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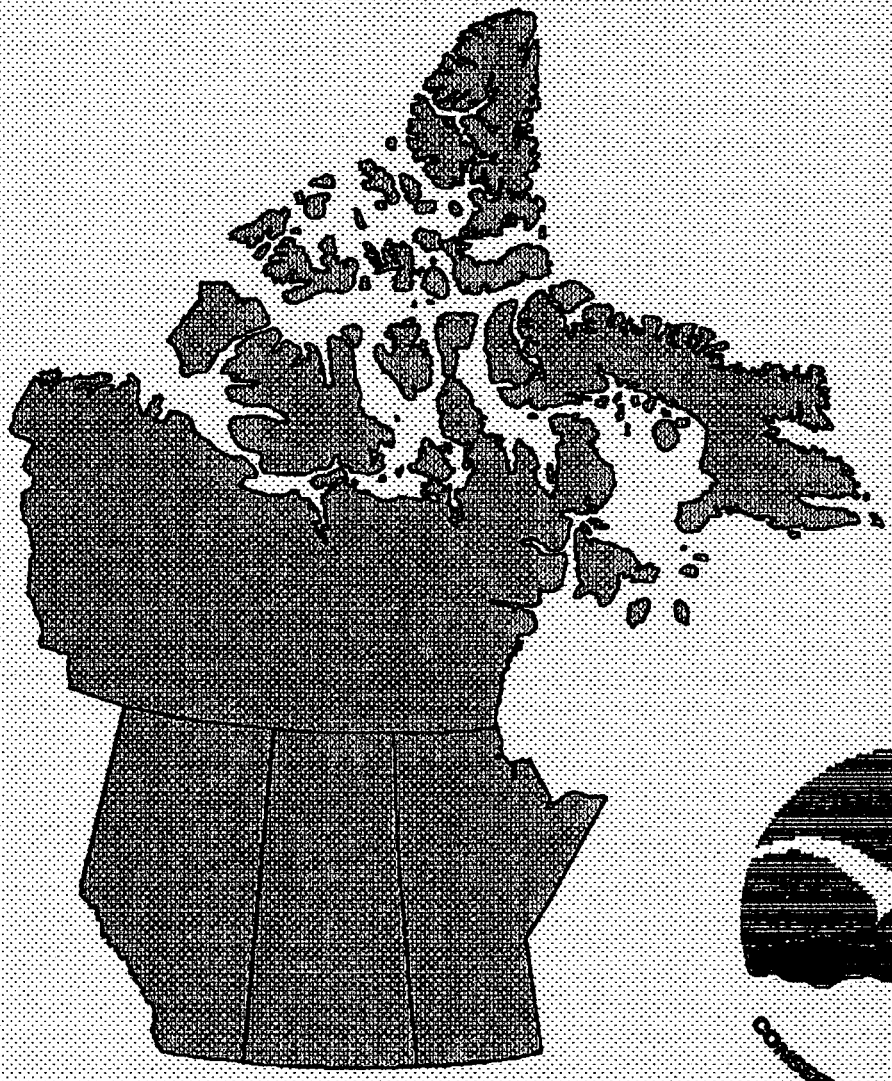
ACCOMPLISHMENTS REPORT
1985/86 - 1992/93



CONSERVATION & PROTECTION

INLAND WATERS DIRECTORATE
WESTERN & NORTHERN REGION

Environment Canada Environnement Canada

Acknowledgement

The IWD staff members listed below contributed the information that was used to complete this Report. I would like to thank each of you for your participation.

A very special thanks to Bev Burns, Regional Director General, C&P, for his continuing advice and guidance and his patience during the review of many, many drafts. To the Advisory Team of Jean-Guy Zakrevsky, Jesse Jasper, Ross Herrington, Ron Hofer, and Russ Boals. Your dedication, through thick and thin, to complete this Report is acknowledged. It was a pleasure working with each of you.

My personal appreciation to Jim Rogers, Mark Gilchrist, Dwight Quiring and Jeannette Godwin for their expertise in editing, designing, drafting and preparation of the final report. Your continuing commitment to completing our goal was inspiring.

Very much has been accomplished by IWD, Western and Northern Region, over the past seven years, and this Report is dedicated to all the staff who participated in turning dreams into reality.

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November 30, 1993

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1. INTRODUCTION

Over the past seven years (1985/86 - 1992/93) Inland Waters Directorate (IWD), Western and Northern Region has addressed numerous issues and has been in a stage of evolution. The thrust of IWD's scientific and technical expertise and data and information program in water resources management is evolving from focusing on economic development to a more ecosystem approach.

The emergence of public concerns to environmental aspects of water resource management in the 1980s has transformed IWD's activities and products as demonstrated by the environmental assessment and reviews surrounding the Oldman River Dam Project in Alberta, and Rafferty-Alameda Dams Project in Saskatchewan. As part of Conservation and Protection Service (C&P), Western and Northern Region has reinforced a movement towards an ecosystem approach for environmental and water resource management, as illustrated by IWD's involvement in the Northern River Basins Study.

