samples with concentrations that exceeded 80 mg/L could not be completed.

The discrepancy in trends for suspended material in the main Ausable channel suggests that site-specific attributes may be important in determining suspended solid concentrations.

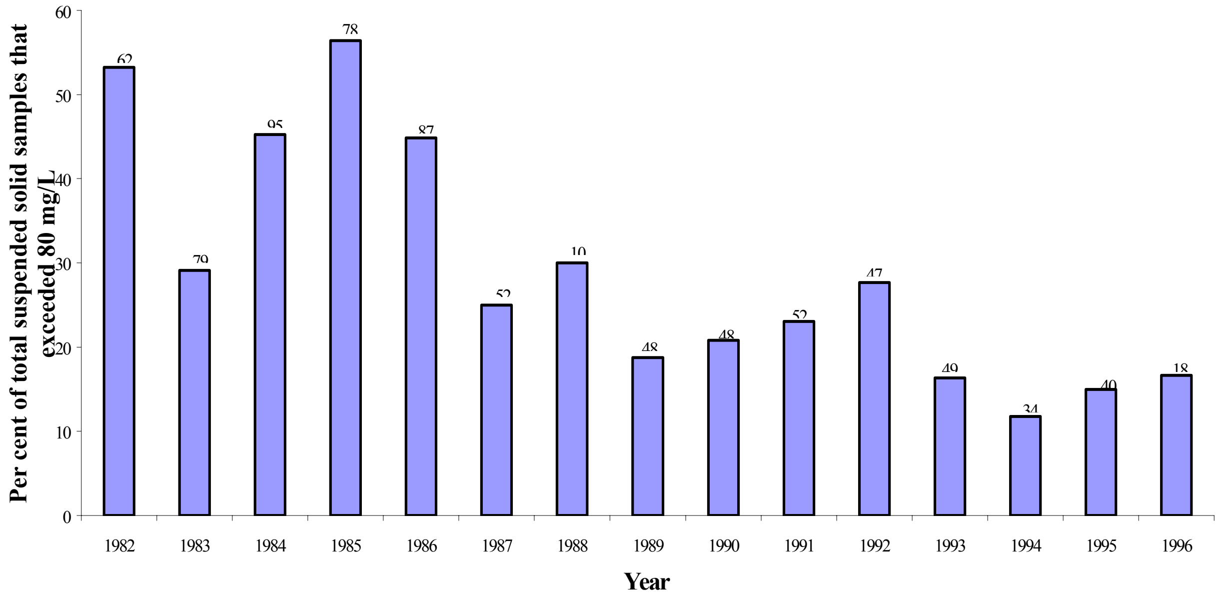

Figure 3.7: Per cent of the total suspended solid samples that exceeded 80 mg/L at the Lower Ausable Provincial Water Quality Monitoring Network (PWQMN) station from 1982 to 1996. The number of samples collected each year is noted above the bar. Samples collected from 1997 to the present are excluded due to low number of samples collected each year.

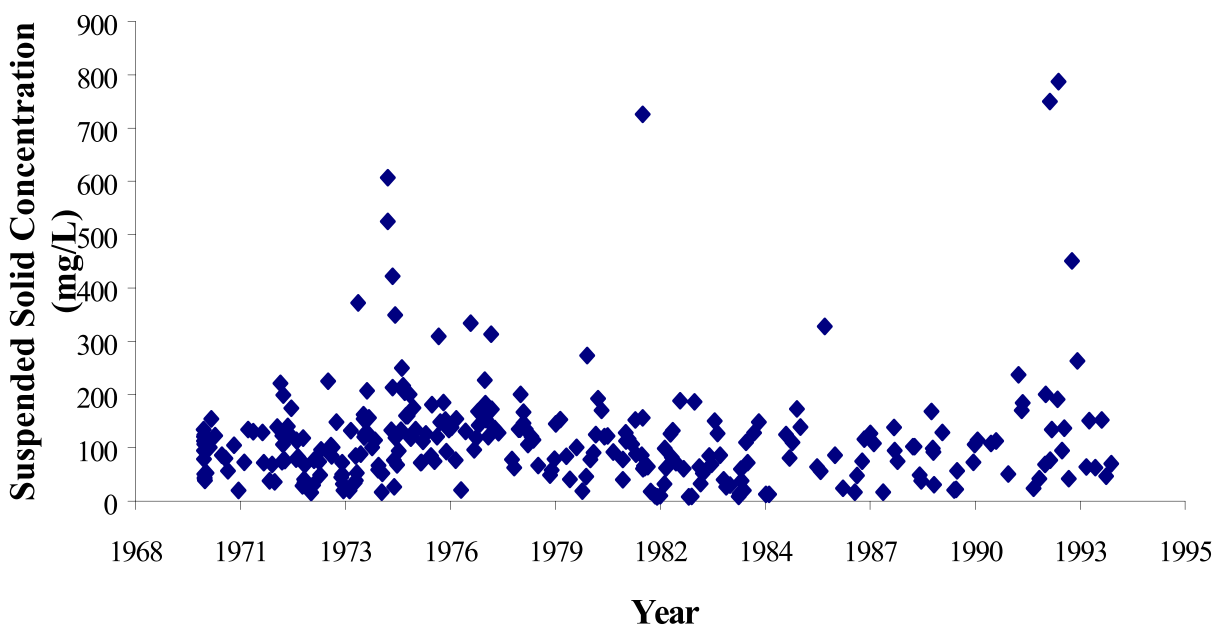

Figure 3.8: Suspended sediment concentrations (mg/L) at the Springbank station in the Middle Ausable sub-basin from 1970 to 1993 (Environment Canada 2000).

Dissolved Oxygen

The recommended freshwater dissolved oxygen minimum concentration is 6.0 mg/L for the protection of freshwater organisms (CCME 2001). Mean dissolved oxygen concentrations were above this standard at all stations and rarely fell below this guideline. Except in situations of extreme organic enrichment, flowing waters typically have dissolved oxygen concentrations that reach saturation due to exchange with the atmosphere (Allan 1995).

3.1.3 Potential Sources of Nutrients and Suspended Sediment

Phosphorus (P), nitrogen (N) and sediments enter the aquatic environment as a result of both natural processes and human activity. In the Ausable River and Parkhill Creek, potential anthropogenic sources of sediment and nutrients include both point sources such as WTPs and non-point sources such as septic systems and runoff from agricultural lands. Potential non-point agricultural sources of P, N and sediment include soil from water and wind erosion, fertilizer and pesticide application, plant residues, and animal manures from cropland, pasture lands, and animal confinement areas. Soil erosion is a natural process but some agricultural activities such as the removal of vegetation or crop harvesting, tilling, and overgrazing may accelerate the loss of soil (International Joint Commission 1977). Associated with the loss of soil is the loss of P, which strongly adheres to soil particles (Ryden et al. 1973). Factors influencing additional N and P losses are precipitation, irrigation, temperature, soil characteristics, crop type, types of fertilizers and pesticides, application method and rates, and tillage practices.

In 1989, the Clean Up Rural Beaches (CURB) project assessed the relative contribution of contaminant sources (i.e., TP and faecal coliform) to the Ausable and Bayfield rivers, Parkhill and Mud Creeks and the Gullies and Lakeshore sub-basins (ABCA 1989). This study did not consider potential sources of nitrogen. Potential watershed contaminant loadings included agricultural sources, discharge from WTPs, rural and lakeshore septic systems, wildlife, and manure spills. Agricultural sources included milk-house wastewater, livestock access, exposed manure stack runoff, winter-spread manure runoff, and summer-spread manure runoff.

The CURB study estimated that the largest source of P and bacteria in the ABCA area were faulty septic systems. Although, an overestimation of the percentage of faulty systems may potentially inflate the contaminant loading from the septic system source, the CURB study suggested that private waste water systems contributed substantial TP and bacteria to rural Lake Huron beaches. One significant limitation of this report was that there was no attempt to calculate P loadings from fertilizer or pesticide applications. Improvement of septic systems was recommended as the most effective approach to reduce TP and bacteria concentrations in rural Lake Huron beaches. Similar findings were reported by a study conducted in the Maitland Valley Conservation Authority jurisdiction north of the Ausable River basin (MVCA 1989).

The findings from the CURB studies (ABCA 1989, MVCA 1989) conflict with current findings on a national scale. Chambers et al. (2001) calculated potential P and N loadings to Canadian surface waters from sources that included WTPs, septic systems, industry, agriculture, aquaculture, and atmospheric deposition. Phosphorus loadings from agriculture were calculated as the difference between the amount of P added to cropland and the amount removed in the harvested crop; data were not available on to the portion of this residual that moves to surface or ground water. The agricultural estimates did not incorporate P lost by erosion. (For more information about the calculations made for the other sources see Chambers et al. (2001) pp. 17 - 58). Chambers et al. (2001) found that P loadings from agriculture surpassed all other sources combined. Chambers et al. (2001) also suggested that P loading from agriculture was 28 times that produced from private septic systems. Furthermore, comparison of P loading from septic systems on a per capita per year basis between ABCA (1989) and Chambers et al. (2001) suggests loadings approximately 10 times higher in the ABCA jurisdiction (1989) (Appendix D in Veliz 2003a).

The overestimated P loadings from septic systems and lack of consideration of P loadings from fertilizers and pesticides in the CURB analysis (ABCA 1989) suggest that attempts to determine source information at the local watershed need further consideration. The relatively high concentrations of TP in the surface waters in the Ausable River and Parkhill Creek suggest that both human and agricultural contributions are important and both need to be reduced across the entire basin.

3.2 Benthic Invertebrate Surveys

To complement the water chemistry monitoring, benthic macroinvertebrate community analyses were also conducted. Benthic macroinvertebrates are common inhabitants of lakes and streams. The term "benthic" means “bottom-living", so these organisms usually inhabit bottom substrates for at least part of their life cycle; the prefix "macro" indicates that these organisms are retained by mesh sizes of ~200 to 500 mm (Rosenberg et al. no date). This group of organisms includes aquatic insects (e.g., stoneflies, mayflies, caddisflies, beetles, bugs and true flies), crustaceans (e.g., isopods, amphipods and crayfishes), molluscs (e.g., snails, clams and mussels), annelids (e.g., leeches and oligochaetes) and a few other groups (e.g., cnidarians, nematodes, proboscis worms and flatworms) (Griffiths 1993). Benthic macroinvertebrates are a highly diverse group and the presence and relative abundance of these animals reflect the current and past physical and chemical conditions of the river.

3.2.1 Benthic Invertebrate Community Survey Methods

The Ausable Bayfield Conservation Authority began a benthic invertebrate monitoring program in 2000. A bi-annual sampling regime was established whereby samples were collected in the headwater streams (i.e., first or second order streams) one year and samples were collected from the main channel the following year (Figure 3.1). In 2000 and 2001, benthic invertebrates were sampled from eleven sites in the Ausable River and Parkhill Creek basins.

Physical habitat, particularly substrate size, is a key determinant of stream benthic communities (De March 1976, Richards et al. 1993, Lammert and Allan 1999). Only sites that had similar substrate were included in the analysis and discussion of this report. Samples were collected with a D-frame net (250 µm mesh size) using a three-minute walking kick technique. Limited information regarding physical habitat (stream width, bank width and height, riparian cover, in-stream vegetative cover and substrate size) was also collected.

The samples were preserved on-site in 10 per cent formalin. In the laboratory, 100 animals were randomly sub-sampled from the year 2000 samples and identified to the family level of taxonomy. In 2001, 200 animals were randomly sub-sampled (Robert Bailey, pers. comm., 2001). Benthic invertebrate samples collected from sites in the Ausable River and Parkhill Creek were summarized for relative density, taxa richness, and the Family Biotic Index (FBI) Hilsenhoff (1988). Taxa richness refers to the number of different families present in a sample. The FBI is an average of the organic pollution tolerance values for the different invertebrate families present in a sample. The organic pollution tolerance values were derived from Hilsenhoff (1988) and a University of Western Ontario key that included aquatic oligochaetes (Bailey 2000).

3.2.2 Benthic Invertebrate Survey Results

Benthic invertebrate communities differed between the headwater and main channel sites on the Ausable River and Parkhill Creek (Table 3.3). Chironomids, elmid beetles and physid snails dominated the headwater sites. These are taxa frequently associated with organic enrichment and potentially dry conditions (Clifford 1991). Chironomids were the dominant taxon at two of the six main channel sites, while capniidae stoneflies dominated at the other four main channel sites. Stonefly larvae are sensitive to a lack of dissolved oxygen, and their presence is typically an indication of minimal organic pollution.

Table 3.4: Summary of benthic invertebrate community analyses from the Ausable River and Parkhill Creek basins from 2000 and 2001.
H is a headwater site, M is a main channel site.

Sub-basin and Site	Relative Density (no./ 3 minute kick)	Taxa Richness	Family Biotic Index	Dominant Taxon
Ausable River Headwaters				
Staffa (H)	1926	17	5.5	Elmidae
Morrison Dam (M)	5075	15	5.3	Chironomidae
Upper Ausable River				
Ailsa Craig (M)	1725	12	3.7	Capniidae
Middle Ausable River				
Lower Ausable River				
Decker (H)	582	19	6.7	Physidae
Black Creek				
Black (H)	n/a	10	4.9	Chironomidae
Black (M)	3517	16	5.3	Capniidae
Little Ausable River				
Elimville (H)	4307	17	6.9	Physidae
Little Ausable River (M)	2300	15	5.1	Chironomidae
Nairn Creek				
Nairn Creek (M)	4140	16	2.9	Capniidae
Upper Parkhill Creek				
Highway 83 (H)	1300	17	6	Chironomidae
Parkhill Creek (M)	289	16	3.3	Capniidae

The main channel sites on the Ausable River and Parkhill Creek had lower FBIs than did the headwater sites. Family biotic index values can range from 0 to 10. An FBI less than 3.5 implies no organic pollution while a value greater than 6.5 implies significant organic pollution (Hilsenhoff 1988). The mean (±1 SE) FBI at the five headwater stations and six main channel stations was 6.00 (±0.37) and 4.27 (±0.45), respectively. The presence of capniid stoneflies, mayflies and caddisflies at some of the main channel sites contributed to the lower FBIs at these locations. This biotic index suggests more degraded conditions in Ausable headwaters than in the main channels. The benthic community in the headwaters likely reflected cumulative stresses of increased summer temperatures, disruption of normal flow regimes through low summer discharge, channelization and subsurface tile drainage, nutrient enrichment, episodes of high concentration of suspended sediments, sedimentation and potential inputs of chemical fertilizers and pesticides (Barton 1996).

The causal connection between any, or all, of these potential stresses and the benthic invertebrate community in headwater streams is difficult to examine. Currently, the aim of the benthic monitoring program at the ABCA is to monitor "stream health" at various locations in the watershed. However, further examination of these complex factors may help to define physical and chemical limitations for the biota in the Ausable River and Parkhill Creek.

3.3 Water Quality and Biological Monitoring Summary

Water quality and benthic invertebrate community survey results suggest that the tributaries and headwaters were more degraded than the Ausable main channel. For example, mean TP concentrations were highest in Ausable Headwaters (Staffa), Black Creek, and Decker Creek sub-basins. The dissolved portion of TP and un-ionized ammonia were also highest at Black and Decker creeks. The dominance of chironomids in the headwater sites compared to stoneflies in the main channel sites also indicated that the headwater sites were more degraded than the main channel sites. The proximity of the terrestrial activities that may influence water quality and stream health and the discharge from WTPs in these smaller systems likely contributed to the degraded conditions found in the lower order systems.

Water quality indicators that might have influenced the distribution and abundance of biota, including species at risk, in the Ausable River and Parkhill Creek basins are nutrients and suspended solids (Table 3.5). Dissolved oxygen concentrations were adequate at all stations most of the time and were not likely limiting aquatic organisms. Concentrations of ammonia in Black and Decker Creeks were high enough to be considered toxic, and therefore, limiting to some aquatic organisms.

Phosphorus and nitrogen are recognized as nutrients that limit aquatic plant production and may cause eutrophication in excessive amounts. Mean TP concentrations at all stations were substantially higher than the PWQO. At all sites, mean nitrate concentrations, the most biologically available form of nitrogen, were also greater than the CCME (2002) guideline to avoid eutrophication. The high nitrate and phosphorus concentrations in the Ausable River and Parkhill Creek may have contributed to excessive plant growth and may have resulted in disruptions to the aquatic community.

Turbidity and suspended solids levels were highest in southern downstream locations of the Ausable River and Parkhill Creek. For those aquatic animals that rely on good visibility, water clarity may be limiting in Parkhill and Decker creeks and at the Lower Ausable station.

Table 3.5: Summary of water quality and benthic invertebrate community analyses in the Ausable River and Parkhill Creek basins.

Indicator	Result	Implication for Species at Risk
Phosphorus	Mean total phosphorus (TP) greater than Provincial Water Quality Objective at all PWQMN stations. TP decreasing over time at Black and Decker Creeks, and the Lower Ausable. Total dissolved phosphorus an important proportion of TP at all sites.	Eutrophication effects possible.
Nitrogen	Nitrate high at all PWQMN stations. Nitrate increasing in tributaries over time. Un-ionized ammonia high in Black and Decker Creeks.	Eutrophication effects possible. Possible toxicity at Black and Decker creeks.
Clarity/TSS	Turbidity and total suspended solids (TSS) high at the Lower Ausable; TSS decreasing over time at Lower Ausable.	Visibility reduced, disruptions to ecosystems such as reduced light penetration.
Dissolved oxygen	Dissolved oxygen typically met the Canadian Water Quality Guideline for warm water biota.	Dissolved oxygen does not appear to be limiting.
Benthic Invertebrate Community	Family Biotic Index and dominant species indicated more degraded conditions in the headwater sites compared to the main channel sites.	Better water quality conditions in the main channel versus tributaries where most species at risk are present.

