State of the Environment Report for the Miramichi Watershed - 2007

Prepared By:

Miramichi River Environmental Assessment Committee
P.O. Box 85, 21 Cove Road
Miramichi, NB
E1V 3M2

and the

Atlantic Coastal Action Program (ACAP)
45 Alderney Drive
Dartmouth, Nova Scotia
B2Y 2N6

April 2007

ACAP is supported by:

Environment Canada **Environnement Canada**

ACKNOWLEDGEMENTS

The report is made possible through funding support from the Science Linkage program through Environment Canada. The Miramichi River Environmental Assessment Committee (MREAC) recognizes the unfailing support and guidance of Mr. George Lindsay, Environment Canada's "window" into Federal Agencies. George's eighteen years of regular and after-hours support to MREAC has been essential to allow our community-based initiatives in Miramichi science to advance. The scientists who have contributed to this report from government and academia are many as will be noted by the reader throughout in the constant mention of there personal contributions. Thanks to all! MREAC members, several who have been volunteering since 1989, have offered constant guidance as staff and consultants have ushered this report through the inevitable hurdles. Shortcomings of this report are assumed by the authors and we invite whatever critique arises to assist in a future revision a decade or so hence.

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EXECUTIVE SUMMARY

The successful spawning of Atlantic salmon can be taken as an indicator that the state of the Miramichi River is generally good. Despite this, there are stresses on the Miramichi watershed that should be examined when considering its long-term well-being or sustainability. This report examines the state of the environment of the Miramichi River watershed and specifically how it has changed over the past decade or so and how it may be changing in the near future. It draws upon existing studies and reports as well as discussions with individuals and scientists who have special interest and knowledge of the watershed. It is part of the ongoing mission of the Miramichi River Environmental Assessment Committee (MREAC) operative on the Miramichi since 1989.

The Miramichi River evokes images of fly fishing and pristine settings along one of the many major tributaries. A robust recreational fishery for Atlantic salmon still exists on the Miramichi River as has been the case for over two centuries. In the late 1800's, the Miramichi became one of the most highly prized destinations for Atlantic salmon angling among Europeans and Americans. Many people in riverside communities have an intense interest and passion for this sport. As well, many outsiders come to participate in fishing the legendary Miramichi, bringing a sustainable sport fishing economy to the region. It is true that salmon is one of the more sensitive fish species and it has rigorous habitat requirements and depends on a relatively undisturbed environment for successful breeding and survival. Hence, its presence is a "good news" indicator for the river system and the environmental quality of the watershed.

The Miramichi watershed, the second largest in the Maritimes, covers a large expanse of north-eastern New Brunswick and is home to some 55,000 people, most of whom are concentrated in the communities which make up the amalgamated area of the City of Miramichi on the upper estuary of the Miramichi River. The remainder of the nearly 14,000 km^2 watershed is sparsely populated and about 90 percent forested and, for this reason in part, river water in the majority of the watershed is of a high quality. Forestry is the major industry throughout most of the area and forestry-related industries (pulp and paper, wood treatment and manufacturing) have had a significant impact on the environment, particularly in the lower reaches of the river system. Forestry activities have also had an impact on fish habitat throughout the system by increasing siltation,

water temperature, runoff, human access and, in past years, contamination from pesticide use.

One major exception to the good quality of river water occurred over a 40-year period between 1960 and 2000 and involved the Heath Steele base-metal mining activity in the Tomogonops River watershed, a tributary of the Northwest Miramichi. This river became seriously contaminated with heavy metals, combined with depressed pH levels, which basically eliminated native fish populations from the river. The mine was decommissioned in 2000 and an ongoing remediation plan is in place with action to protect the river from further environmental insults. A legacy of this activity, and the associated storage and shipping of metal ore concentrate at wharves at the river mouth, can be found in sediments which still show heavy metal contamination in the estuary. There they are among the environmental stress which affects the survival of aquatic species. With mine process improvements and its closure, improvements in stream habitat and reductions in sediment contamination have already been noted and are expected to continue.

Dramatic changes have taken place in the watershed over the past two decades. These are highlighted throughout the report. Many are positive environmental changes leading toward a more sustainable environment. The closure of the kraft pulp mill has removed a major source of organic pollution to the estuary and has improved air quality in the Miramichi area. The two new sewage treatment plants serving the city of Miramichi are located on the south and north sides of the river and have resulted in substantial reductions to bacterial contamination. This, along with a multi-year program of upgrading private septic systems has resulted in the opening of an additional area of 10 km^2 for shellfish harvesting at the head of the bay. Closure of the Chatham air base has removed a source of pollution for the Napan River. There remains a legacy of elevated levels of PCB and other organic contaminants in fish and sediments. The earlier closure of the Domtar wood treatment plant near Newcastle eliminated one of the most serious polluters in the estuary. High levels of PAH are still found in local sediments and the plant was also likely the source of PAH in sediments further out in the estuary and inner bay. Sediment sampling, however, indicates that the high levels of these contaminants that were present when the plant was operating, diminished quickly after its closure in the early 1990's.

Most forestry activity in the watershed takes place on Crown Reserves and is carried out by a few major companies or licensees under the management of the New Brunswick Department of Natural Resources and the 1982 Crown Lands and Forest Act of New Brunswick. Operations on private land are governed by the New Brunswick Clean Water Act. Management requirements are rigorous, and in recent years, both the increased efforts of the government and better cooperation and effort on the part of the forestry companies have resulted in considerable improvements in forestry practices. While research into the impact of forestry activities on salmon habitat has certainly found evidence of stress to the ecosystem, the impacts from road construction, stream crossings and vegetative stream cover removal have been reduced in recent years.

One of the more serious impacts of clear-cutting, reforestation and herbicide use, which are standard practices in New Brunswick, is the loss of old forest habitat and an increase in softwood monoculture. This places a stress on wildlife species dependent on old forest or a diverse mixed forest environment. Recent changes in the government and industry "vision" of New Brunswick forests has resulted in particular efforts to provide diverse habitat for wildlife, protect old forest habitat and ensure a variety of forest types for New Brunswickers to enjoy. This, along with pressures for companies to meet "green" requirements in international markets has had a positive effect on all aspects of the industry from an environmental perspective. Another stress on fish and wildlife, as a result of a growing network of logging roads into previously inaccessible areas, is the ability of recreational fishers and hunters to penetrate into wilderness refuge areas where wildlife and fish may now be harvested.

Climate change is identified as possibly the most serious form of stress that the environment of the watershed might face in the long-term. The implications of a changing climate are far-reaching, from sea-level rise to changes in fish and wildlife habitat, to alterations in forest structure and the prevalence of disease and invasive species. Over the next 100 years, mean temperature increases for New Brunswick have been predicted, anywhere from +2 to +6 ° C, by the year 2100. Some of the other physiographic changes that will likely occur are: changes in ice cover and ice break-up in rivers, changes in precipitation (increases in the case of Miramichi area), changes in river discharges (maxima & minima), more extreme weather events, a rise in sea level and an

increase in storm surges. It is probable that some of these changes will occur too quickly for certain species to adapt. It could ultimately change the way in which environmental resources are utilized and alter the way of life for watershed residents. As with elsewhere on the planet, immediate attention would be prudent to adapt to the projected changes climate change will bring.

Chemical contamination of river and marine sediments creates stress on aquatic species and increases the risk of the dispersion of contaminants if the sediments are disturbed. Two studies, one in 1993 and one in 2002, looked at various contaminants such as organic carbon, PAH, PCB, heavy metals such as cadmium, lead, copper, zinc and mercury, chlorophenols and organic halides in estuary sediments. These contaminants arose mainly from base metal mining, pulp and paper production, wood preservation and the discharge of domestic sewage. Comparisons over the nine year period show that most of the contaminants remain basically unchanged and seem to have reached a stable state except for heavy metals which appear to have diminished slightly. Sediments from locations where fine silt or clay has accumulated are still found to be toxic with implications for the diversity of benthic animals living in those areas.

Overall, the state of the Miramichi watershed is good and improving, but there is no room for complacency in striving for long term sustainability. Environmental stresses should continue to be addressed and diminished. The potential impacts of Climate Change are hard to overstate. Some natural resources are being used more quickly than they can recover. These issues should be addressed immediately. In the battle ahead for a sustainable future the authors of this report assert that the Miramichi is capable of supporting activities essential to a thriving society with such as traditional economic drivers in the fisheries, forestry, and diverse recreational activities presently enjoyed. In its relatively healthy position it is suggested that the eco-economy potential of the watershed should be considered as having significant potential to provide future livelihoods and increased health and well being of a changing environment.

1. INTRODUCTION

State of the environment reporting is one way of reading the pulse of our surrounding environment, of evaluating its health and well-being, and accounting for changes which might be for the better or worse. While the quality of the environment might be a personal judgement, the state of its health can be measured in such things as the diversity of animals, disease, the level of toxic chemicals in water, air and sediments, the breeding success or survival of sensitive or "indicator" species and the quantity and condition of wildlife habitat. It also provides an opportunity for the broader community of scientists, environmental managers, industry and the general public to consider the health of their surrounding environment and its sustainability. Human health and well being, as intricately tied to the state of the natural environment, is the underlying motivation in undertaking this report.

This State of the Environment Report for the Miramichi River watershed provides a review of changes, events and activities in the Miramichi watershed since 1992. It addresses environmental issues with regard to watershed resources, air quality, water quality, aquatic, terrestrial and marine ecosystems, and the sources of environmental stress as well as the nature of improvements. The report builds on the unpublished "Summary: Final Report Miramichi River Environmental Assessment Committee 1989-1992 (MREAC 1992) by Dr. M. Burt. This report includes a wider range of issues including climate change and changes to terrestrial ecosystems that were previously not considered. The report incorporates recent findings described in the "State of the Environment Review: Miramichi Science Workshop" which was held in March, 2006, in Miramichi City and draws upon other studies and reports made available over the last decade.

In 1988, completion of an expansion of Miramichi Pulp and Paper Inc.'s mill aroused considerable local concern about potential impact on the river water quality and the health of the river in general. In January 1989, the Miramichi River Environmental Assessment Committee (MREAC), representing stakeholders from many sectors of industry, government and community, was formed and accepted the task of assessing the health of the river. A $100,000 grant from the industry enabled them to carry out a

two year study and, in 1992, they issued their MREAC Final Report (1992) which provides the baseline against which progress, or change, can now be measured. MREAC continues to provide environmental services and leadership to the communities in the Miramichi watershed. Since its inception MREAC has held several workshops and initiated and encouraged many of the research projects or investigations undertaken in the Miramichi watershed which enabled the preparation of this report.

1.1 Background on the State of Environment Reporting

State of the Environment (SOE) reports attempt to answer five key questions:

- **What is happening in the environment (i.e., how are environmental conditions and trends changing)?**
- **Why are these changes happening (i.e. how are human activities and other stresses linked to the issue in question)?**
- **Why is it significant (i.e. what are its ecological and socio-economic effects)?**
- **What is being done about the changes (i.e. how is society responding to the issues through government and industry action as well as voluntary initiatives)?**
- **Is the development sustainable (i.e. are human actions depleting environmental capital and causing deterioration of ecosystem health)?**

Developed in the early 1980's to provide a mechanism for consolidating a mass of complex scientific data and information on environmental status and trends, SOE reporting has become a major tool for educating the public and others on environmental sustainability issues and concerns. Two of the main purposes of SOE reports are to foster the use of science in policy and decision making and to report to Canadians on the condition of their environment. SOE reports provide an easily understood overview of important environmental issue for the non scientist, examine the key trends of those issues, discuss links with other issues, and describe the efforts of government, industry, and others to address problems and to make progress toward environmental sustainability. The above summary was adapted from Environment Canada, 2006.

1.2 Summary of 1992 Findings

The MREAC Report, issued in 1992, provided a baseline against which changes could be measured. That report addressed basic questions that were almost exclusively about aquatic concerns within the watershed. In the summary, it offered the following three conclusions:

(a) After routine treatment in most areas, the water is safe to drink and waters are safe for swimming at many but not all locations;

(b) In most, though not all, parts of the River System, the water is suitable as a habitat for fish and shellfish;

(c) In general, most contaminants are not present at high enough concentrations to make commercial species of fish unsuitable for consumption by children and pregnant women. Contamination of shellfish with faecal coliform bacteria has caused closures of large areas in Miramichi Bay and the complete closures of the upper and lower estuary.

While in general the river was found to be in reasonable health, the report identifies areas of concern. These areas included some parts of the headwaters of the Northwest Miramichi affected by significant mining activity and high levels of metals in the water and sediments. Uncertainty was expressed about the long-term effect on fish utilising this area as habitat. A specific concern was the possible effects of spill or equipment failure in mining operations in the tributaries, such as the Tomogonops River basin, a tributary to the Northwest Miramichi River.

Other pollution concerns were largely focussed in the urbanised estuarine area. A number of wood processing, pulp and paper, and other industrial operations in this area utilise the waters of the Miramichi in their process and directly or indirectly for waste disposal. Absorption of toxins such as dioxin in fish and shellfish, although currently acceptable to Health and Welfare Canada, remained a concern for the future. The urban growth around this industrial activity was regulated by a combination of standards in both solid and wastewater disposal. Concern was expressed particularly with regard to water contamination with E. Coli and its threat to public health in swimming areas. Questions were also asked about the implication of this bacterial contamination on

commercial and recreational fishing, particularly in the upper estuary and the Inner Bay.

The report highlighted concern about the viability of certain fish stocks such as Atlantic salmon and Striped bass. A theme that went throughout the 1992 report was concern about the numbers of government departments at both federal and provincial levels that had overlapping jurisdictions over many aspects of environmental issues in the watershed. It was perceived that this led to both confusion and to cases of genuine environmental abuses being overlooked or not addressed as a result of governmental bureaucracy.

MREAC continued their work with the general population and set up a "hotline" to direct reports of abuses to various government departments and to try to monitor responses. Since its inception in 1989, MREAC has continued to receive funding from various federal and provincial bodies and local industry to undertake or encourage various studies and hold numerous workshops to advance scientific knowledge about the watershed and engage public participation in addressing problems.

1.3 Process and infrastructure changes since 1992

Since 1992, there have been a number of changes in structure and infrastructure in the local communities. Principal among these has been the amalgamation of a number of communities around the head of tide, including the former towns of Chatham, Loggieville, Douglastown, Nordin, Nelson, Chatham Head and Newcastle, into one municipality, the City of Miramichi. Major infrastructure changes have resulted from this amalgamation. From an environmental standpoint, the construction of modern sewage treatment plants on both the north and south banks of the inner estuary ranks very high. Work is still progressing on the handling of wastewater in more outlying areas of the new municipality and the handling of storm water is also being addressed. Improvements in wastewater treatment have also been undertaken in smaller communities, such as Rogersville and Red Bank, throughout the Miramichi watershed.

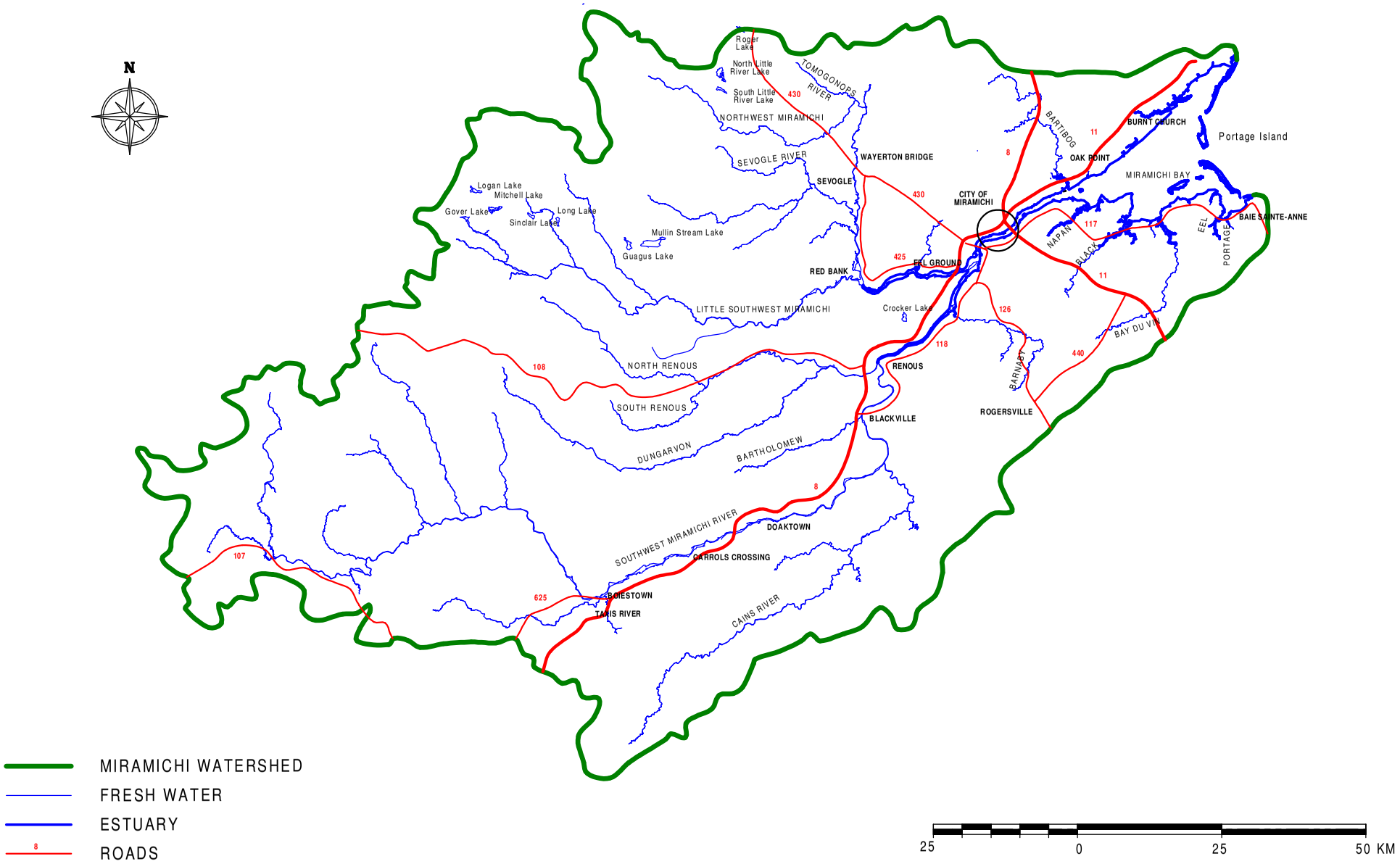
1.4 Closures and other changes in industrial activities

Significant changes in the nature and ownership of a number of industries in the estuarine area have occurred since 1992. Some industries have ceased operations; others have improved or decreased liquid and air emissions. Heath Steele mine on the Tomogonops River was closed in 2000 and remedial activities commenced. A major reduction in both air emissions and liquid effluent was associated with the closure of the kraft pulp mill in 2005.

Infilling and shallowing in the shipping channel through the Miramichi estuary, coupled with the downturn in industry, has resulted in fewer and fewer large ships utilising the port. High dredging costs to government has resulted in no significant shipping channel dredging being carried out since 1996. The dredged channel is said to be in poor condition and ships use it at their own risk without pilotage. Only a few large commercial vessels now use the port annually. Public Works Canada, DFO, and the Atlantic Pilotage Authority have expressed the opinion that it is unlikely that any further channel dredging will take place.

1.5 Physical Environment

Many aspects of the aquatic environment were addressed in the 1992 study and have been dealt with in subsequent reports and workshops. There has been less attention given to air quality, land-based activities or to demographics and social changes. The map presented (Figure 1-1) outlines the Miramichi watershed which encompasses a vast area of north-eastern New Brunswick, being the second largest watershed in the province. The tributaries of the two main branches, the Southwest Miramichi and the Northwest Miramichi, rise in the New Brunswick Highlands at elevations of 300m to 600m before flowing into a wide estuary and out into the Southern Gulf of St Lawrence. The greatest change in the landscape over the last two decades would be the result of forestry activities with the expansion of forestry roads and spreading areas of clear-cut land.



MREAC STATE OF THE ENVIRONMENT REPORT **MIRAMICHI WATERSHED STUDY AREA**	**NATECH** Environmental Services Inc. Patterson Rd., Harvey Stn., N.B., E6K 1L9 ph: (506) 366 1080, fax: (506) 366 1090	DATE: 06/03/09	SCALE: AS SHOWN
		FILE: MREAC-05-01	FIGURE: 1-1

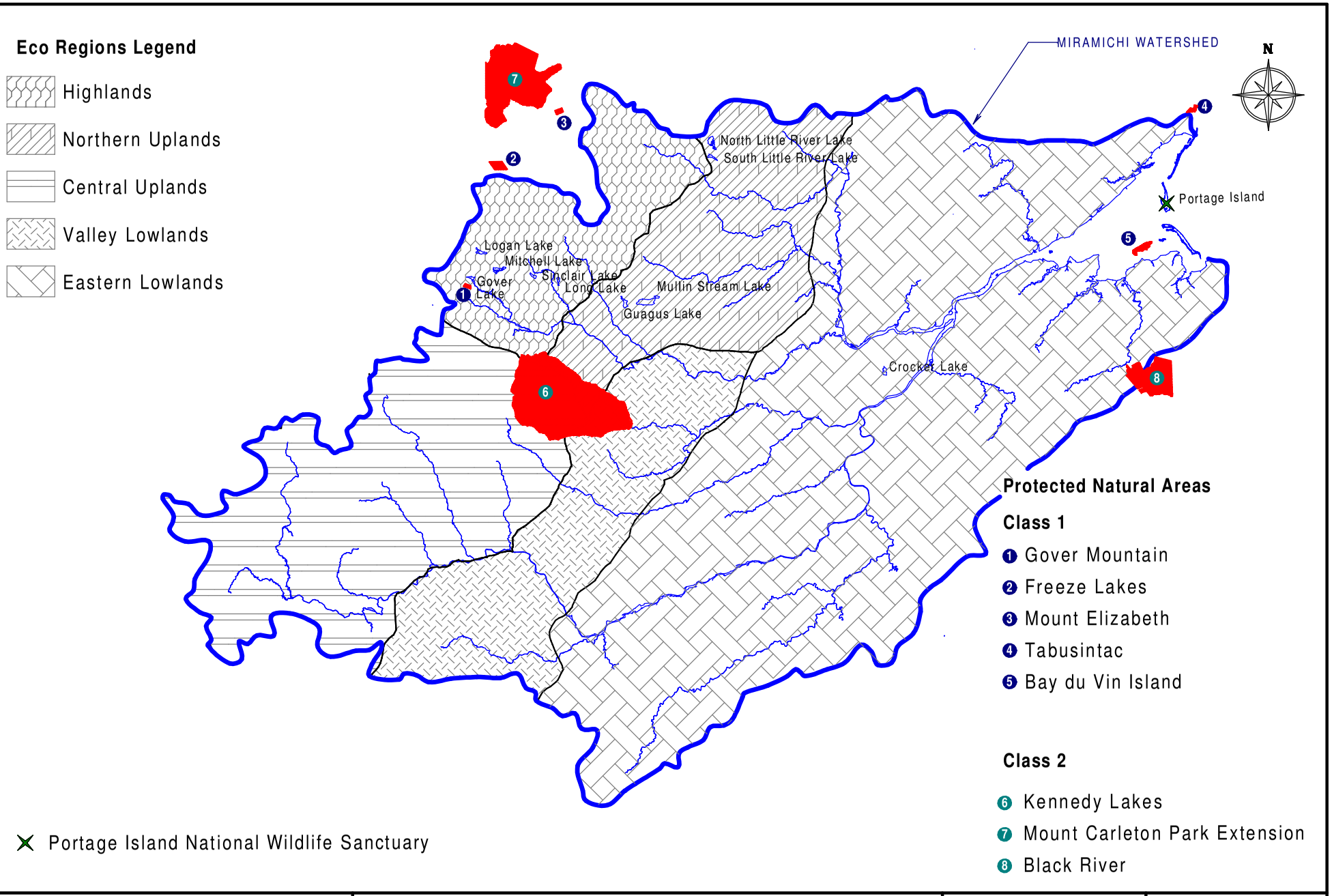
1.6 Social Environment

Population density is very low over most of the watershed and continues to decline annually. Using Northumberland County population figures as a guide, a population of 53,533 in 1996 dropped to 51,000 in 2004 indicating there has been an outward migration from the area. The total population of the watershed is currently estimated to be between 50,000 and 55,000 with more than half of them concentrated within 15 kilometres of the centre of the City of Miramichi. This new municipality, formed in 1995 from the communities concentrated around the head of the estuary, has changed the way they are managed and has created a new and vigorous approach to environmental issues which affect them. Most other significant centres in the watershed are located along Route 8 and include Doaktown (1,000 in the village itself, and close to 5,000 - 6,000 if smaller adjacent communities are included), Boiestown, Rogersville (2,500), Blackville (3,500) and Renous. The village of Neguac (1,700) is situated east of Burnt Church on Route 11 on the coast at the north end of Miramichi Bay. A number of small communities in the Baie-Sainte-Anne area are located at the seaward south side of the bay.

There are three substantial First Nation communities in the watershed, Red Bank (340) at the mouth of the Little Southwest Miramichi, Eel Ground (450) on the lower Northwest Miramichi, and Burnt Church (1,000) on the north shore of Miramichi Inner Bay. The combined native population in the watershed is close to 2,000.

1.7 Biological Environment and Eco-regions

In 1998, the Provincial Department of Natural Resources characterized the Province of New Brunswick by establishing seven eco-regions (see Figure 1-2). The Miramichi watershed includes five of these seven eco-regions, (i.e. Highlands, Northern Uplands, Central Uplands, Valley Lowlands, and Eastern Lowlands).



MREAC STATE OF THE ENVIRONMENT REPORT

ECO REGIONS & PROTECTED AREAS
OF THE MIRAMICHI WATERSHED

NATECH Environmental Services Inc.
Patterson Rd., Harvey Stn., N.B., E6K 1L9
ph: (506) 366 1080, fax: (506) 366 1090

DATE: 06/03/09	SCALE: AS SHOWN
FILE: MREAC-05-01	FIGURE: 1-2

In May, 2001, the New Brunswick Minister of Natural Resources declared the government's intention to protect 10 areas covering approximately 2% of the New Brunswick land base representing the seven eco-regions of the province (Fig 1-2). These areas have been designated Class 2 protected areas with limited access. One of these areas, Kennedy Lakes, is wholly within the Miramichi watershed, specifically within the Renous River drainage.

Bay du Vin Island, situated in the Miramichi estuary, was earlier declared a Provincial Class 1 protected area with very restricted access in order to protect bird habitat. Gover Mountain was added to the Class 1 list to protect a remnant hardwood stand dominated by mature Sugar Maple.

Federally, one of the barrier islands of the estuary, Portage Island, had been declared a National Wildlife Area to protect rare plants, a unique habitat, and nesting birds. The expansive barrier island system provide important habitat to the Piping plover, recognized as an endangered species.

1.8 Environmental Stress and Sustainability

Amongst other things, this report focuses on the nature of the various environmental stresses, which affect the state of the environment of the Miramichi watershed and the health of its residents. It also points out changes that have occurred over the past two decades or so and describes how those changes have moved the area toward, or away from, environmental sustainability. The term, environmental sustainability, means a condition in which the living and non-living resources that support our survival and well-being can continue to do so without becoming depleted or degraded to a point where living systems and human health are jeopardized. A sustainable environment is one which continues to provide clean water and air, healthy and diverse animal and plant populations, a diversity of natural landscapes, undepleted natural resources and a healthy and suitable life-style, over the very long term, i.e. generations.

Over the past 30 years, the earth's natural ecosystems have declined by about 33% while the ecological pressure of humanity on the earth increased by about 50% over the same

period. There is abundant evidence of the depletion and degradation of ecological resources in North America, including pollution of marine and fresh water ecosystems, loss of old growth forests, collapse of fisheries and loss and alteration of habitat. These have all become a primary threat to biodiversity and environmental sustainability. Although the Miramichi River watershed is relatively intact, from an environmental perspective, it does face such threats though on a smaller scale. It would be foolhardy to become complacent about the survival or sustainability of our local environment and the way of life which it supports.

2. MIRAMICHI VALUES AND SOCIAL CHANGES

The Miramichi region has seen numerous changes over the past centuries. The Mi'kmaq first nations have inhabited the region for more than 3,000 years, with a resource-based economy founded on sustainable fishing, hunting and gathering practices. Around 1500, the first Europeans arrived to fish in the area during favourable summers. By 1700, a few French families had settled in the region. After 1755 and the deportation of Acadian settlers, English, Scottish and Irish settlements were established. A number of Loyalists moved to the area following the American Revolution of 1775 to 1783 (Miramichi Prosperity Task Force, 2004).

Lumber and shipbuilding industries developed utilising the high-quality forestry resources. Saw mills were established during the past two centuries. The pulp and paper industry started a century ago and grew significantly during the 20th century, along with mining activities. Some of these industries stopped their activities at various times, which pushed the community to adapt and attract or create different businesses. For example, the Great Fire of the Miramichi in 1825 put an end to the ship mast-building industry, but shipbuilding continued until the end of the 19th century, until it was replaced by the forest industry (Miramichi Prosperity Task Force, 2004).

The commercial salmon fishery was closed by DFO in 1984 to preserve stocks, but shellfish and lobster harvesting remains an important source of income. Also, the Heath Steele mine stopped its activities in 2000, and the UPM-Kymmene pulp and paper mill closed in 2005. Currently, the main job providers in and around Miramichi are the forest industry, commercial fishing and related activities, the peat industry, knowledge-based industries, and tourism. Farming is a common activity but not a large economic sector.

In general, communities in the Miramichi watershed have grown out of their utilisation of natural resources. Of the 50,000 population in the watershed, 40% reside in Miramichi City. The community was developed on the upper estuary, with a focus on manufacturing and service industries.

Three first Nations communities are among the villages that are distributed around the river systems, in a manner that reflects old transportation systems, the attraction of the

rivers for fishing, and access to the forest for timber and wildlife. This very direct association with the riparian and heavily forested area has led the communities to have a unique sense of values.

The City of Miramichi was formed in 1995 through the amalgamation of the smaller municipalities including: Chatham, Newcastle, Douglastown, Loggieville. Chatham Head, Nordine and Nelson-Miramichi, making it not only the newest, but also the largest city in northern New Brunswick with a population of 20,000.

2.1 Social aspects

2.1.1 Miramichi values

As noted The Miramichi River is a name that evokes an image of outdoor recreation, especially fly-fishing for the much prized Atlantic salmon. The resonance of this name has spread globally and seems to have special recognition in the north-eastern US and much of Europe. Conversely the name, river and pronunciation seem to be a mystery to many in Upper Canada and the west.

This recognition comes in part from the attention and visits the Miramichi received by the rich and famous in earlier decades when the Miramichi was the destination spot for the passionate angler after the elusive prize of Atlantic salmon. An exclusive number of camps catered to this clientele. Remnants of this offer and traces of these glory days remain.

