Highlights

The Mackenzie River Basin Board (MRBB) State of the Aquatic Ecosystem Report, 2003 uses indicators to assess the state of the aquatic environment throughout the Mackenzie River Basin with respect to two major issues:

- Climate change
- Contaminants.

The report also uses indicators to assess whether the Board's water management goals are being met in each of the major sub-basins that comprise the Mackenzie River Basin. Those goals are:

- Improve water quality
- Ensure sufficient water quantity
- Sustain in-stream water uses
- Ensure healthy, abundant and diverse aquatic species and habitat
- Ensure human health and safety.

We can improve our collective knowledge about water as a natural resource by examining the state of the aquatic ecosystem in the Mackenzie River Basin, and we can apply this knowledge to effectively manage our use of this precious resource.

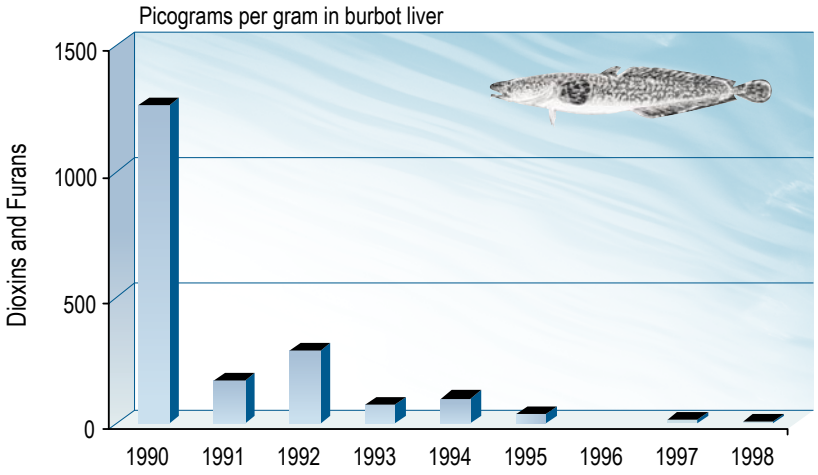
Issue: Climate Change

Scientific monitoring and community observations from the Mackenzie River Basin show an increase in temperature and changes in precipitation, suggesting that climate change is affecting the environment of the basin. Aboriginal residents of the basin have reported that the weather has become more variable and is more difficult to predict. They have observed changes in ice thickness and in the processes of freeze-up and break-up. In some areas, water levels have decreased and small lakes and streams have disappeared. People have also reported an increase in erosion and landslides, changes in vegetation and an increase in forest fires, all of which may be related to climate change. Elders explain that changes in climate have affected wildlife habitat, resulting in changes to the population size, distribution, and migration of certain species. Human activities are directly affected by changes in climate and the resulting changes to the landscape and wildlife communities. The issue of

climate change is a global concern and several initiatives are underway to better understand its potential effects, to identify ways to adapt to a changing climate, and to reduce greenhouse gas emissions. *The Mackenzie Global Energy and Water Cycle Experiment Study* (GEWEX-MAGS) is examining the climate of the Mackenzie River Basin. Through this study, much is being learned about the factors that control the climate in the Mackenzie River Basin. One of the objectives of the study is to improve our ability to assess changes to Canada's water resources that arise from climate variability and climate change caused by human activity.

Issue: Contaminants

A contaminant is a substance that is found in a place where it should not be. This does not necessarily mean that it is harmful but, depending on what it is and the amount that is present, it may be. Contaminants in the Mackenzie River Basin come from natural and human sources and originate in locations distant and nearby. There are many different contaminants in the Mackenzie River Basin. Some of them are present in food that people eat, such as fish. Contaminants known as chlorinated dioxins and furans are unwanted industrial by-products created by several human activities and industries. In the Mackenzie River Basin, bleached kraft pulp mills are the major industrial sources of chlorinated dioxins and furans in the aquatic environment. In the past, the effluents from these mills posed a significant threat to water quality in the Peace and Athabasca sub-basins. Technological improvements made in the early 1990s reduced the production and release of these industrial by-products and the levels of dioxins and furans in bleached kraft pulp mill effluents have since declined substantially. As the levels of dioxins and furans in the effluents declined, so did the levels in livers of burbot caught downstream from the pulp mills. Dioxins and furans bioaccumulate through food chains so the



Concentrations of dioxins and furans in fish living near bleached kraft pulp mills declined substantially during the 1990s, as illustrated by this graph of dioxin and furan concentrations in livers of burbot collected downstream from a pulp mill on the Wapiti River, a tributary of the Peace.