The first PWQMN stations in the Ausable River were sampled in 1965. There have been changes in nutrient concentrations since this time. Overall, TP concentrations have decreased and nitrate concentrations have increased. However, the changes in these water quality parameters were generally attributed to a strong trend at a few stations.

Five of the eight PWQMN stations were directly downstream of WTPs. Therefore, improvements in treatment process for TP, or lack of further treatment for nitrate, have influenced water quality trends. The location of PWQMN stations directly downstream of an important point source means that it was more difficult to determine the effects of landscape level changes (e.g., improvements in cropping practices and application of buffer strips).

Potential sources of nutrients and sediments in the Ausable include agricultural sources, discharge from WTPs, and septic systems. The Clean Up Rural Beaches study (ABCA 1989) suggested that private septic systems were a very important source of phosphorus and bacteria to Lake Huron. A report completed at the national scale found agriculture to be the largest source of phosphorus (Chambers et al. 2001). The per capita per year load of phosphorus from septic systems was approximately 10 times higher in ABCA (1989) compared to the national average

(Chambers et al. 2001). However, ABCA (1989) did not attempt to measure the contribution from fertilizer or pesticide applications. As over 80% of the basin was in row cropping in 1986 this may present a significant weakness of this assessment. Current and accurate potential source information for sediments and nutrients for this watershed is lacking. The high concentrations of nitrogen and phosphorus in the surface waters of the Ausable River and Parkhill Creek suggest that agriculture and human waste inputs are both considered substantial.

4.0 Species at Risk

4.1 Background Information

Mussels

There are few historical records available for freshwater mussels in the Ausable River prior to the 1990s. Detweiler (1918) surveyed the river in 1916, primarily for commercially valuable species (used in the pearl button industry), and recorded only nine species. Only four additional historical records are known from museum collections from the Ausable River at Hungry Hollow collected in 1929 and 1950. Surveys conducted at six sites in 1993 and 1994 (Morris and Di Maio 1998) found 14 live species, three of which had been previously unrecorded. The presence of COSEWIC-listed species in these and previous collections prompted more rigorous surveys by the National Water Research Institute (NWRI) in 1998 (eight sites) and 2002 (seven sites) (Metcalfe-Smith unpublished data). These surveys employed 4.5 person-hour timed searches, a technique which is described in detail in Metcalfe-Smith et al. (2000). In total, 3370 live mussels of 21 species were collected with shells representing an additional three species. Of the 24 species of mussels known to occur in the Ausable River basin, four have been listed as endangered by COSEWIC.

Fishes

Our knowledge of fish distributions in the Ausable watershed is largely based on four main data sources: a database containing fish distribution records primarily from the Ontario Ministry of Natural Resources (OMNR) and Royal Ontario Museum (ROM) (985 records); a Department of Fisheries and Oceans (DFO) survey conducted in 2002 (791 records); an Ontario Department of Planning and Development (ODPD) survey conducted in 1947 (200 records); and, an ABCA drain survey conducted between 1999 and 2002 (325 records). The OMNR/ROM database contains records representing 76 fish species collected primarily by seining at sites between 1928 and 1997. In 2002, DFO (with assistance from ABCA and OMNR) conducted watershed-wide, targeted surveys for species at risk. Sampling methods included seining, backpack electrofishing and boat electrofishing depending on site conditions. In general, each site was sampled intensively until no new species were encountered on 2 consecutive hauls/passes. A total of 65 species were collected at 25 sites. In addition, DFO conducted intensive sampling in a 5 km reach of the Old Ausable Channel employing several survey techniques (boat electrofishing, boat seining, minnow traps, windermere traps and hoop nets). This gear comparison study collected 22 species at 56 sites. The ODPD collected 31 species at 59 sites by seining. A drain survey was conducted by ABCA between 1999 and 2001 yielded 37 species at 46 sites. The majority of historical records do not include information on sampling methods/effort (presence/absence only); therefore, identifying population trends over time is difficult to assess for most species. One notable exception is comparison of the results of seining conducted in the Old Ausable Channel in 1982 and 1997 (Holm and Boehm 1998).

Based on available historical data, Veliz (2001) lists a total of 73 fishes that have been recorded from the Ausable River watershed. However, when this list was reconciled with more recent data, a grand total of 83 species were noted. The presence of previously undetected species in 2002, such as the black redhorse (COSEWIC-listed as 'Threatened'), illustrates the inadequacies of historical sampling. In total, seven COSEWIC-listed fishes have been recorded from the Ausable River watershed.

Reptiles

There are few historical records available for reptiles in the Ausable River and Parkhill Creek. A comprehensive survey of the reptile fauna of the Ausable River basin does not exist. The few records in the basin for reptiles are generally from two sites - Hungry Hollow and Rock Glen Conservation Area. Rigorous methods have not yet been used to sample for reptiles, and most species records in the basin have been through incidental observations indicating presence/absence rather than abundance.

Dragonflies and Damselflies

The dragonflies and damselflies of the Ausable River and Parkhill Creek basins were not intensively surveyed prior to the 1990s. Skevington and Carmichael (1997) reported on the dragonflies and damselflies collected in a formal insect survey of the town of Bosanquet in the northwestern Lambton County. This survey included the Pinery Provincial Park, the Port Franks Forested Dunes and areas adjacent to the Ipperwash Army base immediately to the southwest of the Lower Ausable sub-basin. Over 600 hours were spent hand collecting adult specimens in Pinery Provincial Park and 343 hours spent hand collecting and using malaise traps to survey areas adjacent to Port Franks. Sites were surveyed between May 1991 and September 1994, including less intensive surveys in the summers of 1995 and 1996. Three species of dragonflies and four species of damselflies considered rare (S1 to S3) in Ontario were identified during these surveys. The OMNR is conducting surveys for reptiles, dragonflies, and damselfies across the Ausable River basin during the summer of 2003.

4.2 Trends in Distribution

Mussels

The lack of intensive mussel surveys prior to 1993 makes assessing population trends over time difficult, however some inferences can be made. Of the four COSEWIC-listed species, only a single historical record exists for the snuffbox, which was first reported from Hungry Hollow in 1950. Despite intensive sampling in the past 10 years, this species has not been collected live and was represented by two fresh and 11 weathered shells collected by NWRI in a 55 km reach of river between Rock Glen and Brinsley. Although this species may once have occurred in low densities over a considerable stretch of river, it now appears that the snuffbox may be extirpated from the basin. The remaining three COSEWIC-listed mussel species were collected live in the Upper and Middle sub-basins of the Ausable River and the wavy-rayed lampmussel was also found in the lower stretch of the Little Ausable River. This species was represented by no more than a single live specimen at three sites with low numbers of fresh shells found at a few additional sites. Similarly, the northern riffleshell presently occurs in very low densities; a total of three live individuals were recorded from two sites near Brinsley and Nairn. A large number of fresh and weathered shells of the northern riffleshell were found extending over a larger 55 km reach indicating that the population has declined and at one time was much larger. Morris and Di Maio (1998) first sighted the kidneyshell in the Ausable River in 1994. Subsequent surveys by NWRI have indicated a healthy population in the Ausable River with a total of 59 live animals encountered at seven sites extending over a 50 kilometre reach between old Highway 81 and Huron Park (Metcalfe-Smith, unpublished data). In terms of abundance, the Ausable River kidneyshell population is thought to be the strongest remaining in Canada.

Fishes

Of the seven COSEWIC-listed fishes known from the Ausable River basin, two species (pugnose shiner and lake chubsucker) are known only from the Old Ausable Channel (OAC). These species were first found in 1982; however, subsequent sampling in 1997 has suggested a decline in the population of pugnose shiners (Holm and Boehm 1998). Additional surveys in 2002 appear to support this assertion, as well as the suggestion that the fish community of the OAC may be shifting from a cyprinid dominated to a centrarchid-dominated community. The relative abundance of the lake chubsucker appears unchanged since 1982 and the population currently appears stable. The remaining five COSEWIC-listed fishes occur predominantly in the main branch of the Ausable River. The eastern sand darter is known from only one record from the Ausable River at Ailsa Craig where "a series of yearlings to breeding adults" were taken (Hubbs and Brown 1929). This species has not been reported since, despite extensive sampling conducted in 2002, and may be extirpated.

Difficulty in proper identification among the six redhorse species may have confounded results from historical surveys. The river redhorse was first reported from the Ausable River at Ailsa Craig in 1936 and this species has been absent from any subsequent surveys. The greater redhorse (not currently listed by COSEWIC) was first reported upstream of Ailsa Craig in 1928. It has since been confirmed during 2002 at 2 sites upstream of Ailsa Craig where 15 individuals were captured. The first confirmed record of the black redhorse was taken from a single site in the lower reaches of the Little Ausable River during 2002. A juvenile black redhorse was captured, suggesting the presence of a reproducing population. Another species previously unknown from the basin, the bigmouth buffalo, was captured in 2002 in the lower end of the Ausable River near the confluence of the OAC and the "Cut". This species is considered a recent invader and is likely expanding its range. An unidentified species of *Ictiobus* was also found – perhaps a smallmouth buffalo (*Ictiobus bubalus*). The greenside darter is widespread and locally abundant in the Ausable River basin. During a survey of 25 sites in 2002, the species was found at over half (13) of the sites surveyed with as many as 71 individuals at a single site.

Reptiles

The absence of historical intensive surveys for reptile species in the Ausable River and Parkhill Creek basins prevents the determination of historical trends. The first record of the eastern spiny softshell turtle was from Port Franks in 1987 and this species was most recently recorded from the Ausable River in 1992. A total of seven records of the northern map turtle exist from the Ausable River between the 1970s and 1990s all from the Hungry Hollow and Rock Glen Conservation Area. Records of the queen snake have also been confirmed from the Hungry Hollow and Rock Glen Conservation Area between the 1960s and 1970s (Judd 1962, Spurr 1978, Spurr and Smith 1979).

4.3 Conservation Priority

Population trends for the 14 COSEWIC-listed species are presented in Table 4.1. To summarize, one species was found to be expanding its range (bigmouth buffalo), three species are apparently stable (lake chubsucker, greenside darter, and kidneyshell), three species are declining (pugnose shiner, northern riffleshell and wavy-rayed lampmussel), and three species may be extirpated from the Ausable River (snuffbox, eastern sand darter, and river redhorse). There was insufficient data to infer general population trends for four species. These include all three species of reptiles (eastern spiny softshell turtle, queen snake and northern map turtle), which are known from only a few records, and the black redhorse, collected at one site in 2002.

To help prioritize species and location of specific recovery actions, conservation priorities were assigned to all 14 species at risk (Table 4.1). These conservation priorities were assigned based on COSEWIC status, global (G-rank) and provincial rarity (S-rank), as well as population trends within the Ausable River watershed. Species listed as Endangered or Threatened by COSEWIC and/or globally rare (G1, G2, or G3) were assigned a 'High' conservation priority ranking. Species listed as Special Concern by COSEWIC were assigned a 'Medium' priority ranking if they were provincially rare (S1 or S2), and a 'Low' priority ranking if they were more widespread provincially (S3 to S5) with a stable or expanding population in the Ausable River. It is important to note that a low conservation priority ranking does not equate to low conservation concern, but is simply a relative ranking system to help in prioritizing species and location-specific recovery efforts.

Table 4.1: Summary of status and limiting factors for species at risk in the Ausable River.
Refer to Ausable River Recovery Team (2003) for more detailed information on each species.

Species	G-rank	S-rank	COSEWIC	Status in Ausable	Extant sites	Limiting Factors	Conservation Priority*
northern riffleshell	G2T2	S1	END	Declining	Upper & Middle Ausable	primarily siltation, nutrient and pesticide inputs, muskrats	High
wavy-rayed lampmussel	G4	S1	END	Declining	Upper & Little Ausable	water clarity (turbidity)	High
snuffbox	G3	S1	END	Extirpated?	---	Siltation	High
kidneyshell	G4/G5	S1	END	Stable?	Upper & Middle Ausable	Siltation	High
pugnose shiner	G3	S2	END	Declining?	Lower Ausable (OAC)	'extreme sensitivity to turbidity', shifts in fish community?	High
eastern sand darter	G3	S2	THR	Extirpated?	---	clean, fine sand habitats	High
lake chubsucker	G5	S2	THR	Stable?	Lower Ausable (OAC)	Siltation, turbidity, wetland loss, shifts in fish community?	High
black redhorse	G5	S2	THR	Insufficient data	Little Ausable	Siltation, turbidity	High
river redhorse	G4	S2	SC	Extirpated?	---	Siltation, Turbidity	Medium
greenside darter	G5	S4	SC	Stable	Widespread	Turbidity?	Low
bigmouth buffalo	G5	SU	SC	Expanding	Lower Ausable	Temperature?	Low
eastern spiny softshell turtle	G5T5	S3	THR	Insufficient data	Lower Ausable	Unknown	High
queen snake	G5	S2	THR	Insufficient data	Lower Ausable	Unknown	High
northern map turtle	G5	S3	SC	Insufficient data	Lower Ausable	Unknown	Low

* High - globally rare (G1, G2, or G3) and/or COSEWIC designation of endangered or threatened. Medium - globally common (G4 or G5), COSEWIC designation of special concern, limited or declining distribution in Ausable. Low - COSEWIC designation of special concern, widespread provincially (S3-S5), widespread and stable or expanding distribution.

The 10 species with a high conservation priority ranking are located within the reaches indicated in Figure 4.1. In addition, this high priority zone includes nearly all distributions (present and past) of the remaining species, with the notable exception of the widely distributed greenside darter. The high conservation priority zone can be divided into three major areas:

1. Ausable River - main channel from mouth to Hay Swamp
2. Old Ausable Channel
3. Little Ausable River - lower reaches

To date, species at risk have not been found in the headwater or upper reaches of the tributaries (Table 4.2). The three reptile species have been found only in the Lower Ausable sub-basin. This is likely an artifact of the limited sampling effort that has occurred in the Ausable River basin. The main channel of the Ausable River is providing or has provided habitat to 11 species at risk. The Old Ausable Channel, with its clear waters and dense aquatic vegetation, represents unique habitat within the watershed and is the only region where pugnose shiner and lake chubsucker occur. The Little Ausable River is the only tributary that harbours high priority species – both wavy-rayed lampmussel and black redhorse were confirmed in the lower reaches in 2002.

Table 4.2: Summary of historical and present distributions of species at risk in the Ausable River basin.

Dark grey-filled cells indicate that the species was found in the past 10 years of surveys (1993-2003), while light grey-filled cells indicate where the species was historically found, but may be currently absent. In light-grey-filled cells, the year indicates the last time the species was found alive. Shells = no live mussels recently encountered, but shells were collected.

Species	Ausable Head-waters	Black Creek	Upper Ausable	Little Ausable	Nairn Creek	Middle Ausable	Lower Ausable	Dunes
northern riffleshell							Shells	
wavy-rayed lampmussel						Shells		
snuffbox			Shells			Shells	Shells	
kidneyshell								
pugnose shiner								
eastern sand darter			1929					
lake chubsucker								
black redhorse								
river redhorse			1936					
greenside darter								
bigmouth buffalo								
eastern spiny softshell turtle							1992	
queen snake								
northern map turtle							1990	
Total species extant	0	1	4	3	1	3	3	2

To identify significant reaches in terms of both diversity and the conservation status of the individual species present, Metcalfe-Smith et al. (unpublished data) developed a conservation scoring system which awards points for each species present based on their sub-national ranks (S1=5, S5=1). Using this system, the conservation score for a particular location equals the sum of the values for all species present at a site. In this analysis, non-native fish species were excluded from the analysis. Conservation scores for recent mussel sampling in the Ausable conducted by the National Water Resources Institute (NWRI) in 1998 and 2002 (Metcalfe-Smith et al., unpublished data) are indicated in Figure 4.2A. Sites with the highest conservation scores (41-50) for mussel communities were all located in the Upper Ausable sub-basin. A similar trend is noted for fish sampling conducted by the Department of Fisheries and Oceans (DFO) in 2002 (Mandrak unpublished data) with the majority of high conservation scores (31-50) also appearing in the Upper Ausable, but also in the lower Little Ausable sub-basin and the Old Ausable Channel (Figure 4.2B). Taken together, conservation scores for current fish and mussel communities generally underscore the importance of the three identified high conservation priority zones for species at risk. However, for the main channel of the Ausable River, the conservation scores clearly emphasized the significance of upper reaches that extend upstream somewhat beyond the priority zone for COSEWIC-listed species at risk.

4.4 Habitat Preferences

Information on habitat preferences for the 14 species at risk was used to identify similarities in habitat use, and to help determine the primary factors that may impact these species and their habitats. General habitat preferences for all species were taken from their COSEWIC status reports. All species were then grouped according to their general habitat preferences (Figure 4.3). The majority of species at risk (seven) are found almost exclusively in areas with firm gravel bottoms and moderate to swift currents. These species include the four mussels, black redhorse, river redhorse, greenside darter, and queen snake. The queen snake shows the greatest preference for coarse substrates such as gravel bottoms, often in calmer bays and backwaters where it forages for crayfish. Of the remaining species, the eastern spiny softshell turtle and northern map turtle prefer deeper sections with sand and soft substrates. An important feature of their riparian habitat needs includes basking areas such as overhanging branches for the northern map turtle, and muddy banks for the eastern spiny softshell turtle. A suitable nesting area close to the river with a sandy substrate and abundant exposure to sunlight is also required. Lake chubsucker, pugnose shiner, and bigmouth buffalo all prefer soft substrates with aquatic vegetation, however, the former two species require clear waters and are intolerant of turbidity. Finally, the eastern sand darter is very strongly associated with sand substrates.