Inherent in the international reputation the Miramichi developed over the years is the intact natural environment. Strikingly attractive settings throughout the Miramichi and her many tributaries bespeak of health and well being in the ecosystem. For the most part this picture is accurate but needs to be tempered with a touch of reality.

The industrial history of the Miramichi initially developed around the rich forest resources the region has to offer. The opening of the Miramichi evolved around the demand for wood in England during the Napoleonic blockades. Harvesting went on apace until the tragic Miramichi fire of 1825 that consumed half the province and took __ lives. Constant pressure on the renewable forest resources and specific management goals has changes the composition structure of the forest ecosystem over the decades. No longer do we have the historic Acadian forest ecosystem that greeted our early

ancestors. A well structured twenty five year management regime is now the principle management tool on crown lands. The pressure remains on forest resources for a variety of forest products. As an industry forestry is in decline and has an uncertain future.

Commercial fishing in the expansive Miramichi Inner Bay (estuary) and the adjoining Gulf of St Lawrence are another resource use that has sustained much of the coastal population of the Miramichi region. Most commercial fisheries have suffered a significant decline in recent decades, attributed in most part to fishing pressure and over-harvesting. Succeeding governments seem incapable of stemming the tide of decline through the needed changes in resource management.

Agriculture has never been a large sector on the Miramichi but has often been a small scale sideline for hundreds of residents. As such relatively little of the vast watershed of the Miramichi is dedicated to agriculture. Mixed small scale farming is the most common form of activity in this sector. A few larger operators are engaged in dairy and beef operations.

Many, maybe most, Mirmaichiers are emotionally connected with the river. The river is a source of pride and helps define its residents. This connection to the river does not extend to an in-depth understanding about the life support that river basins provide in water, food and shelter. As the region diversifies and globalizes this connection needs to be retained and the basic dependence needs to be reinforced.

2.1.2 Population changes

Canadian census reports over the past decades have been demonstrating a population drift from rural to urban centres in Canada. The advent of industrial changes and closures in the Miramichi area over the past decade appears to have exaggerated the population changes in this region compared to the relatively steady Provincial rates. More recently, the employment boom of resource industries in the Western Canadian Provinces coupled with higher wages has been attracting the attention of younger workers. Larger and growing cities like Moncton, Fredericton and Saint-John also have

attracted workers. The last four Census results for Miramichi City given in Table 2.1 provide the pattern of the current trend in the area.

Table 2.1. Comparison of local and national population trends

Year	*Miramichi City*	*Northumberland County*	*New Brunswick*	*Canada*
1991	*21,165*		*723,900*	
1996	*19,241 (-9.6%)*	*52,153*	*738,133 (+2%)*	*28,846,761*
2001	*18,508 (-3.8%)*	*50,817 (-2.6%)*	*729,498 (-1.2%)*	*30,007,094 (+4.0%)*
2006	*18,129 (-2%)*	*48,868 (-3.8%)*	*729,997 (+0.1%)*	*31,612,897 (+5.4%)*

Current population densities range between 100.8 inhabitants per km^2 in Miramichi City, to 4.0 on average in Northumberland County. The provincial average is 10.2 inhabitants per km^2. Table 2.2 shows a breakdown of the population within the County.

Table 2.2 Evolution of the population of Northumberland County communities

Community	1996	2001	2006
Alnwick Parish	*6,884*	*6,566*	*6,152*
Big Hole First Nation	*40*	*61*	*69*
Blackville Parish	*2,620*	*2,421*	*2,347*
Blackville Village	*957*	*1,015*	*931*
Blissfield Parish	*674*	*636*	*560*
Burnt Church First Nation	*816*	*1,002*	*1,120*
Chatham Parish	*555*	*519*	*502*
Derby Parish	*1,197*	*1,122*	*1,068*
Doaktown Village	*986*	*955*	*888*
Eel Ground First Nation	*ND*	*445*	*503*
Glenelg Parish	*1,735*	*1,712*	*1,652*
Hardwicke Parish	*2,694*	*2,564*	*2,484*
Ludlow Parish	*1,827*	*1,709*	*1,568*
Miramichi City	*19,241*	*18,508*	*18,129*
Neguac Village	*1,735*	*1,697*	*1,623*
Nelson Parish	*994*	*1,021*	*814*
Newcastle Parish	*1,257*	*1,228*	*1,209*
Northesk Parish	*2,731*	*2,606*	*2,480*
Red Bank First Nation	*268*	*343*	*383*
Rogersville Parish	*1,427*	*1,356*	*1,247*
Rogersville Village	*1,336*	*1,248*	*1,165*
Southesk Parish	*2,178*	*2,083*	*1,964*
Tabusintac First Nation	*1*	*0*	*10*
Northumberland County	**52,153**	**50,817**	**48,868**

It should be noted that only the First Nations Communities show an increasing population trend, all other communities have been declining over the past ten years. By comparison, the New Brunswick population has been steadily growing since the first census in 1851, from 193,800 to a maximum of 738,133 in 1996. Only between 1996 and 2001 did the New Brunswick population decline.

2.1.3 Employment

The Report of the Miramichi Task Force (2004) suggests that a significant number of young people with Grade 12 or higher leave the region because of poor employment prospects. Indeed, unemployment rates have been high in the past decade, (15.9% in 1996 and 14.5% in 2001 in Miramichi City, 21% in Northumberland County in 2001, and 12.5% in New Brunswick in 2001). Unemployment rates recently decreased to 13.2 for the Campbellton-Miramichi area and 8.1% in New Brunswick in February 2007.

2.1.4 Quality of life

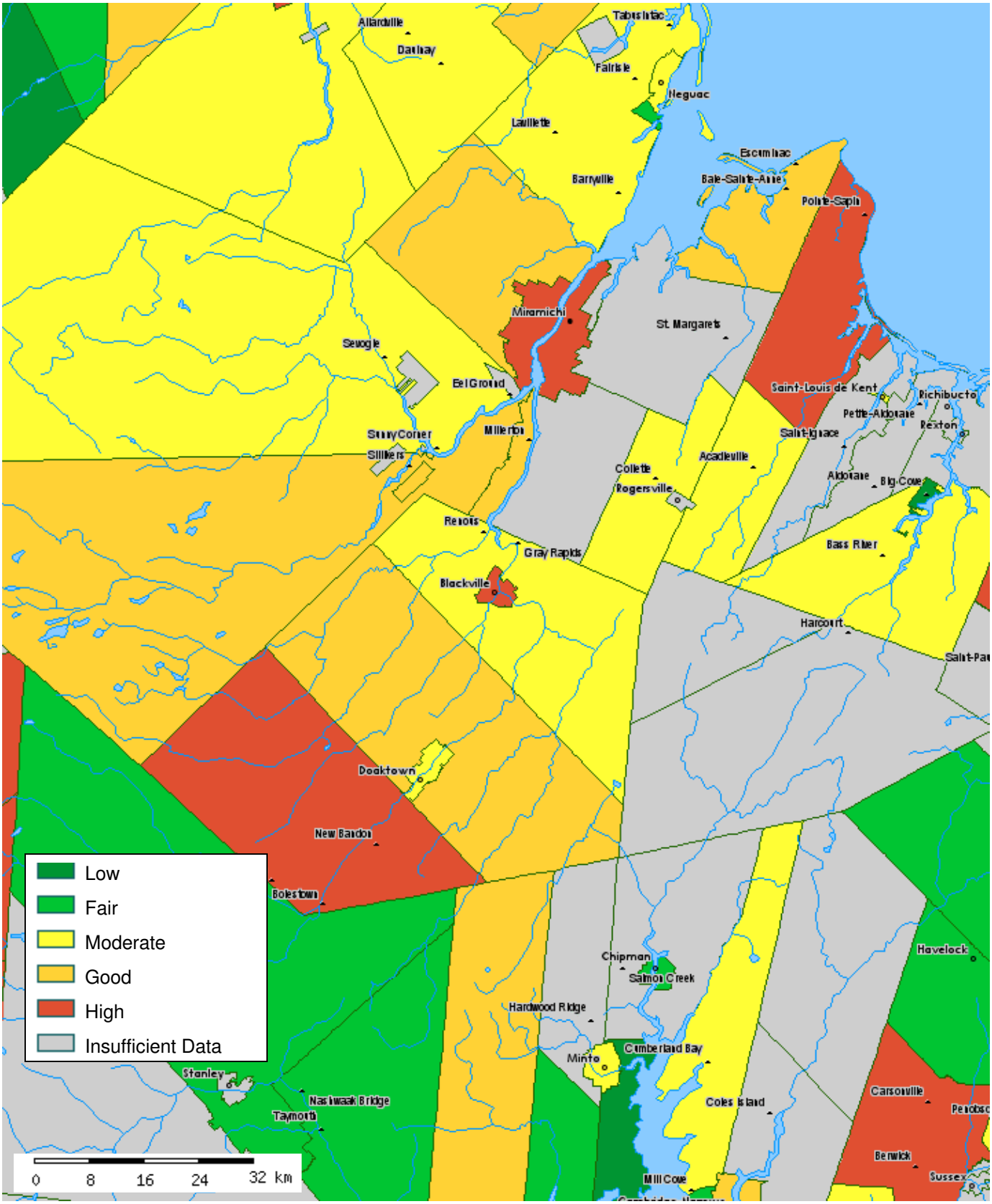
Natural Resources Canada in their map series has attempted to capture the "Quality of Life" throughout the country. Quality of life is a term used to measure well being, or how well people feel about their environment. Indicators are used to represent the most important aspects of a person's life (called domains), which include, for example, housing, education, employment and household finances. The individual indicators (and their domains) were categorised into three broad groups called the social environment, economic environment and physical environment. The data used was obtained during the 2001 census.

Figure 2-1 illustrates how the social environment index varies across the region. This index represents the external conditions under which people engage in social activity within their community. It includes aspects of social opportunity, leisure and recreation, education, access to health services, health status and participation in democratic processes.

Figure 2-2 details the economic environment, which represents the external conditions under which people are engaged in, and benefit from, economic activity. It includes aspects of paid employment, economic status and finances.

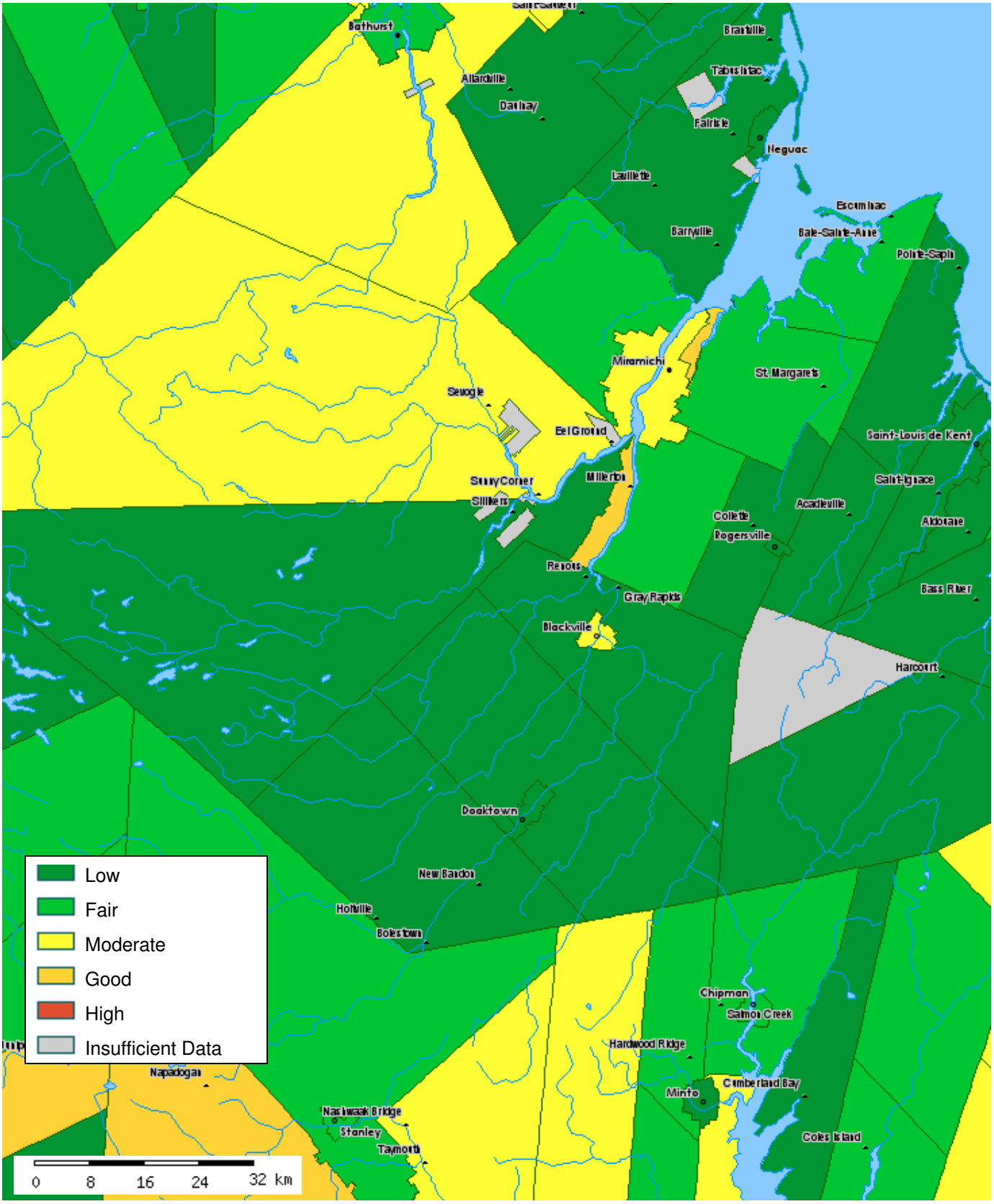
Figure 2-3 illustrates the physical environment, i.e. the external conditions under which people live. It includes aspects of housing, access to services, environmental quality and personal security.

Finally, Figure 2-4 illustrates overall quality of life, which is a composite assessment of the quality of the social, economic and physical environments.



Natural Reasources Canada website http://atlas.nrcan.gc.ca/site/english/maps/peopleandsociety/QOL

MREAC **SoE Report** **Social Environment Index**	NATECH **Environmental Services Inc.** Patterson Rd., Harvey Stn., N.B., E6K 1L9 ph: (506) 366 1080, fax (506) 366 1090	DATE: 2007/03/09	FILE: MREAC-06-01
		SCALE: As Shown	FIGURE: 2-1



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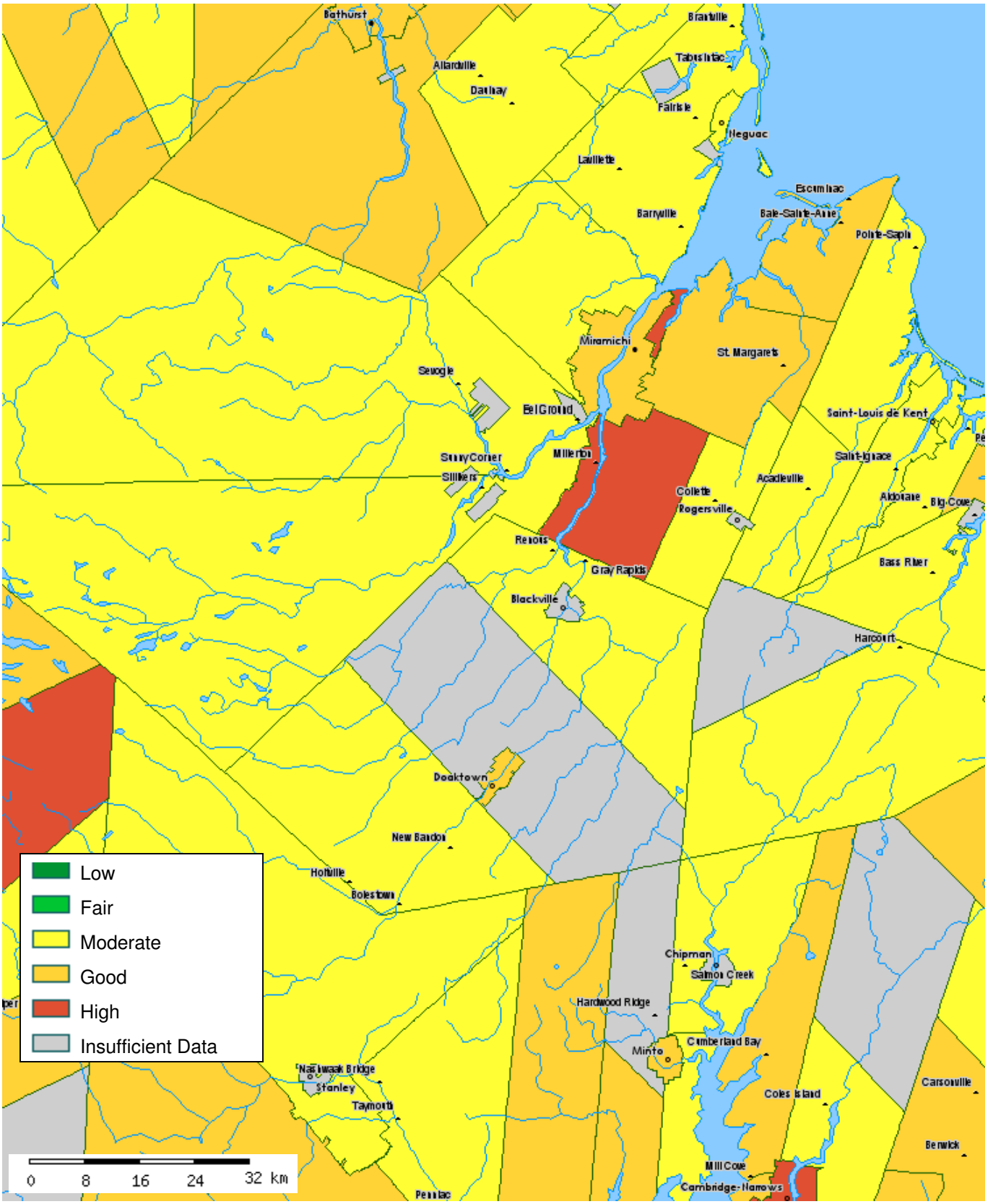
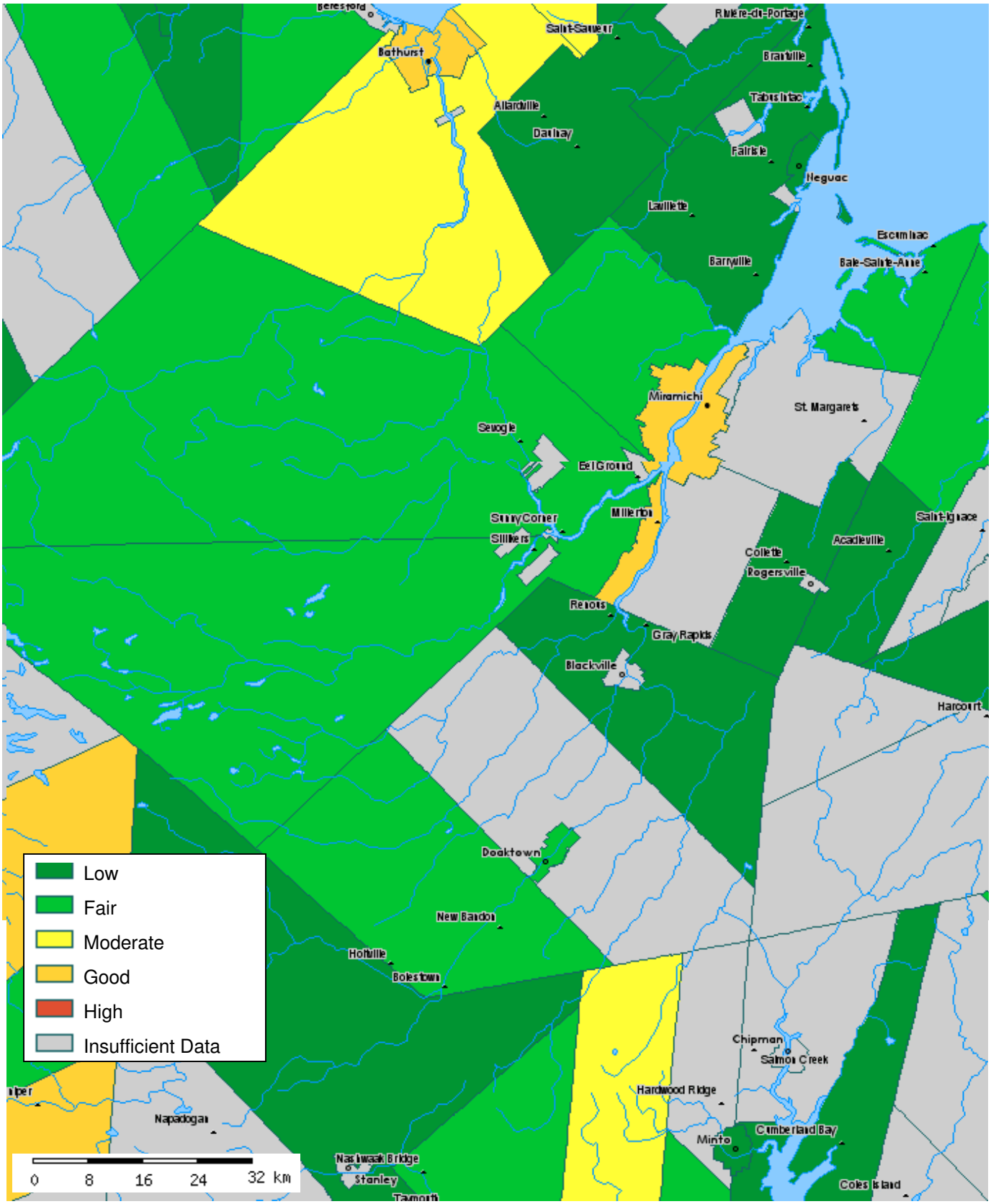
MREAC SoE Report Economic Environment Index	NATECH **Environmental Services Inc.** Patterson Rd., Harvey Stn., N.B., E6K 1L9 ph: (506) 366 1080, fax (506) 366 1090	DATE: 2007/03/09	FILE: MREAC-06-01
		SCALE: As Shown	FIGURE: 2-2



Natural Reasources Canada website http://atlas.nrcan.gc.ca/site/english/maps/peopleandsociety/QOL

MREAC **SoE Report** **Physical Quality of Life**	NATECH **Environmental Services Inc.** Patterson Rd., Harvey Stn., N.B., E6K 1L9 ph: (506) 366 1080, fax (506) 366 1090	DATE: 2007/03/09	FILE: MREAC-06-01
		SCALE: As Shown	FIGURE: 2-3



Natural Reasources Canada website http://atlas.nrcan.gc.ca/site/english/maps/peopleandsociety/QOL

MREAC **SoE Report** **Overall Quality of Life**	NATECH **Environmental Services Inc.** Patterson Rd., Harvey Stn., N.B., E6K 1L9 ph: (506) 366 1080, fax (506) 366 1090	DATE: 2007/03/09	FILE: MREAC-06-01
		SCALE: As Shown	FIGURE: 2-4

2.2 Economic aspects

2.2.1 Activity by sector

As in most western countries, the economy has shifted from mostly primary sector jobs centuries ago, to an industrial-based economy during the 20th century, and from there to a services-based economy today, as illustrated in Table 2.3. This trend is more developed in Miramichi City than in Northumberland County as a whole.

Table 2.3 Employment by sector of activity

Census Year	*Persons in:*	*Miramichi City*	*Northumberland County*	*New Brunswick*
1996	*agriculture and other resource-based industries (primary sector)*	*3.9%*	*-*	*7.4%*
	manufacturing and construction industries (secondary sector)	*20.5%*	*-*	*19.5%*
	service industries (tertiary sector)	*75.6%*	*-*	*72.9%*
2001	*agriculture and other resource-based industries (primary sector)*	*4.3%*	*11.9%*	*7.5%*
	manufacturing and construction industries (secondary sector)	*19.1%*	*21.7%*	*19.0%*
	service industries (tertiary sector)	*76.6%*	*66.4%*	*73.5%*

2.2.2 Transportation

Providing reliable modes of transporting goods, products and people is vital to economic growth. Over the past 20 years, the transportation infrastructure in the region has seen shifts from rail and water based transportation to roads.

Route 8 links Fredericton to Miramichi in two hours, and Highway 11 provides connection to Moncton in the south and Bathurst in the north. The city still offers rail service for both passenger and freight needs through partnership with the Village of Rogersville. Miramichi has an airport located within the city limits. Two national airports with scheduled domestic and international flights are located within a 1.5-hour drive from City. There is one port located in the City of Miramichi on the Miramichi River. The Port of Miramichi - Newcastle (with a depth of 9m) officially commenced operation in 1985. Dredging of the channel through the Miramichi estuary was halted in 1996. The dredged channel is said to be in poor condition and ships use it at their own risk without pilotage. Only a few large commercial vessels now use the port annually. Public Works Canada, DFO, and the Atlantic Pilotage Authority have expressed the opinion that it is unlikely that any further channel dredging will take place.

2.3 Community actions and plans for the future

Enterprise Miramichi (EM) is one of fifteen Community Economic development agencies set up in the Province of New Brunswick to foster Economic development in their region. Enterprise Miramichi, with the aid of P.K. Consulting, developed a Strategic Plan for the Miramichi Region (P.K. Consulting, 2003). The plan was formally adopted by the community. The underlying objective of this plan was to reverse the population decline in the area by the creation of jobs in selected sectors of the economy that would appeal to the younger generations.

The strategic plan focuses on initiatives that are key components of urban development and from an environmental viewpoint can be dealt with under the accepted balancing between urban and environmental needs and concerns. However, there are a few

initiatives that could have direct impact on the state of the environment in the Miramichi Region.

Tourism is often viewed as a possible saviour in rural and coastal areas. In the EM document however the conclusion reached was: "The Miramichi tourism sector can be improved but here again this sector is not likely to grow to replace the jobs and income being lost in the resource sectors". The EM Tourism Sector Task Group did identify a number of key elements required to develop a "Sustainable Tourism Destination" but did not seem to indicate this would be a key or significant growth area. The need for a key "Class A" tourist attraction in the region was identified, but no solution(s) were offered.

The Forestry Sector Task Group identified developing "value added" projects as one major component to better utilise some of the wood already being harvested. A second thrust was for 300 – 400 jobs to be created in silviculture operations. No detail was given on how this was going to be implemented but a change implied in forestry operations of this scale could have both positive and negative implications on the well being of the forests of the region and should be carefully monitored.

While recognising there were constraints on the fishery resources and the industry generally, the Fishery Sector Task Group identified a number of potential activities that could have significant impact on the state of the environment. These included :

- **Establish large scale oyster aquaculture industry through core fishermen.**
- **Establish one new "value added" processing facility.**
- **Increase harvest of under utilised species (snow crab & herring)**
- **Introduce projects for the "shoulder season" including "Shad Fly Fishing"**
- **Maintain or increase current level of lobster catch.**

These initiatives have a potential to directly impact on estuarine components of the Miramichi watershed. Any significant increase in the scale and number of off bottom or suspended aquaculture activities could impact currents, and sediment movement in the estuary. Might these changes impact the estuary as a nursery area for other marine organisms? A scientific study of the carrying capacity of oyster aquaculture in Eastern New Brunswick is needed to guide this industry sector.

One Initiative developed by the Peat Sector Task Group was to explore alternative uses for spent and reserve peat bogs. Restoring former mined peat bogs can be challenging and the recommendation to explore cottage industry development of these areas for cranberry and blue berry culture is to be commended.

The education sector is becoming an increasingly important part of the economy, with the presence of the NBCC Miramichi and Saint-Thomas University. Knowledge-based industries are developing strongly, in particular the information technology sectors, and customer service centres.

As a result of the Report of the 2004 Miramichi Prosperity Task Force, a $25 million Miramichi Regional Economic Development Fund (MREDF) was established. The MREDF will provide assistance to community-driven initiatives in support of education and training, research and development, economic diversification, and strategic infrastructure. (NB Regional Development Corporation, 2007)

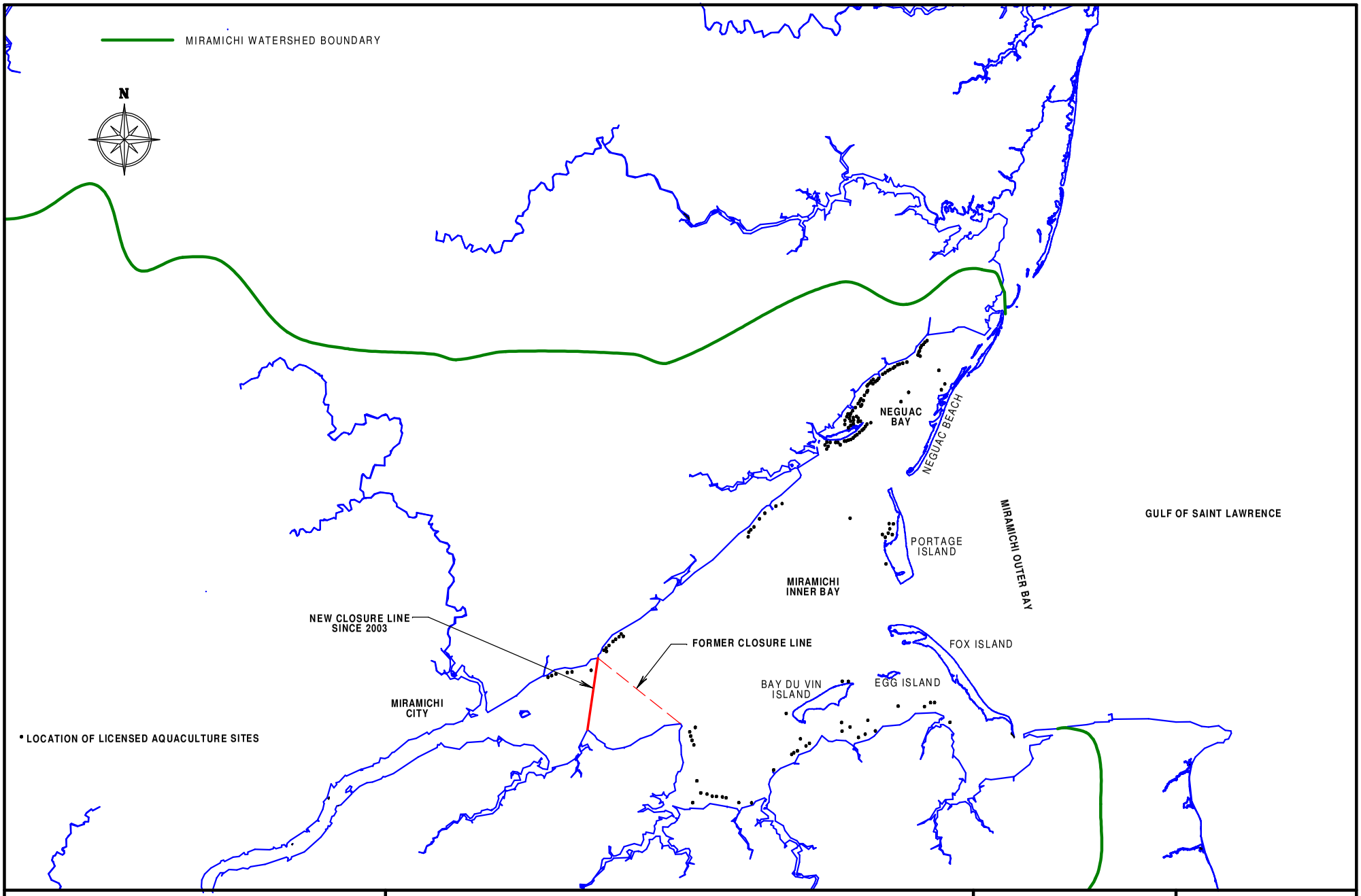
3. ENVIRONMENTAL DATABASE

3.1 Terrestrial

3.1.1 Regional Geography

New Brunswick, as a whole, is generally viewed as an extension of the Appalachian region of eastern North America. The Miramichi watershed encompasses two physiographic divisions: the New Brunswick Highlands and the Gulf of St Lawrence Plain. The Miramichi River rises in the Highlands region with a maximum divide elevation of around 670m.