Data Source: Fraikin *et al.* (Environment Canada and Golder Associates).

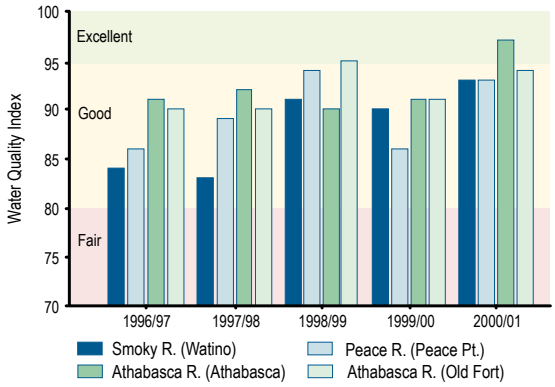
levels of these contaminants in predatory fish like burbot are higher than those found in prey species or in the water itself.

Mercury is another contaminant of concern within the Mackenzie River Basin. Elevated concentrations of mercury found in the flesh of predatory fish species, such as northern pike, have prompted government agencies to issue fish consumption advisories for several water bodies in the basin. Except for a small number of water bodies such as Giauque Lake in the Northwest Territories, mercury has increased very little in the Mackenzie River Basin and industrial pollution has added very little to the natural mercury already present in the basin's water bodies. Nevertheless, because mercury is transported globally, international efforts must be continued to curtail industrial emissions of mercury. Continued monitoring of mercury levels in fish and publication of fish consumption advisories are required to prevent the occurrence of mercury-related health problems.

MRBB Goal: Improve Water Quality

Water quality is influenced by the climate, geology and landscape features of the natural environment, and by human activities such as farming, logging, mining, oil and gas extraction, various other industrial activities and the discharge of treated wastewater. Water quality refers to the amounts of suspended solids, nutrients, minerals, micro-organisms, chemicals, pesticides and other substances present in the water. It can be evaluated by comparing the amounts of these substances in the water with guidelines developed by government agencies.

Water quality indices are a convenient way of summarizing large amounts of water quality data into simple terms. For example, The Canadian Council of Ministers of the Environment has developed water quality indices that evaluate a wide range of substances of concern to rate water quality. Similarly, the Alberta Water Quality Index incorporates information on metals, nutrients, bacteria and pesticides to rate water quality in its major rivers. It is important to keep in mind that other substances, not generally included in water



Water in the Peace and Athabasca rivers has consistently been of good-to-excellent quality, as measured by Alberta's Water Quality Index, since the mid-1990s. In most of the rivers of the Mackenzie River Basin, water quality reflects natural conditions and has not changed substantially as a result of human activities.

Data Source: Alberta Environment.

quality indices, can also affect water quality.

The Alberta Water Quality Index has been calculated for four sites in the Alberta portion of the Mackenzie River Basin. Based on this index, the water at each of these sites has consistently been of good-to-excellent quality since 1996. The water samples that exceeded guideline concentrations were often those taken during periods of high flow, when river water typically contains high levels of suspended particles. Nutrients, metals and other substances are often bound to suspended particles, so high levels of these substances also occur during periods of high flow.

Rivers throughout the Mackenzie River Basin tend to experience maximal levels of nutrients and metals during peak flow periods. It is important to note that because metals and other substances are usually bound to suspended particles during periods of high flow, they have a much reduced effect on aquatic plants and animals. They cannot enter the drinking water supply since treatment plants routinely filter out suspended particles before distributing drinking water into communities.

British Columbia and other jurisdictions are using the Canadian Water Quality Index developed by the Canadian Council of Ministers of the Environment to rate water quality in their lakes and rivers. Not all jurisdictions use the same approach to rate water quality and, as a result, water quality ratings from two or more jurisdictions cannot be compared. To overcome this problem, the different jurisdictions are working together to develop a set of water quality indices that can be applied to aquatic ecosystems across the basin. Such an approach is especially needed for transboundary rivers.