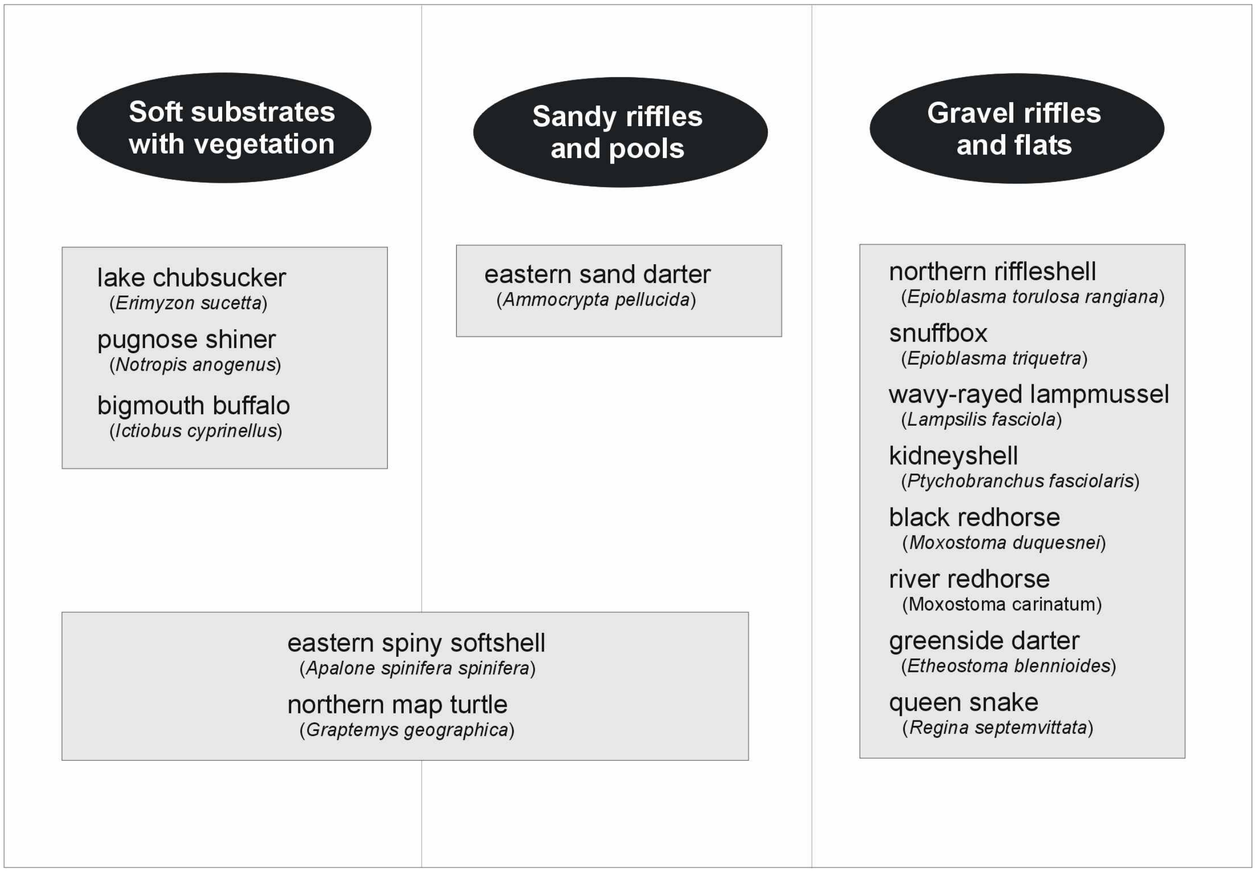

Figure 4.3: General habitat preferences for COSEWIC-listed species at risk in the Ausable River and Parkhill Creek basin.

4.5 Other Rare Species in the Basin

While the mandate of this recovery process is to focus on the aquatic COSEWIC-listed species at risk found within the Parkhill Creek and Ausable River basins, there are many other rare species that exist in the basin. It should be noted that recovery actions with a broad focus, in most cases, have a positive impact on other species not considered. Recovery actions that can be implemented which would benefit other rare species in the basin should be encouraged.

There are records of other terrestrial and semi-aquatic COSEWIC-listed species at risk in the basin including the eastern hog-nosed snake (*Heterodon platyrhines*) [THR], eastern foxsnake (*Eliaphe vulpine gloydi*) [THR], five-lined skink (*Eurnesces fasciatus*) [SC], stinkpot turtle (*Sternotherus odoratus*) [THR], spotted turtle (*Clemmys guttata*) [SC], wood turtle (*C. insculpta*) [SC], Butler's garter snake (*Thamnophis butleri*) [THR], and the blue racer (*Coluber constrictor foxii*) [END] (historic records) (Barrett, K., pers. comm., Ontario Ministry of Natural Resources, 2003). Other terrestrial and semi-aquatic species existing in the basin include the snapping turtle (*Chelydra serpentina*), Blanding's turtle (*Emydoidea blandingi*), painted turtle (*Chrysemys picta bellii*), northern water snake (*Nerodia sipedon sipedon*), eastern garter snake (*Thamnophis sirtalis sirtalis*), red-bellied snake (*Storeria occipitomaculata*), Dekay's brownsnake (*Storeria* *dekayi*), smooth greensnake (*Opheodrys vernalis*), ring-necked snake (*Diadophis punctatus*), and milksnake (*Lampropeltis trangulum*). For additional rare species found in the Ausable River basin please refer to Appendices 3 and 4.

No species of dragonflies, damselflies or crayfishes are currently ranked nationally (COSEWIC) or provincially (Committee on the Status of Species at Risk in Ontario - COSSARO). Seven provincially rare species of odonates (S1-S3) have been recorded in the Ausable River basin. Ontario's Natural Heritage Information Centre has provided the most current listing of Odonata within the Ausable River (Table 4.3, Appendix 4) (Ontario Odonata Database 2002). The majority of confirmed sightings are from Pinery Provincial Park, Rock Glen, and Hungry Hollow.

Table 4.3: Status of dragonfly and damselfly species at risk in the Ausable River basin (Ontario Odonata Database 2003).

	Species	G-rank	S-rank
Dragonflies	green-striped darner (*Aeshna verticalis*)	G5	S2
	pronghorn clubtail (*Gomphus graslinellus*)	G5	S2
	painted skimmer (*Libellula semifasciata*)	G5	S2
Damselflies	blue-ringed dancer (*Argia sedula*)	G5	S1
	dusky dancer (*Argia translata*)	G5	S1
	double-striped bluet (*Enallagma basidens*)	G5	S3
	Westfall's slender bluet (*Enallagma traviatum westfalli*)	G5	S1

All of the rare dragonfly and damselfly species require water for the completion of their lifecycle. Although no definitive habitat requirements exist for any of the listed species, habitat preferences are known (Table 4.4). Many dragonfly and damselfly species are found in relatively calm water, such as lakes or pools in larger rivers (Walker 1953, Walker 1958, Walker and Corbet 1978, Catling et al. 2000). The main factors leading to the degradation of these systems is linked to physical impairments including channelization, the creation of dams and reservoirs, and erosion control (Catling 2000).

Table 4.4: General habitat preferences for rare dragonfly and damselfly species found in the Ausable River basin (Nelson 2003).

<table>
<tr><th>Marsh-bordered lakes and wetlands</th><th>Ponds and lakes</th><th>Rivers - pool sections</th></tr>
<tr><td>green-striped darner</td><td></td><td></td></tr>
<tr><td></td><td>Westfall’s slender bluet</td><td></td></tr>
<tr><td></td><td></td><td>blue-ringed dancer</td></tr>
<tr><td></td><td colspan="2">double-striped bluet</td></tr>
<tr><td></td><td colspan="2">pronghorn clubtail</td></tr>
<tr><td colspan="3">dusky dancer</td></tr>
<tr><td colspan="3">painted skimmer</td></tr>
</table>

The loss of clear, high quality, unimpounded and undisturbed streams is the most significant factor contributing to the threatened status of odonate species in the United States and Canada (Bick 1983). The lower Thames, upper Ottawa, St. Lawrence, Sydenham and Ausable Rivers were identified as having populations of rare dragonflies and damselflies (Catling et al. 1996). The maintenance of water quality and appropriate water levels would be essential to the survival of rare odonates, as well as other rare insects, fishes and molluscs (Catling et al. 1996). The maintenance of adequate surface and groundwater levels must also be ensured so that pond and stream water levels are not adversely affected. Westfall’s slender bluet was specifically mentioned as being susceptible to changes in surface and groundwater levels. Catling (2000) noted that, although only 25 per cent of Ontario’s dragonflies and damselflies complete their larval stages primarily in streams and rivers, these represent the majority (75 per cent) of rare (S1 and S2) species. Additional survey work is necessary to determine the extent of Odonata populations in the Ausable River basin.

4.6 Threats to COSEWIC-listed species at risk

The current distribution and abundance of species at risk in the Ausable River watershed is based upon the natural conditions in the basin and the effect of multiple land use stresses. There are general and specific threats to COSEWIC-listed species at risk in the Ausable River including turbidity and siltation, nutrient enrichment, toxic contaminants, thermal change, and exotic species (Table 4.5). Many of the threats in the table have been assigned ranks of high, medium, or low to describe the relative certainty to which the recovery team estimates a certain cause is affecting, or has the potential to affect, species at risk in a sub-basin. In some cases, isolated threats to the distribution of species may be the single limiting factor affecting a particular species. However, the cumulative effects of multiple stresses must be taken into account. Information on the long-term population trends is incomplete for all species, particularly for the black redhorse and the three reptile species. This lack of understanding creates additional difficulties in determining the impact of various threats on population trends.

Table 4.5: List of general and specific threats to species at risk in sub-basins of the Ausable River.

General Threat	Specific Threat	General Cause	Specific Cause	Sub-basin							
				Ausable Head - waters	Black Creek	Upper Ausable	Little Ausable	Nairn Creek	Middle Ausable	Lower Ausable	Dunes - Old Ausable Channel
Sediments	Siltation and Turbidity	Agriculture	Bank erosion	Low	Low	Low	Low	Low	Low	Low	
			Drainage	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
			Overland runoff	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
		Urban	Wastewater treatment plants		Medium	Low	Low		Low	Medium	
		Dams	Deposition upstream, scouring upstream	Medium		Medium			Medium	Medium	Low
		Roads		Low	Low	Low	Low	Low	Low	Low	Low
		Bridges		Low	Low	Low	Low	Low	Low	Low	Low
Nutrient Enrichment	Phosphorus, Nitrogen, Un-ionized ammonia	Agriculture	Cattle access	Low	Low	Low	Low	Low	Low	Low	
			Drainage	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
			Overland runoff	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
	Phosphorus, Nitrogen, Un-ionized ammonia	Urban	Wastewater treatment plants		Medium	Low	Low		Low	Medium	
			Septic systems	Low	Low	Low	Low	Low	Low	Low	Low
Contaminants	Chlorides	Roads	De-icing	Low	Low	Low	Low	Low	Low	Low	Low
	Oil/grease	Roads	Runoff	Low	Low	Low	Low	Low	Low	Low	Low
	Ammonia	Agriculture	Manure spills	Low	Low	Low	Low	Low	Low	Low	
	Herbicides/Pesticides	Agriculture	Drainage	Low	Low	Low	Low	Low	Low	Low	
			Overland runoff	Low	Low	Low	Low	Low	Low	Low	
Exotic Species	Zebra mussels	Introduction	Reservoirs	Low	Low	Low	Low	Low	Low	Low	Low
	Common carp		Reservoirs	Low	Low	Low	Low	Low	Low	Low	High
	Round goby			Low	Low	Low	Low	Low	Low	Low	Low
Thermal	Increase in stream temperature	Reservoirs	Increased pond surface area	Low	Low	Low	Low	Low	Low	Low	Low
		Loss of riparian area	Reduction in shading	Low	Medium	Low	Low	High	Low	Low	Low
Altered Flow Regime	Increase in peak flow discharge and reduced base flow	Agriculture	Drainage	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
		Land use	Loss of natural areas	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
		Climate change		Low	Low	Low	Low	Low	Low	Low	Low

Sedimentation

The primary threat for the majority of species at risk in the Ausable River basin appears to be related to turbidity and associated siltation. Mussel and fish species that depend on clean gravel and sand substrates are particularly vulnerable to siltation (Richter et al. 1997). Material in suspension may directly or indirectly impact species. Direct impacts could include physiological limitations due to the suspended sediment. Indirect impacts could include impeding utilization of more coarse-grained material, altering feeding ability, covering substrate, and affecting the burrowing ability (e.g., eastern sand darter). Most of these species show evidence of declines and some may even be extirpated. As an example, the northern riffleshell appears to have suffered significant declines across most of its range. Data for this species suggest that the population in the Ausable River was once much stronger than that found in the Sydenham River. However, at present only a few individuals of this species have been located in the Ausable River and densities are well below those found in the Sydenham River (Staton et al. 2000). Concentrations of TSS at areas in the Sydenham River with reproducing northern riffleshell were 50-64 mg/L (Janice Metcalfe-Smith, pers. comm., February 17, 2003). Mean (±1 SE) suspended sediment concentrations (116.73 ± 6.02 mg/L) at the Springbank station in the Middle Ausable (located within the known northern riffleshell range) showed no significant change in concentration between 1970 and 1993. The concentrations of TSS and SS are higher in the Ausable River than in the Sydenham River and may be limiting the Ausable River northern riffleshell populations. Further investigation of TSS concentrations, turbidity, and deposition of material may elucidate reasons for the observed declines of the northern riffleshell and other species.

The Ausable River and Parkhill Creek Rivers naturally carry heavy sediment loads due to climate, geology and soils. However, the conversion of upland and lowland forest to agriculture has undoubtedly exacerbated sediment loading to the Ausable River and Parkhill Creek. Agricultural activities that may accelerate soil erosion and resultant sedimentation in nearby streams include the removal of vegetation or crop harvesting, tilling, overgrazing (International Joint Commission 1977), livestock access to the stream, and surface and subsurface drainage.

Surface and subsurface drainage, and associated agricultural practices, have been shown to contribute more sediment to receiving waters than areas with natural cover (Skaggs et al. 1994). In particular, sediments from tile drainage are characteristically very fine grained and may contribute directly to high turbidity levels (Skaggs et al. 1994). Currently, the extent and distribution of surface and subsurface drainage is not available for the Ausable River or Parkhill Creek basins. However, the most recent information indicates that subsurface drainage is extensive and evenly distributed among the sub-basins, except for the Dunes sub-basin (Ontario Ministry of Agriculture and Food 1983). Combined with the predominantly intensive agricultural land use across the entire watershed and the impact of overland flow from agricultural land use, the contribution of sediment leading to siltation and turbidity from artificially drained lands may be a serious concern.

Nutrient Enrichment

The elevated concentrations of total phosphorus, nitrate and un-ionized ammonia in the Ausable River watershed are a potential threat to many species at risk. Concentrations of these nutrients in the Ausable River and Parkhill Creek systems are indicative of eutrophic conditions. The consequences for species at risk may include the alteration of food webs and in some locations, (e.g., Black and Decker creeks) toxicity from elevated nitrate and un-ionized ammonia concentrations. Sources of phosphorus and nitrogen in the Ausable River include agriculture, WTPs and septic systems. Non-point sources of phosphorus and nitrogen include fertilizer and pesticide application, plant residues and animal manure from croplands, pasture lands, and animal confinement areas. Associated with the loss of soil through erosion is the loss of P because this element strongly adheres to soil particles (Ryden et al. 1973). Factors influencing additional N and P losses include: precipitation, irrigation, temperature, soil characteristics, crop type, fertilizer and pesticide type, application method and rates and tillage practices. Agriculture and related drainage modifications and overland runoff are distributed extensively across all sub-watersheds, except for the Dunes sub-basin.

Generally, PWQMN stations are located downstream of WTPs. Therefore, nitrogen and phosphorus concentrations measured in the Ausable River and Parkhill Creek basins are influenced by WTP effluent. Septic systems are another potentially important source of nutrients to consider and, as the number of systems in the watershed was estimated to be 7,437 in 1989, this is one non-point source that likely contributes nutrients across the entire basin (Ausable Bayfield Conservation Authority 1989).

Altered Flow Regime

Low summer base flows, and associated periodic drought, may have always been a characteristic of the Ausable River (Department of Planning and Development 1949). A variety of activities have changed the hydrologic conditions of the Ausable River over time. For example, changes in land use from natural to agricultural, including wetland loss; extensive drainage alterations; an increase in the area of artificially drained land; and, the increase in the number of closed watercourses undoubtedly changed the hydrologic pattern of the Ausable River. Climate change may also play a contributing role in affecting the amount and timing of annual precipitation levels. The extent to which each identified hydrologic change is a contributing factor to the general threat of an altered flow regime is difficult to determine. However, it is anticipated that the level of certainty of effects of climate change on the Ausable River is lower in comparison to drainage alterations and the loss of natural areas. While an increasingly variable flow regime may not be a direct threat to any species at risk, associated threats from sediment, nutrient and contaminant transport and delivery, thermal changes, and periodic drought will contribute to the stresses affecting species at risk.

Toxic Contaminants

Although no data on toxic contaminants has been investigated, species at risk may be adversely impacted by contaminants introduced into the environment such as herbicides, pharmaceuticals, insecticides, metals, and various other contaminants. The main pathways by which toxic contaminants enter the Ausable River are roads and agricultural land use. Chloride, added in the form of road salt, can pose a risk to freshwater species at high concentrations. The severity of periodic high concentrations above the lethal tolerance limits for aquatic life may pose a concern. However, peaks in chloride concentration may be masked by monthly water quality measurements, which tend to under-emphasize the short-term peaks. Chloride concentrations were not summarized for this current study, therefore, the potential severity of this threat is unknown.