The Miramichi watershed is about 90% forested and encompasses approximately 14,000 km^2 or nearly one quarter the surface area of the Province of New Brunswick. The catchment area measures about 190 km from east to west and 95 km from north to south. After the St John River, the Miramichi is the second largest river in the Maritimes. The two largest tributaries, the Southwest Miramichi (7,700 km^2), and the Northwest Miramichi (3,900 km^2) converge at Beaubears Island below the head of tide. Both of these rivers have extensive often parallel tributary systems, running for the most part from west to east or south-east. There are a few large lakes in the watershed although numerous small ones are to be found among the headwaters in the highland region. A number of smaller rivers enter the estuary and Miramichi Bay, which is an inner bay sheltered from the Southern Gulf of St Lawrence by several barrier islands. These add another 1,400 km^2 to the catchment area (see Table 3-1) and combine to create a large estuarine area in Eastern Canada. Tides in the estuary are small ranging from 0.2 m to 1.2 m. Tidal influence, from the Gulf of St Lawrence, penetrates the two main tributaries for a few kilometres upstream of their confluence at Beaubears Island (i.e. head of tide). The Miramichi estuary has been the subject of numerous studies over the past quarter century. Using mixed classifications, the Miramichi Estuary could be described as starting initially as a drowned river valley, then widening out into a triangular-shaped bar-built inner bay (Fig. 3-1).



MREAC STATE OF THE ENVIRONMENT REPORT

MIRAMICHI ESTUARY

NATECH Environmental Services Inc.

Patterson Rd., Harvey Stn., N.B., E6K 1L9

ph: (506) 366 1080, fax: (506) 366 1090

DATE:	SCALE:
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FILE: MREAC-05-01	FIGURE: 3-1

The seaward boundary of the inner bay is made up of a 30Km long chain of barrier islands which shelter it from the Gulf of St Lawrence. The surface area of the estuary and Inner Bay is approximately 300 km^2, with an average depth of 7m.

Table 3-1, Catchment Areas (km^2)

River	Catchment area
Bartibog	550
Burnt Church	120
Napan	110
Black	260
Bay du Vin	280
Eel	70
Portage	26
Total	1416

Old rock formations underlie the headwaters of all branches of the Miramichi River, often with significant changes in elevation. In general, the headwaters of the Northwest Miramichi River and it tributaries are underlain by granitic rocks which create a number of rapids particularly in the upper reaches. The headwater areas of the Southwest Miramichi River are underlain by less resistant sedimentary rocks such as shale and sandstone. Most of the headwaters lie in the highland area at elevations between 300 and 650m. The Southwest Miramichi has a meander length of about 250 km while the comparable measurement for the Northwest Miramichi is 122 km. The lower part of the watershed is formed by an area of flat or gently dipping upper Palaeozoic sedimentary rocks that are contained within the Gulf of St Lawrence plain, lying between two arms of the Highland region. These rocks are predominantly sandstone, shale and conglomerates which are less compacted and more easily erodible. Relief in the area is gentle and seldom exceeds 180m in elevation.

3.1.2 Eco-regions

The entire provinces of New Brunswick and Nova Scotia fall into the Atlantic Maritime

ecozone (Eaton, et al. 1994). The NB Department of Natural Resources has divided the Province of New Brunswick into seven eco-regions. The Miramichi watershed impinges on or contains five of these eco-regions as depicted in (Fig 1-2). The official description of the various provincial eco-regions serves well to describe the vegetation and typical habitat found in the different areas of the watershed, (N B Dept of Environment. 2001).

The provincial Highlands eco-region is made up of two discontinuous areas of high elevation in northern NB. The western portion is adjacent to Quebec and includes most of the Kedgwick River watershed. The eastern portion encompasses the mountainous area of north-central NB and includes Mount Carleton, the Christmas Mountains and the Naturalist Range. The two areas have different geology but a similar climate as a result of high elevation (mountains over 700 m) and rough topography. The climate is cool and wet with long winters and high levels of precipitation as a result of orographic lifting, a process where warm moist air is forced over mountains at which point it cools and releases its condensed moisture. Because of the predominantly west to east flow of air, more precipitation falls in the west than in the eastern portion of the eco-region. Conifers, particularly balsam fir, black spruce, and white spruce, dominate the forest cover in this eco-region. The understory vegetation is predominantly boreal, reflecting the short, cool, growing season. Riparian strips dominate wetlands with small peatlands in depressions.

The Northern Uplands eco-region arcs across northern NB, between the two areas of the Highlands eco-region. The elevation difference is 522 between the boundary and sea level near Chaleur Bay. As a result of lower elevation and proximity to Chaleur Bay, the climate in the northern Uplands is warmer than in the Highlands. However, it is cooler than the central Uplands area as the slopes predominantly face north. It is also drier than either the Highlands or Central Uplands eco-region, as it lies in the rain shadow of the mountains of the Gaspe. The forest cover of the Northern Uplands is a mix of northern and southern forest types, with many areas dominated by softwoods (balsam fir, black spruce and pines) although tolerant hardwood stands of sugar maple, yellow birch, and beech are common at lower elevations near Chaleur Bay. The understory vegetation of the coniferous forests are similar to those in the Highlands eco-region, however, the understory in the hardwoods stands lacks several of the species that would be found in similar stands in more southerly areas.

The Central Uplands eco-region includes two areas with similar climates that are widely separated. The larger northern area stretches from the provincial panhandle south to York County. The smaller southern area includes a plateau parallel to the Bay of Fundy. The bedrock varies between the two areas, but the climate is similar. Elevations range from 600 m in the north to 180 m in the south. The climate is cool but not as cold as the Highlands or Northern Uplands. This is a result of lower elevations and southern facing slopes in the northern part of the eco-region. Precipitation is high in the north as the areas are not in the rain shadow and there is some orographic precipitation over the hilly terrain. The fire incident is lower than in many areas of the province. The forests are no longer predominantly softwoods, as hardwoods are able to tolerate the warmer climate. Tolerant hardwood stands are found on ridge-tops, as cold air flows down the valleys at night, resulting in localized frost pockets. This is in contrast with the Highlands eco-region where the limited hardwood stands occur in sheltered valleys. The under-story vegetation includes a rich shrub layer and species absent from the northern eco-regions.

The Valley eco-region is the largest eco-region in the province. It includes the St John River valley south of Edmunston, the south-western corner of the province and river valleys stretching east from the St John River. It is very diverse in terms of bedrock and topography, including broad river valleys, ridges, and broad river plains. Elevations range from peaks at 572 m near New Denmark to 100 m at the boundary with the Grand Lake eco-region. The climate is more continental than the Fundy coastal ecosystem with warmer summers and colder winters. There is also less precipitation than in the surrounding eco-regions, due to its generally lower elevation. As a result, fires play a larger role in structuring the vegetation. The forest cover includes softwoods but is distinguished by the relative importance of hardwoods, including many which have southern distributions such as ironwood, silver maple and green and white ash. The under-story contains species frequent in mixed woods, which are less common in other eco-regions.

The Eastern Lowlands eco-region covers a broad wedge of gently sloping low elevation terrain stretching from Bathurst to Sackville and inland to Grand Lake. The bedrock consists almost exclusively of Carboniferous sedimentary rocks with isolated areas of high elevation (400 m) along the border with the Northern Uplands eco-region and high plateaux in the southern interior. Otherwise, elevation decreases towards the

Northumberland Strait and the Gulf of St Lawrence. There is poor drainage throughout much of the area with several large rivers flowing to the east and into the Northumberland Strait or Gulf of St Lawrence. The climate is viewed as being dry as air masses are intercepted in the west by the Highlands eco-region. Summers are warm as there is little air movement and the Northumberland Strait does little to modify the air temperature. The forests are predominantly coniferous despite the warm summers. This is due to the high frequency of fires in the area and to poor drainage, neither of which favours the development of hardwood stands. The under-story vegetation is also boreal and includes species common in acid peaty habitats. Wetlands are an important feature of this eco-region and include bogs, heaths and treed peatlands.

Weather and climate shape much of the landscape and have a strong and variable affect on local plant and animal species. Because of this, any changes to the climate of the region will have an impact on the ongoing state of the eco-regions and their ability to support a stable environment and a sustainable economic and social future for the watershed. Climate change is discussed more extensively in Section 5.1.

3.1.3 Protected areas

The UNEP, Convention on Biological Diversity, defines protected areas as:
"a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives."
The World Conservation Union (IUCN) defines protected areas as:
"areas of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means."

As part of an overall environmental plan, in 2003, the Protected National Areas Act was established in New Brunswick. Under this Act, all protected natural areas provide a refuge for one or more of the following:

- **Rare plants and/or animals in their natural habitat.**
- **Unusual combinations of plants and/or animals.**
- **Old forest stands.**

- **Example of the hills, valleys, waterways, wetlands and soils that are typical of one of the province's seven Eco-regions.**

Two classes of Protected Natural Areas have replaced the former Protected Area Classifications: Ecological Reserves and Conservation areas.

Class 1 Protected Natural Areas do not allow public access. These sites total 2,900 hectares in the province. They require complete protection because human activity could damage the features being protected. Human activity could also affect scientific experiments and monitoring programs conducted in these areas.

Class 2 Protected Natural Areas allow public access. These areas cover 143,000 hectares and may be:

- **Good examples of natural ecosystems or landscapes.**
- **Examples of ecosystems that have been modified by human activity and therefore offer an opportunity to study the recovery of natural ecosystems.**

The Miramichi watershed contains two Class 1 and one Class 2 Provincial Protected Areas and also one Federal National Wildlife Area (see figure 1.2).

Class 1 Protected Areas

The *Bay du Vin Island* Conservation Area, in the Eastern Lowlands eco-region, covers 214 hectares. This island is typical of the Northumberland Strait containing a remnant mixed-hardwood forest, coastal salt marshes and an unusual sand dune community supporting red oak, mature pine and rare plants. It is a shorebird nesting, feeding and staging area as well as a nesting site for Great Blue Heron and Osprey. Despite this being a Class 1 protected area, there are reports that some locals visit the island and there is evidence of camping on the site.

***Gover Mountain* Ecological Reserve (Central Uplands eco-region) covers 66 hectares. The area is dominated by a remnant hardwood stand of mature Sugar Maple, with characteristic under-story vegetation. This is the only portion of Glover Mountain that is not cut and where there is no harvest blocks slated for this area.**

Class 2 Protected Area

Kennedy Lakes Protected Natural Area **(Southern Uplands and Valley Lowlands eco-regions) covers 22,000 hectares. It includes the Kennedy Lakes Conservation Area which is now part of this protected area. The site captures the hills and low mountains of the Southern Uplands eco-region and the ridges and valleys of the Valley Lowlands Eco-region. Elevation varies from 200 to 580 m. The western portion (located in the Southern Uplands eco-region) contains the highest elevations and the most rugged terrain. There is a gradual transition from the rugged terrain of the western side to the lower elevation on the eastern side (located in the Valley Lowlands eco-region). Here, gentler landscapes consist of tolerant hardwoods on the hilltops. In the lower elevations, balsam fir, intolerant hardwood and spruce are found. Jack pine and white pine grow in dry rocky areas in the centre of the site. Black spruce and eastern cedar occupy wetter areas. The site contains a large boulder field exposed when a portion of it recently burned. The Plaster Rock – Renous highway forms part of the site's southern boundary. Two areas within the Kennedy Lakes site will continue to be harvested until 2012. After this, no further harvesting will occur.**

Federally, one of the barrier islands of the estuary, Portage Island, has been declared a National Wildlife Area as representative of islands in coastal southern Gulf of St Lawrence to protect rare plants, unique habitat, and nesting birds.

3.1.4 Wildlife

The Miramichi watershed provides good habitat for most of the province's big game animals. Much of the area consists of Crown Land and NB DNR monitors and manages any harvesting that takes place. Among the large mammals, moose, white-tailed deer and black bear are well represented throughout the area. Hunting licenses are issued to guides and recreational hunters in management areas. NB-DNR also issue trapping licences for 13 species of furbearing animals. In 2004-2005 the value of the furs was estimated at $0.75M. The species trapped include beaver, bobcat, coyote, fisher, martin, mink, muskrat, otter, weasel, rabbit, raccoon, skunk and squirrel (NB-DNR Annual Report, 2004-2005).

Occasional reports are received by NB-DNR staff about the presence of the eastern cougar but as yet no conclusive proof has been provided to NB DNR that this species is present in the watershed.

The Canadian Wildlife Service, based in Sackville N.B., monitors birds and their habitat in the region. They have particular interest in the barrier islands and Bay du Vin Island in the estuary and have recently completed some studies at these sites (Fig. 3-1).

Records suggest Bay du Vin Island once supported the largest Great Blue Heron colony in the province. The province owns the island and as a Class 1 Protected Area requires a permit to visit the island even to conduct scientific research/monitoring. The latest survey, *Great Blue Heron Colony Census and Evaluation of Habitat Use, Bay du Vin Island, New Brunswick* by C.M. MacKinnon et al. (2005), was a sequel to a similar Census carried out in 1993 by the senior author. The colony was found to have become more centralised compared to the previous visit and occupied not much more than 1 Ha (compared to 214 Ha for whole island surface). The study suggested that the colony is healthy and has remained stable for the past 25 years or so. There is a question as to the reason why the colony is becoming more centralised. The boundaries of the island are stable (minimal erosion unlike many other islands or colonies) and the trees seem well able to sustain a colony for some time. It was noted however that while Bay du Vin is a restricted and well-posted protected area there was evidence of frequent public use. The majority of the activities appear to be focused along the shore with little new intrusion into the forested area.

A second report, *Portage Island National Wildlife Area Inspection Visit 2005,* by C.M. MacKinnon et al, (2005a) was undertaken at about the same time. The report consists essentially of a census of the wide range of birds observed by two parties as they traversed the island. The report concludes with tabulated data of the species and numbers observed during eight visits in June, between 1983 and 2005, plus one visit in July, 2003. During a conversation with the senior author, he commented that there appeared to be no trends to give concern either with bird life, erosion, or human activity.

A third report was entitled, *Miramichi Bay, New Brunswick, Coastal Island Survey: 3-6*

***June, 1996*. It included Sheldrake Island, Preston Beach, Portage Island (NWA), Neguac Bar, Fox/Huckleberry Island, Little Huckleberry Island, and Tabusintac Bar (Murray shoal) (Mackinnon 1996). The reports on each island are a bird census with comments on any other activity observed. Preston Beach was obviously well used by ATVs and there was some clamming taking place. Frequent camping was obvious on Sheldrake Island at the landward end of the inner Bay.**

3.2 Aquatic

3.2.1 Physical & Chemical

3.2.1.1 Freshwater

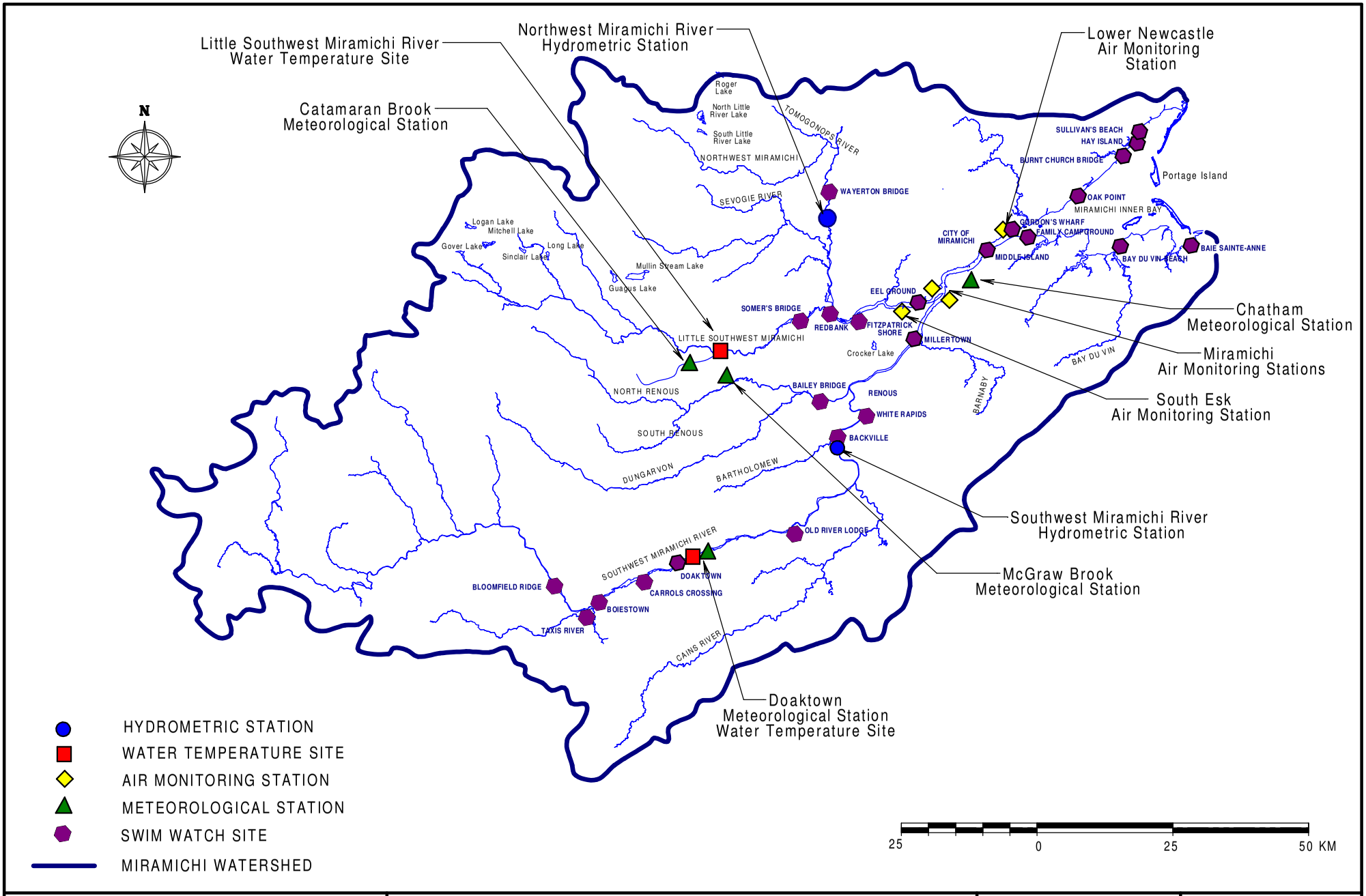
The Miramichi River is a north-temperate river in which estuarine and freshwater areas freeze over during the winter months, from December to early April. It is a relatively small system by global standards, 4.4% as long as the Amazon and 20% as long as the Fraser River in Western Canada. It is the second largest river in the Maritimes. Its freshwater input represents about half of all the freshwater inputs of the southern Gulf of St. Lawrence from the northern tip of Cape Breton and including the Chaleur Bay (Chaput 1995).

The hydrology of the Miramichi has been described in considerable detail by Cassie and El-Jabi (1995) and presented as Chapter 6 in: *Water, Science, and the Public: The Miramichi Ecosystem* Edited by Michael Chadwick (1995).

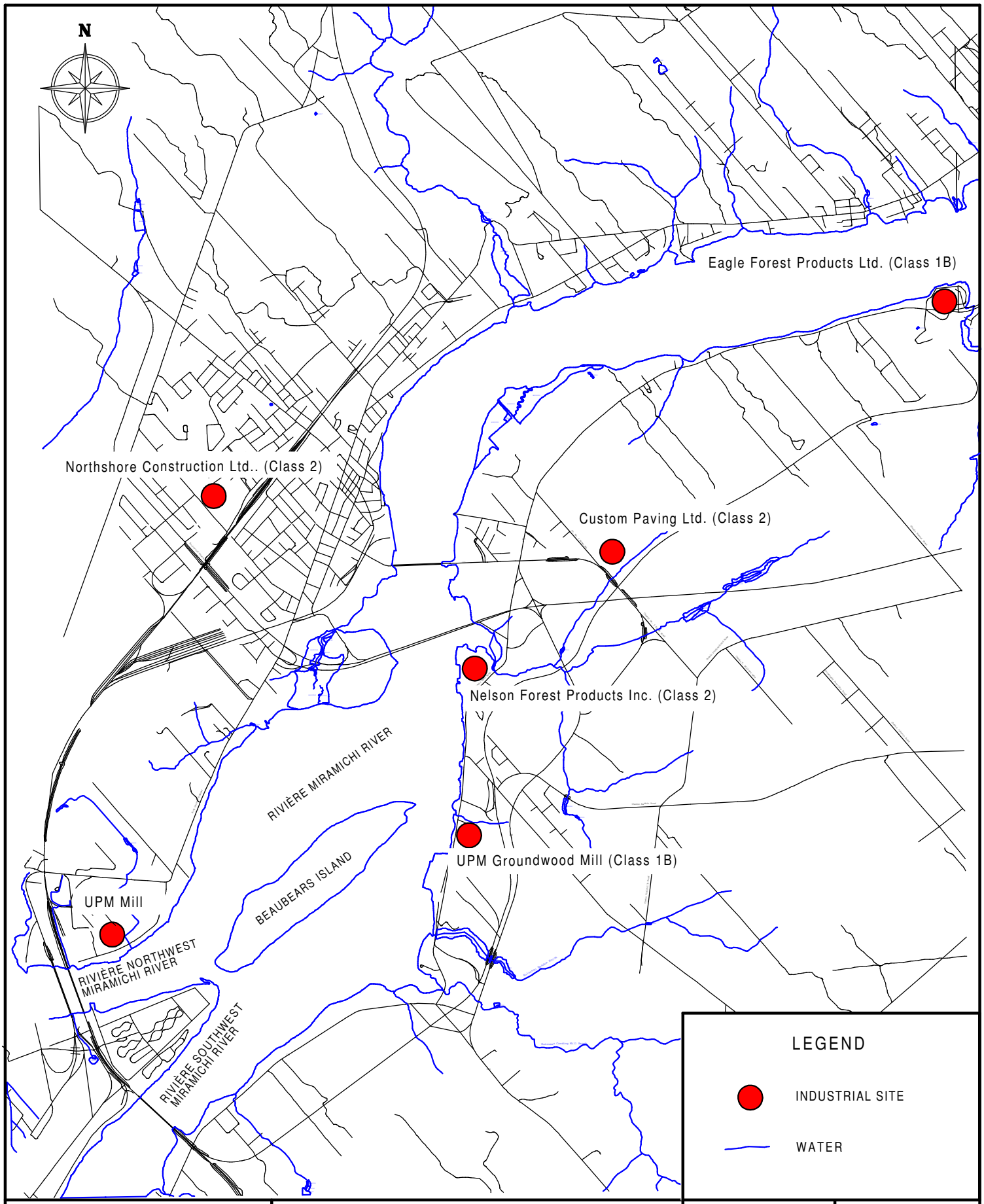
Meteorological data was obtained from two meteorological stations, one on the upper estuary at the city of Miramichi (Chatham), and the other near the centre of the catchment area at the NB DNR Ranger station near McGraw Brook (Fig 3-2). The discharge, or runoff characteristics, was studied using five existing gauged drainage basins positioned at critical points. Some of their findings are summarized below and much is taken almost directly from their abstract.

The Miramichi drainage basin is coldest in January, with a mean monthly temperature of -11.8°C, and warmest in July with a mean of 18.8°C. Between these two extremes, gradual

Figure 3-2



MREAC STATE OF THE ENVIRONMENT REPORT **MIRAMICHI WATERSHED** **MONITORING STATIONS & SWIM WATCH SITES**	NATECH Environmental Services Inc. Patterson Rd., Harvey Stn., N.B., E6K 1L9 ph: (506) 366 1080, fax: (506) 366 1090	DATE: 06/03/09	SCALE: AS SHOWN
		FILE: MREAC-05-01	FIGURE: 3-2



MREAC STATE OF THE ENVIRONMENT REPORT
MIRAMICHI INDUSTRIES

NATECH Environmental Services Inc.
Patterson Rd., Harvey Stn., N.B., E6K 1L9
ph: (506) 366 1080, fax: (506) 366 1090

DATE:	SCALE:
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FILE: MREAC-05-01	FIGURE: 3-3

changes in monthly temperatures occur. This region of New Brunswick can receive between 860 mm and 1365 mm of annual precipitation with a long-term annual value of 1130 mm.

The average annual runoff (or discharge per drainage *unit*) was estimated at 714 mm which represents 63% of total precipitation (1130 mm). Therefore, water consumption by plants or storage in aquifers (groundwater) is 416 mm or 37%. The mean annual river flow from the total Miramichi catchment area was estimated at 317 m^3/sec, with a median flow of approximately 158 m^3/sec (the flow which is equalled or exceeded 50% of the time).

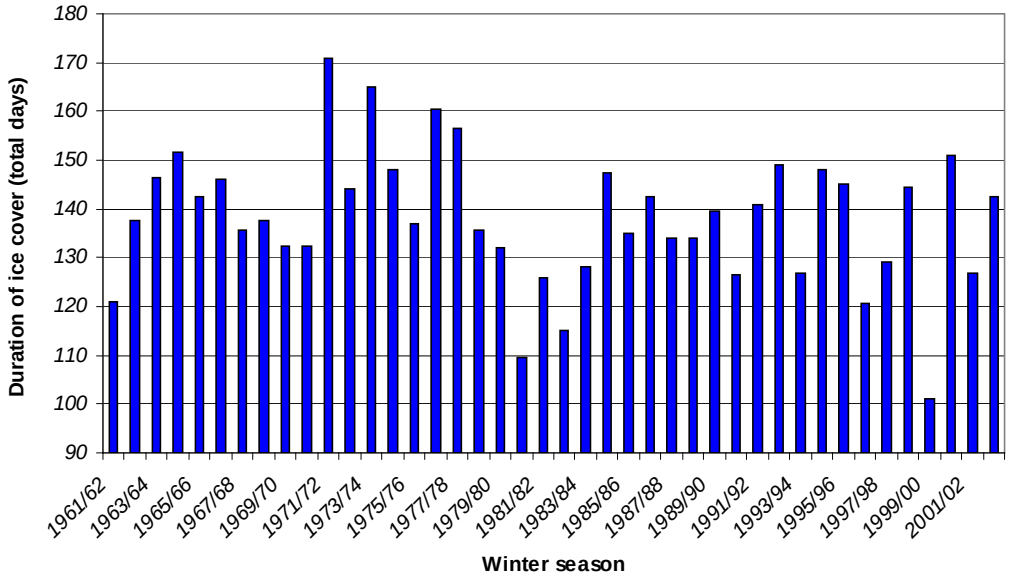
Chadwick (1995) stated that precipitation was reported to occur during an average of 160 days per year. Minimum rainfall is during the months of April and July and maximum rainfall occurs in November. River flows are high in the spring due to the snowmelt in April and lowest in mid to late summer. Peak monthly flows may be six times the annual mean. By contrast, low summer and winter flows are about one tenth of the annual mean. Maximum water temperatures of 18°C to 22°C are reached in July and August. The water cools rapidly to reach freezing point in late November or early December.

River discharge studies carried out by D. Cassie (2006) in several sub-basins within the Miramichi system confirm that small rivers, such as Catamaran Brook, generally experience higher flood discharge per drainage area, being more responsive to rainfall and snowmelt events. By the same token, these smaller streams are less able to maintain summer flows under dry conditions. This could have serious consequences for salmonid survival. Any changes in the overall hydraulic circumstances for these streams as a result of changes in climate and meteorological conditions or land use such as clearcutting, could enhance negative effects on fish habitat and abundance.

While ice cover is a fact of life during the winter months in the Miramichi watershed, its importance to salmon is uncertain. Parr show a preference for ice cover when it is available or first forming and do well in subsurface ice conditions (Linnansaari, 2006). The greater effect that ice has on salmon survival probably occurs during break-up and

spring runoff where ice scour of gravel spawning beds can alter suitable habitat or damage incubating eggs.

Duration of Ice Cover



Daniel Caissie from MREAC Science Day 2006

Several of the studies carried out on the Miramichi fresh water system have reviewed water chemistry (Randall et al. 1989, MREAC 1992 and some later reports, Komadina-Douthwright et al 1999, Cunjak et al 2004, Cunjak & Newbury 2005). The results indicate a near neutral soft water system that is typically low to moderate in productivity. Although the water in the Miramichi system is generally well-buffered (mean pH from 6.5 to 7.8), the melting snow pack during spring thaw can occasionally cause localised, short-term acidic pulses (i.e. pH<5.2). The implications of acidity from acid rain in stream water, its role in releasing toxic metals and its effect on the health of aquatic species will be discussed in Chapter 5 as a stressor on the system.

3.2.1.2. Estuary

The Miramichi estuary (Fig 3.1) has been the subject of numerous studies over the past quarter century. One of the best summaries is given by Chiasson in *The Miramichi Bay*

and Estuary: An Overview, **pp 11-27 (in Chadwick 1995). Descriptions pertaining specifically to the physical characteristics of the estuary are given *in Chapter 4: Seasonal and Short-term variations in the Estuarine Structure of the Miramichi* by Lafleur et al. pp 45-71 and also *Chapter 5: Is the Miramichi a Stratified Estuary* by St-Hilaire et al. pp 73-82 (both in Chadwick, 1995)**

Using mixed classifications, the Miramichi could be described as having a microtidal estuary with the upper part as a stratified drowned river valley then widening out into a bar-built inner bay.