Water quality throughout most of the Mackenzie River Basin reflects natural conditions. There are few places where water quality is severely degraded by wastewater discharges from industries and communities. Stricter regulations and technological advancements in pollution prevention have resulted in improvements in wastewater treatment by industries and communities in recent years. As a result, water at sites that were historically adversely affected by wastewater discharges is cleaner today than it was in the past. Traditional Environmental Knowledge once documented the adverse effects of wastewater discharges on water quality. Unfortunately, Traditional Environmental Knowledge of water quality has not been widely recorded in recent years. It remains unclear whether Aboriginal people have recently observed improvements in water quality similar to those improvements recorded by governmental water quality monitoring programs.

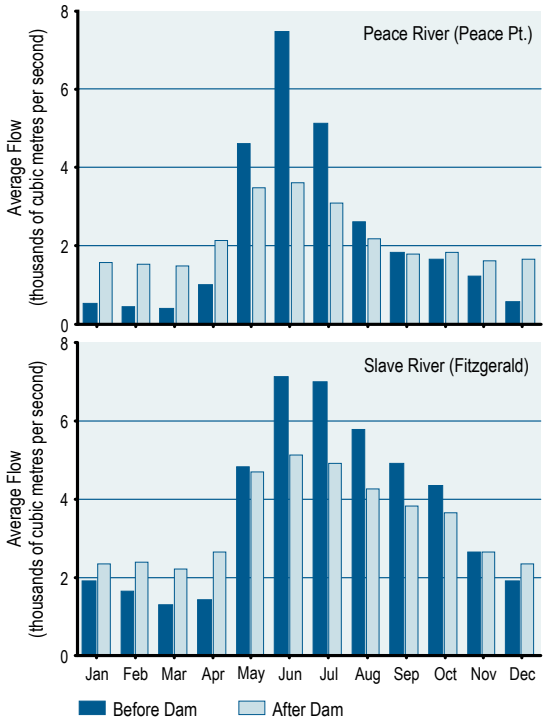
Federal, provincial and territorial governments have enacted laws and adopted regulations that serve to protect water quality. Laws and regulations govern activities related to water use, wastewater discharge, waste disposal, industrial developments, habitat alterations and other types of activities that may affect water quality. First Nations also exert influence over these processes through their involvement in regulatory agencies.

MRBB Goal: Ensure Sufficient Water Quantity

Flows in all rivers of the Mackenzie River Basin are determined by climatic conditions. Flows in some tributaries of the Mackenzie River have remained essentially unchanged over the past several decades. In contrast, flows in the Liard and Smoky rivers, for example, have changed in a manner that is consistent with predictions from climate change models, suggesting that climate change may already be affecting flows, floods and ice formation and break-up in some of the basin's rivers.

It is important to develop a thorough understanding of the impacts of global climate change on the water resources of the Mackenzie River Basin. Equally important is the need to develop adaptive water management strategies that consider the probable changes to our water resources that will arise from a changing climate.

Flow regulation is another factor that affects certain rivers within the basin. For example, operation of the W.A.C. Bennett hydroelectric dam has altered the flow of water in the Peace and Slave rivers. Peak flows in these rivers since construction of the dam have been lower, on average, than those observed prior to the dam. High peak flows in the Peace River are needed to raise water levels in the Peace-Athabasca Delta's large lakes that are connected by channels to the Peace River. In addition, lower than normal snow packs and smaller spring runoffs in the major tributaries of the Peace River were observed from the mid-1970s until the mid-1990s. As a result, major spring floods in the Peace-Athabasca Delta did not occur from 1975–1996. The absence of major flooding during this period resulted in a prolonged period of drying in the Peace-Athabasca Delta. As the delta dried, some of its habitat features changed. These changes have affected several species of wildlife



Summer flows have been lower and winter flows have been higher in the Peace and Slave rivers since the W.A.C. Bennett Dam has been in operation, as illustrated by this graph.

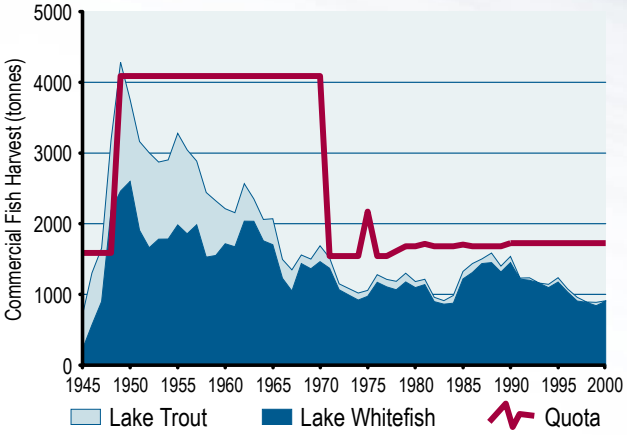
Data Sources: Environment Canada, Water Survey of Canada; Alberta Environment.

that live in the delta and have impacted the traditional way of life of the delta's residents. Further research is required to understand better how climate and flow regulation by the dam affect river flow, ice dynamics, water levels and ice jam-induced floods.