Oils and greases are added to the environment via runoff from roads. It is suspected that the impacts from contaminants from both salt applied in winter to roads and oils and grease inputs are low across the entire watershed. Applied herbicides and insecticides entering the system via drainage or overland runoff may also threaten species at risk (Liess and Schulz 1999). Manure spills may contribute ammonia directly to the landscape. It is difficult to assess risk from many of these contaminants, as each species will respond to different contaminant concentrations, contaminant concentrations are not known, and the application rates of various contaminants are not known. The potential effects of herbicides, insecticides, and other toxic chemicals on species at risk should be investigated further.

Exotic Species

The risk from various exotic species was determined to be low across all sub-basins except for the Old Ausable Channel. Although zebra mussels (*Dreissena polymorpha*) are known to have devastating impacts on freshwater mussels, (Ricciardi et al. 1998) this exotic species has not been found in the Ausable River or Parkhill Creek basins. There is some concern that the Parkhill and Morrison reservoirs may eventually harbour populations of this invasive species. However, the populations of native mussel species at risk are not found in the Parkhill Creek basin and the Morrison Dam and Reservoir at Exeter is substantially upstream of native mussel populations. A water residence time in a reservoir of between 20 to 30 days is required to maintain a population of zebra mussels (Mackie, G., pers. comm., March 2003). The small area of the Morrison reservoir, as well as other impoundments along the Ausable River, suggests that water residence time may be inadequate to maintain zebra mussels. However, the residence time of water should be evaluated for the Morrison reservoir.

The common carp (*Cyprinus carpio*) is present in the Old Ausable Channel and throughout the Ausable River basin. High densities of carp have been associated with increased turbidity levels in wetlands of Lake Ontario, affecting aquatic vegetation and fish species. The destruction of aquatic habitat and increased turbidity may have negative consequences for pugnose shiner and lake chubsucker in the Old Ausable Channel. Public education programs that stress the risks of transporting these exotic species should be encouraged. While the round goby (*Neogobius melanostomus*) has only been found in the Parkhill Creek basin, it is another potential threat to benthic species such as sculpins and darters if it colonizes in the Ausable River. A carp removal and public education program in the OAC should be a high priority for investigation.

Thermal Changes

Increases in stream temperature may stress species at the upper ranges of their temperature threshold. The Ausable River contains a predominantly warm water fishery but the combination of periodic episodes of low water levels in the summer months may exacerbate the risk to fish and mussels. Two main causes of an increase in stream temperature are reservoirs and the loss of riparian cover. Reservoirs and loss of riparian cover allow water to receive radiant heat from the sun.

Two sub-basins in the Ausable River (Black and Nairn creeks) support a marginal cold-water fishery with native brook trout (*Salvelinus fontinalis).* Recent examination of the brook trout population and habitat in Nairn Creek found numbers to be low (i.e., < 10 individuals at four of five locations with brook trout) and habitat to be poor (i.e., warm summer water temperatures, lack of cover and lack of gravel substrate) (Veliz 2003b). Thermal threats were therefore, considered high in the Nairn Creek sub-basin and medium in the Black Creek sub-basin, due to lack of extensive evaluation in Black Creek. Protection and/or enhancement of these two cold water sub-basins could help moderate high summer water temperatures in downstream reaches of the Ausable River where species at risk occur.

Fish Hosts

Freshwater mussels are parasitic on fish during their early glochidial life stage and depend upon the presence of their respective host species for survival. High host specificity appears to be the rule rather than the exception and some mussel species may use one or only a few fish species as functional hosts. Determination of host fish relationships can have important implications for recovery planning. Unfortunately, our knowledge of fish-host relationships for the four mussel species at risk in the Ausable River is incomplete.

The identification of fish hosts for mussel species at risk can be a lengthy process. There are three methods for identifying fish hosts and each has its advantages and disadvantages. (1) Capture fish and examine the gills, fins and body for glochidia. Remove and identify the glochidia. This method has two great disadvantages; (a) unfortunately, there are no taxonomic keys for the identification of glochidia; (b) many glochidia will attach to a fish but drop off later because the fish is an unsuitable host. The best definitive evidence is to allow the glochidia to metamorphose into juveniles that then drop off the fish. (2) Capture fish and examine the gills, fins and body for glochidia. Return the fish to the lab and maintain the fish species in different aquaria until the juvenile(s) drop off. If the source stream has only a few mussel species the chances are that the juveniles will belong to a species at risk. However, the Ausable River has 24 mussel species and the likelihood of identifying fish hosts for mussel species at risk using this method is very small. (3) The third method, and the one used here, is to use an artificial rearing method such as that used by McNichols and Mackie (2003). Gravid female mussel species at risk are collected from the Ausable River and maintained at a cool temperature (to inhibit release of glochidia) until several individuals of numerous species of fish are collected. The fish must be collected from another river, however, because a fish that has already been infested by a mussel develops immunity to further infestations. Also, fish may already be infested with glochidia of unknown mussel species (there may be more than one mussel species per fish). Once the fish are collected and examined to ensure no glochidia are present, the glochidia are flushed from the gills of a mussel and poured over the bodies, gills and fins of all fish species. The gravid female mussel is returned to the river and the fish are maintained in the lab until juveniles drop off, thereby verifying the fish as a host species. If juveniles do not drop off, the fish is evaluated as an unsuitable host for the mussel. The main disadvantage of this method is that although the fish "species" tested are based on the assemblage in the Ausable River, the individuals collected are from another river. However, McNichols and Mackie (2003) have collected fish (e.g., greenside darters) from different rivers and the source river does not seem to be a factor in selection of an individual fish as a host for glochidial development.

Host fish relationships for the wavy-rayed lampmussel and kidneyshell are known from populations in the U.S. but have not yet been confirmed for Canadian populations. Recent work by McNichols and Mackie (2003) has determined fish host relationships for populations of the snuffbox and northern riffleshell from the nearby Sydenham River. Although these populations are likely very similar to those found in the Ausable, fish host relationships have been found to vary for mussel populations within large drainages and therefore, these results should not be taken as conclusive. Further investigation into fish host relationships in the Ausable River is warranted, but may not be feasible given the extremely low densities of all but the kidneyshell.

The wavy-rayed lampmussel has only two known fish host species, the smallmouth bass (*Micropterus dolomieu*) (Zale and Neves 1982), and largemouth bass (*M. salmoides*) (G.T. Watters, Ohio State University, unpublished data) (Table 4.6). Both species were caught at numerous sites in the Ausable River both historically and during 2002 DFO surveys (Table 4.6); therefore, host availability is not thought to be a limiting factor.

Table 4.6: Summary of historical and present occurrence of probable fish host species in the Ausable River basin.

Mussel Species	Probable Fish Host Species	Historical Records – ROM/OMNR and ODPD (1928 to 1997)*	ABCA Drain Survey Records (1999 to 2001)*	DFO (2002)
northern riffleshell	blackside darter	21	8	13
	logperch	3	1	1
wavy-rayed lampmussel	smallmouth bass	15	2	16
	largemouth bass	7	2	6
snuffbox	rainbow darter	51	-	-
	logperch	3	1	1
	greenside darter	5	4	13
kidneyshell	greenside darter	5	4	13
	fantail darter	1	3	2
	Johnny darter	22	70	17

* For more information on these datasets, please refer to Background Information for Species at Risk – fishes (Section 4.1).

The host fish(es) for the kidneyshell in the Sydenham and Ausable rivers are unknown, but Watters (1999) notes that the hosts for three other species in the same genus have been identified as species of Percidae (darters) and Cottidae (sculpins). White et al. (1996) observed four darter species - greenside darter (*Etheostoma blennioides*), fantail darter (*E. flabellare*), johnny darter (*E. nigrum*), and banded darter (*E. zonale*) - habouring kidneyshell glochidia in French Creek, Pennsylvania. All but the banded darter (which is not found in Canada) occurs in the Ausable River. During 2002 DFO surveys, both greenside and johnny darters were particularly abundant and found at over half of the 25 sites surveyed throughout the watershed (as well as in drains) (Table 4.6); fantail darters were reported from only 2 sites. If similar species of darters are host species for the kidneyshell in the Ausable River, it does not appear that host availability would be a limiting factor.

Research conducted by McNichols and Mackie (2003) identified several fish host relationships for Sydenham River populations of the northern riffleshell and snuffbox. Juvenile snuffbox mussels from the Sydenham River transformed on rainbow darters (*Etheostoma caeruleum*) and logperch (*Percina caprodes*), while juveniles from Davis Creek, Michigan, transformed on logperch and greenside darters. McNichols and Mackie (2003) suggested that the logperch appears to be the most suitable host for the snuffbox in both Michigan and Ontario as the number of juveniles developed is highest with this fish species. In the Ausable River, it appears from the historical records that the logperch may never have been a very common species (only three records exist prior to 1997). In 2002 surveys, a single individual was found at one site near the mouth of the river; another individual was recorded during the drain survey. Data on rainbow darters has shown a virtual disappearance of this species from the watershed. Prior to 1982, there were 51 records of this species from the Ausable River, however the species has not been recorded since and appears to be extirpated from the watershed. If the Ausable River snuffbox population did rely on logperch and/or rainbow darters as its host fish, the rarity/disappearance of these fishes may help explain the decline of the snuffbox. In contrast, research suggests that the decline of the northern riffleshell from the Ausable River may not be related to host fish availability. McNichols and Mackie (2003) found that both the blackside darter (*Percina maculata*) and logperch acted as host species for the northern riffleshell in the Sydenham River, but suggested that the former was the most suitable host. In the Ausable River, the blackside darter was found at over half of the 25 sites surveyed in 2002 and was also reported at eight sites during the recent drain survey. If the blackside darter is a host species of the northern riffleshell in the Ausable River, it appears that the decline of this mussel species may be related to factors other than host fish availability.

Threats Specific to the Old Ausable Channel

The Old Ausable Channel appears to be one of few remaining refuges for the pugnose shiner and lake chubsucker in Ontario. These species have a preference for dense aquatic vegetation, normally found in clear waters. This channel is relatively well protected within the Pinery Provincial Park and the threat of siltation and turbidity has been greatly reduced because it is completely isolated from the Ausable River. Populations of these two species may still be threatened, however. Holm and Boehm (1998) noted a decline in the number of pugnose shiners collected in the OAC in 1982 compared to 1997, despite increased sampling effort. A trend towards a predominance of sunfishes with a corresponding decrease in minnows was observed and it was predicted that a continued shift towards a fish community dominated by centrarchids would occur over time. A preliminary analysis of the extensive fish survey data collected by DFO in 2002 appears to support this prediction. Aside from possible shifts in the fish community structure, concerns have also been expressed regarding the safety of groundwater inputs that maintain flow within the Old Ausable Channel, the impacts of baitfish on the overall fish community, and the risk from various climate change scenarios. The presence of common carp also threatens water clarity and aquatic vegetation. The potential increased abundance of common carp may lead to reduced water clarity and aquatic vegetation in the OAC. Last, development pressures exist to the north of the Old Ausable Channel outside the boundary of Pinery Provincial Park.

4.7 Species at Risk Summary

Most of the species identified as having a high conservation priority are located within the main channel of the Ausable River from the mouth to Hay Swamp or in the lower reaches of the Little Ausable River, with the exception of pugnose shiner and lake chubsucker which are exclusively found in the Old Ausable Channel (Figure 4.1). The main threats affecting these species at risk appear to be related to turbidity, siltation and nutrient enrichment. Altered flow regime, toxic contaminants, thermal changes, and exotic species may also be important issues for populations of species at risk in the Ausable system.

The main causes of these threats appear to be linked to the change in land use from natural forest cover to agriculture. The associated increase in surface and subsurface drainage, intensive land use and changes to the drainage network (i.e., channel alterations including the “Cut” and dams) has likely contributed to increased sediment and nutrient loading. Nutrient enrichment concerns also arise from wastewater treatments plants and septic systems. High sediment and nutrient concentrations may limit the distribution and abundance of some freshwater mussel and fish species in the Ausable River.

Continued efforts to implement agricultural best management practices are one of the best options for reducing sedimentation and nutrient loading. Species that depend on clean, coarse substrates that are particularly vulnerable to siltation may receive the greatest benefit. Other species that prefer soft substrates may also benefit. For example, the northern map turtle may currently be limited by a lack of 'abundant aquatic vegetation' due to turbidity. Efforts to reduce sediment loading may reduce turbidity in the lower Ausable River, which would in turn, increase light penetration required for aquatic plant growth. Such conditions may not benefit the turbidity-tolerant bigmouth buffalo; however, this species appears to be expanding its range and is of low conservation concern.

5.0 Recommendations

This report synthesized information regarding geology, land use, water quality, and the biology of aquatic species at risk and outlined specific strategies and implementation tasks for the protection of aquatic species at risk. The overall purpose of this synthesis report is to provide background information for the creation of a Recovery Strategy. The Recovery Strategy will build upon this work to develop priority approaches for research and monitoring, stewardship, management, and public awareness for the protection of species at risk. Specific recommendations follow.

5.1 Research and Monitoring

- Investigate the relationships between species at risk and environmental variables.

  The relationship between species at risk and various environmental variables (e.g., turbidity, suspended sediment, and sediment deposition) is not clearly understood. As the impacts from sediments and sediment deposition are a significant threat for many of the species at risk, studies investigating these environmental variables should be a priority.

- Water quality monitoring should be expanded, especially in the Conservation Priority Zone.

  Five of the eight PWQMN stations are located downstream of wastewater treatment plants (WTPs). Unless additional stations can be integrated into the network it will continue to be difficult to determine whether water quality trends are attributed to changes in landscape level practices or local WTP improvements. In addition, sites sampled in 1998 (Metcalfe-Smith et al. 2000) should be integrated into a long-term water quality monitoring program.

- Continue monitoring trends/changes in aquatic ecosystem health.

Water quality and benthic invertebrate community survey results suggest that the tributaries and headwaters are more degraded than the Ausable River main channel. The proximity of the human activities that may influence various water quality parameters are likely contributing to the degraded conditions found in headwater streams. Further investigation is necessary to define physical and chemical limitations for the aquatic biota in the Ausable River and Parkhill Creek.

- Evaluate the current and future environment of the Old Ausable Channel including groundwater flow.

  The Old Ausable Channel is an important refuge for the pugnose shiner and lake chubsucker in Ontario. Both of these species have a habitat preference for dense aquatic vegetation and are normally found in clear waters. Understanding any risks to the future of the health of the Old Ausable Channel should be a high priority.

- Assess the impact/trends of chloride concentrations and toxic substances listed under the Canadian Environmental Protection Act.

  Toxic substances, such as chloride, may have an impact on species at risk within the basin. An understanding of the relative contribution and impacts of various contaminants is important.

- Conduct a general fluvial geomorphic assessment of the entire Ausable River to establish baseline and to develop a monitoring program.

  A thorough general fluvial geomorphic assessment would quantify the relative health of the stream channel across the basin. In addition to acting as a baseline of the current health of the stream channel, specific impacts, habitats and substrate composition would also be obtained. The Rapid Stream Assessment Technique (RSAT) may be a useful method (Galli 1996).

- Evaluate the extent and impacts of tile drainage to the Ausable River.

  The most recent estimate of the extent of tile drainage is from 1983. Research is required to determine how the drainage of the land is affecting the hydrology of streams and the associated aquatic community. An understanding of the current extent and location of the tile drainage in the basin will aid in determining candidate sites for riparian rehabilitation. While the 2001 Canadian Census information will not provide spatial distribution of tile drainage in the basin, it may provide a comparison measure of the area in tile drainage to 1983 information.

- Conduct a detailed dam assessment throughout the Ausable River basin expanding on the 1991 report (ABCA 1991).

Dams and reservoirs have an impact on stream and river systems. The location and extent that dams and reservoirs are contributing to sedimentation rates across the basin is unknown. This survey should include all reservoirs and water impoundments, assess the effects that these impoundments have, both upstream and downstream and calculate reservoir residence time to determine the suitability of these reservoirs for zebra mussels.

- Conduct studies investigating base flows and precipitation and their impact on habitat for riffle species.

  Low summer base flow is an important issue for aquatic communities in tributaries of the Ausable River and Parkhill Creek basins. The combination of factors contributing to low flow periods is not well understood. Accessing the Environment Canada flow station data may provide one long-term data source. This study would determine the need for re-establishing wetland to augment low flows during summer dry periods and examine the impacts from artificial drainage.

- Conduct an inventory of riparian and interior forest habitat.

  In order to provide recommendations for riparian enhancement a current assessment of riparian and interior forest cover within the basin is required.

- Develop a monitoring program to evaluate trends in the distribution and abundance of species at risk.

  A long-term monitoring program is required to provide trend-through-time information on range, abundance, and status of populations of species at risk. Different protocols will most likely have to be developed for several individual species focusing on their known range and habitat use.

- Conduct surveys for all aquatic species at risk in the Ausable River basin,

  The distribution and abundance of species at risk in the Ausable River basin is incomplete. Additional surveys are required to further clarify the status of these populations.

- Develop a database for the recovery team

  A database of all available species at risk data and information should be made available and easily accessible to the entire recovery team.

- Complete and incorporate findings about potential fish hosts for freshwater mussels found in the Ausable River.

McNichols and Mackie (2003) conducted an assessment for Sydenham River mussels and showed information on fish host species for two of the mussel species at risk. Further study should be completed to determine the fish hosts, and their distribution, for the four mussels species in the Ausable River.

- Report, and conduct studies, on the currently used pesticides within the Ausable River basin.

  The role of pesticides as a potential threat to species at risk has not fully been examined within this report. The Census of Agriculture can provide information on pesticide usage across the Ausable River basin and Environment Canada and Ontario Ministry of Environment can provide information on the relative impact of commonly applied pesticides.

- Research alternative water management options especially related to low flow situations within the basin.

- Assess significance of Hay Swamp and how alterations would affect species at risk downstream.

  Hay Swamp is situated in the headwaters of the Ausable River and is the largest wetland complex remaining in the basin. The upstream range of several species at risk are near Hay Swamp and as such, relative impacts to these species at risk distributions should be evaluated.