At Beaubears Island, the confluence of the two main tributaries, the estuary is about 1.4 km wide and has an average depth of around 4m. Upstream from this point the tide migrates about 10 km up the Northwest Miramichi and over 20 km up the Southwest Miramichi. Moving downstream from Beaubears Island, the estuary meanders through the city of Miramichi for about 30 km to Sheldrake Island where it meets the apex of the triangular-shaped Inner Bay. Initially, it is about 750 to1000 m wide down to Chatham docks, *but by* the time it reaches Sheldrake Island a further 12 km downstream, it is 1.5 km wide before opening out to form the Inner Bay. In this vicinity, the Bartibog River enters the estuary from the north and the Napan River from the south.

The Inner Bay is essentially triangular in shape with a *7.6m deep* dredged navigation channel meandering up the centre. The area is shallow with an average depth at low tide judged to be around 4m and seldom above 7 m. The inner bay widens fairly uniformly from Sheldrake Island for about 20 km to meet the 30 km long barrier islands protecting it from the Gulf of St Lawrence. Four principal islands and numerous smaller ones make up the barrier islands, which stretch along the Northumberland Strait for a distance of about 32 km. The 60 km long navigational channel wends through the southern end and stretches from Chatham docks to outside the barrier islands, with an original dredged depth of 7.6 m. A dredged spoil dumpsite (Dumpsite B) situated in the middle of the Inner Bay has given some environmental concern in the past.

The need for traditional channel dredging has been a result of the annual deposition of some 95,600 tons of sediment from the river. This situation has been exacerbated during the past century due to increasing forestry operations and other developments in the

basin. Between the 1950's and 1970's, an additional 20,000 tons of bark, wood fibre and bio-solids were discharged to the river per year from growing pulp and paper operations at the head of the estuary. The environmental implication of this high organic loading to the estuary was an increase in chemical oxygen demand in both the water column and organic rich sediments. These can have adverse consequences for benthic and aquatic animals (Buckley 1995).

Sedimentation rates in the upper estuary are up to 4 cm per year. These sediments contain contaminant metals from runoff and mining operations in the watershed including zinc, lead, copper, cadmium and mercury. Any considerations about dredging or sediment remediation in the estuary are fraught with concerns over the disturbance of contaminated sediments and the release of toxic substances which, if left undisturbed, pose little threat. The barrier islands show evidence of considerable sediment transport from north to south along the coast which would be the fate of any contaminants leaving the estuary and entering the Gulf of St. Lawrence. (Philpott 1978).

Tides in the estuary are small with ranges of 1.2 m and 0.2 m for large and small tides respectively (microtidal < 2m) and having a mean tidal range of around 1 m. The tides can be described as mixed with semidiurnal oscillations dominating. This is demonstrated by the small percentage change between succeeding high or low waters during the large or spring tides and the very large differences that occur between succeeding high or low water elevations during the small or neap tides. There is a 70 minute phase lag between high water at the barrier islands and inland at Chatham. The tidal range is also about 10 - 20% greater at Chatham.

The penetration of salt water into inner Miramichi Bay and estuary has been the subject of a number of studies (MacLaren-Marex 1978, Phillpott 1978, Chiasson 1995, Lafleur et al 1995, St-Hilaire et al 1995). Fresh water, being lighter or less dense, tends to flow over the top of the heavier salt water, and when there is no side constraint it spreads out in a thin layer. If there were no other influence, the shear between the two layers, caused by the seaward movement of the river water, would cause some salt to be entrained into the upper layer. This in turn would require a small landward flow in the deeper salt water to replace the eroded material. In reality, however, movement of the intertidal prism moving in and out of the estuary causes mixing between these two miscible layers as does the

influence of wind shear on the water surface particularly in shallow waters. Dominating the whole process is the amount of freshwater being discharged into the estuary relative to the tidal prism.

In the inner bay during conditions of average river flow or less, the water column is usually well mixed and of only slightly lower salinity than that found outside the barrier islands. Within the river estuary section, however, some degree of vertical stratification occurs. The degree of stratification or mixing depends on the relative strengths of the tidal prism and freshwater flow occurring at the time and the position in the estuary and water depth at the point under discussion. Fine particulates and dissolved contaminants carried by the river water will be deposited in an area where this mixing occurs (turbidity maximum) causing an area of maximum deposition. At this point, because they tend to become attached to fine particles, there may be elevated levels of contaminants introduced into the river many kilometres upstream or at the area of industrial inputs (Courtenay et.al, 1995).

A number of Van Veen grab samples (area 0.0625 m^2) were taken in the estuary by MREAC during 2003 and 2004 and the organisms identified and quantified by Envirosphere Consultants of Windsor, Nova Scotia as part of the Canadian Aquatic Biomonitoring Network (CABIN Envirosphere Consultants 2003, 2004). Their data can be viewed as being representative of benthic communities dwelling in areas subject to significant estuarine salinity variations and having experienced or experiencing some organic loading. Samples taken in the drowned river valley section of the estuary show lower abundance and species diversity since this area is subject to greater salinity variation from fluctuating river flows and is also closer to industrial and municipal outfalls. Samples taken from the more open inner bay generally represent a coastal community typical of the substrate present. Sampling stations included Dumpsite B and a location near Portage Island. None of the sample reports give rise to any significant concerns.

"All samples looked more or less acceptable and the low diversity at Chatham Marina could be due to its position where considerable salinity variation occurs. The polychaete occurring there (Maranzellaria viridis) is sometimes associated with stressed environments, but the occurrence of the clam Macom suggests more of an estuarine

community than an organically enriched or contaminated one (P. Stewart, Envirosphere Consultants, pers. com.). Referring to the 2003 report, which was more focused on the Douglastown area, he commented that the sites sampled didn't appear to have any contamination issues. They all had an acceptable (although low) number of species present and none of the archetypal pollution indicators were evident. The low numbers could again be attributed to the estuarine influence.

3.2.2 Biological

Despite being one of the few unregulated large rivers in the Maritimes, there have been no comprehensive studies undertaken on the biology and ecology in the upper reaches of the river. The exceptions are the numerous studies of its well-known Atlantic salmon and brook trout populations (Cunjak & Newbury, 2005). Geographically limited studies (Catamaran Brook - Giberson & Garnet 1995) suggested macrobenthic fauna to be diverse and rich, but there was little published information on any of the main branches or tributaries. A few freshwater mollusks are known to occur, but again no systematic study has been undertaken. Conversely, the lower reaches and the estuary of the river system have been well studied and a very comprehensive report on the "Ichthyoplankton and Invertebrate Zooplankton of the Miramichi Estuary (1918-1993)" was provided by Locke et al as Chapter 7 pp 97 -120 in Chadwick (1995). Species diversity was reported as being similar to other Atlantic estuaries.

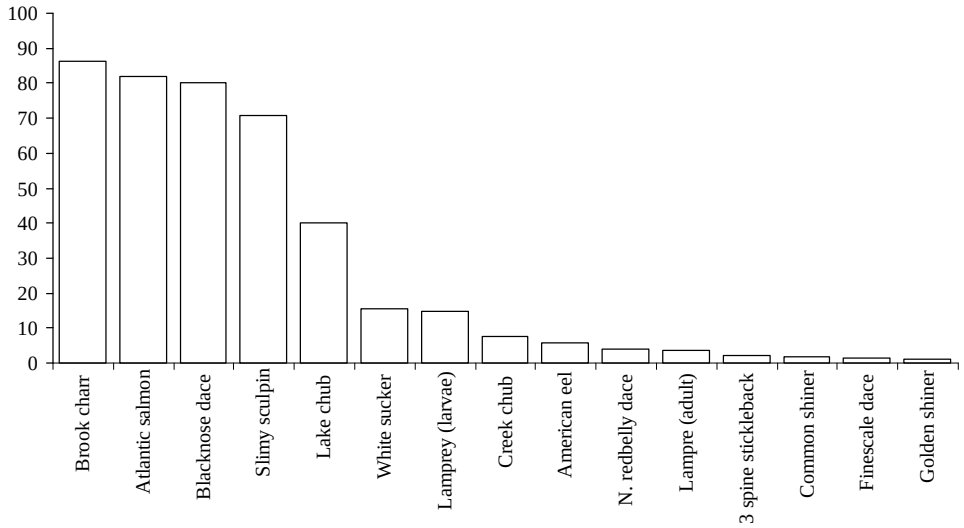
3.2.2.1 Freshwater and Diadromous Fish

In addition to Atlantic salmon and brook trout, the Miramichi river system supports significant numbers of eight other diadromous fishes (sea lamprey, American eel, alewife, blueback herring, American shad, rainbow smelt, Atlantic tomcod and striped bass) (Chaput 1995). Atlantic sturgeon, although reported to be a food fishery in the past (pre-1900), is now only an occasional visitor and those present are thought to be strays from the Gulf of St Lawrence/Quebec population (Bradford, pers. com.). The Miramichi river system is the area of greatest abundance of the rainbow smelt in Atlantic Canada (Scott & Scott 1988).

In sport fishing circles, the Miramichi and Atlantic salmon are 'hand and glove', and the river is still thought to produce more wild salmon than any other river in North America. Despite that claim, however, the salmon returns to the river have been in decline since reaching a recent peak in 1992 (Cunjak & Newbury 2005). The decline in returns is believed to be likely due to poor marine survival and has taken place despite increasing numbers of juveniles found in the rivers and increased management efforts to protect the stocks. The major disparity between sea-going smolt and the subsequent return of the same year class as grilse (first time spawners) is still a major concern. ***(For a fuller account of salmon in the Miramichi see "The Salmon Story", section 3.2.2.1.1.)***

The Miramichi has a diverse fish fauna for the Maritime Provinces. In the river system, Randall et al. (1989) listed 21 species (representing nine families) found entirely in freshwater. Cunjak (2005) added the recently introduced brown trout to this list. Mitchell (2006) reported the relative abundance of 15 fish species regularly occurring in 430 samples from Catamaran Brook over a number of years. The five most abundant species were brook charr (trout), salmon, blacknose dace, slimy sculpin and lake chub all occurring in from 85 to 40 percent of the samples. Riffles supported the largest numbers of salmon where pools provided a more balanced distribution of the top four species, reinforcing the importance of varied habitat in a well-balanced river ecosystem.

Percentage of 430 samples in which each species present



Sean Mitchell from MREAC Science Day 2006

Other non-native fish in the Miramichi system include white perch and chain pickerel *which could threaten the system as invasive species or non-native introductions released intentionally or unintentionally. An isolated occurrence of chain pickerel in one of the lakes in the Miramichi system lead to that species being purged from the lake as a conservation measure (Cunjak, pers com).* Cunjak also expresses concern about the potential impact on native Atlantic salmon and brown trout from further introductions such as small-mouthed bass.

The Northwest Miramichi harbours the most northerly spawning stock of striped bass and has received considerable attention from scientists (Chaput & Robichaud 1995 Bradford et al 1995, Robichaud et al 2000,). The species was extirpated from the St. Lawrence River in the mid-1960's through causes which possibly include habitat degradation from river channel dredging in the vicinity of spawning areas, water pollution and intense fishery exploitation. It is also known that striped bass are very susceptible to anthropogenic inputs from industrial developments (Chaput 1995).

Assessment of the striped bass spawning run to the NW Miramichi shows that it peaked in 1995 at 50,000 fish but dropped to approximately 4,000 fish between 1998-2000. (Douglas et al., 2005). The commercial fishery for striped bass was closed in 1996, but it remains a significant by-catch during the commercial smelt and gaspereau fisheries. Data on by-catch of striped bass in the gaspereau fishery in the mid-1990's supported the perception at the time that striped bass abundance was low relative to the long-term average (Bradford et al. 1995). Due to continuing fishing pressures, recreational fishing of striped bass was closed in 2000 and the native allocation was also suspended (Murray, 2006). Recent studies show a modest but steady return to an average for the years 2001-05 of around 22,000 returning spawners. A small number of these are being used each year in an effort to reintroduce Striped bass to the St. Lawrence River system in partnership with Fisheries and Oceans staff in Quebec.

Despite many unanswered questions over the sustainability of striped bass populations, a large body of scientific information has been gathered on this species over the past decade. Studies and observation have allowed some general conclusions to be made about risks for the sustainability of striped bass. Poaching through illegal gillnetting and

illegal angling is seen as high risk and removes thousands of adult bass each year. Also at high risk is the rainbow smelt fishery where hundreds of thousands of YOY (young of the year) striped bass are taken as by-catch. Also ranked high is the risk of losses to by-catch with the American eel fishery and the aboriginal gillnet fishery for salmon as well as coastal fisheries where gillnets are set too close to shore. Losses to by-catch from the gaspereau fishery are thought to be moderate. Scientific research removes a few fish through beach seining and other sampling methods, but the impact of that activity is low (Douglas, 2006).

Other human activity such as habitat alteration, industrial effluents and power generation can be expected to have an effect on striped bass, but the risk from these is uncertain. Pulp mill waste can be toxic to bass and along with municipal wastes and other effluents contain contaminants such as endocrine disruptors which threaten the health and sustainability of this species.

In an assessment and status report by COSEWIC (Committee on the State of Endangered Wildlife in Canada) (2004), it is noted that striped bass is an important component of the biodiversity of estuarine and coastal water ecosystems. An abundant striped bass population is an indicator that a river and its estuary are in good condition. They are a relatively long-lived species reaching anywhere from 12 to 20 years old (Chaput, 1995). The species requires high quality spawning and nursery habitat and abundant aquatic species for food.

It seems evident that the entire Southern Gulf of St. Lawrence population of striped bass stems from a single breeding location along a limited portion of the NW Miramichi. If this is the case, then the sustainability of this species is at great risk. Consideration is being given to designating striped bass as species at risk in the Gulf of St. Lawrence to provide it long term protection while recovery efforts continue.

American eel landings in the Miramichi peaked around 1970 (Cairns et al., 2004). Landings reported since 1992 have been fairly steady at about one quarter of the peak value with a minor increase in years 2000-2002. An Integrated Eel Fishery Management

Plan was instituted for Eastern Gulf Region (including Miramichi) for the period 2001-2006. More recently the health of the stock has been a concern and their status is under review by COSEWIC.

3.2.2.1.1 The Salmon Story:

A relatively healthy Atlantic salmon population in the Miramichi River is a good-news story for the state of the river basin. The presence of salmonids (trout, salmon and char) in rivers and streams has long been seen as an indicator of good water quality and relatively undisturbed aquatic habitat. These species have a low tolerance for warm water and depleted oxygen levels and are very sensitive to contaminants including silt, heavy metals such as mercury, zinc or copper, pesticides and other organic pollutants. They also have stringent freshwater habitat requirements which include clean gravel beds with good water circulation for spawning and sustaining eggs, unrestricted access to breeding sites on tributaries and feeder streams, and adequate summer flows for adult and young fish. The availability of cool water (< 20° C) either from small well covered tributaries or groundwater seeps is important to young salmon and essential to species such as the slimy sculpin (Breau, 2006). The whole Miramichi watershed is essentially unrestricted with a relatively low gradient and few physical barriers so upstream and downstream access for salmon is not an issue. Because of this, salmon juveniles are well distributed throughout the watershed.

Historical numbers of huge salmon runs are unlikely to return to the Miramichi River. Nevertheless, there are suitable numbers of grilse and large adults to allow for recreational salmon fishing to be pursued, with a catch and release policy for adult salmon and some harvest of grilse. A strong research and monitoring program is ongoing to assist in stock management. Numerous fishing lodges along the length of the river still provide significant economic benefit to the community.

In New Brunswick and eastern North America, the Miramichi River has for many years been renowned for its recreational salmon fishing and, along with the Restigouche River, is one of the best salmon fishing streams in Eastern Canada. These rivers contribute a disproportionate number of spawners to SW2 (Maiden salmon which have spent two years at sea before returning to the river to spawn) salmon production in North America

and are therefore highly important to the overall Atlantic Salmon population (Moore 2006). This population in North America has been under severe decline over the past decade. Extensive scientific studies still do not have definitive answers, but it appears that poor survival at sea is the current root cause along with long-term habitat degradation.

Historically, juvenile salmon populations were severely depressed in the late 1950s and early 1960s. Additionally, some runs of shad, gaspereau and rainbow smelt virtually disappeared from the Northwest Miramichi in 1955 and did not return for the next 13 years (Zitko 1995). From 1970 to 1992, however, returns and spawning escapement of small salmon doubled, and returns of large salmon increased every year between 1986 and 1993 (Chaput 1995). Adult breeding salmon returns have maintained an acceptable level since that time and juvenile abundance in recent years is at carrying capacity of the system. The gap or disparity between sea-going smolt and the subsequent return of the same year class as grilse is still a concern, and the cause or causes remain a mystery (Murray, 2006).

Significant improvements are being made with fish habitat conservation, restoration and development in the Miramichi River Basin (Hache & Plante 2006). Much of this has been accomplished by the removal of a number of impoundments on a various smaller tributaries, This, along with strenuous efforts by industry and municipalities to reduce effluents entering the river from waste treatment plants, pulp mills, mines and other industrial activities, has promoted a stable salmon population. While overall populations may be declining, their presence throughout most of the system bodes well for environmental sustainability from a water quality perspective.

Habitat and the river environment are critical for salmon at certain stages in their life cycle. Miramichi salmon spawn in October/November. In May to mid-June young-of-the year Atlantic salmon emerge from the gravel at a total length of about 2.6 cm (Randall et al, 1982). Juveniles remain in the stream for two to three years where they feed mainly on drifting invertebrates (Breau et al, 2006). The ecosystem that supports juvenile salmon in small canopied streams relies mostly on carbon sources derived from leaf litter falling into the stream whereas in wider streams there is a shift to reliance on carbon derived from algae (Cunjak, 1995). Here one can see the important impacts that might arise from

changes in stream cover and loss of leaf detritus brought about by forest removal adjacent to small streams. Buffer zone policies are extremely important in minimizing such impacts.

Despite its classification as a northern river, water temperatures lethal to salmonids are reached in the Miramichi several days per year (Lund et al. 2002). In such situations, cool water sources play a critical role as thermal refugia for fish such as juvenile and adult Atlantic salmon and brook trout during the summer months (Breau, 2006). The preferred temperature for salmon is between 14-18°C and lethal temperature occurs around 27.8°C. Therefore, thermal refugia such as the mouth of tributaries and groundwater seeps, where temperatures are cooler, are important for the survival of juvenile Atlantic salmon during sub-optimal conditions.

Salmon will move to cooler water and aggregate there even if the temperature difference is only a few degrees, e.g. from 22 ^{o} C river water to a 17°C cool water seep. One of the key findings in a study by C. Breau et al (2006) was that one and two-year old salmon moved to cool water sources during high water temperatures in a moderately flowing, well-oxygenated river. Younger smaller fish did not move or aggregate in the same way in response to high temperatures and seem to be less dependent on these cold water sources (Breau, 2006t). Loss of these cool water refugia through extensive removal of forest cover has a negative affect on juvenile salmon habitat.

Throughout the eastern seaboard of Canada and the United States salmon populations are in a critical state of decline. This is especially true in the southern part of its range and particularly in the Bay of Fundy rivers. There is, however, cautious optimism for New Brunswick's Miramichi and Restigouche Rivers. The Miramichi produces 20% or more of all North America's salmon, and reached 85% of its base conservation level in 2005, an improvement. The Restigouche met its conservation limit in 2005. It may be that returns will be better still in these rivers in the year ahead.

Escapement records for salmon leaving the Miramichi River dramatically show the results of eliminating commercial fishing from the Miramichi in the mid-1980's. In 1982 for example, 30,758 large salmon returned but only 13,258 were estimated to have survived and spawned, a ratio of just 43%. In 1992 however, out of the 37,000 large

salmon returned, it is estimated that 35,927 escaped to spawn, a ratio of 97%. That is a clear demonstration of the great value of conservation efforts to maximize spawning escapement, which was achieved by eliminating the nets and introducing the catch-and-release principle as a way of sustaining the species. Over the past 10 years, repeat spawners to the Miramichi have increased approximately 40 percent, with thousands on their second to fourth spawning migration and hundreds returning for their fifth to sixth spawning runs (Moore, 2006).

While spawning success and salmon returns seem to be up, the production of smolts is less than would be expected. Other than the question of losses at sea, it seems that contaminants such as endocrine disruptors might be affecting the sustainability of salmon populations. The estuary remains a dangerous and less pristine environment than salmon faced historically, despite improvements in river water quality.

There are a number of threats to salmon survival on the Miramichi River including poaching, environmental contamination, habitat disturbance and various environmental factors such as drought, floods and climate change. Predation is another factor. For example, it has been estimated that one adult merganser will consume more than two thousand juvenile salmon in one year. The number of adult female mergansers per hectare varies roughly between 0.1 and 0.25 from year to year. Controlling the merganser population to reduce predation on salmon has been used as a management tool from time to time.

Two serious threats to salmon in past years have been forest pesticide use and heavy metal mining. DDT was used to combat the spruce budworm in New Brunswick between 1954 and 1968 with devastating impacts on juvenile salmon and other fish species, not to mention songbirds and other wildlife. The use of pesticides to control forest pests still continues to this day although the chemicals used are more targeted and have reduced effects on fish and non-target species.

In 1956, a base metal mine was developed on the Tomogonops River, a tributary of the Northwest Miramichi River. Levels of copper and zinc in water and sediments reached a point where salmon were virtually eliminated from the Tomogonops. Although spills and effluents were better controlled and pollution reduced, in the mid-1970's mayflies were

still absent although caddisfly larvae were returning (Zitko, 1995). Such long-term effects have now been reversed since the mine closed in 2000 and there is an ongoing effort by Heath Steele (now owned by Xstrata) to control and neutralize pollution emanating from the mine site.

The wild salmon's life cycle is complex. After hatching in freshwater, salmon go through several growth stages - alevin, parr, fry, smolt - before moving downstream and making a remarkable transition to salt water. At that point they head out to sea for a period of one to two years or more. Salmon from both sides of the Atlantic migrate to waters off southwest Greenland and stay for one or two years. They then make a return journey of up to 4,000 km to their native river to spawn. Salmon that spend only one winter at sea are called grilse.

Like many fish species, salmon survival is a numbers game with large losses at every stage of survival. Generally, out of every 7000 eggs laid, only 70 smolts will survive to migrate to sea. From the 70 smolts that made it to sea, four adults will successfully migrate back to their original river and three will successfully spawn (mgt report 2006). In the colder northern New Brunswick rivers such as the Miramichi, smolts are usually age-three when they leave the system for marine waters and are older than smolts from more southerly Maritime rivers (Cunjak,1995).

In recent years, there has been a disturbing trend of migrating salmon disappearing - failing to appear in their home rivers after migration. This is known as "mortality at sea" and is of grave concern. Every salmon failing to return from Greenland represents lost potential for producing thousands of eggs in rivers already crucially under-populated with salmon. It is now estimated that the average rate of ocean mortality has doubled in the past two decades to about 3% per month.

3.2.2.2 Estuarine fish

The 300 km^2 estuary, Miramichi Inner Bay, is home to many fish and shellfish species. The brackish waters and rich food base of the Miramichi estuary and inner bay make this an important rearing environment for more than 20 fish species. These include “true”

estuarine fish, like tomcod and sticklebacks, as well as marine species such as flounder, herring, and capelin (Locke and Courtenay, 1995). Chiasson (1995) found that the estuary serves as a temporally important habitat for 47 species. *A similar number of species, some of which were rare or transient, was described by Hanson and Courtenay (1995) in a fish survey of the inner and outer estuary.* Among those of commercial importance are smelt, cod, blueback herring, alewife, eel, flounders (sand, smooth and yellowtail), herring, mackerel and shad (a striped bass fishery is now closed). Some of these fish use the area for brief periods en route up river or to the sea (e.g. salmon) for spring/summer feeding (trout), or for overwintering (tomcod, smelt), whereas others use the estuary for their entire life (smooth flounder, mummichog). The south-western portion of the bay, in the Escuminac area, contains important spawning sites for herring.

In the 1992 report, and at some of the subsequent workshops, it was pointed out that the location of spawning and early life forms of some anadromous species in the upper estuary (the area between McKay's Cove and Sheldrake Island) could place them at some risk from industrial pollution at that location. This concern was also linked to Atlantic tomcod and striped bass, which also utilise this area as nursery habitat. In the inner bay, the valued nursery area for a number of marine fish and shellfish species was also recognised as being potentially threatened, in this case not only by sediment and waterborne industrial pollution moving seaward, but also by having contaminated dredge spoil deposited in that location.

Commercial fisheries are confined to the estuary and the lower reaches of the river below the head of tide (Cunjak 2005). Gaspereau (a term used to collectively refer to the freshwater clupeids, blue herring and ale wife) and smelt account for 90% of the total biomass of commercially exploitable diadromous fish passing through the estuary (Chaput, 1995).

3.2.2.3 Shellfish (Crustacia and Molluscs)

There are locally important lobster and crab fisheries in the area with both juvenile and adult lobsters found in the inner bay. The major productive area of these species occurs in the outer bay. Oysters (LeBlanc 2005), mussels, quahogs, and soft-shelled clams can

be found and are a significant commercial component of Miramichi Bay. Faecal contamination has caused closure of the narrow part of the estuary but this situation has improved (2003) and other gains are believed possible. The commercial cultivation of the American oyster has generated considerable interest and a few growers have sizable operations on the estuary. Many other leases have been secured for oyster cultivation.

3.2.2.4 Aquatic Mammals

Beaver, mink, and river otter are the most common aquatic mammals occurring in the Miramichi River basin.

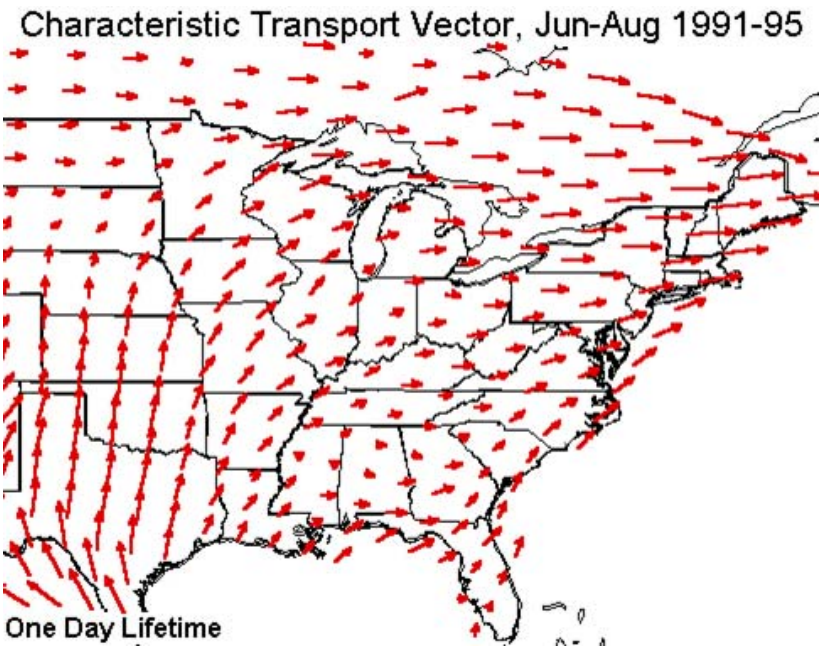
3.3 Air

3.3.1 Regional Climate

The climate of the Miramichi area is considered to be continental rather than maritime. The reduced influence of the ocean is attributable to the general movement of air masses across the area from west to east. The air reaching the area carries the imprint of its passage over the North American continent. There are two major meteorological stations positioned in the watershed. One was at the former Chatham airport, within the new city of Miramichi on the estuary, closed in 2005. The other is further inland at Doaktown.

3.3.2 Imported Air Pollution

In their conclusions after the workshop, the Air Resources Management Area (ARMA), Miramichi committee, concluded that over 80% of the air impacts in the area were imported from the USA and other Canadian provinces. The following figure shows the predominant air flow over eastern Noeth America (Piercey, 2006).



Acid rain, while still considered a concern for the area, had been reduced by about 54% since 1980. About 30% of this improvement was attributed to the USA and it was anticipated that, with measures currently in place, this improvement would continue. Mercury in precipitation was moderately high in the region and raised a problem in some biota. Loons and older age class fish were specifically mentioned, although it was noted at the workshop that there were other potential mercury contributors to the problem and that it was not just in rainfall.

3.3.3 Air Quality

As a result of a *Clean Air Strategy,* announced in 1993, (NB Dept of Environ. 1993) the New Brunswick *Clean Air Act* came into force on December 15, 1997. One of the components of this strategy was to establish five regions in the Province and identify them as Air Resource Management Areas (ARMA) One of these covers the Miramichi area.

The ARMA Miramichi committee was launched in the spring of 1997 with the purpose of bringing together members of the community with concerns and expertise in the area of air quality. As a result of their deliberations, the ARMA Miramichi hosted a workshop in

mid-April, 1998, some details of which are referred to below. Their full report is provided in *ARMA – Miramichi Airshed Management Plan* (Fall 1998). On completion of this report, this local ARMA committee was dissolved. Ongoing annual reports on air quality for the area are issued within the Provincial Department of the Environment.

3.3.4 Miramichi Airshed

The ARMA-Miramichi airshed, for discussion purposes, can be viewed as having substantially the same boundaries as the Miramichi watershed depicted in Fig 1-1. The 1998 ARMA workshop concluded that, in the New Brunswick setting, the Miramichi Airshed represented what could be considered good air quality. However, in the Miramichi City area there were some health and aesthetic concerns mainly related to certain industries.

In addition to industrial impacts on air quality, the Miramichi was noted to be affected by motor vehicle emissions, wood burning for home heating, commercial use of pesticides, and auto body and spray painting operations. Due to the nature of these impacts on the Miramichi air-shed, the parameters of greatest interest are total suspended solids (TSS), carbon oxides (CO2, CO), sulphur oxides (SOx), Nitrogen oxides (NOx), ozone (O3), and volatile organic chemicals (VOC). In some specifics, ARMA recommended better education about causes of air pollution, singling out ozone generation, wood burning and unlicensed activity in auto body repairs.

4. RESOURCE UTILIZATION

This section is devoted to resources that are harvested or utilised from the watershed, changes that have taken place since 1992 and also to record what steps are being taken to replace what has been removed or to restore disturbed habitat. One should keep in mind that the resources associated with water, land and air are not just harvested but are used in other ways; e.g. to generate power, to grow crops or to support recreation. We also use these three environmental media (resources) as a dumping ground for waste and the recipient of effluents and emission. The term "resource utilization" is used in this broader sense in order to show how harvesting and other activities affect environmental resources and the state of the Miramichi watershed.

4.1 Terrestrial

The dominant land use in the watershed is forestry along with its associated industries. The majority of the forestry activity is undertaken on Crown Land. The NB Dept of Natural Resources works with the industry to develop management plans that also consider wildlife. Mining activity in the Tomogonops watershed, a tributary of the Northwest Miramichi, ceased in 2000 and much remedial activity has already taken place. More remedial activities are planned to take place in 2006/7. Peat harvesting has increased at a number of sites in the lowlands around the estuary since the 1992 Report was published. Other peat lands are slated for exploitation. Agricultural activity plays a minor role in the watershed.