MRBB Goal: Sustain In-Stream Water Uses

Fishing is an important activity throughout the Mackenzie River Basin. Commercial, subsistence and sport fishers share the basin's fish and these competing demands can pose a challenge to fisheries managers throughout the basin. The largest commercial fishery in the Mackenzie River Basin is in the western and central portions of Great Slave Lake.

As in most other commercial fisheries in the basin, whitefish accounts for the largest proportion of the catch. In addition to the commercial fishery, the fish stocks of Great Slave Lake support subsistence and sport fisheries, and it is necessary to manage the competing demands of all users. In Great Slave Lake, commercial fishing is not allowed in certain inshore areas that are important for the Aboriginal subsistence fishery, or in the East Arm of Great Slave Lake, which is managed for a trophy lake trout fishery. Great Bear Lake also supports subsistence and sport fisheries with some local sales of fish taking place. The goal of management of this lake is directed towards conserving a world-class trophy lake trout fishery. Early studies observed that the lake trout population



Commercial fishing is an important activity throughout the Mackenzie River Basin, especially in Great Slave Lake, where whitefish account for the vast majority of fish harvested in the central and west basins of the lake. The commercial harvest of whitefish in Great Slave Lake is sustainable under current conditions. The commercial harvest of lake trout in the western basin of Great Slave Lake was not sustainable and the lake trout population in that part of the lake declined soon after commercial fishing began. Fisheries managers are challenged to ensure that fish stocks in the basin are properly conserved in the face of competing demands by commercial, sport and subsistence fishers.

Data Source: Department of Fisheries and Oceans.

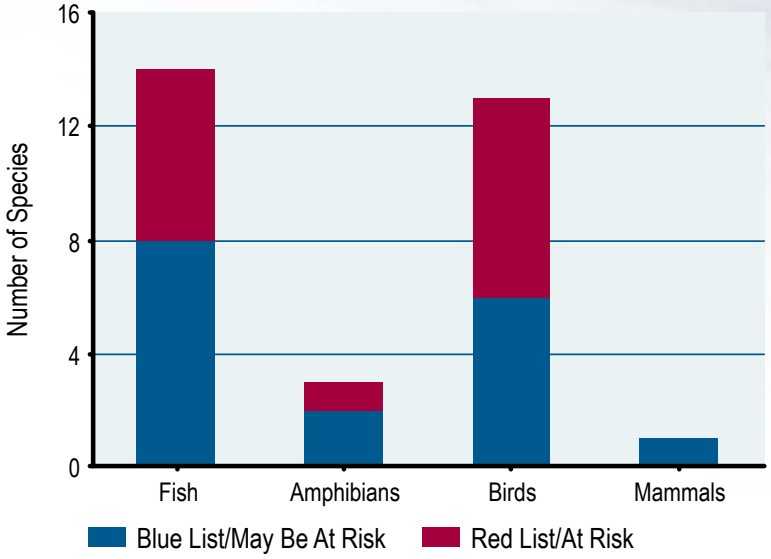
of Great Bear Lake declined until 1984, after which conservation measures were implemented to limit the number of fish caught. The harvest of lake trout from Great Bear Lake declined steadily from the early 1970s to 1990 as a result of these measures, and the current harvest is considered to be well below the maximum sustainable yield. The extensive and diverse fisheries on these and other lakes in the basin have the potential to harm fish populations. It is therefore important that the fisheries are managed to ensure conservation of fish stocks and sustainable use of this natural resource. To do so may require better information about population attributes of key fish stocks.