5.2 Stewardship/Habitat Improvement

There are established stewardship practices that reduce nutrient and sediment loadings to watercourses. Monk (2002) developed a list of potential situations with stewardship solutions and current incentives for the Ausable Bayfield Conservation Authority (Appendix 5).

- Promote and enhance existing stewardship and habitat improvement options.

  The framework for funding agricultural best management practices (BMPs) is currently operating through other non-species at risk initiatives (i.e., Healthy Futures for Ontario Agriculture). The Ausable Bayfield Conservation Authority should continue to administer information to landowners about the funding assistance for agricultural best management practices (BMPs) that benefit species at risk in the basin. Priority for projects should recognize the importance of sub-basins impacting the Conservation Priority Zone.

In addition to promoting and enhancing existing stewardship and habitat improvement options, the recovery team should:

- pursue additional funds for future projects
- pursue additional partnerships (e.g., farm organizations),
- evaluate potential projects for species habitat such as in-stream projects, wetland reconstructions, land securement, and habitat protection, and
- research urban stewardship initiatives.

5.3 Management

Coordinating actions among the various responsible management agencies within the basin will ensure a coordinated approach to species at risk. Where possible, the recovery team should encourage responsible management agencies to:

- Coordinate actions among the various responsible management agencies within the basin

  Drain maintenance activities may result in aquatic habitat alterations (i.e., changes to riparian vegetation, substrate composition and width: depth ratios). The municipal drain class authorization system was designed to minimize effects of drain maintenance on aquatic habitat. The continued success of the drain classification program will depend on ongoing dialogue and education regarding the application of the program and continued monitoring of the aquatic habitat.

- Work with the Ontario Ministry of Environment to encourage municipalities with wastewater treatment plants (WTPs) to continue to improve facilities.

  Point sources of pollution in the basin are contributing to the water quality problems that persist. Continued improvement of the WTP facilities will be a significant factor in improving the water quality of the entire basin.

- Evaluate large-scale drainage alterations for hydrological consequences to both downstream fish and species at risk.

  The Conservation Authority already has a role to play in the approval of drainage operations in the basin. The additional information regarding the sensitivities and location of species at risk should be integrated into the evaluation process that the Conservation Authority undertakes.

- Investigate different approaches to land securement for conservation of significant riparian zones or other natural areas.

- Coordinate with all partners to ensure that species at risk information is available for project review.

- Work to minimize gaps in knowledge by improving water management technologies.

5.4 Public Awareness

Many of the actions required to reduce the risk to many of the aquatic species at risk relate to improve overall public awareness about species at risk and recovery program initiatives in the basin. In order to enable a coordinated approach to this message, it is recommended that the recovery team:

- Post Conservation Areas and reservoir locations with bulletins about the risk of transporting exotic species by small boats and/or bait buckets.

  The OAC is a very important refuge for the pugnose shiner and lake chubsucker and reducing the risk from the introduction of baitfish and exotic species should be a priority action item.

- Develop a communications plan defining what would be achieved, information products, and educational opportunities.

- Promote stewardship activities and initiatives.

- Continue to develop public awareness tools such as workshops, a website, and promotional materials.

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7.0 Appendices

Appendix 1: Figures 1.1, 2.4, 2.5, 2.6, 2.7, 3.1, 4.1, 4.2A, and 4.2B.

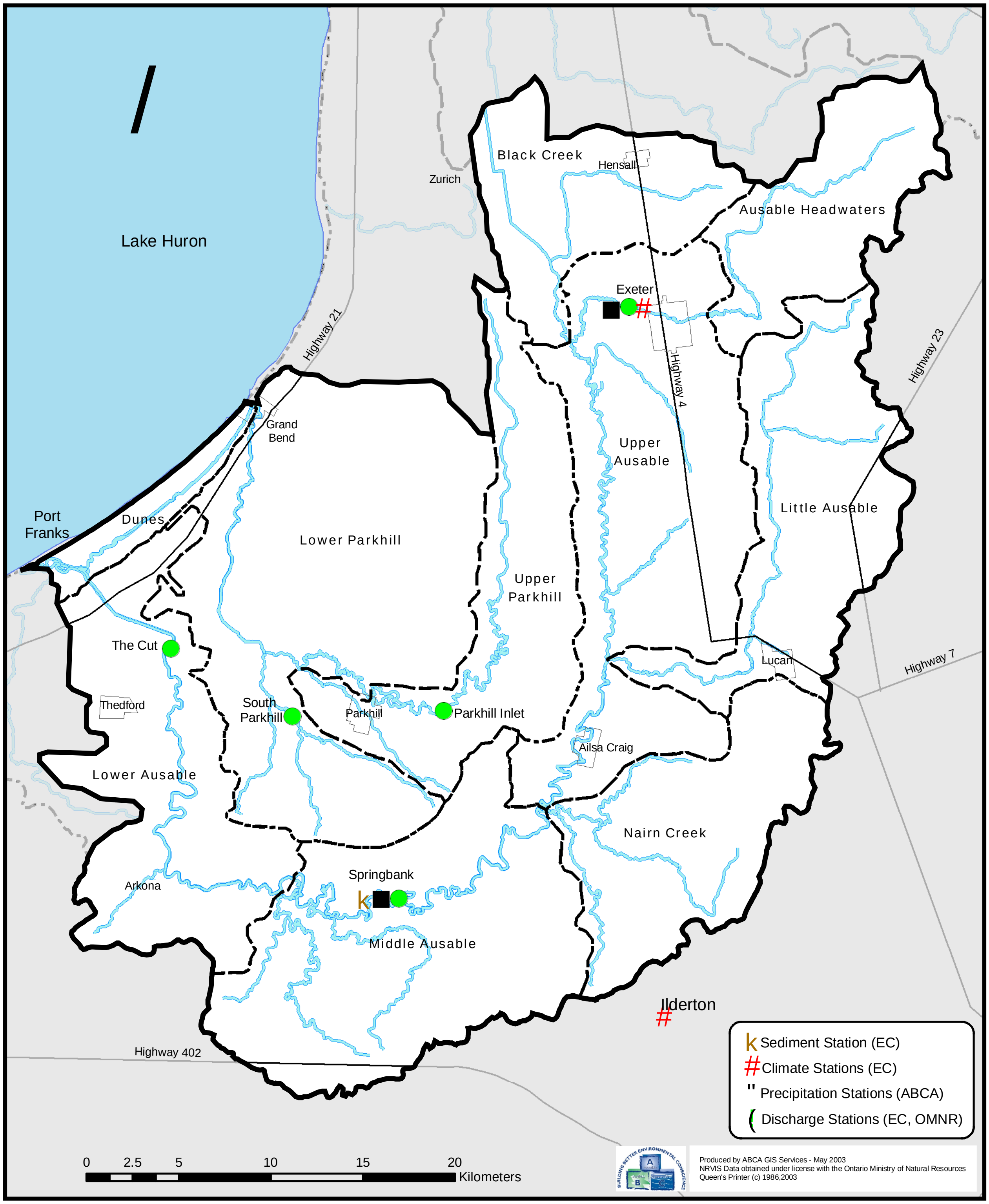

Figure 1.1: Location of climate (Environment Canada (EC)), precipitation (Ausable Bayfield Conservation Authority (ABCA)), discharge (EC and Ontario Ministry of Natural Resources (OMNR)), and sediment (EC) stations in the Ausable River and Parkhill Creek basin.

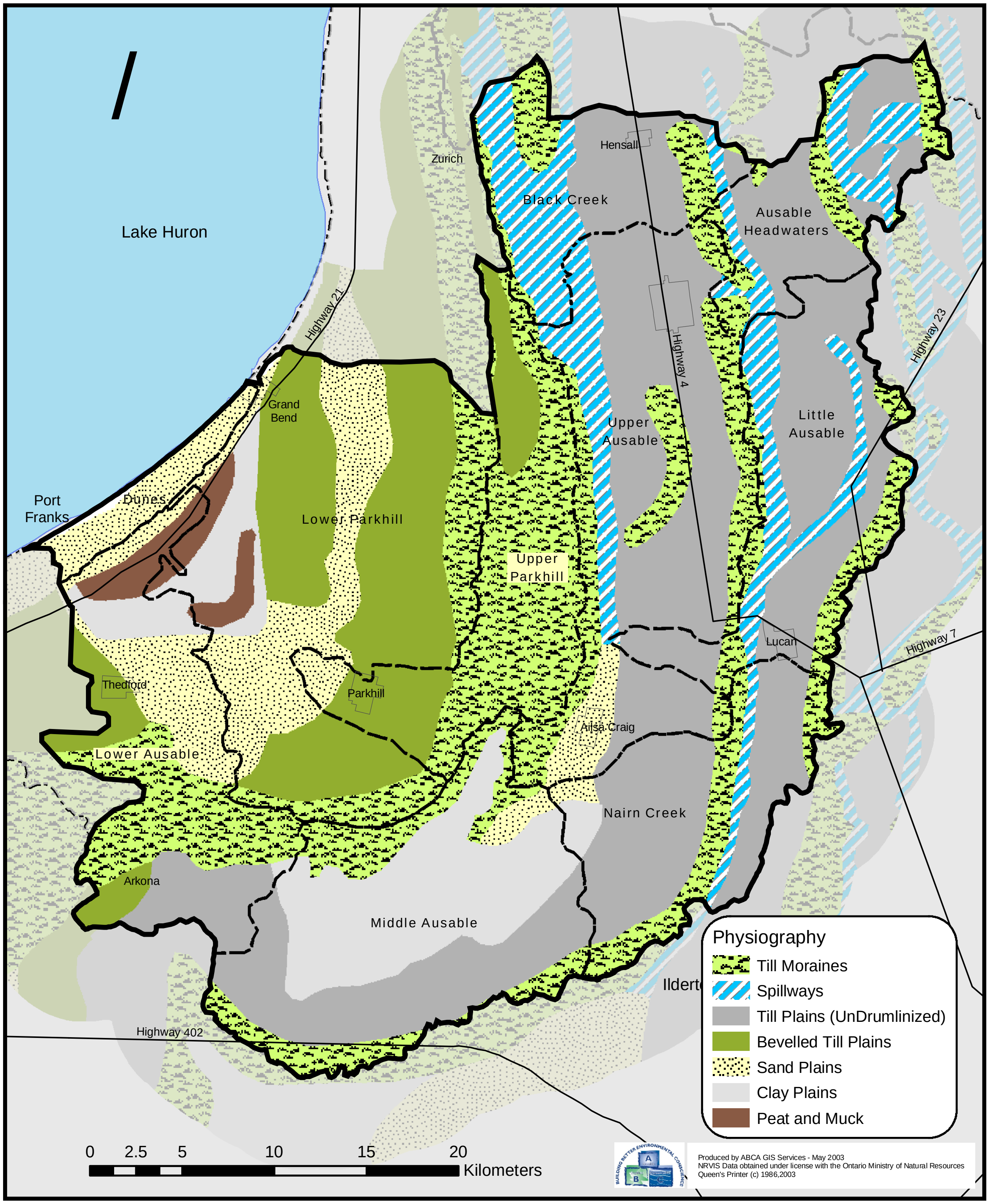

Figure 2.4: Physiography of the Ausable River and Parkhill Creek basin (Chapman and Putnam 1984).

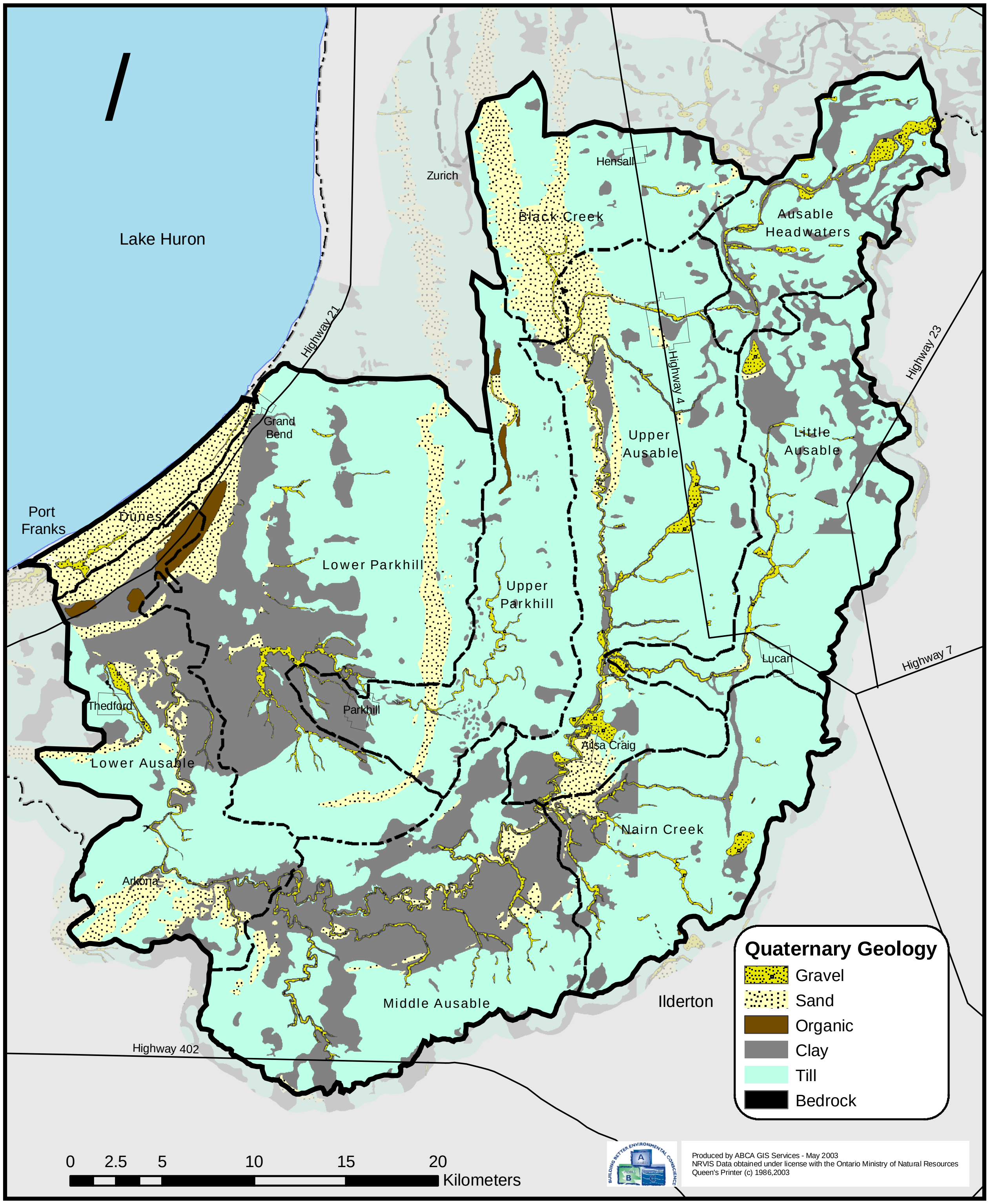

Figure 2.5: Quaternary geology of the Ausable River and Parkhill Creek basin (Cooper 1974).

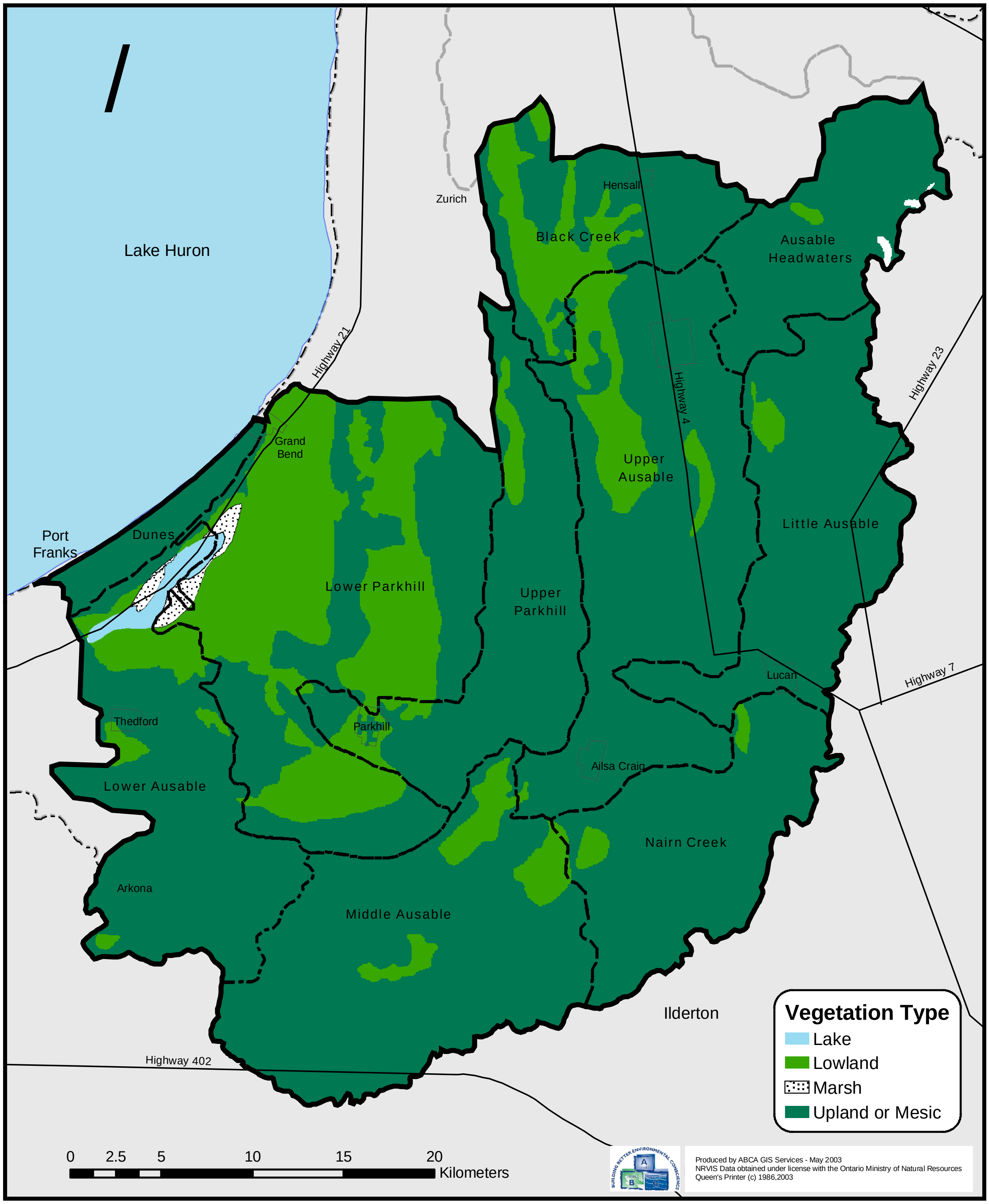

Figure 2.6: Pre-settlement vegetation in the Ausable River and Parkhill Creek basin (Ontario Ministry of Culture, Tourism and Recreation).