Recreation and tourism, particularly in the winter, has increased. The organising of a snowmobile trail system, and a more extensive and better logging roads has opened up much of the higher ground in the watershed. Increased activity by snowmobilers and ATV's utilising the back country raises some concerns about wildlife disturbance and poaching.

4.1.1 Forestry

In 2005, the value of forestry exports from New Brunswick was $1.9 billion (Cdn) with approximately 17,700 jobs directly related to the industry (Canadian Forest Service, 2005). Wood products are the major natural resource in the Miramichi watershed. As noted, over 90% of the Miramichi watershed is covered by forest, mainly softwoods but containing a significant portion of hardwoods with most of the activity occuring on crown land (Crown Reserves) harvesting is conducted under NB DNR management plans. These plans are required under the 1982 Crown Lands and Forest Act of New Brunswick. Under the act, licences are provided to major forestry companies for large blocks of land. Licensees are required to provide a detailed minimum 25 year plan for their blocks of land showing an inventory of the new resources, their harvesting plan on a five year basis and their accounting for any special environmental considerations (e.g. deer yards, species at risk and their habitat, and other special wildlife requirements like old forest habitat). At this time, major leaseholders include UPM-Kymmene, J.D. Irving Ltd., Bowater and Weyerhaeuser.

The Crown Lands and Forest Act affords protection to streams and other watercourses through various requirements including buffer-zones, well situated culverts and bridges and diversion ditches for road runoff. Buffer-zones are particularly important for maintaining water quality and fish habitat. They are zones or areas of restricted activity leaving relatively undisturbed vegetation between the stream and adjacent forestry operations. They range from 3 m on each side of very small watercourses to 60 m on steep sided large streams.

Private woodlot owners must meet the requirements of the Clean Water Act of New Brunswick (1989) which has more complicated and less effective controls. This is because of variable local interpretation and implementation of the Act and its regulations and mixed application and enforcement particularly for small streams (Cunjak et al, 2005).

The standard harvesting technique has been clear cutting, a technique that has generated a great deal of debate and often some misunderstanding. The science generated from the Catamaran Brook project is expected to provide better scientific

information (see section 4.1.1.3). The data presented below have been taken from NB DNR annual reports. While the areas quoted do not cover the Miramichi watershed in its entirety they are believed to be representative of the activities taking place.

In these NB-DNR Annual Reports, the Miramichi watershed contains two reporting areas for forestry: the Lower Miramichi and the Upper Miramichi. Parts of the higher areas of the watershed are included in other designated districts but general trends are likely to be similar. In some of the tables the records are noted to be for Northumberland County only and again do not encompass the whole watershed.

4.1.1.1 Reforestation and woodlot management

Over the past 20 years or more there has been a shift in the vision of forests for New Brunswick from one of all-young forests particularly suitable and efficient for pulp and paper production to one of a mixture of young and old forest with diversity of product and supporting a variety of forest habitats and a rich diversity of forest wildlife. The New Brunswick Department of Natural Resources states that public forest will be managed sustainably to provide the greatest possible environmental, social and economic benefits for New Brunswickers (NB-DNR, web site) They intone public participation, consultation with Aboriginal interests, education, understanding and awareness, and inspection of operations and evaluation of performance as means of achieving this vision.

Wildlife habitat protection is a high forestry management priority. For example, old spruce-fir habitat (OSFH) provides habitat for 56 vertebrate species. Thirty-four of those are habitat-generalists whose requirements are met in a broad range of habitat conditions. The remainder utilise spruce-fir forest only, and 17 of those require OSFH: American marten, white-tailed deer, black-backed woodpecker, red-breasted nuthatch, red crossbill, white-winged crossbill, evening grosbeak, olive-sided flycatcher, boreal chickadee, winter wren, golden-crowned kinglet, ruby-crowned kinglet, solitary vireo, Cape May warbler, Blackburnian warbler, bay-breasted warbler and pine siskin. The structural characteristics of a forest which are required to maintain such species relate to tree cavities, woody debris, dead or dying trees, conifer cones, over-story crown closure,

and a shrub layer. A separate strategy exists for management of white-tailed deer; hence its requirements do not contribute to the definition of OSFH (N B-DNR 2004).

Wintering areas are key to deer survival in New Brunswick. Two winter habitat types have been defined for deer and are managed for in deer wintering areas on Crown land. Under severe winter conditions, deer seek refuge in conifer dominated stands with mature canopies that provide lower snow depths and wind speeds, and higher temperatures. While conifer cover is the required components of suitable habitat under severe winter conditions, it must be in combination with at least some browse. The preferred arrangement is for both components to be provided within stands managed for deer under severe winter conditions. During moderate winter conditions deer take advantage of increased mobility to seek stands of high food value with at least low to moderate cover.

Silvaculture plays a large part in managed woodlands and the province maintains a large tree nursery at Kingsclear near Fredericton (also Irving's tree nursery near Juniper within the Miramichi watershed). This nursery supplies a large portion of seedlings utilised in planting in the Miramichi although plants are also obtained from other private tree nurseries. In the case of Kingsclear seeds, mention is made of the use of 221 Kg of genetically modified seeds and the benefits of their use in forest production (NB-DNR Annual Report 2004-2005). No information was given as to where the seedlings were planted.

The following tables show a significant increase in reforestation efforts from 1998 to 2004/2005 and a smaller increase in stand improvement or thinning activity.

Table 4-1. Planting on Crown land (Ha)

	2004-2005	2003-2004	2002-2003
Lower Miramichi	1804	1180	1217
Upper Miramichi	2186	3092	1304

Table 4-2. Thinning (Ha)

	2004-2005	2003-2004	2002-2003
Lower Miramichi	2398	2869	2636
Upper Miramichi	4986	6723	4470

Table 4-3. From the 1998 Annual report (Ha)

	Reforestation	Stand improvement	Aerial herbicide spraying
Lower Miramichi	901	1992	192
Upper Miramichi	197	3973	35

In reporting activity on Private land woodlots the province utilises the data from Forest Products Marketing boards.

Table 4-4. Activity on private land for Northumberland County (Ha)

	Site Preparation	Tree Planting	Plantation tending	Pre-Commercial thinning
2004/2005	127	113	46	713
1998	73.1	94.5	27.2	1447.7

The above tables indicate similar trends in silviculture activity between crown land forests and within the private woodlots in the watershed. Reforestation in each category has more than doubled between 1998 and the present and has been fairly consistent over the past 3 years. Likewise, during this period, greater attention has been given by the forestry industry toward thinning and stand improvement of the forests.

The forest industry in north-eastern New Brunswick still relies on herbicide spraying to manage hardwood growth after clearcutting. In the 2005 – 2006 season, 310 Ha of the lower Miramichi and 1241 Ha of the upper Miramichi were sprayed with herbicide. Glycosphate is the primary chemical of choice since its impact on non-target animals and aquatic ecosystems in minimal (W. Ernst, pers.com.). The major concern with the use of this herbicide is one of habitat alteration. Removal of re-growth hardwoods eliminates the natural regeneration to a mixed forest habitat with effects on wildlife diversity and the survival of a certain number of species which require hardwood stands. Forests in New Brunswick are fast becoming young forests with a prominence of monoculture softwoods even where mixed forests originally existed (Steve Gordon, pers.com).

4.1.1.2. Harvesting

Table 4-5. Forest Products Harvested from Crown Land (m^3)

	Softwood			Hardwood		
	2004-2005	2003-2004	1998-1999	2004-2005	2003-2004	1998-1999
Lower Miramichi	279,195	280,792	367,910	57,710	64,770	104,210
Upper Miramichi	411,880	440,116	528,515	90,022	91,925	107,615

The above tables demonstrate that harvesting on crown lands over the period, 2003-2005, has been at a lower level than that undertaken in 1998. This is particularly true of hardwoods harvested from the Lower Miramichi. Harvesting in recent years appears to have been maintained at a consistent level and is probably a reflection of the forestry management plans being executed in the area.

In recent years, partly due to the closure of the kraft mill, there is no local market for low quality trees which are now shipped out of the watershed and out of the province. There is also a shift in forestry products with a greater emphasis on better quality saw logs, good quality hardwoods and top quality timber for veneer (plywood industry). There is an anticipated growing need for biomass fuel to operate existing mills. This creates some

concern over the removal of too much trash or detritus from clear cuts which might inhibit natural land recovery in the regeneration processes (B. Dubee, pers.com.). Air quality is also a possible issue with the use of biomass fuel.

4.1.1.3 Research Projects

A number of projects that have been ongoing over the past decade *were* reported on at the Miramichi Science Workshop in March, 2006. These reports will include a variety of topics related to science on the Miramichi and detail a current project at Catamaran Brook.

Cataraman Brook, a third order tributary of the Little Southwest Miramichi River with a drainage area of 52 km^2 and an annual mean discharge of 1.2 m^3 s^{-1}, has been studied extensively for over 18 years as a site for monitoring the impact of forestry activities on a river system (Cunjak et al, 2005). In the Miramichi basin, much of the recent scientific understanding of the effects of forestry on the movement of sediments, mobilizations of ions, changes in runoff and flow, alterations in water temperature and alteration to stream habitat are derived from work done on Catamaran Brook. These studies have followed from a cooperative effort among scientists from federal and provincial agencies, universities, the forest industry and other stakeholders.

The prolific work completed a Catamaran Brook was reported on at the 2006 MREAC Science Workshop. Since 1990 the site has generated:
16 honors thesis
22 M.Sc, M. Sc. F, M. Sc. Eng
12 Ph. D
4 Post doctoral researchers
87 scientific papers published or submitted
(Rick Cunjak – pers. Comm.)

4.1.1.4 Tree Nurseries

Superior seed and seedlings are essential for reforestation where tree planting is required. Foresters have been developing improved seed sources since the 1980's to improve traits of economic importance and maintain broad genetic diversity. Some of these traits are growth rate, straightness, branch size, insect and disease resistance and wood properties. These characteristics are located in superior trees in the natural forest, collected through cuttings and grafts and transferred to nurseries where they are used for producing superior seeds.

The Forestry Division of New Brunswick Natural Resources operates a nursery at Kingsclear where they produce about 20 to 25 million seedlings per year. Nursery seedlings are shipped to New Brunswick's major forest companies and are used to reforest the Crown land these companies have harvested. About 80 percent of the harvested area regenerates naturally. The remaining 20 percent (around 10,000 hectares) is replanted with approximately 20 million seedlings each year. Some forest companies also operate their own nurseries to grow seedlings for the reforestation of industrial freehold land and other private woodlots (Forestry Division, web site).

At the J.D. Irving, Limited Tree Improvement Nursery in Sussex, for example, they have the capacity for producing 25 million seedlings per year. There, seed orchards are managed for seven species of conifers including white spruce, black spruce, red spruce, Norway spruce, jack pine, white pine and tamarack. Long term testing is conducted across the region to ensure stock planted is properly adapted (J.D. Irving Ltd. web site).

Seeds produced in the orchards are stored, until required, in state-of-the-art facilities at the company's nursery in Juniper, NB. At Juniper, seeds are mechanically sown in containers filled with a mixture of peatmoss and vermiculite. They are then grown in greenhouses with two crops per year providing a total production capacity at 25 million trees per year. Roots of seedlings in the soil cannot tolerate temperatures colder than -15° C. For this reason, Juniper Tree Nursery uses snow-making equipment to cover the seedlings and insulate their roots. Seedlings are shipped from Juniper across the region from northern Maine to south-western Nova Scotia.

4.1.2 Mining

4.1.2.1 Minerals

In 2000, the Heath Steele (now owned by Xstrata) base metal mine on the Tomogonops River was closed and decommissioned, thereby removing active mining of base metals from the watershed. Noranda also constructed a major collection system and treatment plant at the mine site to collect and neutralise run-off. In 2001, the company prepared "A Development-to-Closure Review" (Heath Steele 2001). As part of these remedial activities, the removal of two water supply dams in the vicinity of the mine have been completed (2005). Mine decommissioning has also resulted in eliminating the stockpiling of ore and the associated leachate from local wharves in the City of Miramichi.

Prior to closure, Beak International had carried out Environmental Surveys of the Tomogonops River in 1994 and 1998, on behalf of the company, to assess residual damage caused by the release of mine waters into the Tomogonops River from a broken pipeline. The work included chemical analysis of water, sediment and biota (Beak 1999). While some degree of environmental impairment was still detected, the studies concluded there were ongoing improvements as a result of advances in environmental management by Heath Steele. Concurrent with these activities, DFO carried out some related activities (St-Hilaire & Caissie 2001). Subsequent to closure, monitoring on the Tomogonops River have been carried out by MREAC & others.

4.1.2.2 Peat Extraction

The Province of New Brunswick is the primary peat producing region of Canada. It is seen as a non-renewable resource extraction activity. The Government of New Brunswick, in consultation with environmental groups and the science community, has developed a management approach that balances resource use and conservation. In 2001, policies were developed to encourage secondary processing and to establish zones where peat extraction is not permitted in order to protect wetland habitat. Peat extraction is carried out on public lands under the Quarriable Substances Act

administered by the New Brunswick Department of Natural Resources. On private land, it is controlled under the Clean Water Act of the province administered by the New Brunswick Department of Environment and Local Government. It is estimate that in New Brunswick there are approximately 11,000 ha of peat deposits with commercial potential available to industry (Thibault, 2002).

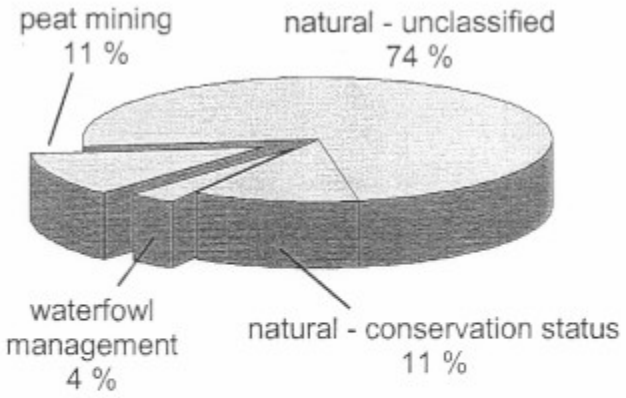


Figure 2: Use of peatlands in New Brunswick: of a total 142 000 ha, 85% is in a natural state (74% unclassified and 11% conservation status); 11% under peat mining lease agreements; 4% used for waterfowl management.

Site abandonment has been an environmental concern which, under the new policy, is dealt with through the requirement of a restoration plan and a security deposit to ensure restoration takes place. The 2001, Provincial Wetland Conservation Policy, addresses concerns over protecting New Brunswick wetlands which have the following make-up:

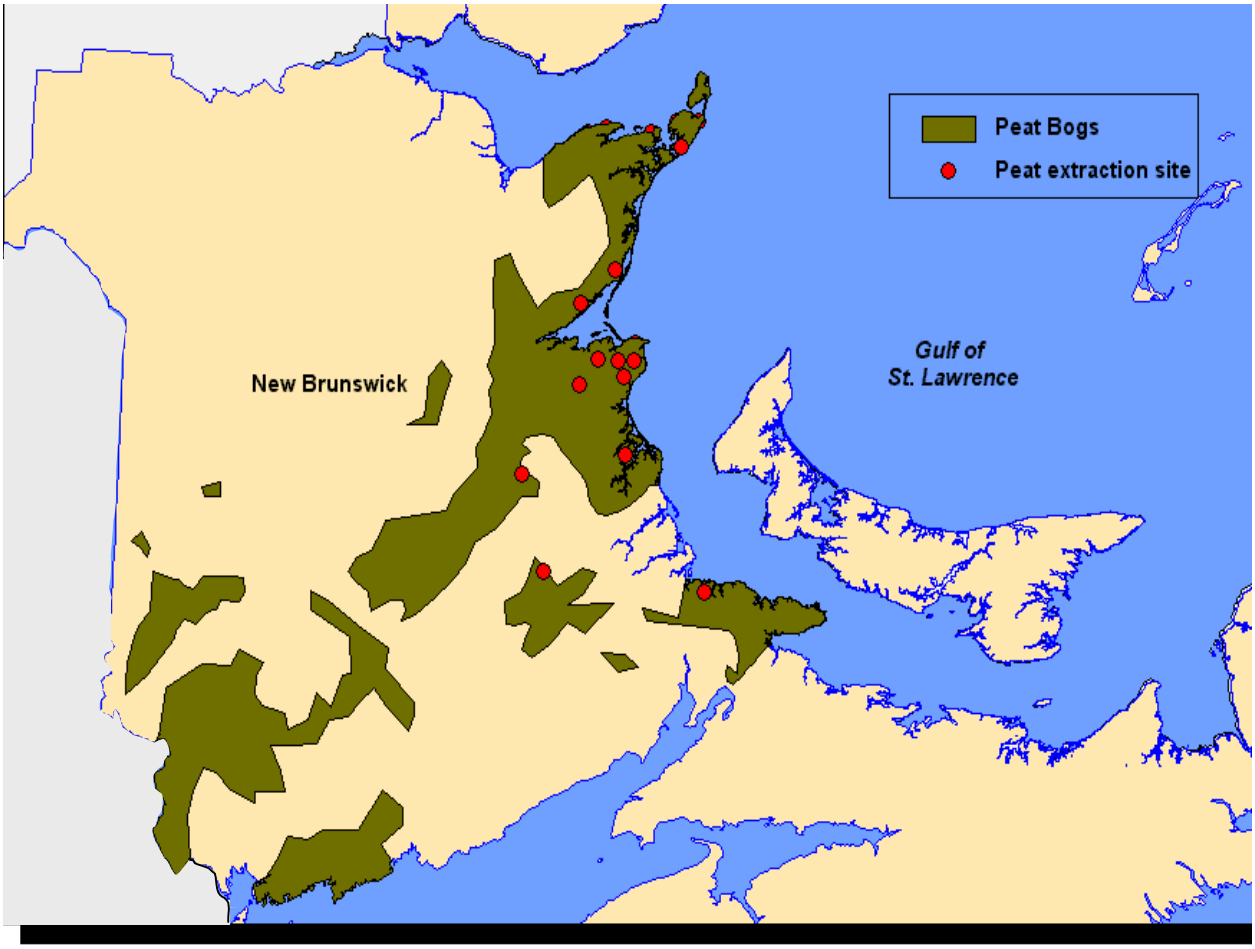
- **Coastal salt marsh, 3%**
- **Saint John River floodplane wetlands, 7%**
- **Freshwater inland wetlands, 42%**
- **Peatlands, 48%**

Surveys of post-harvested bogs of Quebec and NB suggest that these sites do not rapidly return to their original state if nothing is done at cessation of peat extraction. Thus, the wetland policy and restoration plans are important to maintaining some integrity of wetland habitat over the long-term.

Peat Harvesting Operation – Miramichi, NB

Large peat mining operations occur in the Baie-Sainte-Anne region with operations extending from mid May to mid September. It relies on warm sunny days to lower the surface moisture in the peatlands. Harrowed peat is exposed to sun and wind, dried to about 50% moisture content and then collected by tractor pulled vacuum harvesters before being screened and bagged. Some producers use mechanical block cutting machines to cut and stack blocks of peat. The blocks are then dried, crushed and bagged, which leaves the peat fibres more intact and creates a higher priced product. About 85% of the processed peat is compressed into bales. The remainder is mixed with fertilizers, fish meal, perlite, compost or vermiculite for sale as potting soil. New Brunswick peat is shipped principally to US and Japan.

Peat Moss Harvesting in New Brunswick



The potential for peat extraction to affect local water and sediment quality has been studied in the Richibucto river area by A. St-Hilaire (2006). He describes the inefficiency of holding ponds and other pollution control methods in protecting local streams and estuaries from contamination by peat fibres. Over a period of three years, from 1997 to 1999, at the location where runoff from the peat operation enters a small estuary on the Richibucto River, the spread and accumulation of peat fibres (up to 40 - 60 cm) has grown to cover an extensive area. Research shows that the most serious consequence of this pollution is the effect it has on the distribution and condition of the bottom dwelling bioessential invertebrate, Crangon sepeimspinosa. While this study is not in the Miramichi watershed, similar consequences could occur with runoff from peat operations there.

NB holds less that 1% Canada's peatlands but produces 35% of *the* country's peat shipments; *a $95M industry in Canada*. About 25,000 hectares of peatlands makes up about 2% of the Northumberland County land surface. There are 13 commercial peatlands in the coastal lowlands of *north-eastern New Brunswick* with about 1500 ha currently under production (NB DNR 2004). *It would appear that four* of these operations occur within *the estuarine segment of the* Miramichi watershed boundary as of 2006. Other peat bogs are being targeted for harvesting. Peat extraction in the Miramichi River watershed is already at maximum allowable capacity (J. Thibault, pers.com).

4.1.2.3 Sand & Gravel

The surficial geology of the Miramichi watershed is such that large resources of sand and gravel are available and extraction pits are found in widespread locations throughout. On a number of occasions, these borrow pits have resulted in serious erosion problems along various tributaries. The mining of sand and gravel occurs on a larger scale in the Sevogle watershed where extensive glacial deposits can be found. Material from that site is shipped throughout much of New Brunswick. The Sevogle mining operations are well away from the Miramichi River and do not affect water quality. Smaller gravel removal operations, such as "Johnston's Pit" site, are adjacent to the Southwest Miramichi where eroding banks and other complications have caused localized siltation problems (NBDNR pers. com). Generally speaking, the overall impact of sand and gravel removal on the environmental quality of the Miramichi watershed is minimal.

An even larger issue is the clearing of private shoreline properties. The removal of trees adjacent to the river de-stabilizes the shoreline with the resulting accelerated rates of erosion. Public awareness appears to be the biggest hurdle and the damage is often done before the landowners can be informed of the problems they may be creating for the security of their properties.

4.1.3 Agriculture

In terms of the scale of the Miramichi watershed, agriculture is a relatively minor and localized activity. As such it has some local impact on water quality. With the exception of a few larger farms, there are many small scale hobby farms of smaller scale operations that are usually mixed with some farm animals and limited hay and crop production.

There has been considerable recent movement within the farming community to develop environmental farm plans to improve performance and reduce risks. This community has the support of various government agencies and are further assisted through local farm support organizations.

4.1.4 Transportation

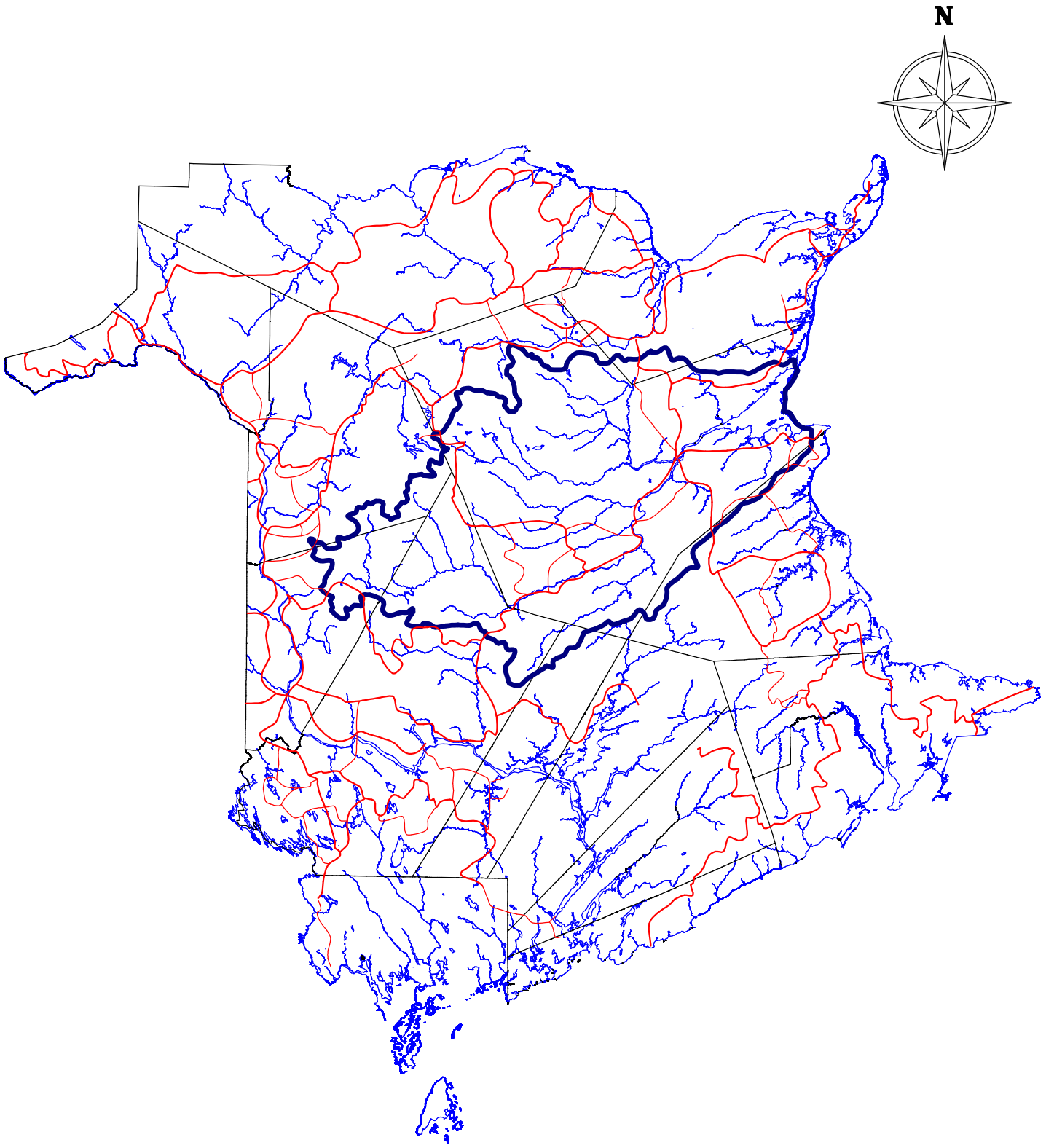
There have been no recent physical changes to the railroad system within the watershed. Changes in the industrial makeup of the area, the reduction of shipping from the port and the improvement of the road system have, however, made a difference in the amount and nature of the goods being transported by rail. More petroleum products are now being shipped by rail. Improvements have been carried out on trunk roads, Route 8 and 11, since the 1992 report resulting in higher traffic and speed.

The ever evolving harvesting of trees has meant an increase in the number of woods roads constructed or upgraded giving access to the backcountry. New Brunswick Department of Natural Resources (NB-DNR) monitors the use of fords to provide access by logging trucks and forestry equipment. Established fords that pose little threat of stream bed erosion are still used with the permission of NB-DNR. New fords are not permitted and authorized crossings are used in low water conditions.

4.1.5 Recreation & Tourism

The people of New Brunswick are known for their love of the outdoors and have a strong heritage of hunting and fishing. Access to wilderness and remote lakes and streams is essential to that lifestyle. There are literally thousands of kilometres of back country roads that have been developed by forestry companies to access forest resources in the Miramichi watershed. The new approach to harvesting selected stands rather than just moving from one clearcut to another has resulted in the need to push roads more deeply and quickly into the Crown reserves. This tends to open up large areas of wilderness which were previously almost inaccessible. These better and more extensive logging roads have greatly increased access of the general public via ATVs, snowmobiles and four wheeldrive vehicles into what was formerly back country frequented only by loggers, trappers or hunters.

One of the most widely publicised New Brunswick tourist attractions during winter is the snowmobile trail system depicted in Figure 4-1. Provincial snowmobile trail numbers 23, 42, 52 and 58 allow access to a winter experience and access in parts of the watershed that hitherto were not easily accessible. It has to be recognised that with a number of snowmobile events being organised by clubs during the winter months, the traffic on these trails can almost be viewed as having the same effect on wildlife as highway traffic. Some snowmobilers also leave the posted trails to travel waterways and get access to cabins or views from particular vantage points which extend their impact on the environment.



NOTE: NOT ALL CONNECTOR TRAILS ARE SHOWN ON MAP.

MREAC State of the Environment Report NB Snowmobile Trails Map	NATECH Environmental Services Inc. Patterson Rd., Harvey Stn., N.B., E6K 1L9 ph: (506) 366 1080, fax: (506) 366 1090	DATE: 06/03/03	SCALE:
		FILE: MREAC-05-01	FIGURE: 4-1

During other times of the year, ATVs access the trails and woods-roads systems to reach fishing holes, explore the region, or to access private camps or cabins. Excursions into the area are sometimes organised by clubs or outfitters. The network of trails and woods roads also allow hikers and campers to venture further away from the provincial highway system.

The environmental consequence of this activity is to reduce the areas of true wilderness which provide refuge for species which do not respond well to human intrusion. It creates greater hunting and trapping pressure on some species of wildlife and has reduced fish populations in many lakes and streams which were previously an undisturbed reserve. Some management practices, such as the closure of selected lakes or streams to fishing, are brought to bear on this form of stress, but the administration of such protection measures is difficult logistically (NBDNR, pers. com.).

4.1.6 Ecotourism

One of the fastest growing uses of environmental resources is ecotourism where people come to experience elements of the natural or cultural environment as the prime attraction. It is generally a low-impact industry with a focus on education and outdoor activities generally aimed at imparting a greater appreciation for the environment and/or cultural history and significance of a particular area.

Located on the Little Southwest Miramichi River near Metepenagiag (Red Bank) are two sites where ecotourism has gained prominence; The Augustine Mound and the Oxbow Village National Historic Site. The Metepenagiag Mi'kmag Nation in partnership with Parks Canada is undertaking the development of the Metepenagiag Heritage Park, with the primary objective of protecting and presenting the national significance of Augustine Mound and Oxbow National Historic Sites of Canada (NHSC) - two of the most outstanding Aboriginal heritage archaeological sites in Eastern Canada. Visitors to the park will more fully understand, appreciate, and enjoy the history and culture of Metepenagiag and the Mi'kmaq people and their cultural heritage.

There is considerable potential for this industry to flourish in the watershed with a growing world interest in learning vacations and culturally and environmentally important destinations. For example, a tourist facility resort on the Southwest Miramichi is owned and operated by German interests and caters to visitors from overseas. Clean water, safe beaches, protected wildlife and forest areas, well-developed cultural sites, and sound environmental policies and management are essential to keep this kind of resource use sustainable.

Palisades, North Pole Stream

4.2 Aquatic

Concern over water quality was the dominant issue that resulted in the formation of MREAC in 1989. There were questions about the potential impact of mining in the Tomogonops River drainage basin, a tributary of the Northwest Miramichi. Increased industrialisation and the usage of the waters of the upper estuary to dispose of industrial and domestic wastes were very visible to the local population. Health and safety was a concern for recreational activities like swimming and boating. Questions were asked regarding whether fish and wildlife and their habitat were being seriously compromised, and whether fish and shellfish were safe to eat.

Comments by local residents were being made like " --- there was an oily taste in the little grilse I caught the other day---" or "It's a shame the way the gravel pit on the Oxbow is

filling in the river." or "Every year this slime gets worse---". Much of the blame for such problems was directed at specific activities in the watershed from forestry to industrial discharges. As well, there was frustration over the inability of various government agencies to adequately manage environmental and resource concerns or administer effective controls in a consistent and harmonized manner. Overlapping responsibilities of government departments and their frequent inaccessibility to local watershed residents were cited as two major problems (MREAC, 1992).