MRBB Goal: Ensure Healthy, Abundant and Diverse Aquatic Species and Habitat

Each province and territory of the Mackenzie River Basin has its own process for evaluating wildlife species and identifying those that are at risk of extinction or extirpation. Although the various processes and categories differ to some extent, most jurisdictions identify species considered to be "at risk" or "may be at risk". In certain jurisdictions, these species are placed on "red lists" and "blue lists". Species on "red lists" are endangered or threatened while those on "blue lists" are considered especially sensitive to human activities or natural events. The provincial and territorial approaches to identifying species "at risk" are broadly similar to the approach used by the Committee on the Status of Endangered Wildlife in Canada, the organization responsible for assessing the national status of wild species. Thirty-one species of aquatic and riparian-dependent wildlife that live in the Mackenzie River Basin are considered to be "at risk" or "may be at risk". Some of these species are naturally rare and are not under imminent threat from human activities. However, habitat loss from human activities that modify or fragment the land is a key reason why many wildlife species are at risk. Other possible threats include pollution, excessive harvest, disease, climate change and introduction of alien species. Species at risk can experience such pressures in the Mackenzie River Basin as well as in other areas to which some species migrate. In comparison to more heavily populated and industrialized areas of Canada, the Mackenzie River Basin has relatively few species at risk and continues to support a diversity of wildlife. Protecting all species in an ecosystem is important because the loss of even a single species may have negative consequences that ripple through an ecosystem. Federal, provincial and territorial legislation exists to protect species at risk and their habitats. Recovery plans have been developed for some species. Of special

significance was the enactment, in 2003, of the federal *Species at Risk Act* (SARA). The act gives legal protection to species at risk in Canada and provides a process which prevents sensitive species from becoming endangered, develops recovery strategies for species that are endangered, and, if necessary, protects critical habitat for endangered species. Together with the federal-provincial-territorial *Accord for the Protection of Species at Risk* and the federal Habitat Stewardship Program, SARA represents one of the three pillars of the federal strategy to protect species at risk.

In addition to species at risk or species that may be at risk, there are a great number of aquatic species that are of economic and cultural importance to many of the Mackenzie River Basin's residents. Traditional Environmental Knowledge indicates that some of these species are declining in abundance in some parts of the basin. It further suggested that population declines of waterfowl and muskrats in the Peace-Athabasca and Slave River deltas were caused by reductions in water levels possibly as a result of operation of the Bennett Dam. Excessive harvest of certain species of fish was identified as a concern in some areas. In many cases, however, including ducks and muskrats in the Liard sub-basin, the causes of declines in populations of aquatic and riparian-dependent species were not identified.



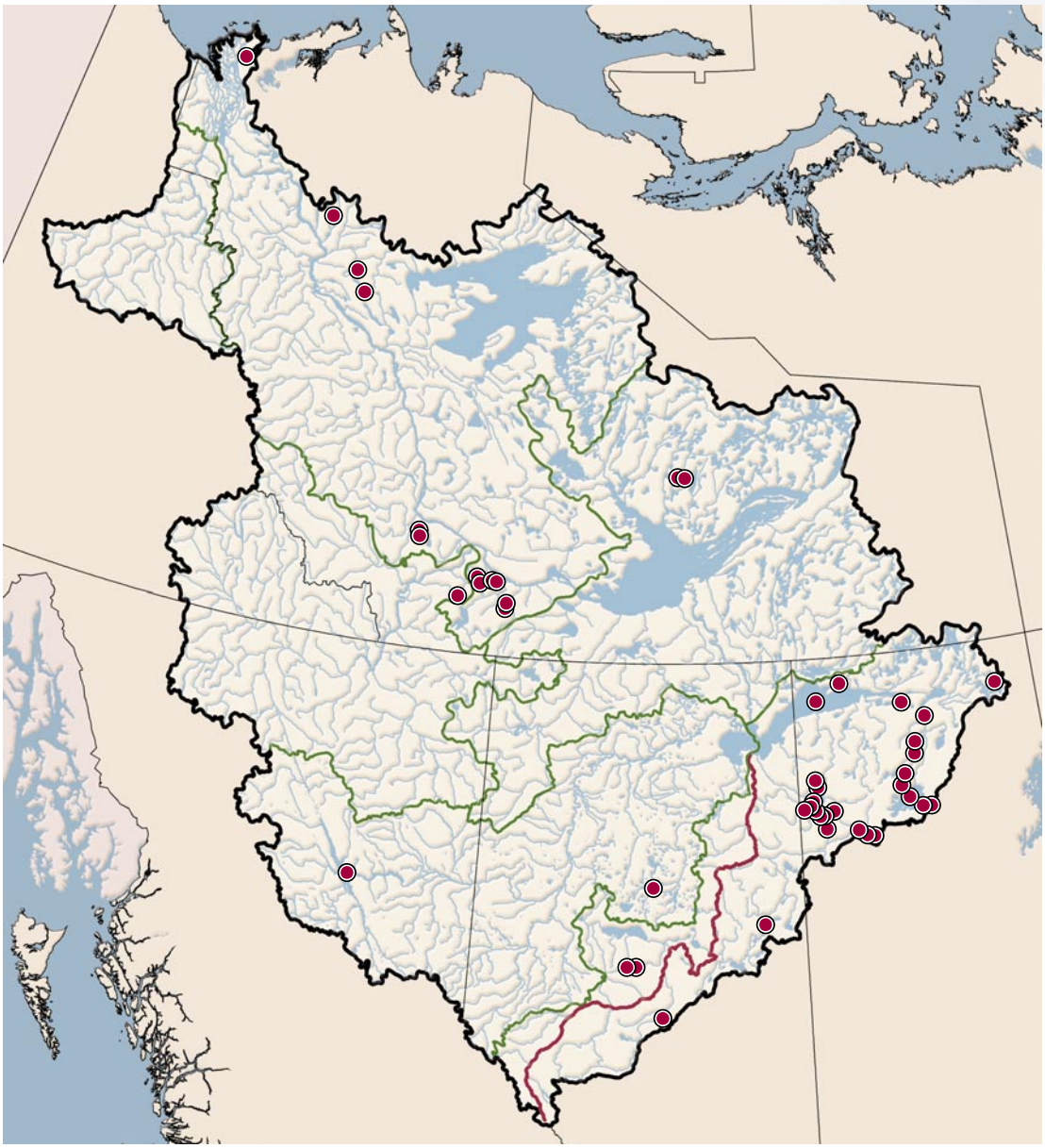
There are thirty-one species of aquatic or riparian-dependent wildlife that are "at risk" or "may be at risk" of extinction or extirpation in the Mackenzie River Basin. That number is relatively small compared to other parts of the world, especially when the large size and diversity of ecozones in the basin are considered.