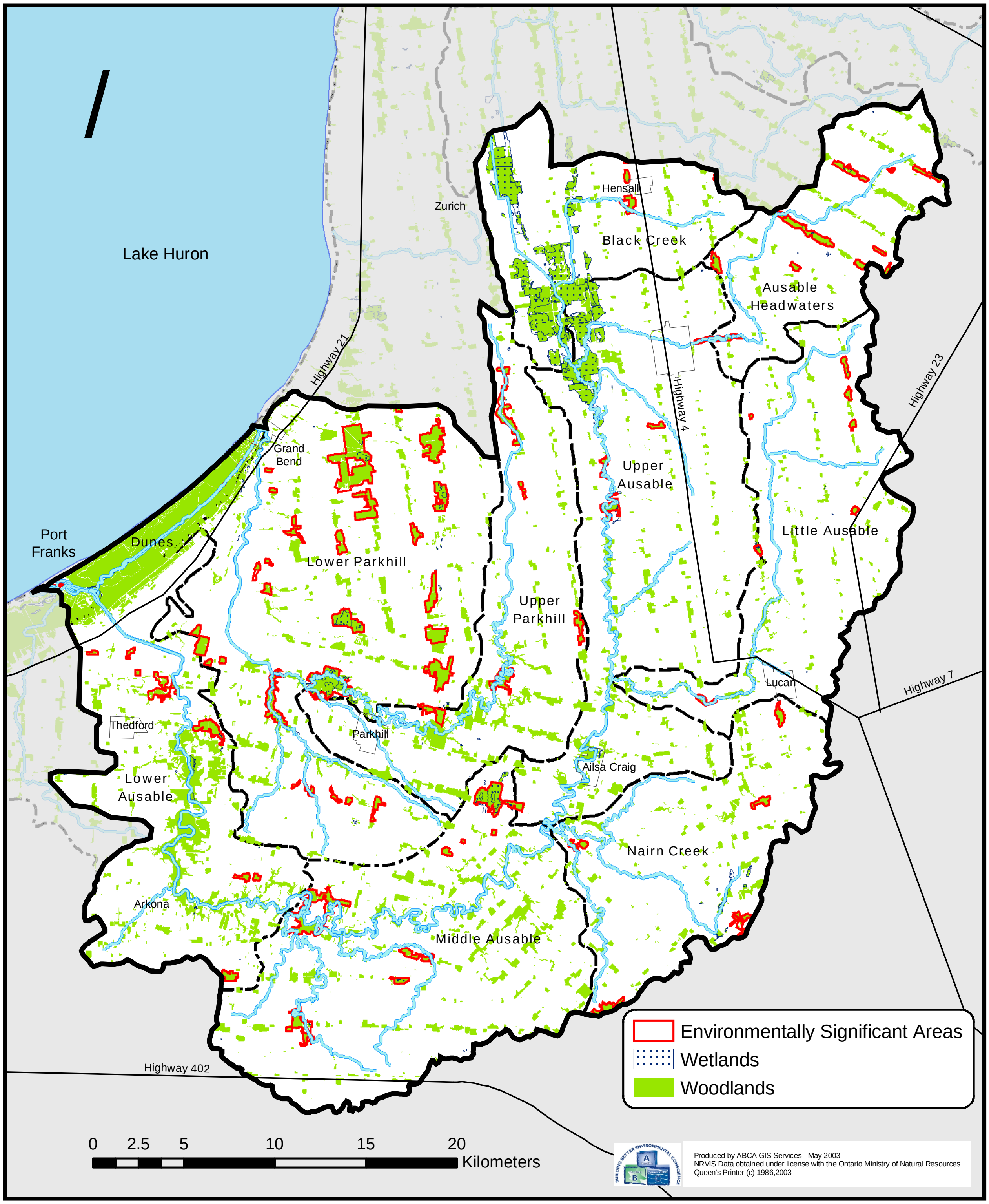

Figure 2.7: Forests, wetlands and Environmentally Significant Areas (ESAs) in the Ausable River and Parkhill Creek basin. Forests and wetlands are identified from (Ontario Ministry of Natural Resources 1986) and ESAs from (Ausable Bayfield Conservation Authority 1995).

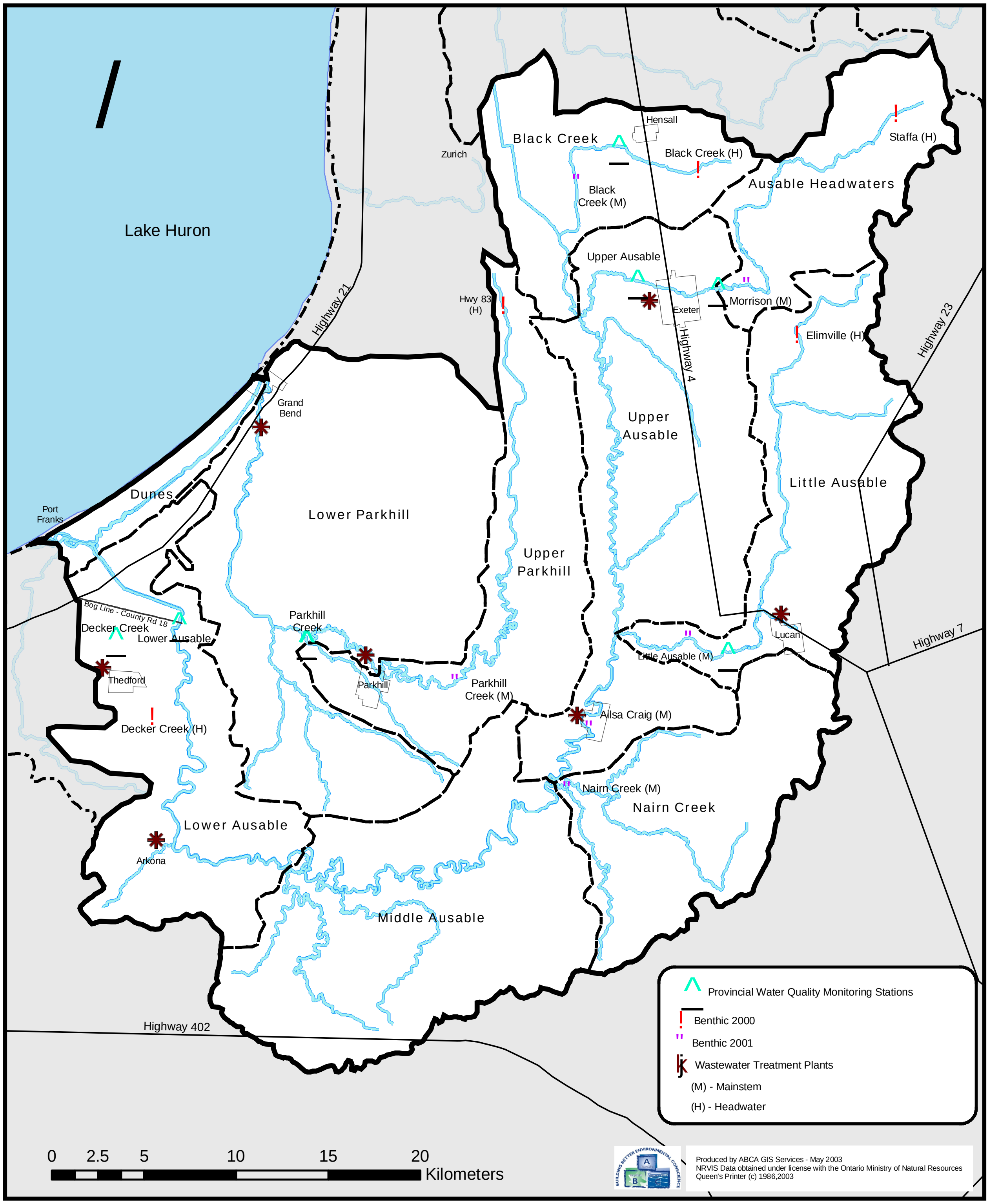

Figure 3.1: Provincial water quality monitoring network (PWQMN) stations, benthic invertebrate survey sites from 2000 and 2001 (Veliz 2003) and wastewater treatment plants in the Ausable River and Parkhill Creek basin.

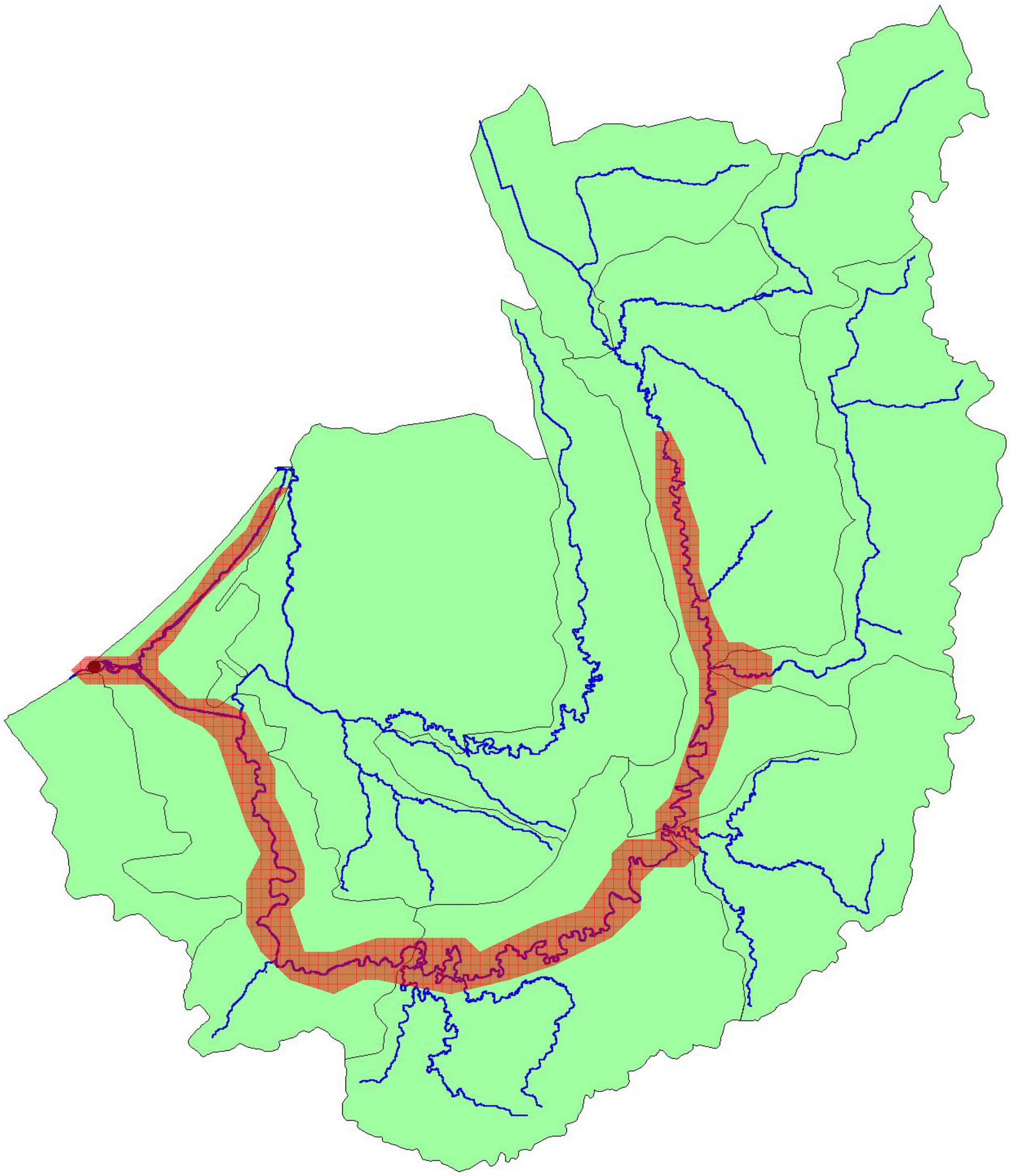

Figure 4.1: Conservation Priority Zone within the Ausable River and Parkhill Creek basins. All known records of species at risk of high and medium conservation priority are located within the zone of high conservation priority as indicated in red.

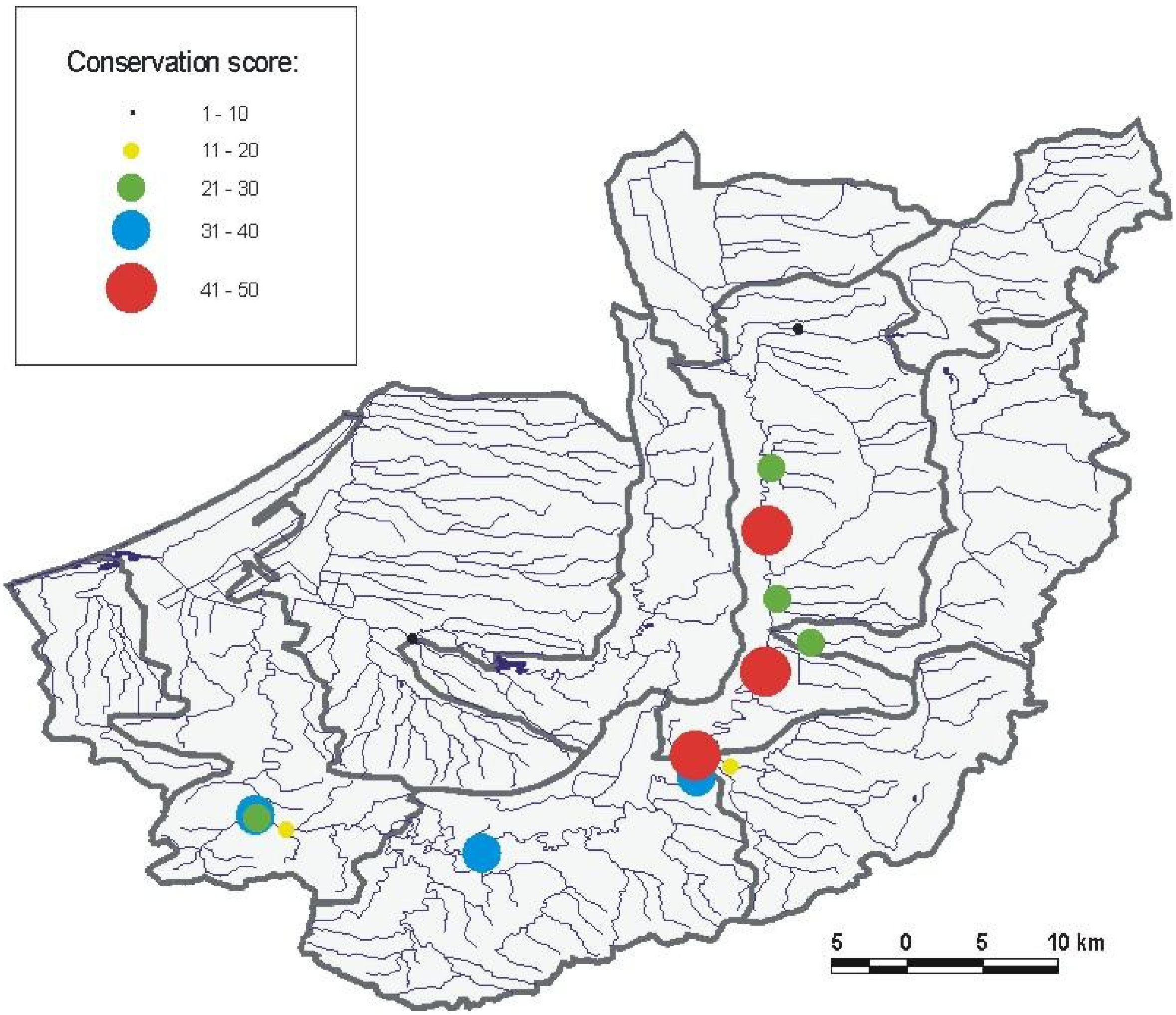

Figure 4.2 (A): Conservation scores for mussel survey sites sampled from 1998 to 2002 (National Water Research Institute).