The 1992 MREAC report addressed many of these fears and found that, as a whole, water quality in the Miramichi watershed was relatively good. The report did however highlight some of the areas where it was felt that future attention could lead to some improvement. These areas included domestic waste water treatment, industrial wastewater and stack discharges. Since then a number of studies, reports and conferences have taken place and improvements have been realised. As mentioned above mining activity is now in the remedial stage and of reduced concern. Improvements in industrial processes with industrial and economic downturns have contributed to reduced impact on aquatic habitats. As well, there have been considerable improvements in the way some government departments have become more responsive to public concerns and have partnered with community groups to improve on addressing resource management issues.

4.2.1 Effluent discharge

4.2.1.1 Municipal and Domestic Discharges

While the concern about wastewater discharges was greatest in the urbanised area of the upper estuary around what is now the City of Miramichi, many rural households had minimal or no waste treatment (i.e. approved on-site septic systems). Over the past decade there has been some improvement.

The amalgamation of communities into the city of Miramichi has aided in improving sewerage infrastructure. The city's commissioning of a sewage treatment plant on the north bank in1997 followed by a second STP on the south bank in 2003 has done much to

City of Miramichi – Southside Sewage Treatment Plant

improve water quality in the upper estuary. These two treatment plants were designed with adequate capacity and have allowed many old and overloaded facilities to be decommissioned. Other communities have also upgraded their waste treatment facilities.

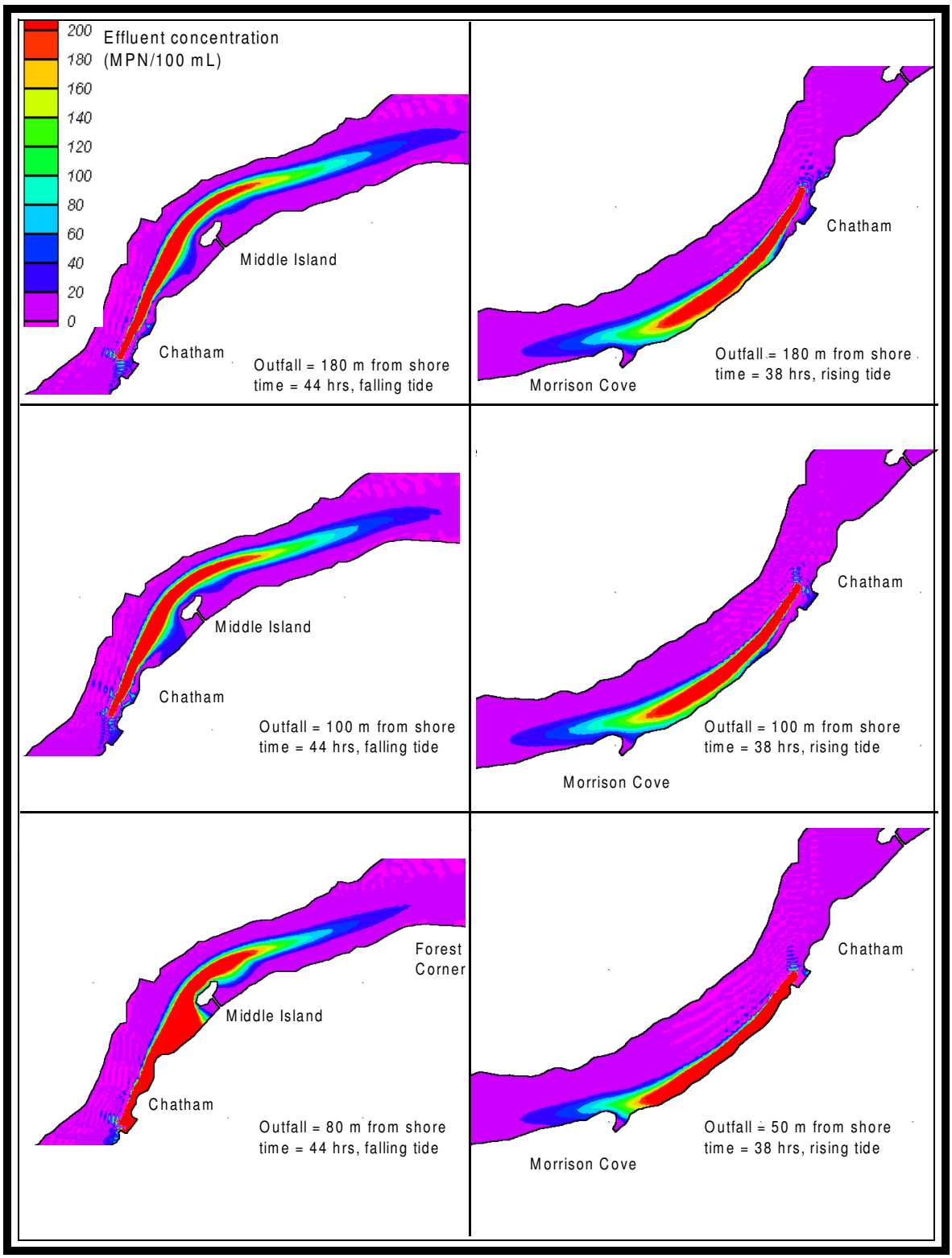
During the past decade the provincial the NB Environmental Trust Fund and in partnership with MREAC, has done much to implement the use of proper septic tanks and drain fields in rural areas. Education on the proper maintenance of on-site facilities has also been included to decrease local pollution of waterways. MREAC's on-site remediation program, operated in 1997, 2004, 2005 *and 2006*, has resulted in the remediation of *55* failing on-site systems among low-income Miramichi residents. This program is sponsored through the New Brunswick Environmental Trust Fund. Much remains to be done to remediate untold numbers of other failing systems and promote public awareness on the care and maintenance of on-site septic systems.

4.2.1.2 Bacterial Contamination

One indicator of domestic pollution in a watercourse is the presence of E. Coli bacteria. It was registered as a concern in the 1992 report. In addition to standards for drinking water there are also provincial water quality guidelines for swimming areas. Since 1992 MREAC has taken implemented a Swim Watch project to monitor water quality at a number of swimming sites throughout the watershed. Figure 3-2 shows the monitoring locations. Table 4-7 provides a summary of the "Swim Watch" results undertaken by MREAC. This long term data set of water quality (1993-2006) demonstrates a system wuth generally good water quality throughout the watershed.

The reduction in bacterial contamination is particularly noteworthy in the estuary where the shell fish harvesting closure line has been adjusted, opening 10 sq. km. of the

estuary (Fig 3-1) during 2003. Much of this improvement can be attributed to the provision of the two major sewage treatment plants by Miramichi City but as tables 4.2 and 4.3 show there is still work that can be done. Figure 4-2 shows a series of computer simulated snapshots of predicted E. Coli distribution from the new Chatham diffuser outfall (NATECH 1998). The use of a diffuser provides better distribution and initial mixing of the effluent while the use of computer modeling enables better site selection for the outfall to maximise mixing and minimise shoreline contact particularly near swimming/wading areas. The numerical model also predicts the patterns of E. Coli concentrations that could occur during various receiving water conditions.



MREAC State of the Environment Report

NATECH

Figure 4-2

E. Coli Distribution from Chatham Outfall

4.2.1.3 Industrial discharge

The Miramichi River has been a recipient of Industrial waste, both intentionally and accidentally, for many years. Some 200 years ago, saw mill operations were a significant industry in the watershed. Pulp mill operations started some 100 years ago. Between 1950 and 1977, the loss of bark, wood-fibre and bio-solids from the pulp mill at Newcastle contributed an average of 20,000 tons of organic material to the river annually (Buckley, 1995). Throughout the past four or five decades, the river has also received waste from a wood treatment plant, the airbase at Chatham, and numerous other small sources. These discharges have all affected the health of the river in one way or another; some with more serious long-term consequences (see Section 5.2 under Stresses).

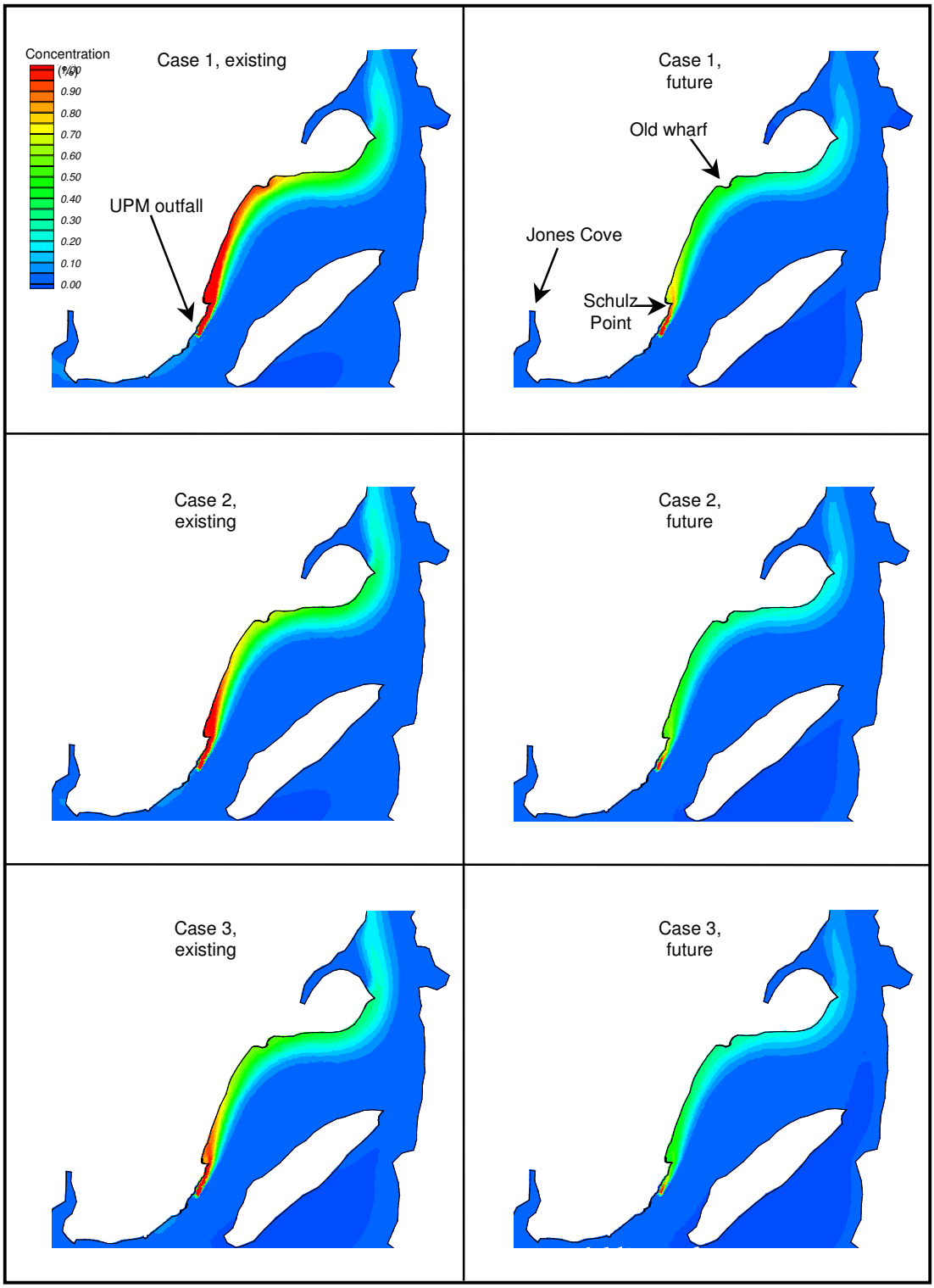
UPM-Kymmene is the present owner of the paper facility that is sited on the North bank of the river opposite Beaubears Island at the confluence of the SW and NW Miramichi. Between 1989 and 1994 concentrations of dioxins and furans in the effluent dropped dramatically as the pulp and paper industry met the no trace dioxin and furans CEPA standards in 1995.

Table 4-3. Effluent quality, UPM Mill in Miramichi

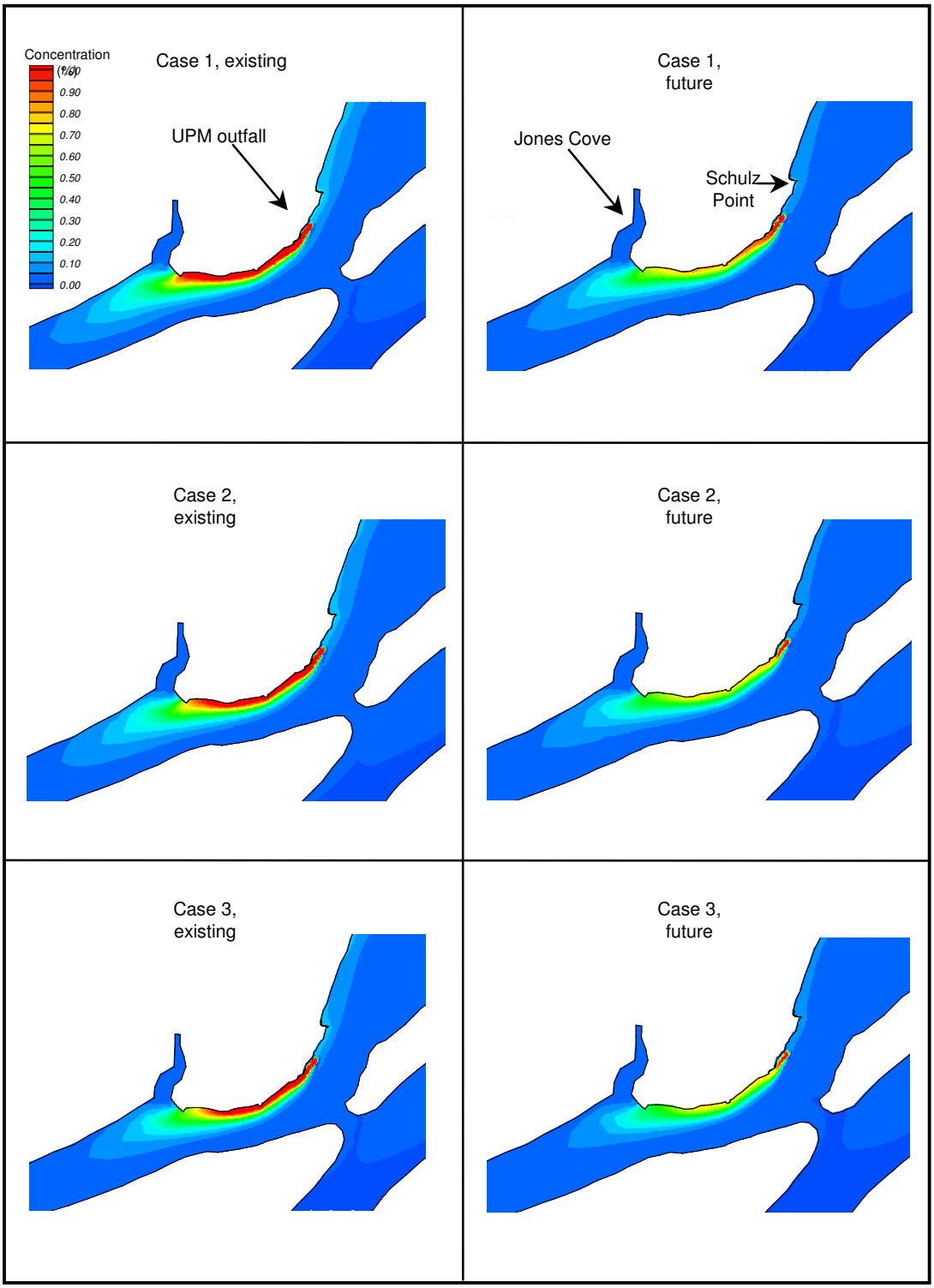
Characteristic	Year	Amount
BOD	1992	5300 kg/day
	2001	1800 kg/day
TSS	1996	8 t/day
	2002	6 t/day

In 1992 the effluent discharge from this facility was 90,000 m^3/day and carried a heavy pollution load even after passing through lagoons. In 1992 the mill was judged to be the main contributing sources to organic loading and toxic chemicals found present in the sediments downstream and in the Inner Bay. Over time the organic loadings were significantly reduced. For example, between 1992 and 2002, the BOD loading was reduced from 7,000 kg/d to 2,000 kg/d. Similarly, the TSS concentration was reduced from 12,000 kg/d to 3,000 kg/d over the same period (UPM Kymmene, Environmental

Statements, 2002 and 2004). New clarifiers at the kraft mill contributed to these significant improvements. In 2004 the kraft mill closed and the effluent quantity and pollution load was reduced even further. Figures 4-3 and 4-4 depict computer modeling output showing the reduced impact of these changes on the receiving waters (NATECH 2002 and NATECH 2005). The kraft mill was permanently closed in December, 2004 and is now de-commissioned (UPM Miramichi Environmental Performance Report, 2004)



MREAC State of the Environment Report	NATECH **Environmental Services Inc.** Patterson Rd., Harvey Stn., NB, E6K 1L9 ph: (506) 366 1080, fax: (506) 366 1090	**Figure 4-3** **Plumes from UPM Pulp Mill during falling tide**



MREAC State of the Environment Report	**NATECH Environmental Services Inc.** **Patterson Rd., Harvey Stn., NB, E6K 1L9** **ph: (506) 366 1080, fax: (506) 366 1090**	**Figure 4-4** **Plumes from UPM Pulp Mill during rising tide**

The Groundwood Mill in Nelson is also owned by UPM Kymmene. Due to improved water management efforts, the Groundwood mill was able to reduce its water consumption from 18,000 m^3/d in 1993 to 4,000 m^3/d in 2002. A similar rate of water use (2400 m^3/day) continued through 2004 (UPM, 2004). Improvements in BOD and TSS discharge were even more dramatic as result of improvements in wastewater treatment in 1995. Before 1995, the effluent BOD was in the order of 6,500 kg/d. In recent years, the BOD was reduced to less than 500 kg/d. Similarly, TSS averaged 2,000 kg/d before 1996 and approximately 500 kg/d since 1996.

The oriented strand-board (OSB) mill operated by Weyerhaeuser has no process water discharge and sanitary effluent is diverted to a leaching field, after primary treatment. In this case, water quality is not affected although particulate in air emissions from this operation have been a concern (see section 4.3.2. Industrial Air Emissions).

The former air base at Chatham which operated over a period of some four decades (closed in 1990) remains a stressor on the local environment. The effluents and runoff from this operation have left a legacy of industrial-like contaminants in the Napan River which flows into the head of the Miramichi estuary. High concentrations of PCBs and other organic contaminants have been found in sediment and fish throughout the river but particularly in proximity to the CFB Chatham site (Lindsay, 2006). Sampling done in 2001 and 2003 of sediment and fish in Whites Brook, a tributary to the Napan River and close to the air base, show elevated levels of total PCB. In most cases, levels exceeded the CCME Interim Sediment Quality Guidelines of 31.1 ng/g and the Probable Effects Levels set at 277 ng/g. This was also the case for PAHs.

Sampling in the Napan River downstream from Whites Brook also shows elevated levels of these contaminants, but upstream sediments and fish were not contaminated. It is clear that the source of contamination is Whites Brook which drains the Chatham air base and its original sewage treatment plant. These elevated levels might pose a potential health risk to wildlife such as otters, loons, mergansers and ospreys that are primarily fish consumers. They are, however, unlikely to pose a health risk to humans

since levels are below the Health Canada fish tissue standard ot 2 ppm for PAH (Parker,2007).

The Northwest Miramichi River system were the receiving waters for mine water and runoff from the Heath Steele base metal mine on the Tomogonops River developed in the early 1960's. This resulted in serious contamination of the river with depressed pH levels coupled with high levels of copper, zinc, cadmium and other heavy metals. Despite the headwater source of this mine, many of these metals can be detected in sediments in the estuary. This may have been more of a function of the stockpiling of ore at local wharves prior to shipping and the resulting leaching of contaminants from these piles. Various management and control efforts over the years to reduce pollution from the mine site, closure of the mine in 2000 and current treatment and control of the site runoff by the owners have corrected much of the pollution problems in the river. The sediments in the estuary, however, contain high levels of these metals which have accumulated over the past several decades to depths of 8 to 30 cm. These would pose a hazard to wildlife in the estuary if there were efforts to remove them (e.g. dredging) or disturb them in any way (Buckley, 1995).

The lower tidal section of the Miramichi River and its estuary have been used as receiving water for wastes from pulp mill operations, a wood preservation plant, a power generating station, numerous sewage outfalls and various other small industrial inputs and untold numbers of failing on-site septic systems from private residents. The history of pollution as spelled out in sediment samples collected from the river and estuary tell a story of contamination but with signs of improving.

In a recent assessment of sediment quality carried out by R.W. Parker (2006) on data collected in 1993 and 2002 it is clear that sediments of the lower Miramichi River are still contaminated with various heavy metals, organic pollutants such as PCB and PAH and are still toxic according to certain toxicity tests. The benthic community evaluations carried out in 1993 and 2002 show that the benthic community in the estuary is impoverished. The values for the abundance and species richness were higher in 2002,

however, which may indicate an improving trend. This could be accounted for by seasonal differences in the 1993 (June) and 2002 (October) sample collection times.

A closer look at the results of these two surveys, by Environment Canada (1993) and MREAC (2002), shows somewhat of a pattern of contamination and environmental impact. PAH was detected in almost all of the samples from both surveys with highest levels at 1.89 ppm in 1993 and 1.35 in 2002. These samples exceeded the CCME sediment quality guidelines for the protection of marine aquatic life. Overall, however, the concentrations of PAH in the sediment samples were considered low.

PCB's were detected in 3 of 8 samples in 1993 with one sample (1.70 ppm) exceeding the CCME PEL (Probable Effects Level) of 0.709 ppm. In samples from 2002, 4 of 5.contained PCBs with two exceeding the CCME ISQG (Interim Sediment Quality Guidelines) of 0.022 ppm. In both surveys the highest concentrations of PCB were detected in the most downriver sampling stations.

In both 1993 and 2002, many of the heavy metal samples exceeded the ISQG for cadmium, zinc, copper, lead and mercury. None exceeded the PEL concentrations. The concentrations of metals seem to have decreased slightly from 1993 to 2002 and were 30% to 50% lower at one station just above Newcastle. The concentrations of most pollutants were directly related to the percentage of silt in the sample. Metals and organic pollutants attach themselves to fine particulates and thus tend to be more concentrated in areas where fine particulates accumulate.

Downstream samples from both 1993 and 2002 were shown to be toxic as well as one of the most upstream samples from the 1993 series. These results were consistent with the fact that the highest concentration of pollutants were in sediments with the highest silt content. It is possible that this condition has contributed to the impoverishment of the benthic community, although other factors such as the fluctuating salinity concentrations in the estuary might play a role.

4.2.2 Fisheries Resource Utilisation (commercial and recreational)

4.2.2.1 Finfish

Smelt and Gaspereau are the most abundant commercial fishes in the Miramichi Inner Bay and the Estuary. Cod, blueback herring, sand smooth and yellowtail flounders, herring, mackerel, and shad are also found. The Miramichi river system is the area of greatest abundance in Atlantic Canada of the rainbow smelt (Scott & Scott 1988). The smelt and gaspereau fishery is pursued commercially both by gill nets and by hook & line. Smelt and eel are both fished during the winter through the ice.

The by-catch of striped bass in this fishery is an important consideration in attempts to allow recovery of the populations of striped bass (between 2000 and 2005 an average of 84 bass/net /day during the gaspereau fishery). There is general agreement among stock managers and stakeholders that poaching has a significant impact and continues to limit the recovery of this species.

Landing of smelt, tomcod, shad, bass and salmon all dropped dramatically in the southern Gulf of St. Lawrence due to over-fishing over the last several decades. The proportion of diadromous fish (those which migrate between sea and fresh water) from the Miramichi Estuary in the total commercial catch in the southern Gulf has also decreased, from 50% prior to 1940 to just over 30% in 1995 (Chaput 1995). The percentage of Miramichi-area smelt in the southern Gulf catch declined from 40% historically to 30% in the 1990's, tomcod declined from 75% in the 1970's to 50%, and Miramichi area shad declined from over 75% of the commercial catch between 1917 and 1955 to around 50% in the 1980s and 1990s (Chaput 1995). Even for gaspereau and eel, for which landings in the southern Gulf appear to be increasing again, the proportion from the Miramichi is still well below that seen historically. (Murray, 2006).

When landings (and other measures of abundance) of all the diadramous species which make extensive use of the estuary have declined over time, changes in the nature of the estuary could be a possible cause. Industrial development is concentrated adjacent to the upper estuary and has had detectable effects on spawning success, survival and

behaviour, and may be expected to influence the health of fish species over some time to come (Chaput 1995).

After reaching a peak in 1992, Atlantic salmon returns to the Miramichi have been on a steady decline (Cunjak and Newbury, 2005). This decline has come about despite increasing numbers of juveniles being found throughout the river system and a number of local measures aimed at increasing the stock, including closure of the commercial fishing in 1984. DFO in 2001 (DFO 2001) estimated that the highly regulated recreational and aboriginal fishery collectively accounted for less than eight percent of potential egg disposition. The consensus among scientists and others is that poor marine survival continues to adversely affect the return of salmon to Atlantic rivers. (See the Salmon Story, section 3.2.2.1.1 for more details.)

Striped bass in the Southern Gulf of St Lawrence return to the Northwest Miramichi to spawn in May. Despite recent attempts to locate additional spawning grounds the Northwest Miramichi river remains the only known spawning location in the Southern Gulf and as such defines the Northern limit for the species. Conventional tagging studies and genetic analysis indicate that striped bass in the southern Gulf are distinct and isolated from neighbouring striped bass populations in the Bay of Fundy and the USA. Because the genetic make-up of Quebec's St Lawrence population was not determined prior to their extirpation their relatedness to striped bass in the southern Gulf remains unknown. Striped bass tagged in the Miramichi river have been recaptured as far north as Perce in Quebec. (Douglas 2005) Because of their likely connection with the St. Lawrence 'stripers', Miramichi fish are being used in an effort to reintroduce bass into the St. Lawrence River.

Beach Seining – Courtesy of Nelson Poirier

Analysis of striped bass by-catch in the gaspereau fishery of the NW Miramichi during 2000-2005 has indicated an average of 84 bass per net per day. This closely relates with estimates of population size derived from marking /recapture experiments. "In short striped bass in the southern Gulf are holding their own and stock status has improved dramatically since the late 1990's. (Personal communication, Scott Douglas)

The Atlantic sturgeon is known as an occasional visitor to the Miramichi. Over the last decade there have been three Atlantic sturgeons captured in the Northwest Miramichi estuary and all were believed to be migrants from Quebec. No eggs or larvae have ever been collected in the Miramichi and if they ever did spawn there it was decades ago. Cox (1893) collected "juveniles" through the ice and concluded at that time there was a spawning population. As far as the species at risk team are concerned the status of the Atlantic sturgeon in the Miramichi has not changed for more than three of their generation times and is therefore a non issue.

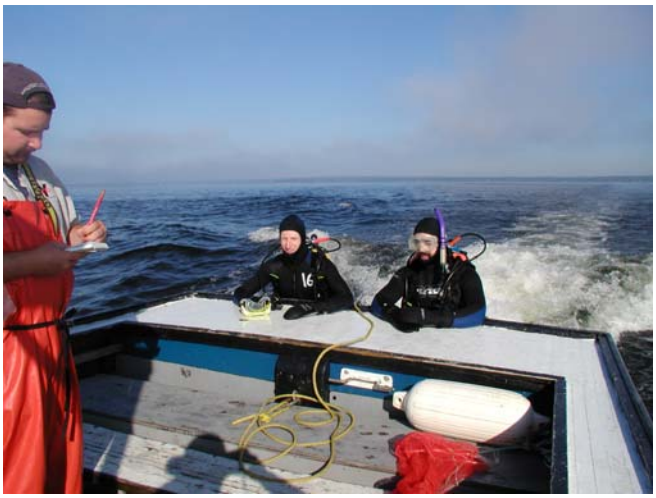
The American eel population in the Miramichi has fluctuated during the past 50 years. However a data report by Cairns et al. (2005) providing data from 1952- 2002 suggests that over the past two decades there has been little change in eel population in the Miramichi from what was present in the 1950s.

4.2.2.2 Shellfish

An important commercial fishery for lobster occurs in both the Inner and Outer Bays. Juvenile lobster is often found in the Inner Bay possibly implying a valuable nursery area. A population description and resource valuation of the American oyster was

carried out to assess the commercial impact of the success in opening up a further 10 sq Km of the estuary with the movement upstream of the closure line (LeBlanc et al 2005). A sustainable harvest of wild oyster from this area was estimated to be around $50,000 per annum. Both blue mussels and soft-shell clams are resident in the Miramichi estuary and are harvested by local fishers.

Shellfish Sampling – Miramichi Inner Bay



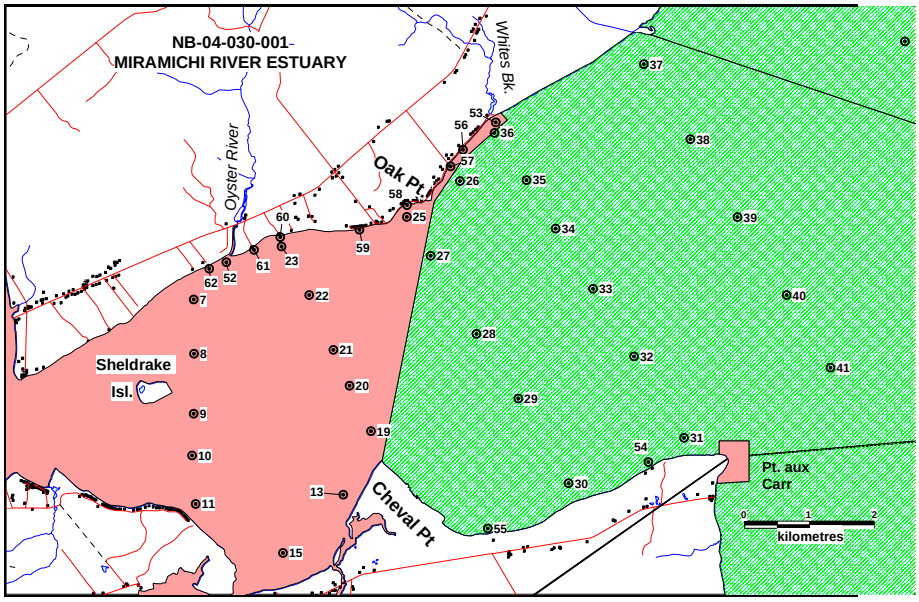


Figure 4 Present Shellfish Classification, Miramichi River Estuary

From Bernard Richard, MREAC Science Day 2006

4.2.2.3 Aquaculture

Over the past decade American oyster *(C. Virginica*) culture has become a significant activity in the inner bay. Nearly 500 hectares (5.0 km^2) or 1.67% of the area is under lease to oyster growers. Figure 3-1 shows the inner bay including the more heavily utilised Neguac Bay. The Inner Bay contains approximately 240 hectares of leases the most densely situated is in the vicinity of Bay Du Vin Island. Most leases throughout the estuary are of the order of 1 to 5 hectares but here there is one site of 60 hectares and one of 17 hectares. Along the north shore there are groups of sites a few 100m offshore in the vicinity of Oak point and Burnt Church. When initially granted the majority of the leases were designated for the bottom culture or in trays raised on legs just off the seabed. Since that time many of the active leases have been converted over to suspended culture but this culture method is still viewed by NB-DAFA as being marginal for this area. As a result of the improved wastewater treatment of upstream, E. coliform counts in the water column have decreased. Figure 3-1 demonstrates how this decrease has allowed the closure line for shellfish harvesting to be moved 5 km upstream along

the south shore. Local near shore sources of contaminants on the north shore are limiting a similar north shore retreat of the closure line.