Data Sources: Alberta Sustainable Resource Development; Saskatchewan Environment and Resource Management; Conservation Data Centre of the BC Ministry of Sustainable Resource Management; Yukon Department of Environment; Resources, Wildlife and Economic Development (GNWT).

MRBB Goal: Ensure Human Health and Safety

People use water to drink, cook and bathe in, and for other domestic purposes. The best way to make sure that water is safe, clean and reliable is to use a multi-barrier approach, sometimes called a source to tap approach. The four main components of this approach are source water protection, drinking water treatment, water distribution systems and monitoring and reporting. Provincial, territorial and federal governments have committed to safeguarding the water system through good management, monitoring, reporting, research, guidelines, legislation, and public involvement and awareness. This report focuses on human health in regards to the protection of source water and its effects on fish species that are eaten by people. It also examines flooding and the hazard it poses to human safety.

Fish is an important source of food for many residents of the Mackenzie River Basin, but fish from certain lakes and rivers contain potentially harmful levels of contaminants. In such cases, fish consumption advisories are issued to inform the public about the amount of fish that can be consumed without adverse effects to health. By following fish consumption advisories and limiting their consumption of contaminated fish, residents of the Mackenzie River Basin can safely enjoy the benefits of eating fish they have caught themselves. There are approximately fifty water bodies in the Mackenzie River Basin with fish consumption advisories based on mercury. Mercury occurs naturally in the soils and bedrock of the Mackenzie River Basin and enters aquatic ecosystems with runoff. Once in the aquatic ecosystem it increases at successive stages in the food chain, sometimes rising to relatively high levels in predatory fish such as northern pike. Thus, it is not surprising to find some lakes and rivers in the Mackenzie River Basin with mercury advisories. Mercury is also an industrial pollutant that is transported globally through the atmosphere and is often deposited in areas far-removed from where it was produced. A small portion of the mercury in the Mackenzie River Basin is likely derived from industrial sources in other parts of the world. Elevated levels of mercury in fish in Williston Lake Reservoir likely resulted from the increased production of methyl mercury that is known to occur when organic soils are flooded. In addition to advisories for mercury, there are fish consumption advisories for dioxins and furans in parts of the Peace and Athabasca sub-basins. These advisories have changed in the past few years because pulp mills have substantially reduced releases of dioxins and furans in their effluent, resulting in a reduction in concentrations of these substances in fish.