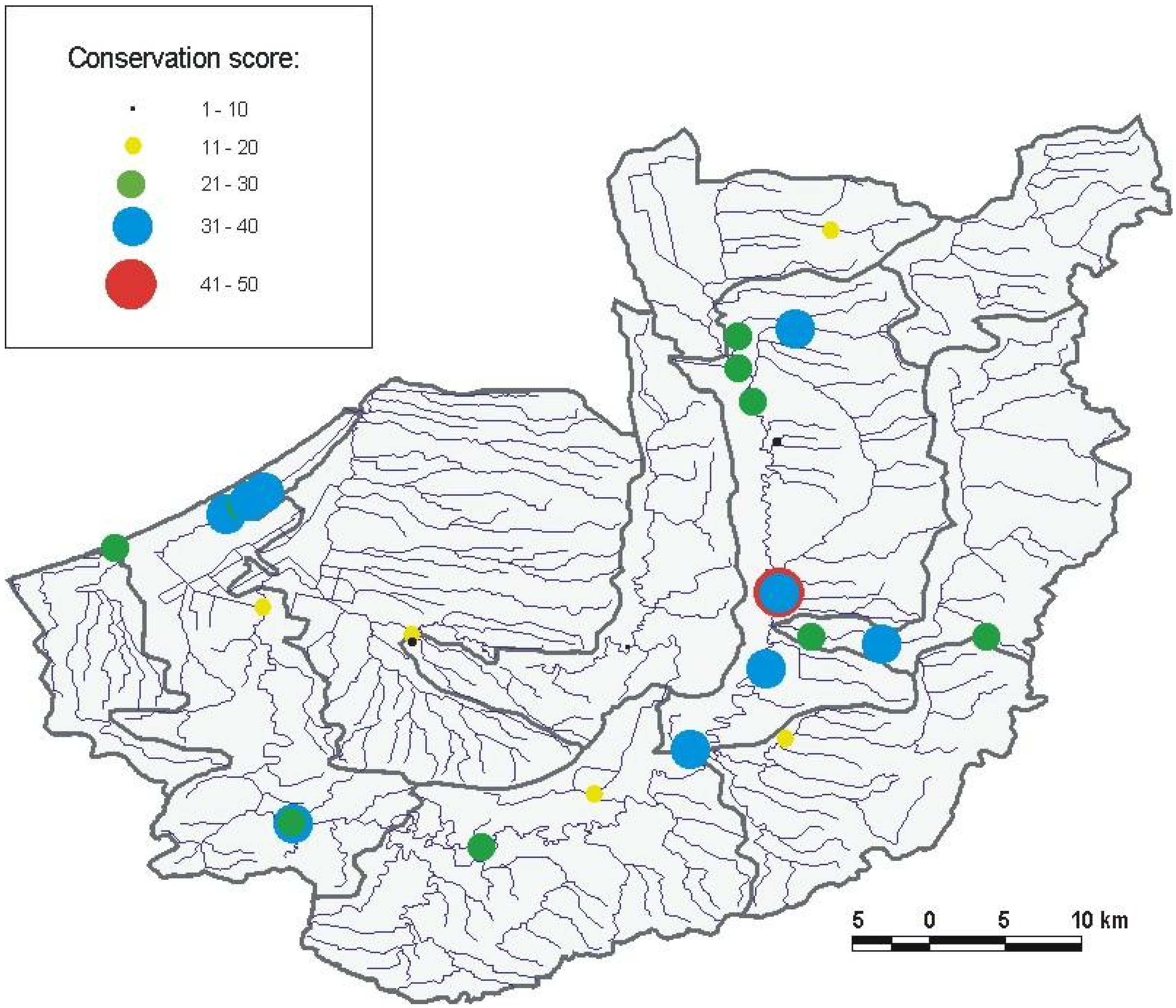

Figure 4.2(B): Conservation scores for fish survey sites sampled in 2002 (Department of Fisheries and Oceans 2002).

Appendix 2: Climate Data for Ilderton and Exeter from 1971 to 2000 (Environment Canada 2002).

	Ilderton				Exeter			
	Rainfall (mm)	Snowfall (cm)	Daily Mean (°C)	Days with thunders-torms	Rainfall (mm)	Snowfall (cm)	Daily Mean (°C)	Days with thunders-torms
January	28.2	50.6	-6.0	0.3	25.9	54.5	-6.0	0.1
February	27.1	34.4	-5.1	0.6	20.7	32.2	-5.7	0.1
March	51.5	23.4	0.2	0.9	43.4	22.5	-0.5	0.5
April	79.1	6.2	7.0	2.5	73.5	6.0	6.2	1.3
May	87.6	0	13.6	3.8	77.3	0.1	12.9	2.0
June	85.4	0	18.7	5.1	77.7	0	18.0	2.6
July	82.3	0	21.1	5.7	84.9	0	20.4	3.6
August	96.1	0	20.0	4.2	85.7	0	19.5	2.6
September	97.5	0	16.1	3.9	114.5	0	15.3	2.4
October	74.7	2.2	9.7	0.8	84.8	1.8	9.1	0.4
November	76.1	17.8	3.4	0.9	74.9	17.3	3.1	0.4
December	43.8	51.5	-2.8	0.4	42.8	48.2	-2.9	0.3
Annual Mean			8.0				7.5	
Annual Total	829.4	186.1		29.1	805.8	182.7		16.3
Total Precipitation	1015.5				988.5			

*Snowfall is the measured depth of newly fallen snow, measured using a snow ruler. Measurements are made at several points that appear representative of the immediate area, and then averaged. Total precipitation represents the water equivalent of all types of precipitation – rainfall and snowfall combined (Environment Canada 2002).

Appendix 3: List of fish, mussel, reptile, and amphibian species from the Ausable River and Parkhill Creek basins.

All COSEWIC and OMNR status, G-, and S-rank information for fish, reptile, and amphibian species at risk provided by Peter Sorrill (pers. comm., Ontario Ministry of Natural Resources, 2003). Information for mussels provided by McGoldrick and Metcalfe-Smith (2002).

Fishes

The source of individual records has been indicated beside each species - historical ROM surveys (1), Department of Planning and Development survey in 1947 (2), ABCA Drain Classification project in 1999/2000 (3), and Department of Fisheries and Oceans surveys in 2002 (4). For more information on these datasets, please refer to section 4.1.

SCIENTIFIC NAME	COMMON_NAME	COSEWIC Status	OMNR Status	G-Rank	S-Rank
Ambloplites rupestris	rock bass (2,3,4)			G5	S5
Ameiurus melas	black bullhead (3,4)			G5	S3
Ameiurus natalis	yellow bullhead (4)			G5	S4
Ameiurus nebulosus	brown bullhead (1,2,4)			G5	S5
Amia calva	bowfin (2)			G5	S4
Ammocrypta pellucida	eastern sand darter (1)	THR	THR	G3	S2
Campostoma anomalum	central stone roller (3,4)	NAR	NIAC	G5	S3
Carassius auratus	goldfish (4)			G5	SE
Carpiodes cyprinus	quillback (1,4)			G5	S4
Catostomus commersoni	white sucker (3,4)			G5	S5
Cottus bairdi	mottled sculpin (2,3,4)			G5	S5
Culaea inconstans	brook stickleback (2,3,4)			G5	S5
Cyprinella spiloptera	spotfin shiner (3,4)			G5	S4
Cyprinus carpio	common carp (3,4)			G5	SE
Dorosoma cepedianum	gizzard shad (3,4)			G5	S4
Erimyzon sucetta	lake chubsucker (1,4)	THR	THR	G5	S2
Esox americanus vermiculatum	grass pickerel (2,3)			G5	S3
Esox lucius	northern pike (2,3,4)			G5	S5
Esox masquinongy	muskellunge (2)			G5	S4
Etheostoma blennioides	greenside darter (1,3,4)	SC	NIAC	G5	S4
Etheostoma caeruleum	rainbow darter (1,2)			G5	S4
Etheostoma exile	Iowa darter (1)			G5	S5
Etheostoma flabellare	fantail darter (2,3,4)			G5	S4
Etheostoma microperca	least darter (2,3,4)	NAR	NIAC	G5	S4
Etheostoma nigrum	johnny darter (2,3,4)			G5	S5
Fundulus daphanus	banded killifish (1)	NAR	NIAC	G5	S5
Hybognathus hankinsoni	brassy minnow (2,3,4)			G5	S5
Hypentelium nigricans	northern hog sucker (2,3,4)			G5	S4
Ictalurus punctatus	channel catfish (2,4)			G5	S4
Ictiobus cyprinellus	bigmouth buffalo (1,4)	SC	NIAC	G4	S2
Ictiobus spp.	*suspected smallmouth buffalo (4)				
Labidesthes sicculus	brook silverside (4)	NAR	NIAC	G5	S4
Lepomis cyanellus	green sunfish (3,4)	NAR	NIAC	G5	S4
Lepomis gibbosus	pumpkinseed (2,3,4)			G5	S5
Lepomis macrochirus	bluegill (2,3,4)			G5	S5

SCIENTIFIC NAME	COMMON_NAME	COSEWIC Status	OMNR Status	G-Rank	S-Rank
Lepomis megalotis	longear sunfish (1,2,4)	NAR	NIAC	G5	S3
Luxilus chrysocephalus	striped shiner (3,4)	NAR	NIAC	G5	S3?
Luxilus cornutus	common shiner (2,3,4)			G5	S5
Lythrurus umbratilis	redfin shiner (1,4)	NAR	NIAC	G5	S4
Micopterus dolomieui	smallmouth bass (2,3,4)			G5	S5
Micropterus salmoides	largemouth bass (2,4)			G5	S5
Moxostoma anisurum	silver redhorse (4)			G5	S4
Moxostoma carinatum	river redhorse (1)	SC	VUL	G4	S2
Moxostoma duquesnei	black redhorse (4)	THR	THR	G5	S2
Moxostoma erythrurum	golden redhorse (1,2,4)	NAR	NIAC	G5	S3
Moxostoma macrolepidotum	shorthead redhorse (1,4)			G5	S5
Moxostoma valenciennesi	greater redhorse (1,4)			G4	S3
Neogobius melanostomas	round goby (4)			G?	SE
Nocomis biguttatus	hornyhead chub (3,4)	NAR	NIAC	G5	S4
Nocomis micropogon	river chub (1,2,4)	NAR	NIAC	G5	S4
Notemigonus crysoleucas	golden shiner (1)			G5	S5
Notropis anogenus	pugnose shiner (1,4)	END	THR	G3	S2
Notropis atherinoides	emerald shiner (4)			G5	S5
Notropis buchanani	ghost shiner (1,4)	NAR	NIAC	G5	S2
Notropis hererodon	blackchin shiner (1)	NAR	NIAC	G5	S4
Notropis heterolepis	blacknose shiner (1,2,4)			G4	S5
Notropis hudsonius	spottail shiner (1,2)			G5	S5
Notropis rubellus	rosyface shiner (2,3,4)	NAR	NIAC	G5	S4
Notropis stramineus	sand shiner (1,4)			G5	S4
Notropis volucellus	mimic shiner (1,4)			G5	S5
Noturus flavus	stonecat (3,4)			G5	S4
Noturus gyrinus	tadpole madtom (1)			G5	S4
Noturus miurus	brindled madtom (4)	NAR	NIAC	G5	S2
Oncorhynchus gorbuscha	pink salmon			G5	SE
Oncorhynchus kisutch	coho salmon			G4	SE
Oncorhynchus mykiss	rainbow trout (3,4)			G5	SE
Oncorhynchus tshawytscha	chinook salmon			G5	SE
Osmerus mordax	rainbow smelt (4)			G5	S5
Perca flavescens	yellow perch (2,4)			G5	S5
Percina caprodes	logperch (3,4)			G5	S5
Percina maculata	blackside darter (2,3,4)			G5	S4
Percopsis omiscomaycus	trout-perch (1,4)			G5	S5
Phoxinus eos	northern redbelly dace (2,3,4)			G5	S5
Pimephales notatus	bluntnose minnow (2,3,4)	NAR	NIAC	G5	S5
Pimephales promelas	fathead minnow (3,4)			G5	S5
Pomoxis annularis	white crappie (4)			G5	S3
Pomoxis nogromaculatus	black crappie (4)			G5	S4
Rhinichthys atratulus	blacknose dace (2,3,4)			G5	S5
Rhinichthys cataractae	longnose dace (2,4)			G5	S5
Salvelinus fontinalis	brook trout (3)			G5T5	S5
Semotilus atromaculatus	creek chub (2,3,4)			G5	S5

SCIENTIFIC NAME	COMMON_NAME	COSEWIC Status	OMNR Status	G-Rank	S-Rank
Stizostedion vitreum	walleye (2,4)			G5T5	SE
Umbra limi	central mudminnow (2,3,4)			G5	S5

Mussels

SCIENTIFIC NAME	COMMON NAME	COSEWIC Status	OMNR Status	G-Rank	S-Rank
Alasmidonta marginata	elktoe			G4	S3
Alasmidonta viridis	slippershell			G4G5	S3
Amblema plicata	threeridge			G5	S4
Cyclonaias tuberculata	purple wartyback			G5	S3
Elliptio dilatata	spike			G5	S5
Epioblasma torulosa rangiana	northern riffleshell	END		G2T2	S1
Epioblasma triquetra	snuffbox	END		G3	S1
Fusconaia flava	wabash pigtoe			G5	S2/S3
Lampsilis cardium	plain pocketbook			G5	S4
Lampsilis fasciola	wavy-rayed lampmussel	END		G4	S1
Lampsilis siliquoidea	fatmucket			G5	S5
Lasmigona complanata	white heelsplitter			G5	S5
Lasmigona compressa	creek heelsplitter			G5	S5
Lasmigona costata	fluted-shell			G5	S5
Leptodea fragilis	fragile papershell			G4	S4
Ligumia recta	black sandsheel			G5	S3
Potamilus alatus	pink heelsplitter			G5	S3
Ptchobranchus fasciolaris	kidneyshell	END		G4/G5	S1
Pyganodon grandis	giant floater			G5	S5
Quadrula quadrula	mapleleaf			G5	S5
Strophitus undulatus	creeper			G4G5	S2
Truncilla truncata	deertoe			G5	S2S3
Utterbackia imbecillis	paper pondsheel			G5	S2
Villosa iris	rainbow			G5	S2S3

Reptiles and Amphibians

SCIENTIFIC NAME	COMMON_NAME	COSEWIC Status	OMNR Status	G-Rank	S-Rank
Apalone spinifera spinifera	eastern spiny softshell turtle	THR	THR	G5T5	S3
Chelyydra serpentina	snapping turtle			G5	S5
Chrysemys picta bellii	painted turtle			G5T5	S5
Clemmys guttata	spotted turtle	SC	VUL	G5	S3
Clemmys insculpta	wood turtle	SC	VUL	G4	S2
Coluber constrictor foxii	blue racer	END	END	G5T5	S1
Diadophis punctatus	ring-necked snake			G5	S4
Eliaphe vulpine gloydi	eastern foxsnake	THR	THR	G5	S3
Emydoidea blandingii	blanding's turtle			G5	S3?
Eumeces fasciatus	common five-lined skink	SC	VUL	G5	S3
Graptemys geographica	northern map turtle	SC		G5	S3
Heterodon platirhinos	eastern hog-nosed snake	THR	VUL	G5	S3
Lampropeltis trangulum	milksnake	SC		G5	S3
Nerodia sipedon sipedon	northern water snake	NAR	NIAC	G5T5	S5
Opheodrys vernalis	smooth greensnake			G5	S4
Regina septemvittata	queen snake	THR	THR	G5	S2
Sternotherus odoratus	stinkpot turtle		THR	G5	S3
Storeria dekayi	Dekay's brownsnake	NAR	NIAC	G5	S5
Storeria occipitomaculata	red-bellied snake			G5	S5
Thamnophis butleri	Butler's gartersnake	THR	VUL	G4	S2
Thamnophis sirtalis sirtalis	eastern gartersnake			G5T?	S5

Appendix 4: List of bird, mammal, insect, and plant species tracked by NHIC from the Ausable River and Parkhill Creek basins (Peter Sorrill, pers. comm., Ontario Ministry of Natural Resources, 2003).

A tracked species indicates that the species is considered rare (S1 to S3) in Ontario and that the NHIC maintains occurrence data. Generally, tracked species have fewer than 100 recent occurrences in Ontario, or are ranked high (G1 to G3) globally.

Birds and Mammals

SCIENTIFIC NAME	COMMON_NAME	COSEWIC Status	OMNR Status	G-Rank	S-Rank
Colinus virginianus	northern bobwhite	END		G5	S1S2
Dendroica cerulea	cerulean warbler	SC	VUL	G4	S3B,SZN
Dendroica discolor	prairie warbler	NAR	NIAC	G5	S3S4B,SZN
Empidonax virescens	acadian flycatcher	END		G5	S2B,SZN
Ixobrychus exilis	least bittern	THR	VUL	G5	S3B,SZN
Microtus pinetorum	woodland vole	SC	NIAC	G5	S3?
Myotis septentrionalis	northern long-eared bat			G4	S3?
Protonotaria citrea	prothonotary warbler	END	END	G5	S1S2B,SZN
Seiurus motacilla	louisiana waterthrush	SC	VUL	G5	S3B,SZN
Sterna forsteri	forster's tern	DD	IND	G5	S2S3B,SZN
Taxidea taxus	american badger	END		G5	S2
Wilsonia citrina	hooded warbler	THR		G5	S3B,SZN

Insects

SCIENTIFIC NAME	COMMON_NAME	COSEWIC Status	OMNR Status	G-Rank	S-Rank
Amphiagrion saucium	eastern red damsel			G5	S3
Argia apicalis	blue-fronted dancer			G5	S4
Argia sedula	blue-ringed dancer			G5	S1
Argia translata	dusky dancer			G5	S1
Arisaema dracontium	green dragon	SC		G5	S3
Asterocampa clyton	tawny emperor			G5	S2S3
Atrytonopsis hianna	dusted skipper			G4G5	S1
Cicindela hirticollis	beach-dune tiger beetle			G5	S2?
Cicindela patruela	a tiger beetle			G3	S1
Clastoptera hyperici	a spittlebug			G?	S1
Enallagma basidens	double-striped bluet			G5	S3
Enallagma traviatum	slender bluet			G5	S1
Erynnis brizo	sleepy duskywing			G5	S1
Erynnis martialis	mottled duskywing			G3G4	S2
Gomphus fraternus	midland clubtail			G5	S3
Gomphus graslinellus	pronghorn clubtail			G5	S2
Libellula semifasciata	painted skimmer			G5	S2
Perithemis tenera	eastern amberwing			G5	S3
Prosapia ignipectus	red-legged spittlebug			G4	S1?