Neguac Bay hosts 86 leases totally over 250 acres (or hectares). Most leases are in the 1-3 hectare range. Most leases are congregated close to the shoreline with the larger leases in mid-bay. The largest lease is 22 ha followed by one at 16Ha, five around 11Ha, the remainder 6Ha or less. NB DAFA estimate the industry currently employs about 50 - 70 people. In the Baie Sainte-Anne Bay about 4 acres is devoted to mussel culture. (*M. Edulis*)

4.2.2.4 Fish Plants & Processors

There are three fish plants situated along the shores of Miramichi Inner Bay. One is a modern shellfish processing plant at Neguac where the major portion of shellfish harvested in the area is processed. The two other plants are located in Baie Ste-Anne and process a variety of seafood products.

Recent public concern about fish plant discharges has resulted in studies of enrichment and other impacts on NB Northwest shore. The Miramichi plants have not been heavily criticized for their operations, perhaps due to natural flushing and the assimilation capacity of Miramichi Inner Bay. Process changes are expected to be mandated in the future to limit receiving waters impact.

4.2.2.5 Hatcheries

The status of Atlantic salmon to the well being of residents of the Miramichi watershed and the health of the ecosystem is clearly understood as a sustainability issue. Nevertheless, in 1997 the Department of Fisheries and Oceans divested itself of its Salmon Enhancement Centre at South Esk. This hatchery facility has since been taken over by the Miramichi Salmon Association (MSA) along with their watershed management partners. A new company, Miramichi Fisheries Management Ltd., was

formed to help sustain the long term future operations of this hatchery. This facility, the Miramichi Salmon Conservation Centre (MSCC) established in 1873, is the oldest operating Atlantic salmon hatchery in Canada. The MSCC has operated continuously since that time growing both speckled trout and Atlantic salmon.

The mission statement of the Miramichi Salmon Association is, "Management actions to optimize the populations of juvenile salmon stocks in the Miramichi River". Partners with them in the operation of the hatchery and the management of the river include: several conservation groups, First Nations, corporations, outfitters and guiding associations from the region as well as the Department of Fisheries and Oceans, Parks Canada and the New Brunswick Department of Natural Resources. The MSA has completed a major renovation to the facilities at the Miramichi Salmon Conservation Centre to create a Centre of Excellence for Atlantic salmon studies with research and educational capabilities (MSA website).

4.2.2.6 Recreational Fisheries

According to 1995 statistics, anglers in the Atlantic provinces spent approximately $100 M (Can) which is about 4% of the recreational fishery for all of Canada (Cunjak et al, 2005). A robust recreational fishery for salmon still exists on the Miramichi River and has been so for over two centuries as it became one of the most highly prized destinations for Atlantic salmon angling among Europeans and Americans. Section 3.2.2.1.1 expands on the Salmon story and provides details of the nature of this species and its sustainability in the Miramichi system.

Salmon has played a prominent role in the culture of the Miramichi. Thousands of New Brunswickers still spend a great deal of time thinking about, talking about, planning and going salmon fishing. Many people in riverside communities have an intense interest and passion for this sport. As well, may outside "sports" come to participate in fishing the legendary salmon of the Miramichi bringing a substantial sport fishing economy to the region (MREAC, 1992).

Over the past half century, the Atlantic salmon population has seriously declined due to many factors ranging from industrial development in the watershed to commercial fishing and poaching and possibly for other reasons yet to be revealed. Recreational fishing takes only around 700 salmon per year (data from Crown Reserves) compared with numbers caught just a few decades ago (NB-DNR web site).

Other species are important to the sport and recreational fishery. These include Brook trout, American shad, striped bass, gaspereau, Atlantic tomcod and rainbow smelt fished mostly in the estuary (Hare, 2002). Trout are fished in the upper brooks and streams tributary to the Miramichi. Shellfish are harvested commercially in the estuary and recreationally in areas open for that purpose.

4.2.3 Transportation

4.2.3.1 Shipping Channel

There is a compulsory pilotage requirement for commercial ships entering the 65 km shipping channel to Miramichi. Captain Patrick Gates of the Atlantic Pilotage authority provided the following figures for ships using the port.

Table 4-7. Number of ships using the port

2001	2002	2003	2004	2005
3	3	4	12	5

Asked to comment on the burst of activity in 2004 Captain Gates suggested it was in response to consideration by the Atlantic Pilotage Authority around that time to remove compulsory pilotage if low ship usage continued. - this is still under consideration by the Authority. Ships using the port are mainly coastal oil tankers about 8-9,000 tons dead-weight.

Captain Gates also indicated there is steady infilling occurring at certain points in the channel. Draft is a concern for many of the ships and freshwater and silting concerns results in many vessels ntering or leaving at less than full capacity.

Courtesy Russell Parrott, MREAC Science Day 2006

Dredging in the Miramichi channel started in 1872 and continued until 1996. Until 1930, some 510,000 m^3 were removed from the channel. Between 1981 and 1983, 6,160,000 metric tons were dredged in a major channel deepening project. The dredged spoils, most of which were deposited at dumpsite B in the inner estuary, still appear to be intact after 20 years. There is little evidence of changes in sedimentation over the rest of the bay since the time of glacial deposition except in the area of Bartibog where the turbidity maximum occurs and rapid deposition took place in the early 1980's (Parrott, 2006).

DFO Coastguard stated that they were aware of the deteriorating channel but have no plans to undertake any further channel dredging. The last time they dredged was in 1996 when the spoil was placed on dumpsite B in the Inner Bay. Sediment work under the Canadian Aquatic Biomonitoring Inventory Network (CABIN) program suggests that any adverse effect of this dumping site is no longer present but additional sediment sampling and analysis is warranted.

4.2.3.2 Recreation

Fly fishing for Atlantic salmon is the mainstay of recreation on the Miramichi River. Other outdoor pursuits, summer and winter, have followed.

The large natural river system offered by the Miramichi system makes for a very high level experience for outdoor enthusiasts. As such the activities are diverse and there seems to be a high level of capacity for further promotion in most activities.

Recreational canoeing and kayaking have become active pursuits, especially early in the season during higher water levels. A traditional tension between paddlers and recreational fishers remain but greater compatibility has been recognized over the years.

Commercial tubing operations are very popular on the Little Southwest Miramichi with many hundreds of adherents on warm summer weekends. Residents along the most popular stretch of the tubing run are concerned about litter and unruly conduct. The operators are making an effort to respond to these issues.

Due to the diversity and geology of the watershed, the system offers a wide variety of challenges in outdoor recreation. Expert paddlers can find challenges on branches of the Northwest Miramichi. Novices are better directed to the lower gradient streams of the Southwest Miramichi.

Two marinas serve recreational and some commercial vessels on the upper estuary. The first one located in Douglastown and a more recently developed marina in Chatham. Of note these marinas allow vessels to pump out their "heads". Many other wharves are located at communities lower in the estuary on both the north and south sides. While used by recreational vessels these facilities are more geared to commercial fishing boats. Used oil facilities are also provided at some of the busier wharves.

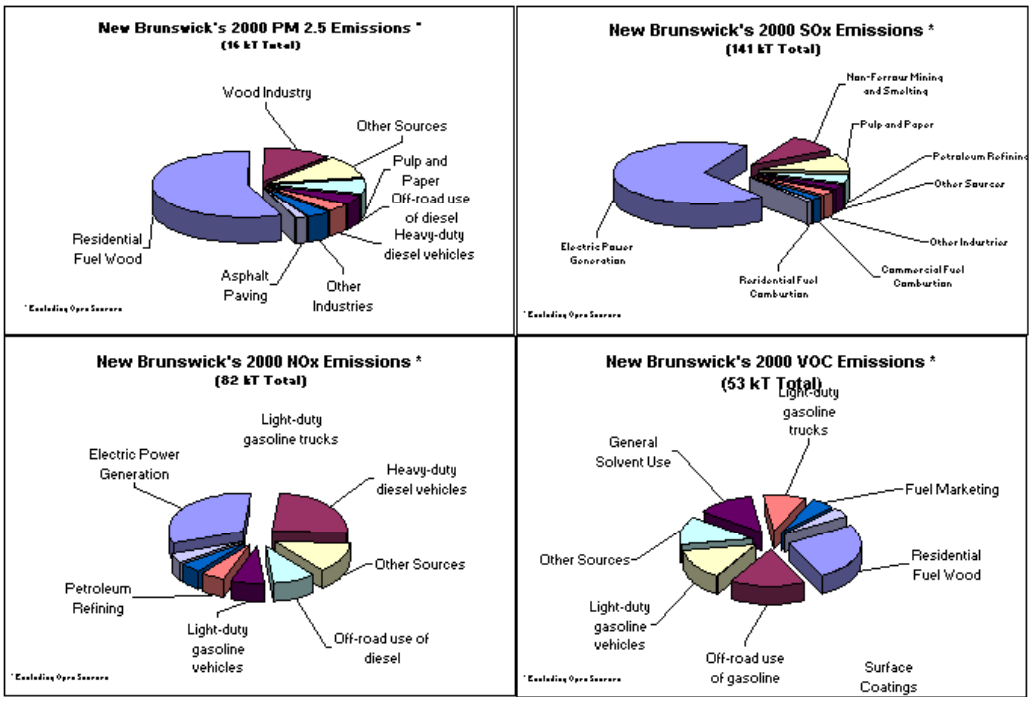
Winter recreation has become popular over the past decades. The development of a snowmobile trail network throughout New Brunswick includes well managed and groomed trails traversing the Miramichi (see Fig. 4-1). This same trail network is used by ATV enthusiasts during the summer and shoulder seasons. Dedicated hiking trails are also available and more often than not the trails are accessible to all user types.

4.3 Air

The Miramichi airshed is taken to be comparable with the watershed. Obviously the watershed is influenced by inputs from distant sources of air pollution and is within the greater airshed of north-eastern North America. As Shown in Figure 3-2, there are several stations where air quality parameters are measured. In addition to cross border air pollution, there are a number of local issues with both domestic and industrial activities.

Dominant air pollutants in New Brunswick include: sulphur dioxide, nitrogen dioxide, ground level ozone, particulate matter, carbon monoxide, total reduced sulphur, volatile organic compounds and greenhouse gases. An emissions summary for some of these pollutants is illustrated below (Piercey, 2006).

2000 Annual Emissions Summary of PM 2.5, SOx, NOx, and VOC for New Brunswick



There are indications that nitrogen and sulphur oxides and volatile organic carbons are on a downward trend, where ozone levels seem to remain constant over the period 1990 – 2004. Greenhouse gasses in New Brunswick are on a steady increase which is reflected worldwide.

4.3.1 Residential Wood Burning

Wood burning as the primary and secondary source of heating is common throughout the Miramichi watershed, even within the city of Miramichi. In 1998 the ARMA (Air Resource Management Area), report, the authors did not believe that significant improvements in the efficiency of word burning technology had translated into improved overall emissions and this was reflected in discussions with local wood stove distributors. ARMA recommended better education and promotion of these improved wood-burning units coupled with providing greater awareness about firewood quality.

Since that time, there has also been a considerable increase in outdoor wood burning units throughout the watershed area. These units are used to heat homes and small businesses. NB DOELG has had several complaints and has had to take action in a number of cases.

4.3.2 Industrial air emissions

The former REPAP Inc. (pulp and paper mill) was foremost in the areas of industrial concern listed in the 1998 ARMA Miramichi Report (MREAC 1998). While improvements were being carried out since that time, the more recent decisions of the new owners, UPM-Kymmene, to close the Kraft mill in Sept 2004 has resulted in a major improvement in the air quality in the immediate vicinity of the plant and in the City of Miramichi.

Another air quality focal point was the oriented strand board mill operated by Eagle forest Products at Morrison Cove, now owned by Weyerhaeuser. A wet electrostatic precipitator was installed late in 1998 and removed much of particulate emissions that were causing most of the concern. More recently, in 2001/2, a major refit reduced emissions of SOx and NOx substantially. The provision of a new 200ft, 11ft diameter, main stack also reduced local impacts substantially. Despite these improvements the mill location in the centre of the City of Miramichi make for much scrutiny and the impacts are still widely reported on.

Some smaller sawmills and woods operations within the City of Miramichi have caused local concern regarding fugitive dust and sawdust. These are dealt with by NBDOE during their routine renewal of approvals to operate.

4.3.3 Transportation

4.3.3.1 Vehicles

The 1998 report identified some 35,000 vehicles registered in Northumberland County of which 3,000 were heavy trucks and an equal number of all-terrain vehicles. It is suggested that the slight population decrease in the area coupled with improved emissions from newer vehicles is likely to be counterbalanced with the potential for increasing numbers of vehicles per family (including ATVs), resulting in little change in emissions from this source.

Ground level ozone is a pollutant which arises from the burning of hydrocarbons and is generally associated with the transportation sector and emissions from some industrial activities. Ozone is often referred to as photochemical smog and is a secondary pollutant formed in air from NOx and hydrocarbons. It is very corrosive to the respiratory tract and can cause complications in people with respiratory diseases or other associated problems. Ozone is also very damaging to vegetation and is a contributor to crop losses in tomatoes, beans, tobacco and potatoes each year in New Brunswick. Forest trees and other crops may also be affected.

Monitoring of Ozone levels at the Chatham meteorological station has demonstrated a number of days in the past decade when levels of Ozone have exceeded the national objectives of 65ppb for an 8 hr average and 82ppb for 1 hr average (NB-DELG 2002).

4.3.3.2 Recreational Vehicles

Air emissions from recreational vehicles and other equipment are known to contribute to ambient air pollution. Sometimes referred to as “off-road” or “off-highway,” the non-road category includes outdoor power equipment, recreational vehicles, farm and

construction machinery, lawn and garden equipment, marine vessels, locomotives, and many other applications. Until the mid-1990s, emissions from these engines were largely uncontrolled.

Non-road equipment emits large amounts of nitrogen oxides (NOx), hydrocarbons (HC), carbon monoxide (CO) and particulate matter (PM). In general, off-road vehicles are estimated to have total emissions almost as high as highway motor vehicles. In the case of diesel particulate matter, off-road emissions are significantly higher than highway emissions.

Lawnmowers, string trimmers, leaf blowers, chain saws, commercial turfequipment, and lawn and garden tractors fall within this category as do engines used for marine propulsion (outboard motors) and recreational vehicles (ATVs and snowmobiles). In the United States, these engines currently contribute about 16 percent of HC emissions and 21 percent of CO emissions from mobile sources nationwide (US-EPA, 2003). There are no figures for such emissions in the Miramichi area, but the growing popularity of snowmobiles and ATVs and the prevalence of lawnmowers and outboard motors testify to the importance of these emissions in overall air quality considerations.

4.3.4 Other air emissions concerns

The 1998 ARMA report expressed concern that while licensed businesses in New Brunswick received information regarding the correct techniques to use, store and dispose of chemicals, the standards on these issues were not always enforced. Particular mention was made of concerns about unlicensed or backyard automobile body shops where sand blasting and painting activities were being undertaken. ARMA recommended establishment of reasonable and enforceable guidelines for these activities.

4.3.5 Outdoor Pollution and Community Health

In their 1998 report, ARMA addressed the effect of air quality on human health. In addition to providing information about the various health disorders and their causes, the following table was provided to give some indication of prevalence of respiratory problems in the Miramichi area.

Table 4-8. Admissions to hospital due to respiratory problems on the Miramichi (1993-1995)

	Asthma	Bronchitis	Emphysema
Average Age of Patient	33	51	73
Number of appointments	339	232	87
Number of days in hospital	5	7	11

The incidences of cancer in a community can be an indicator of exposure to environmental pollutants, including air pollution, as well as contaminants in food, water and through skin contact. Many other factors influence the occurrence of cancer such as life style, genetics, smoking, other tobacco uses, diet, drinking, various occupational exposures, high-energy radiation and a variety of naturally occurring carcinogens. This makes it very difficult to pinpoint environmental connections with the incidence of cancer in a community.

Nevertheless, it is worth noting that cancer and mortality rates in Miramichi differ in some instances from the rest of New Brunswick. In males, for example, oral and laryngeal cancers were higher than the rest of the province. In females it was lung cancer, thyroid cancer and non-Hodgkin's lymphoma that was significantly higher. In terms of mortality data for males, oral cancer, laryngeal cancer and leukemia were more significant in the cause of death than in the rest of the province. With females, there was no significant difference (New Brunswick Health and Wellness, pers. com.). What role air pollution or other environmental exposures play in these finding is difficult to say, but it illustrates how the health

and well being of a community can be compromised. Some of these cancer causing factors may have similar implications for wildlife and the adjacent ecosystem as a whole.

4.3.6 Wind energy

In the wind atlas of New Brunswick prepared by University de Moncton it is implied that the general area of Escuminac point has good potential for wind power generation. (i.e. ranked below very good and excellent) Other areas in the watershed rank possible through to poor.

5. STRESSES ON THE ENVIRONMENT AND CURRENT ACTION

The quality or state of the environment is, for the most part, the result of the complicated relationships between its living and non-living components. The interrelationship among its plant and animal species, and the impact that human activity has on that interrelationship, provides another layer of influence on the state of local and global environments. Considered together, these influences represent various forms of stress which can shape the nature and health of ecosystems. Both kinds of stress come to bear on the Miramichi watershed; the influence of non-living substances such as chemical pollutants, siltation and alterations in climate as well as human activities such as industrial development, forestry and fishing.

Obviously society requires the use of resources, sources of energy, food, recreation and jobs to sustain life/life-styles. What must be considered, however, is the amount of stress these activities and needs have on the environment and whether the quality and health of the environment is being maintained or whether it is running down. Are we managing our activities in a way that the current lifestyle can be sustained, and at the same time is the environment in which we live and on which we depend also being sustained?

The most profound and widespread stress forecasts for watersheds are likely associated with climate change. Within 100 years, climate change is projected to affect our river discharges, the temperature of our waters, our seasonal climate fluctuations, and our coastline. In turn, these changes will affect our wildlife and vegetation and other aspects of our way of life. While events causing climate change can be accepted as a worldwide phenomenon, there are local issues that can be addressed at least in part. As environmental stresses caused by industry are decreasing, stresses caused by individual action could be on the rise. Individual wealth encourages more travel and more recreation. This can result in more vehicles per household including ATV's, power lawn mowers and outboard motors. The availability of specialised vehicles permits more access to what was previously wilderness or only utilised by individuals or groups with a vested interest in at least maintaining the status quo. Disturbing sensitive vegetation or wildlife habitat can have far-reaching effects. Increasing internal combustion emissions,

along with the greater use of wood for burning to provide heat in our larger and/or poorly sealed homes, are seen as impacting air quality in the region and climate change in general.

5.1 Climate Change

Over the next 100 years, mean temperature increases have been predicted for the Atlantic Provinces. Parks Canada (1999) suggests +2 to +6 °C while Houghton et al (2001) projects +3 to +5 °C; Swansburg et al. (2004) estimates +4 to +5 °C for New Brunswick by the year 2100. Lines and Pancura (2005) attempt to narrow down both location and time frame and provide, in tabular form, the temperature increases centred around the years 2020, 2050 and 2080 for a number of sites in Atlantic Canada (Table 5-1). This includes five sites in NB, one of which is in the City of Miramichi (i.e. Chatham). The table below also demonstrates the different values obtained utilising two different statistical techniques in down scaling the projections from global models. The two models used were Statistical Downscaling Model (SDSM) (Wilby et al. 2001) and the first generation of the Canadian Coupled General Circulation Model (CGCM1) (Boer et al 2000; Flato et al 2000) It should be noted that maximum temperatures are projected by Lines and Pancura to rise faster than minima. This latter prediction is contrary to that of Swansburg et al. (Table 5-2 below) who also used the CGCM1

Table 5-1. Predicted changes in temperature in NB (Lines and Pancura, 2005)

	Tmax						Tmin						Precipitation					
Method	SDSM			CGCM1			SDSM			CGCM1			SDSM			CGCM1		
Year20xx.	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80
Unit	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	%	%	%	%	%	%
Moncton	1.8	3.2	5.6	1.3	2.5	4.1	1.3	2.6	4.3	1.5	2.6	4.0	-1	0	1	2	2	5
Chatham	1.8	3.3	5.6	1.3	2.5	4.1	1.5	2.9	4.8	1.6	2.6	4.0	14	12	0	2	2	5
Charlo	1.5	2.9	4.8	1.1	2.1	3.9	1.2	2.1	4.0	1.6	2.3	4.2	-4	-7	-6	2	-2	3
Fredericton	1.8	3.1	5.0	1.1	2.1	3.9	1.8	2.8	4.2	1.8	2.9	4.2	20	21	21	2	-2	3
Saint John	1.8	2.9	4.2	1.1	2.1	3.9	1.5	2.2	3.8	1.6	2.9	4.2	18	20	21	2	-2	2
NB Mean	1.7	3.1	5.0	1.2	2.2	4.0	1.5	2.5	4.2	1.6	2.7	4.1	10	10	7	2	0	4

Table 5-2. Predicted changes in temperature in NB, in °C (Swansburg et al., 2004)

	T max			T min		
Year 20xx	20	50	80	20	50	80
Aroostook	1.4	2.6	4.4	1.5	2.9	5.0
Charlo	1.2	2.4	4.1	1.2	2.3	3.9
Chatham	1.3	2.3	4.2	1.5	2.6	4.5
Doaktown	1.4	2.6	4.4	1.5	2.7	4.7
Moncton	1.4	2.5	4.4	1.5	2.5	4.6
Fredericton	1.4	2.6	4.4	1.4	2.4	4.3
Saint John	1.3	2.4	4.1	1.2	1.7	3.7

Increased temperatures are forecast to trigger other weather related changes:

- **Melting of the ice-caps, leading to sea level rise**
- **Changes in ice cover and ice break-up in rivers**
- **Change in precipitation (increases in the case of Miramichi area)**
- **Changes in river discharges (maxima & minima)**
- **Increase in number of extreme events (wind & storms)**
- **Increase in storm surges**

Table 5-3. Projected seasonal precipitation changes, in % (Lines and Pancura, 2005)

	2020'S		2050'S		2080'S	
	Winter	Summer	Winter	Summer	Winter	Summer
Moncton	-12	7	-8	8	-5	9
Chatham	12	18	20	9	7	1
Charlo	-4	2	-5	-5	-3	-4
Fredericton	4	20	6	25	7	30
Saint John	8	21	10	22	12	35
NB Mean	2	17	6	15	4	18

Table 5-4. Projected wet day precipitation increases, in mm/day (Swansburg et al., 2004)

	WINTER			SPRING			SUMMER			AUTUMN		
Year 20xx	20	50	80	20	50	80	20	50	80	20	50	80
Chatham	0.05	0.55	0.9	-0.25	0.05	0.7	0.1	0.25	1.2	0.2	0.45	1.0
Doaktown	0.25	0.3	1.25	0.25	0.3	0.45	0	0.3	0.35	0.25	0.3	1.1

5.1.1 Terrestrial Effects

5.1.1.1 Stresses due to climate change

The increase of extreme weather events implied above, including temperatures, precipitation, storms, hail, floods and droughts, will affect forests and crops, wildlife and livestock, fishing and aquaculture, communications and power. As storms become more frequent and intense due to climate change, the risk of trees blowing down increases (e.g. 1994 Christmas Mountains). The drier warmer summers increase

the risk of forest fires.

A longer, warmer summer would lengthen the growing season and increase the yield of warm-weather crops. A change of winter temperatures by 4-5 °C would change any plant cultivation around the city of Miramichi by half a hardiness zone, perhaps offering greater opportunities in horticulture and agriculture. However, the projected conditions could also result in more droughts and greater need for irrigation. Warmer winters may benefit agriculture by reducing winterkill of forage and fruit but could also create problems for farmers by increasing the range and abundance of insect pests. Warmer winter temperatures may allow invasive insects, such as gypsy moth, to become more pervasive. This is because prolonged temperatures at or below -9 °C or short periods below -23 °C are necessary to limit development and survival of these species.

5.1.1.2 Fire Potential

Warmer drier summers will increase the potential for forest fires. This potential will be added to, if the trend showing an increase in the number of recreation vehicles and people accessing the backcountry continues.

5.1.2 Aquatic Effects

5.1.2.1 Climate change effects on river flow

Based on the changes in precipitation they predicted, Swansburg et al. went on to project increases (m^3/sec) in the mean annual discharges for hydrometric stations 01BO001 (SW Miramichi) and 01BQ001 (NW Miramichi). Table 5-5 reflects the implications of their projections.

Table 5-5. Projected increases in mean annual discharges, in m^3/sec (Swansburg et al., 2004)

Year 20xx	20	50	80	W.S.C. Av
SW Miramichi	8	18.5	41	116.4
% increase	7	16	35	
NW Miramichi	6	15	28	20.9
% increase	29	72	134	

These are very significant changes in the average annual daily discharge with the greater change being seen on the Northwest Miramichi River (more than doubled by the year 2080). In terms of seasonal changes, analyses indicate greater decreased flows in the summer on the NW Miramichi.

Table 5-6. Predicted seasonal changes in mean daily discharges in m^3/sec estimated from Fig 10 in Swansburg et al (2004b). Average flows estimated from Environment Canada data for stations 01BO001 SW Miramichi and 01BQ001 NW Miramichi

Table 5-6

	Winter			Spring			Summer			Autumn		
Year 20xx	20	50	80	20	50	80	20	50	80	20	50	80
SW Miram.	10	15	30	18	42	88	-14	-22	-35	-3	-7	-12
Av Flow	58			246			57			101		
%Increase	17	26	52	7	17	36	-25	-39	-61	-3	-7	-12
NW Miram.	6	8	21	18	39	65	-13	-21	-32	-2	-4	-6
Av Q	9			47			10			17		
%increase	67	89	230	38	83	138				-12	-24	-35

The Southwest Miramichi is looking at winter and spring average daily discharges increasing by 52% and 30% respectively. The summer average daily discharges would be cut in half and the fall discharges decreased by around 10%. In the Northwest Miramichi, the winter and spring predictions are increases of 230% and 138% while the summer predictions imply that it will virtually dry up. It should be recognised that these are based on statistical predictions and, while absolute values may have been extrapolated too far, the trends are consistent and the implications should be considered.

A better understanding has to be obtained before extrapolating these predictions to 20 or 50 year floods or similarly to extremely dry weather discharge projections. Superficially at least, these projections could imply that there would be spring spates (and possibly also in winter with intermittent ice break-up) that are going to repeatedly overtop and erode existing banks. Any existing weak areas of the banks or potential areas of flooding will be consistently challenged.

Beltaos (2003) discusses the impact of climate on the ice and on the discharge regime of the Southwest Miramichi. In that paper, he states that ice cover typically forms at the Blackville gauging station in December and breaks up in April. Mid-winter thaws are not uncommon, but they do not often produce sufficient run-off to cause break-up of the ice cover. The report states that winter break-ups are rare on the river. He does add, however, that when they do occur, these winter break-ups can be devastating and cites the winter floods of January, 1909 and of February, 1970. If these occurrences do become more frequent, it will not only have socio-economic impact but also impact aquatic life including salmon fry (Cunjak et al., 1998). Swansburg et al 2004a) note the time of ice break-up is already getting earlier by about 5 days every decade.

The significantly lower summer flows, coupled with predicted higher air temperatures, combine to raise concerns about summer water temperatures and fish habitat. These climatic changes, which are forecast to take place in the next 100 years, are expected to be the largest and most rapid of the last 10,000 years, and if they occur as projected are likely to have profound effects on our lives and the ecosystems around us.

Among the expected effects of climate change in the Miramichi watershed will be the increased precipitation and the increase in mean annual stream discharge. The effects of these increases are multiplied when the projections show a skew to increases in daily discharges during winter and spring and significant decrease in mean daily flows during the summer. These have been discussed at length above.

5.1.2.2 Sea Level Rise

A sea level rise of 67 cm plus or minus 30 cm has been forecast for the mouth of the Miramichi by 2100. Significant storm surges are already becoming a more frequent occurrence. One of the largest ones recorded at the gauge at Escuminac occurred in 2005 and was nearly two metres in height. (Personal communication Real Daigle, Manager Sea Level Rise in NB, Environment Canada, Moncton).