Mackenzie River Basin

Locations of fish consumption advisories attributable to mercury in 2002 and 2003

Mercury advisories extending along the Athabasca River

Fish consumption advisories may be issued when contaminant levels in fish are high enough to warrant concern for the health of people who eat fish. There are forty-seven water bodies in the Mackenzie River Basin where fish consumption advisories have been issued based on high mercury levels in certain species of fish.

Data Sources: Alberta Sustainable Resource Development; BC Sustainable Resource Management; Department of Indian Affairs and Northern Development; Saskatchewan Environment and Resource Management.

Summary of Overall Assessments

The following tables show the overall assessments for the indicators described in the report. Thirty-one indicators merited a "Favourable" rating, twenty-nine merited "Mixed Signals" and eleven were considered "Unfavourable". Indicators of water quality and in-stream water uses were generally regarded as favourable. Unfavourable assessments for some aspects of climate change indicate that future efforts need to address this key issue. The climate of the Mackenzie River Basin has changed substantially in the past fifty years and is predicted to undergo even greater changes in the future. The basin's aquatic ecosystems are likely to undergo profound changes because of future climate change. This important issue needs to be dealt with internationally, nationally and regionally to reduce the production of greenhouse gases by human activities and industries and to adapt existing water management policies to the changes that our aquatic ecosystems will inevitably undergo.

There was a wide discrepancy between the ratings of indicators based on traditional knowledge and those based on information obtained from government programs and research institutes. Of the eleven unfavourable assessments, ten were based on traditional knowledge while only one was based on information from government or research institutes. A key challenge for governments and First Nations is to understand why such differences exist. More importantly, both knowledge systems may benefit from the mutual exchange of information to broaden their perspectives on and approaches to issues related to aquatic ecosystems in the Mackenzie River Basin.

Definition of Symbols

- Environmental quality is favourable or improving or pressure on the environment is decreasing.
- Environmental quality is intermediate or there is no clear trend in environmental quality because of (1) insufficient information or (2) the presence of mixed (positive and negative) signals.
- Environmental quality is unfavourable or deteriorating or pressure on the environment is increasing.

Summary of overall assessments of indicators for climate change and contaminants in the Mackenzie River Basin. Symbols and their definitions are shown at left

	Indicator	Overall Assessment
Climate Change	Traditional Knowledge	●
	Spring Melt of River and Lake Ice	●
	Permafrost	▼
Contaminants	Mercury	▼
	Chlorinated Dioxins and Furans	✓

Summary of overall assessments of indicators for the six sub-basins of the Mackenzie River Basin

MRBB Goal	Indicator	Athabasca	Peace	Liard	Peel	Great Slave	Mackenzie-Great Bear
Improve Water Quality	Traditional Knowledge	▼	●			●	
	Dissolved Phosphorus	▼					
	Dissolved Oxygen	▼					
	Adsorbable Organic Halides		✓				
	Organic Matter in Pulp Mill Effluent		✓				
	Sewage Effluent			✓			✓
	Arsenic in Yellowknife					▼	
	Water Quality Guidelines and Indices	✓	✓	✓	✓	✓	✓
Ensure Sufficient Water Quantity	Traditional Knowledge		●			●	▼
	Flow in Rivers	✓	▼▼	▼▼	▼	▼	✓
	Water Level of Lake Athabasca	✓					
	Timing of Spring Freshet					▼	
Sustain In-Stream Water Uses	Traditional Knowledge	▼	●				
	Water Allocations	✓	▼	✓			✓
	Fishing	✓	✓	▼	✓	✓	✓
	Harvest of Fur-Bearers	✓					
	River Tourism				✓		
	Transportation (ferries and ice bridges)						✓
	Hydroelectric Facilities					▼	
Ensure Healthy, Abundant and Diverse Aquatic Species and Habitat	Traditional Knowledge	▼	●	●	✓	●	▼
	Fish Populations				✓	▼	
	Waterfowl Populations [i]	|←▼→|				|←▼→|	
	Species at Risk [i]	✓	▼	▼		|←✓→|	
Ensure Human Health and Safety	Traditional Knowledge	●					
	Fish Consumption Advisories	▼	▼			▼	▼
	Flood Hazard Management			✓			✓

[i] *Arrows indicate that assessment covers more than one sub-basin*