Plants

SCIENTIFIC NAME	COMMON_NAME	COSEWIC Status	OMNR Status	G-Rank	S-Rank
Acronicta albarufa	barrens daggermoth			G3G4	S1
Agrimonia parviflora	small-flower groovebur			G5	S3S4
Allium burdickii	narrow-leaved wild leek			G4G5	S1?
Ammophila breviligulata	american beachgrass			G5	S3
Aristida longespica var. longespica	three-awn			G5T5?	S2
Arnoglossum plantagineum	tuberous indian-plantain	SC		G4G5	S3
Asclepias verticillata	whorled milkweed			G5	S2
Asclepias viridiflora	green milkweed			G5	S2
Asimina triloba	pawpaw			G5	S3
Astomum muehlenbergianum	a moss			G5	S2
Astragalus neglectus	Cooper's milkvetch			G4	S3
Aureolaria pedicularia	fernleaf yellow false-foxglove			G5	S3
Bidens coronata	southern tickseed			G5	S2
Bidens discoidea	swamp beggar-ticks			G5	S4
Bryum gemmiparum	a moss			G3G5	S1
Buchnera americana	bluehearts	END		G5?	S1
Calamovilfa longifolia var. magna	sand reed grass			G5T3T5	S3
Carex careyana	Carey's sedge			G5	S2
Carex emoryi	Emory's sedge			G5	S3
Carex formosa	handsome sedge			G4	S3S4
Carex hirsutella	hirsute sedge			G5	S3
Carex meadii	Mead's sedge			G4G5	S2
Carex muskingumensis	muskingum sedge			G4	S2
Carex tetanica	rigid sedge			G4G5	S3
Celithemis eponina	halloween pennant			G5	S3
Celtis tenuifolia	dwarf hackberry	SC		G5	S2
Chenopodium foggii	Fogg's goosefoot			G3Q	S2
Cirsium pitcheri	pitcher's thistle	END		G3	S2
Conioselinum chinense	hemlock parsley			G5	S3
Corallorhiza odontorhiza	autumn coral-root			G5	S2
Coreopsis tripteris	tall coreopsis			G5	S2
Corispermum pallasii	bugseed			G4?	S1S3
Cornus florida	flowering dogwood			G5	S3?
Crataegus brainerdii	brainerd's hawthorn			G5	S2
Crataegus dodgei	Dodge's hawthorn			G4	S4
Crataegus dodgei var. dodgei	Dodge's hawthorn			G4T4	S4
Crataegus dodgei var. flavida	a hawthorn			G5T?	S4
Crataegus lumaria	a hawthorn			G3G4	S3S4
Crataegus perjucunda	middlesex frosted hawthorn			G1?Q	S1?
Crataegus suborbiculata	hawthorn			G3?	S1
Cuscuta coryli	hazel dodder			G5	S1
Cypripedium arietinum	ram's-head lady's-slipper			G3	S3
Desmodium rotundifolium	prostrate tick-trefoil			G5	S2
Diarrhena obovata	beak grass			G4G5	S1
Draba reptans	Carolina whitlow-grass			G5	S2

SCIENTIFIC NAME	COMMON_NAME	COSEWIC Status	OMNR Status	G-Rank	S-Rank
Eleocharis rostellata	beaked spike-rush			G5	S3
Elymus virginicus var. jenkinsii	wild-rye			G5T?	SH
Enemion biternatum	false rue-anemone	SC		G5	S2
Erigenia bulbosa	harbinger-of-spring			G5	S3
Euchloe olympia	olympia marble			G4G5	S4?
Euonymus atropurpurea	burning bush			G5	S3
Eupatorium purpureum	sweet joe-pye-weed			G5	S3
Euphorbia commutata	spurge			G5	S1
Fraxinus profunda	pumpkin ash			G4	S2
Galium pilosum	hairy bedstraw			G5	S3
Gentianella quinquefolia	stiff gentian			G5	S2
Geum vernum	spring avens			G5	S3
Hieracium venosum	rattlesnake hawkweed			G5	S2
Hybanthus concolor	green violet			G5	S2
Hydrastis canadensis	golden seal	THR	THR	G4	S2
Hypoxis hirsuta	eastern yellow star-grass			G5	S3
Koeleria macrantha	prairie june grass			G5	S2
Krigia virginica	dwarf dandelion			G5	S1
Lechea villosa	hairy pinweed			G5	S3
Liatris aspera	tall gay-feather			G4G5	S2
Liatris cylindracea	slender blazing-star			G5	S3
Liatris spicata	dense blazing star	THR		G5	S2
Linum medium var. texanum	wild flax			G5T5	S1
Lithospermum canescens	hoary puccoon			G5	S3
Lithospermum caroliniense	plains puccoon			G4G5	S3
Lithospermum incisum	fringed puccoon			G5	S1
Lithospermum latifolium	broad-leaved puccoon			G4	S3
Lupinus perennis	wild lupine			G5	S3
Lycopus virginicus	Virginia bugleweed			G5	S2
Lythrum alatum	winged loosestrife			G5	S3
Magnolia acuminata	cucumber tree	END	END	G5	S2
Muhlenbergia tenuiflora	slender muhly			G5	S2
Oenothera pilosella	evening primrose			G5	S2
Packera obovata	roundleaf ragwort			G5	S3
Packera plattensis	prairie ragwort			G5	S2S3
Panax quinquefolius	american ginseng	END		G3G4	S2
Panicum gattingeri	witch grass			G4	S3
Panicum rigidulum	redtop panic grass			G5	S2S3
Phegopteris hexagonoptera	broad beech fern	SC		G5	S3
Phlox subulata	moss phlox			G5	S1?
Piptochaetium avenaceum	black oat-grass			G5	SH
Plantago cordata	heart-leaved plantain	END	END	G4	S1
Polygonum tenue	slender knotweed			G5	S2
Prosartes lanuginosa	yellow mandarin			G5	S4
Pterospora andromedea	giant pinedrops			G5	S2
Pycnanthemum tenuifolium	slender mountain-mint			G5	S3

SCIENTIFIC NAME	COMMON_NAME	COSEWIC Status	OMNR Status	G-Rank	S-Rank
Quercus prinoides	dwarf chinquapin oak			G5	S2
Ranunculus rhomboideus	prairie buttercup			G4	S3
Ratibida pinnata	gray-headed coneflower			G5	S2S3
Salix myricoides var. myricoides	blue-leaf willow			G4T4	S2S3
Saururus cernuus	lizard's tail			G5	S3
Schizachyrium scoparium spp. littorale	dune little bluestem			G5T?	S2?
Scirpus expansus	woodland bulrush			G4	S1
Scleria verticillata	low nutrush			G5	S3
Scutellaria parvula var. leonardii	shale-barren skullcap			G4T4	S2
Solidago hispida var. huronensis	Lake Huron hairy goldenrod				S3?
Solidago riddellii	Riddell's goldenrod	SC	VUL	G5	S3
Solidago rigida ssp. rigida	stiff goldenrod			G5T5	S3
Solidago speciosa var. rigidiuscula	showy goldenrod	END		G5T4	S1
Spiranthes magnicamporum	Great Plains ladies'-tresses			G4	S3
Spiranthes ochroleuca	yellow ladies'-tresses			G4	S2
Sporobolus asper	longleaf dropseed			G5	S1S2
Stipa spartea	porcupine grass			G5	S3
Stylophorum diphyllum	wood-poppy	END	END	G5	S1
Symphyotrichum dumosum	bushy aster			G5	S2
Trillium flexipes	drooping trillium	END	END	G5	S1
Triosteum perfoliatum	perfoliate tinker's-weed			G5	S1
Vernonia gigantea	giant ironweed			G5	S1?
Viola striata	cream violet			G5	S3
Vulpia octoflora	slender eight-flowered fescue			G5	S2

Appendix 5: Best management practices and incentive grants for agriculture.

Situation	Solutions	Benefits and Grants
Farm Planning		
Unaware of environmental issues or solutions	Environmental Farm Plan	Identifies environmental issues and potential solutions, Helps farmers make positive environmental changes, $1,500 grant to do environmental project
Nutrient and Manure Management		
Manure application and use difficulties	Nutrient Management Plan	Protects soil and water from excessive nutrients Achieves optimal crop yields and produce quality, Manages input costs, 50 per cent grant; $1,000 maximum
Manure leaving farm through field tiles	Environmental protection valve	Prevents field tile contaminants from entering watercourse, Pumps contaminated liquid out of tile, Place to take samples to determine water quality, Visual assessment of water quality
Manure odours; runoff; uneven distribution	Manure injectors	Prevent loss of nutrients and pathogens to surface runoff, Nutrients placed near plants' root zone in a standing crop, Reduce pollution of waterways, Minimize odours
Unknown soil requirement needs	Soil testing	Helps identify appropriate rate of nutrient application, Increase yields while managing input costs, Protects the environment
Manure runoff; poor water quality; poor timing of spreading	Concrete manure storage	Contains runoff, Protects water quality, 50 per cent grant; $15,000 maximum
Milkhouse washwater not treated or recycled	Milkhouse washwater trench or recycling system	Contains and treats runoff, Frees up space in manure storage, Protects water quality, 50 per cent grant; $7,500 maximum
Family and Herd Health		
Chemical or fuel pollution of yard	Chemical and fuel storage and handling areas	Protect stream and well water quality, Personal and family safety, Financial savings from optimal use of crop and farm inputs
Poor well water or stream quality	Properly functioning Septic system	Protects family and herd, groundwater and surface water health
Unused well in field or farmstead	Well decommissioning	Eliminates link to groundwater from surface, Protects quality of nearby wells, 67 per cent grant; no maximum
Poor drinking water quality	Well casing upgrade	Protects family and herd health and groundwater 64 per cent grant; no maximum

Situation	Solutions	Benefits and Grants
Erosion Control		
Soil erosion; lack of organic matter; pests	Cover crops	Maintain soil structure and add organic matter to soil, Reduce soil erosion caused by wind, Tie up excess nutrients, Control pests
Soil erosion; decreased yields	Crop rotation	Covers soil longer to reduce wind erosion, Improves structure and adds organic matter, Increases yields 5-15 per cent, Releases nutrients and breaks pest cycles
Soil erosion; Excess nutrients	Green manure crops	Cover soil to reduce wind erosion, Add organic matter and take up excess nutrients
Soil erosion by wind or water; soil compaction	Reduced tillage systems	Reduce soil erosion from wind and water erosion, Reduce erosion from tillage and improve soil structure, Allow earthworm populations to increase
Soil compaction and crusting	Timely tillage	Reduces compaction and crusting, Reduces organic matter depletion
Cattle trampling stream banks; poor herd health or weight gain; lack of herd drinking water	Fence cattle out of stream; Alternate watering devices	Reduces compaction and erosion of banks, Protects water quality, Better drinking water for livestock and downstream users, 50 per cent grant; $10,000 maximum
Bank erosion; field runoff; poor water quality	Buffer strips	Filter run-off during rainfall, Shade cools water and improves fish habitat, Reduce soil erosion and protect water quality, Easy equipment access to field, Excellent site for valuable hardwood trees, 50 per cent grant; $15,000 maximum, Up to 70 cents per tree/shrub
Soil erosion; sediment loading	Grassed waterways, berms, drop inlets	Control surface water flow, Reduce soil erosion and protect water quality, 50 per cent grant; $15,000 maximum
Soil erosion; no protection for livestock; barren farmstead; poor return on crop inputs	Windbreaks and tree planting on erodible or flood-prone farm land	Reduce wind erosion and keep soil on fields, Increased crop productivity and better use of crop inputs, Reduce heating and cooling costs, shelter livestock, Enhance farmstead beauty and wildlife habitat, Reduce sediment load in drains; fewer drain clean-outs, Timber production, 50 per cent grant; $15,000 maximum, May also be eligible to receive up to 70 cents per tree/shrub

Appendix 6: Species at risk definitions.

This appendix provides the status, G Rank and S Rank definitions as assigned by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Ontario Ministry of Natural Resources (MNR), and other international organizations. COSEWIC was established in 1977 for the purpose of evaluating and assigning conservation status to species at risk. This committee is an apolitical committee that includes representatives of federal, provincial and territorial governments, as well as university and museum academics and independent biologists with expertise in relevant fields. Although COSEWIC currently has no legal mandate, it will officially be established as a government advisory body with the proclamation of the federal Species at Risk Act (*SARA*), which is expected of occur during the summer of 2003. COSEWIC lists each species following the completion and review of a species status report. Status reports contain information on the biology, range, abundance and possible threats to the species.

COSEWIC Status

Status assigned to species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (www.cosewic.ca).

EXT Extinct. A species that no longer exists.
EXP Extirpated. A species no longer existing in the wild in Canada, but occurring elsewhere in the wild.
END Endangered. A species facing imminent extirpation or extinction throughout its range.
THR Threatened. A species likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.
VUL or SC Vulnerable or Special Concern. A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events, but does not include an extirpated, endangered or threatened species.
IND Indeterminate. A species for which there is insufficient information to support a status designation.
NAR Not At Risk. A species that has been evaluated and found to be not at risk.

OMNR Status (OMNR)

In 1996, the provinces signed the *Accord for the Protection of Species at Risk in Canada*. As a result of this Accord, the government of Ontario was committed to assessing and reporting on the status of all native species to the province. In order to accomplish this, the province struck a committee entitled the Committee on the Status of Species at Risk in Ontario (COSSARO) to review status reports on species and determine their level of risk.

Status assigned to species by the Ontario Ministry of Natural Resources (www.omnr.gov.on.ca)

EXT Extinct. Any species formerly native to Ontario that no longer exists.
EXP Extirpated. Any native species no longer existing in the wild in Ontario, but existing elsewhere in the wild.
END Endangered. Any native species that, on the basis of the best available scientific evidence, is at risk of extinction or extirpation throughout all or a significant portion of its Ontario range if the limiting factors are not reversed.
Endangered species are protected under the province's Endangered Species Act.
THR Threatened. Any native species that, on the basis of the best available scientific evidence, is at risk of becoming endangered throughout all or a significant portion of its Ontario range if the limiting factors are not reversed.
VUL Vulnerable. Any native species that, on the basis of the best available scientific evidence, is a species of special concern in Ontario, but is not a threatened or endangered species.
IND Indeterminate. Any native species for which there is insufficient scientific information on which to base a status recommendation.
NIAC Not In Any COSSARO Category. Any native species evaluated by COSSARO which does not currently meet criteria for assignment to a provincial risk category.

Provincial Rank (SRANK)

Provincial (or Subnational) ranks are used by the Natural Heritage Information Centre (NHIC) to set protection priorities for rare species and natural communities. These ranks are not legal designations. Provincial ranks are assigned in a manner similar to that described for global ranks, but consider only those factors within the political boundaries of Ontario. By comparing the global and provincial ranks, the status, rarity, and the urgency of conservation, needs can be ascertained. The NHIC evaluates provincial ranks on a continual basis and produces updated lists at least annually. The NHIC welcomes information which will assist in assigning accurate provincial ranks. (www.mnr.gov.on.ca/MNR/nhic/)

S1 Extremely rare in Ontario; usually 5 or fewer occurrences in the province or very few remaining individuals; often especially vulnerable to extirpation.
S2 Very rare in Ontario; usually between 5 and 20 occurrences in the province or with many individuals in fewer occurrences; often susceptible to extirpation.
S3 Rare to uncommon in Ontario; usually between 20 and 100 occurrences in the province; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances. Most species with an S3 rank are assigned to the watch list, unless they have a relatively high global rank.
S4 Common and apparently secure in Ontario; usually with more than 100 occurrences in the province.
S5 Very common and demonstrably secure in Ontario.
SH Historically known from Ontario, but not verified recently (typically not recorded in the province in the last 20 years); however suitable habitat is thought to be still present in the province and there is reasonable expectation that the species may be rediscovered.
SR Reported for Ontario, but without persuasive documentation which would provide a basis for either accepting or rejecting the report.
SU Unrankable, often because of low search effort or cryptic nature of the species, there is insufficient information available to assign a more accurate rank; more data is needed.

Global Rank (GRANK)

Global ranks are assigned by a consensus of the network of natural heritage programs (conservation data centres), scientific experts, and The Nature Conservancy (www.tnc.org) to designate a rarity rank based on the range-wide status of a species, subspecies or variety. The most important factors considered in assigning global (and provincial) ranks are the total number of known, extant sites world-wide, and the degree to which they are potentially or actively threatened with destruction. Other criteria include the number of known populations considered to be securely protected, the size of the various populations, and the ability of the taxon to persist at its known sites. The taxonomic distinctness of each taxon has also been considered. Hybrids, introduced species, and taxonomically dubious species, subspecies and varieties have not been included.

G1 Extremely rare; usually 5 or fewer occurrences in the overall range or very few remaining individuals; or because of some factor(s) making it especially vulnerable to extinction.
G2 Very rare; usually between 5 and 20 occurrences in the overall range or with many individuals in fewer occurrences; or because of some factor(s) making it vulnerable to extinction.
G3 Rare to uncommon; usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances.
G4 Common; usually more than 100 occurrences; usually not susceptible to immediate threats.
G5 Very common; demonstrably secure under present conditions.
GU Status uncertain, often because of low search effort or cryptic nature of the species; more data needed.
G? Unranked, or, if following a ranking, rank tentatively assigned (e.g., G3?).
G A "G" (or "T") followed by a blank space means that the NHIC has not yet obtained the Global Rank from The Nature Conservancy.
Q Denotes that the taxonomic status of the species, subspecies, or variety is questionable.
T Denotes that the rank applies to a subspecies or variety.