Storm surges are caused when low pressure and strong onshore winds combine to raise water levels, sometimes a meter or more above normal. Storm surges are

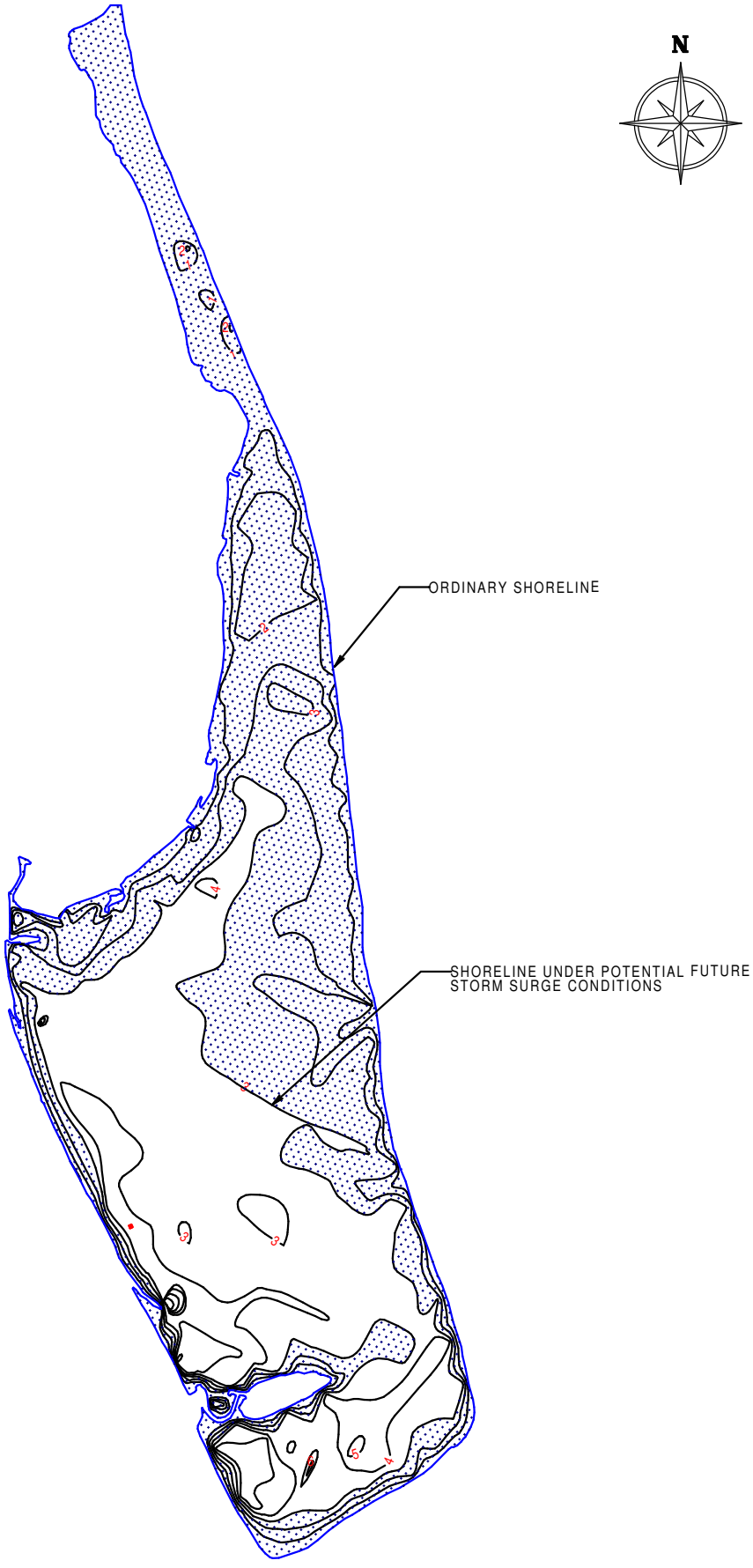
particularly destructive when they happen to coincide with a particularly high tide. As sea levels on the Atlantic coast are expected to rise dramatically over the next century, storm surges will be able to flood areas never before flooded. Low lying coastal areas will be most threatened. Sinking of coastal land could compound the problem as much of this coast is low lying and sensitive to erosion and flooding.

The effect of an extreme event, with the maximum sea level rise of 1 m topped by a storm surge of 2 m, could have significant implications for the estuary and inner bay. Using Portage Island as an example, and adding 0.5 m to the water level of a large tide, the island would lose more than 50% of its exposed area (See Fig 5.1). It should be recognised that a storm surge of this magnitude would be accompanied by significant wave action and that the barrier islands are for the most part composed of sediments deposited by littoral drift. This situation could have significant implications for the stability of all the barrier islands and also for the inner bay which, until then, would have been sheltered.

Fortunately there are some factors on the plus side. There will be some increase in the volume of the estuary at low tide, providing a larger body of rich productive estuarine water for the diverse aquatic organisms. A minor decrease in tidal velocities may be observed. The increased water depth and warmer coastal waters could improve the viability of suspended oyster culture in the Inner Bay. The head of tide will move up both Miramichi branches and other estuaries, such as the Bartibog, providing additional habitat for diadromous fishes.

PORTAGE ISLAND

NORTHUMBERLAND COUNTY



MREAC STATE OF THE ENVIRONMENT REPORT PORTAGE ISLAND	NATECH Environmental Services Inc. Patterson Rd., Harvey Stn., N.B., E6K 1L9 ph: (506) 366 1080, fax: (506) 366 1090	DATE: 06/03/03	SCALE: AS SHOWN
		FILE: MREAC-05-01	FIGURE: 5-1

5.1.2.3 Water temperature changes

Air temperature increases of 3-4 °C are projected for Atlantic Provinces and scientists forecast that a warmer climate will change not only terrestrial but also aquatic ecosystems. Water temperature increases and lower discharges are of particular concern for cold-water species such as Atlantic salmon and trout that are currently near the southern limit of their habitat. In general, many freshwater and marine fish are sensitive to temperature; therefore, changing temperatures would influence the distribution and population abundance of many species.

Rising water temperatures also make freshwater and estuarine waters more susceptible to certain invasive species, some of which have already invaded freshwater systems and coastal waters of the eastern Canada. A new threat to rivers and streams is an invasive diatom which forms thick adhesive mats over the bottom substrate, reducing the suitability of fish habitat. This species, *Didymosphenia geminata* a.k.a. Didymo or "Rock Snot", has already invaded some river systems in Quebec, and it is likely to find its way into the Miramichi system.

Ocean temperatures will also increase and affect marine ecosystems. These changes could be greater in shallow coastal waters, which would be of particular significance for the inner bay. Already in the eastern Gulf of St. Lawrence, an invasive invertebrate, the green crab, and an invasive tunicate species are having serious effects on estuarine ecosystems in some locations. Furthermore, climate change may increase the frequency, range and extent of organisms responsible for toxic algae blooms such as red tides. Toxic blooms pose a serious threat to both fish and human populations.

5.2 Industrial Impacts

While climate change might pose a serious future stress on the aquatic and terrestrial environments of the Miramichi watershed, there are other human induced stresses which threaten the long-term sustainability of its environmental quality. For example, the long-term discharge of various industrial pollutants over the past 50 years has placed a stress on the aquatic environment of the Miramichi River which lingers to this day. Although many of the pollution sources have been slowed or stopped, most are still measurable in the environment and some of their effects are still measurable.

For example, Buckley (1995) notes that organic loading to the water and sediments of the Miramichi estuary has by itself had the most significant impact on the environmental quality of this system.

On the positive side, changes to the mining and forestry sectors have led to decreased levels of industrial pollution being discharged into the Miramichi watershed (C. Murray, 2006).

- **Concentrations of dioxins and furans in effluent from Miramichi Pulp and Paper Mill at Newcastle dropped dramatically between December 1988 and May 1994 (Figures 3.6-3 and 3.6-4);**
- **The Heath Steele base metals mine at Tomogonops was closed and decommissioned in 2000;**
- **Acid mine drainage and metal leachate on the NW Miramichi, as well as the leaching from stockpiled metals for shipping at local wharves, are no longer contaminant sources.**
- **The pulp and paper industry met the no-trace dioxin and furan CEPA standards in 1995.**

Figure 3.6-3. Concentrations of dioxins in effluent from Miramichi Pulp and Paper Mill at Newcastle, 1988 to May 1994. (Source: Courtenay et al., in Chadwick 1995.)

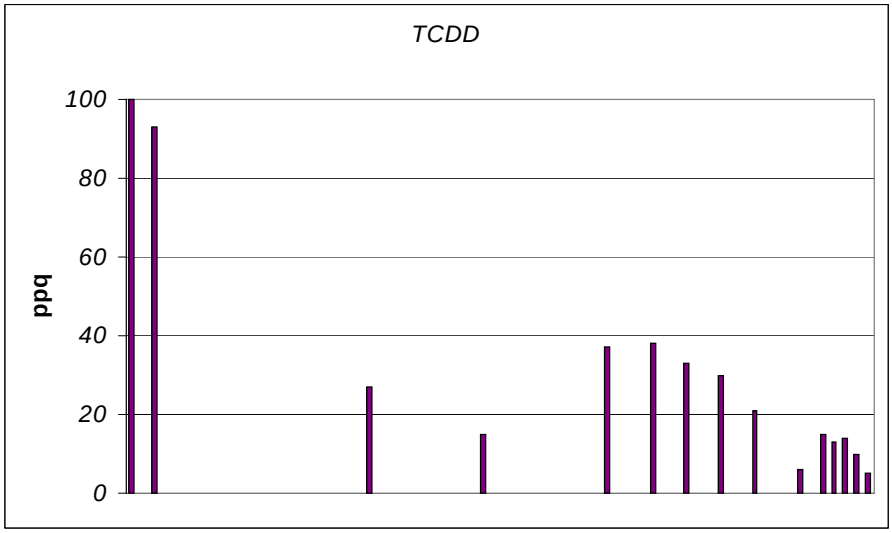
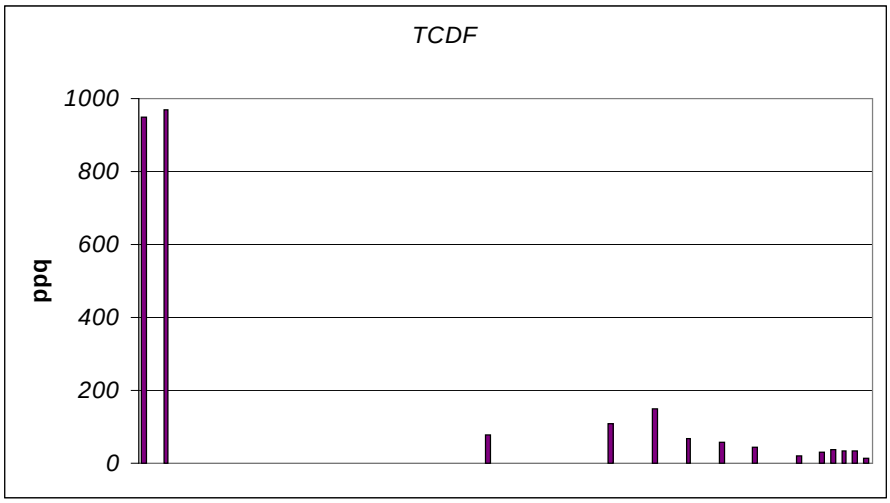


Figure 3.6-4. Concentrations of furans in effluent from Miramichi Pulp and Paper Mill at Newcastle, 1988 to May 1994. (*Source: Courtenay et al., in Chadwick 1995.)*



Several other noteworthy advancements in industrial waste management have been made in recent years. These include the construction of a multi-million dollar treatment system by Noranda (now owned by Xstrata) at the decommissioned Heath Steele mine site to collect and neutralize run-off. There have been reductions in commercial shipping and associated hydrocarbon contamination in sediments. The closure of the UPM-Kymmene Kraft Mill operation resulted in improved air and water quality for the City of Miramichi (Murray, 2006).

The diversion of wood waste to a Miramichi based composting operation has dramatically reduced the volume of these wastes to land fills. Major industrial operations have all but eliminated this waste stream either by this diversion or by the use of wood waste as hog fuel in their industrial processes.

Elements of a new environmental assessment, called for by Buckley (1995) in reference to work done in the 1970's and 1980's, are found in the recent report by Parker (2006) (see section 4.2.1.3). He compares the findings of two more recent sediment surveys, one done by Environment Canada in 1993 and another carried out by MREAC in 2002. This work allows us to evaluate changes in risk to the aquatic environment which may have happened over the nine year period between these two studies.

The contaminants measured in the two surveys are substances arising mainly from both historical and current industrial activities. They include total organic carbon, PAH, PCB, heavy metals such as cadmium, lead, copper, zinc and mercury, chlorophenols and organic halides. These contaminants arise mainly from base metal mining, pulp and paper production, wood preservation and the discharge of domestic sewage. Also measured is the toxicity of the sediments and the diversity or state of health of the benthic invertebrate community. Several points can clearly be made:

- **The sediments in the Miramichi River estuary have concentrations of metals and organic contaminants that exceed the Interim Sediment Quality Guidelines established by the Canadian Council of Ministers of the Environment.**
- **Polycyclic aromatic hydrocarbons (PAH) can still be found in river sediments at elevated levels particularly near the Wharf Inn.**
- **The levels of polychlorinated biphenyls (PCB) are still elevated particularly at downstream locations.**
- **Metal levels are still elevated in the estuary and, although some decreases may be detected, many metal concentrations in sediments exceed the Interim Sediment Quality Guidelines established by the Canadian Council of Ministers of the Environment.**
- **Sediments from locations where fine silt or clay has accumulated are still found to be toxic.**

- **The Miramichi River estuary supports an impoverished benthic community with low numbers of species, although there is a suggestion that some recovery may have occurred between 1993 and 2002.**

Given these findings, it is possible to see that the recovery of the aquatic ecosystem is going to take some time. These lingering stressors must be taken into account when trying to assess the current state of the watershed and its sustainability over time. It shows that there can be a considerable lag time for some stressors after their source has been removed. There is no "quick fix" in such cases.

It would appear that serious contamination may have existed in the 1980's. S. Courtenay (1995) reported a maximum PAH level as high as 61.48 ppm (one of the highest levels recorded in North America) above Newcastle from sediment sampling conducted in the late 1980's. If one compares the level of PAH (0.59 ppm) several years later (1993), as measured by Environment Canada in much the same area, it is encouraging to see that the contamination likely caused by the Domtar wood treatment facility throughout the 70's and 80's had quickly dropped to a more stable level shortly after the plant closed. Nevertheless, the legacy of this industrial operation remains in the sediments where it exerts its own form of stress on the aquatic ecosystem.

5.2.1 Forestry and Forest Products

Forestry operations in New Brunswick and Atlantic Canada in general have changed significantly over the past two decades in terms of environmental considerations and protection of aquatic habitats. Both the provincial jurisdictions and the industry itself have responded to local and international concerns over sustainable forestry practices and are applying protective measures more rigorously and consistently.

Nevertheless, the forestry sector probably has, and will continue to have, profound impacts on the overall state of the environment of the Miramichi watershed with long-term effect on its sustainability. The longstanding forestry operations on the Miramichi include pulp and paper, oriented stand board and plywood as speciality products as well as softwood and hardwood lumber. Most of the product is exported and it has been long noted that there is little else in the way of value added products

produced here.

Within this sector large industrial operations lease the majority of the Miramichi watershed. These operations are regulated by the New Brunswick Department of Natural Resources. Harvesting regulations require the protection of watercourses, wetlands, deer-yards, and other considerations. Private lands remain a significant contributor to forest products but these often do not have the rigor of the regulations applied to their operations. As such more issues arise on private lands than occur on lease hold or free hold. .

Despite positive changes in forest practices, the process of tree harvesting with heavy equipment has its problems. Stress on the aquatic and terrestrial ecosystems comes from such activities as the construction of access roads, use of chemicals, removal of forest cover and fragmentation of wildlife habitat, as well as the general increase in human activity and access to remote areas.

As noted in the section on Atlantic salmon, for example, changes in the hydraulic regime, increases in the temperature of small streams and the removal of leaf litter as a primary carbon source in small feeder streams can pose a threat to the sustainability of healthy salmon populations. Impacts like these are nearly always found in areas of forest harvesting. As well, the viability of salmon eggs and suitability of breeding habitat can be deteriorated by siltation from poorly managed forestry operations.

The protection of wildlife and their habitat is an important concern of forest managers and a requirement under the provincial Crown Lands and Forest Act. Habitat is defined in terms of stand structure criteria for operational planning and assessment, and in terms of timber volume development patterns for the longer-term strategic forest planning. From an operational perspective, forestry companies are required to identify and plan for such wildlife considerations as deer wintering areas, endangered species or species at risk, and old forest stands such as old spruce-fir habitat. Nevertheless, there is a growing loss of old forest and a steady increase in new stands predominantly of softwood. The stress on those wildlife species with a dependence on old forest for their survival is on the rise.

The province has a mandate to manage the forests for the protection of deer wintering

areas, old forest, protected areas, wetlands, and water courses. For example, since temperature and snow conditions vary across the province, forest companies or licensees must provide habitat for deer wintering areas suitable for both moderate and severe winter weather. New Brunswick manages over 280,000 hectares of deer wintering areas throughout the province providing winter habitat for some 80,000 deer that reside on Crown land. In the case of the 30 or so protected areas in New Brunswick, the province seeks public, scientific and stakeholder advice both locally and through broader provincial bodies (NB-DNR web site). Unfortunately the nature of environmental degradation from stress caused by certain forestry activities is long-term and the effectiveness of management efforts may not be evident for a number of years at which point the damage may not be easily rectified.

The 2005 closure of the kraft mill and its subsequent decommissioning will impact marketing of lumber harvested in the region. Despite this change the market demand is such as to fully subscribe all the marketable wood made available. However the current dramatic changes in markets and mill operations in the province suggest that all this is subject to change in relatively short order. As partners in the overall forest products market, lumber mills are likewise in a time of uncertainty. It is expected, and hoped, that demands for sawmill products will remain steady. The degree of uncertainty increases over the longer term as climate change is expected to impact the composition of the forest structure, increasing hardwood habitat at the expense of softwoods.

5.2.2 Mining

Environmental stress relating to mining activity is much diminished since the Heath Steele closure. The remediation and ongoing management of the site appears adequate to mitigate any potential threat the site continues to pose. Other major remediation activities (2007) are expected to reduce these risks even further.

Of particular note, the removal of impoundments and improvements in fish passage since the mine closure has resulted in dramatic improvement to fish habitat.

The mining of sand and gravel resources continues and remains a potential concern to environmental managers, especially related to water courses. Following provincial

regulations related to providing buffer zones along water courses should mitigate any major issue. A few sites where such care was not exercised continued to impact select locations on Miramichi waterways.

Erosion on the Little Southwest Miramichi

5.3 Air Quality

5.3.1 Long Range Air Pollution

The Maritimes have been cited as 'the tail-pipe of North America' due to the continental flow of air masses. As such many air pollutants which create a stress on the environment of eastern Canada and the Miramichi basin are transported into the region from outside sources. Despite this the Miramichi watershed is situated such as it does not receive a direct hit from this flow pattern and the geology is such that these impacts, especially of acid deposition, is ameliorated at least in part.

Acid rain is a pollutant of concern which over the years has affected the health of sensitive vegetation in New Brunswick and altered the pH of poorly buffered lakes and streams in the Maritimes. In several areas salmonids have been extirpated or severely depleted from some affected watersheds. Monitoring throughout New Brunswick between 1988 and 1993 showed a decline in sulphate concentrations and deposition (Albin, 1995). This downward trend seems to be consistent with observations elsewhere in Canada and should continue given efforts to control acid generating emissions throughout North America.

Another well-studied pollutant is mercury. Levels of mercury in water striders in the southern part of New Brunswick tend to be higher (0.25ug/g) than those in the north (0.15 ug/g). Water striders are common aquatic predators and are being used as an indicator species of aquatic levels of mercury (Jardine, 2006). Some other air pollutants such as nitrogen sulphur oxides and volatile organic carbons are decreasing where others such as ground level ozone are not. Local stress from stationary sources and vehicle operation remain.

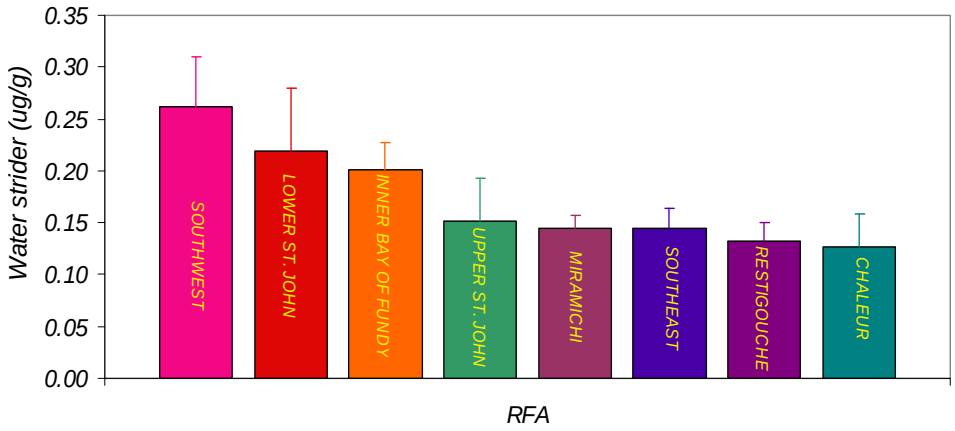


Figure 3.6-5. Mercury levels in Miramichi River system. (Source: Tim Jardine, MREAC Science Day 2006)

5.3.2 Local Air Pollution

The number of "bad air days "caused by smog is expected to increase due to a warming climate. Smog is a mixture of pollutants, including nitrogen oxide and volatile organic compounds, which react together to form ground level ozone. The increase in use of large outdoor wood furnaces and increased use of wood for heating will add to this phenomenon. In the City of Miramichi, the high numbers of wood burning units, especially during inversions in cold winter conditions, are suspect in causing locally poor air quality. This is a topic that requires more study and may be an opportunity to engage community based monitoring efforts.

Recreational use of small engines may affect local air quality as the use of off- road vehicles increases. Spark-ignition engines, which are part of the off-road category, include: small engines typically used for lawn and garden applications, large engines

used in industrial applications and specialty engines used in recreational applications. Spark-ignition engines below 19 kW (25 horsepower) usually run on gasoline and are used primarily in lawn and garden equipment. Lawnmowers, string trimmers, leaf blowers, chain saws, commercial turf equipment, and lawn and garden tractors fall within this category as do engines used for marine propulsion (outboard motors) and recreational vehicles (ATVs and snowmobiles). These engines are known to contribute a large percent of HC and CO emissions to North American air pollution (US-EPA, 2003).

There are no specific figures for such emissions in the Miramichi area, but the growing popularity of snowmobiles and ATVs and the prevalence of lawnmowers and outboard motors testify to the importance of these emissions in overall air quality considerations.

5.3.3 Forest spray programs

The most commonly applied chemical pesticides used in forestry in New Brunswick are herbicides with the active ingredient glyphosate. It is applied several years after reforestation or as natural re-generation is getting under way to remove new growth hardwoods that would compete with the softwood species such as spruce, pine and fir which are preferred by the industry. As noted earlier in Section 4.1.1.1, this chemical has a minimal effect on wildlife species. It does, however, kill all broad-leafed plants and therefore eliminates most hardwood species resulting in a predominantly softwood forest. As noted above, such monoculture places a stress on those wildlife species which require a more diverse forest habitat.

Forestry companies (licensees) working on Crown Land are required to identify all planned treatments using such chemicals in their silvaculture plans. These are reviewed by NB Department of Natural Resources which is also responsible to inform the public as to where and when such treatments are to take place. As a region that has a particularly difficult legacy related to forest sprays with both the DDT and the spruce budworm program, the residents are suspicious at best about these operations.

Table 5-7. Crown land treated with Herbicide (by both aerial and ground application) (glyphosate based –Forza, Vision, and Vantage Forestry)

	2004-2005	2003-2004	2002-2003
Lower Miramichi	849	875	305
Upper Miramichi	1226	439	65

5.4 Wastes

The disposal of various industrial, domestic and municipal wastes can place a serious stress on aquatic and terrestrial ecosystems and human health. Some wastes are designated as "hazardous" which generally means they are a danger to human health and safety as well as the environment. Others are seen mainly as a stress on animal and plant viability and causing a general deterioration of environmental quality which, as in domestic sewage, can expose humans to various disease pathogens.

5.4.1 Hazardous Wastes

Used oil is a common hazardous waste with some 2.5 million litres of it being generated in New Brunswick each year. When used oil is poured down a storm drain, stored in a basement or garage, openly burned, or simply disposed of with household garbage, the risks to the environment are greatly increased. Used oil can seep into and contaminate the water table, create unwanted emissions to the air, and when disposed of on land, can create expensive clean-ups for homeowners. In short, these practices have created both environmental and safety hazards. To protect the environment from this type of hazardous waste, the Province of New Brunswick has created the Used Oil Regulation which prohibits anyone in New Brunswick from disposing of used oil as part of regular household garbage; releasing it into drains or storm sewers; dumping it on private or public land; burning it (unless approved by the Department) or using it for dust suppression (N. B. DOE).

There are other typical household products that can become hazardous wastes if they are discarded into the environment. Such hazardous products can include paints, solvents, drain opener, oven cleaner, batteries, certain hobby supplies, chlorine bleach, and pesticides. Improper disposal of such products can not only harm the

environment but can threaten the health of children and adults who might come in contact with them. Effects may also be cumulative in both cases.

Included in the category of hazardous waste are certain products which contain PCB, although new uses of these substances are banned in Canada. PCB is known to be toxic and carcinogenic, it bio-accumulates in fatty tissue and persists for a long time in the environment. Old electrical transformers and some other types of electrical equipment may contain PCB. Disposal of such material requires specialized treatment and is carefully controlled under both provincial and federal laws.

In 2005 the Northumberland Solid Waste Commission held its first Hazardous Waste Collection days at select locations, including the City of Miramichi and Rogersville. This service was well supported and residents were pleased to discard quantities or old paint, used oil, cleaning products and other materials. This event was repeated in 2006 and is expected to be an ongoing annual service to the Miramichi communities.

Solid waste management, especially household garbage remains an issue. These materials are trucked to the Red Pine Landfill site near Bathurst. The traffic and expense of this operation is out of proportion to the service as a result of community opposition to a transfer station situated in proximity to the City of Miramichi. There are still limited efforts to sort or recycle solid waste on the Miramichi but some initiatives are demonstrating a measure of success.

5.4.2 Municipal and On-site Sewage Waste Disposal

Sewage and the resulting bacterial contamination continue to compromise water quality in the lower reaches of the Miramichi River. This is demonstrated in the limitations poor water quality poses on the commercial use of the water resource for wild shellfish harvesting and aquaculture.

In the MREAC Final Report, 1992 (ed. Dr. Michael Burt, unpublished), the old sewage system infrastructure in Newcastle and Chatham were inadequate and permitted the by-pass of raw sewage into the river during high flow conditions. Additionally, surveys by MREAC in 1993 and 1994 of more than 900 rural on-site septic systems,

showed that 30% – 40% were not maintained properly, dooming the system to ultimate failure

The presence of untreated or improperly treated sewage raises the risk of exposure to several dangerous pathogens that can endanger community health as was demonstrated in Upper Canada in recent years. Pertaining to shellfish harvesting, the bacterium, E. Coli, is used as an indicator of the presence of untreated sewage. The shellfish classification of coastal waters is largely based on this bacterium as carried out by Environmental Canada. Fisheries and Oceans Canada enforces shellfish regulations while the Canadian Food Inspection Agency tests shellfish meat quality and inspects shellfish for the presence of biotoxins such as red tide (B. Richard, 2006).

Government and community efforts over the past decade are improving the situation by helping to educate residents, working to change attitudes and providing funding to help with upgrading sewage treatment. In 1998 and 2003, the City of Miramichi brought the North Side and South Side Sewage Collection and Treatment Systems on line respectively. With the assistance of the provincial Environmental Trust Fund, MREAC was the lead agency in upgrading 55 failing on-site systems among low income residents within the watershed. In 2003, these efforts lead to an additional 10 km^2 being opened for shellfish harvesting after being closed for well over 20 years (LeBlanc et al 2005).

5.5 Environmental Accidents

Environmental accidents are situations where environmentally dangerous substances are released into the environment contaminating adjacent waterways, land or marine habitat. Serious environmental accidents are usually one time or infrequent occurrences which result from a highway, shipping, rail or aircraft crash or upset. In such serious large accidents there is an intergovernmental Environmental Emergencies Response Team which deals with the incident. There are, however, dozens of smaller environmental accidents ranging from spilled heating fuel to ships spilling fuel or bilge water in a harbour or near the coast. They can also occur when an industrial process fails or materials such as waste tires or a building or storage facility burns, releasing toxic substances or contaminants into the environment.

The Miramichi watershed has a major rail and highway corridor which crosses the lower portion of the Miramichi River, and also supports a small amount of commercial shipping. There is, therefore, a certain risk of an environmental accident occurring which could affect the watershed. There are also a few large industries on the river with the potential to accidentally release contaminants.

Courtesy of Environment Canada

Substances that have been involved in past environmental accidents include petroleum products of various kinds (e.g. oil, gasoline, bunker oil) acid, caustic substances, pesticides, industrial chemicals, mine-water leachate, black liquor from pulp mills, PCB and other such environmental contaminants. Most of these accidents are reported to Environment Canada's Environmental Emergencies network, which investigates all reported accidents. Although records of such accidents are provided to a central repository, they are not readily available on an area specific basis such as the Miramichi River watershed.

6. STRATEGIC PARTNERSHIPS

In recent memory the stewardship and management of the Miramichi watershed has been improved with the engagement and volunteer contributions of many community-based organizations. This new reality has been a boon to government at all levels who are more and more willing partners with these resource-based organizations. Particularly prominent in working on environmental issues are groups engaged in recreational fishing, hunting, watershed management and the resource sustainability. Many branches of the Miramichi support a group of engaged anglers who contribute to the management of their particular tributary (e.g. Bartibog, Cains, White Rapids, Northwest Miramichi, Southwest Miramichi etc.). Umbrella organizations have been successful in supporting and coordinating the activities and interest of these smaller groups. These are found in such organizations as the Miramichi Salmon Association and the Northumberland Salmon Protection Association. The watershed environment has been the focus of the Miramichi River Environmental Assessment Committee, one of fifteen Atlantic Coastal Action Program sites throughout Atlantic Canada.

While this level of engagement by community-based involvement is relatively new the early results are exciting. The organizations offer valuable contributions in way of insight, offering solutions to problems and often directly engaged in delivery. As such the jurisdictional agencies are recognizing and acknowledging the value of these groups with greater empowerment. This experiment is expected to continue and grow stronger in subsequent years as the groups mature.

7. SUMMARY

In part by virtue of its size and limited population, the environmental integrity of the Miramichi watershed is largely intact. Additionally, process improvements implemented over the last decade and longer have improved the environmental performance of several industries. A regional economic downturn with the resultant closure of a number of industrial activities has also reduced environmental impacts to air, water and land. Two new sewage treatment plants for the City of Miramichi have dramatically improved the quality of waste-water discharge into the upper estuary. Other sewage treatment facilities of local towns and villages have been upgraded or replaced.

Despite all of these positives there has rarely been a time of such anxiety of what is to come. The actual longer-term impacts of climate change will only be determined over that long-term and on how well we adapt. At best we will be challenged. This is not to suggest that the Miramichi is isolated from climate change impacts on a national and global scale. Those challenges are likely to test the fibre of society to the core.

Socially, the Miramichi is already challenged by the economic impacts of industrial decline, mechanization, and large reductions in the traditional work force. A diversification of the economy has helped but has not been effective in stemming the out-migration of the work force, especially our youth.

Sustainability will be a major test to this region. Much needs to be accomplished in the traditional pursuits of commercial fishing and forestry. Prospects for the future appear to rest with the resource base that is here-to-fore stable; that of clean air, water and land on an internationally renown landscape. The eco-economy of the Miramichi offers an untouched market opportunity that may soon be discovered.

It seems incumbent on the residents of the Miramichi to prepare, adapt and take advantage of what the future will bring. We need to position ourselves intelligently and root ourselves well to be benefactors rather than the victims of the future.

As noted in the opening paragraph, the future of the Atlantic salmon may remain the best indicator of the state of the Miramichi environment. A great deal is at stake with regard to this specie. Our reputation is on the line as resource managers and

stewards of the environment. Miramichiers, not government, ought to be the architects of the future, taking ownership of successes and failures along the way. May our failures be minor ones, as neither time nor salmon allow for major ones.

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