The overriding constants that shape the activities and accomplishments of IWD are the geography of the region and the institutional management of water resources. The following factors are particularly important:

i the size and diversity of Western and Northern Region

ii the jurisdictional characteristics

iii the unique geographic, climatic and water resource characteristics of the Prairies and the NWT

iv the pattern of human settlement, development and water use

v the constitutional division of authority over water resources between the federal and provincial/territorial governments

vi our legislative mandate - the Department of the Environment Act, the Canada Water Act, International River Improvements Act and, indirectly, the Boundary Waters Treaty

vii our policy mandate - the Federal Water Policy and Canada's Green Plan

To appreciate the work and accomplishments of IWD requires an understanding of each of the above. A general overview of regional characteristics and institutional context follows.

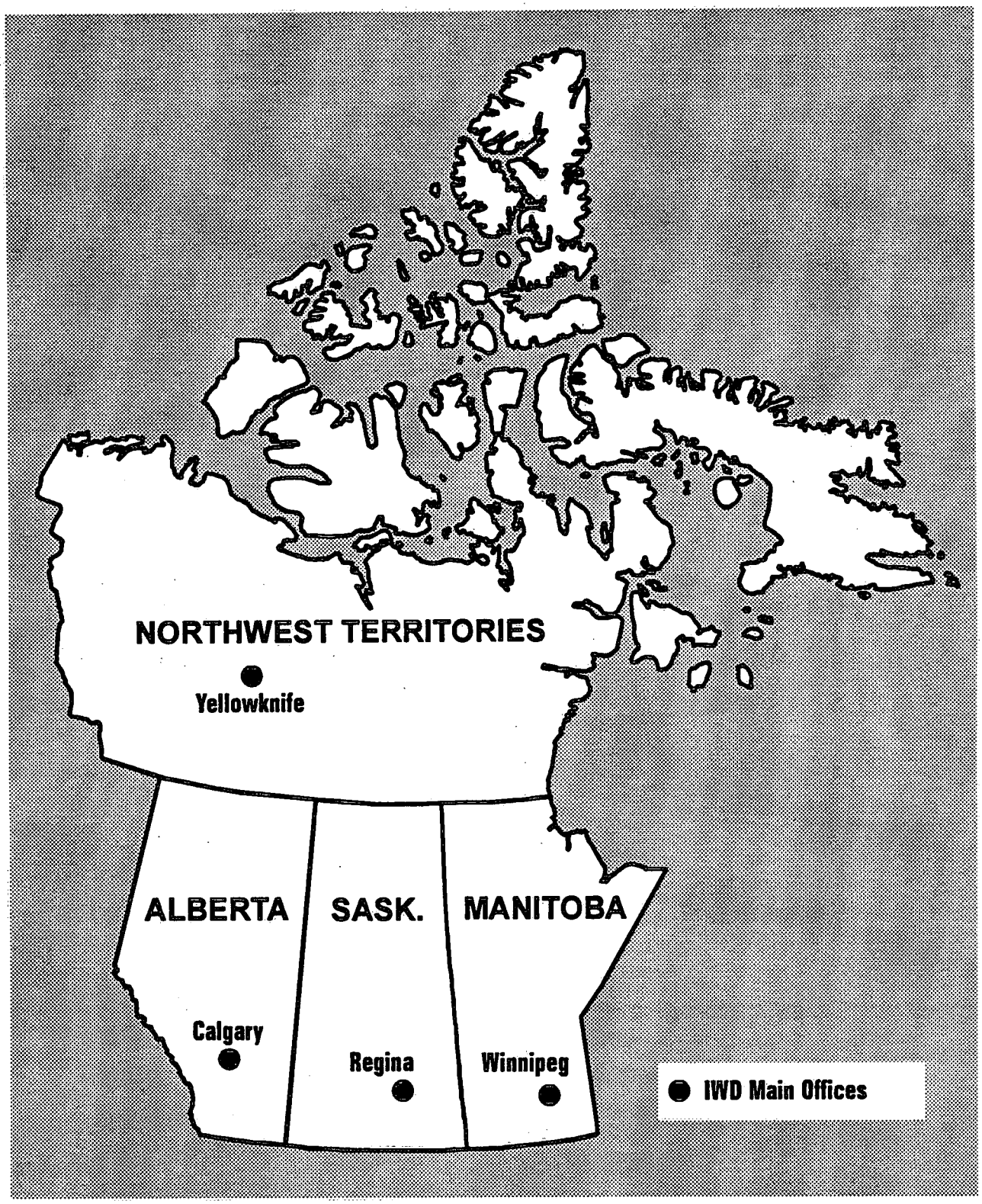
1.1 Regional and Historical Context

The Region administered by IWD, as part of C&P, is the largest and most diverse in Canada. It includes the Northwest Territories and Alberta, Saskatchewan and Manitoba plus the collection of surface water information in northwestern Ontario. This broad geographic area includes nine major ecozones (large scale ecosystems) extending from the northern and southern Arctic ecozones, to the Prairie ecozone. The western portion includes the mountain and tundra ecozones and the Boreal Shield is on the eastern side. Each of these ecozones has unique characteristics and is associated with different environmental and water resource issues requiring varying approaches to scientific and technical data collection, data interpretation and management.

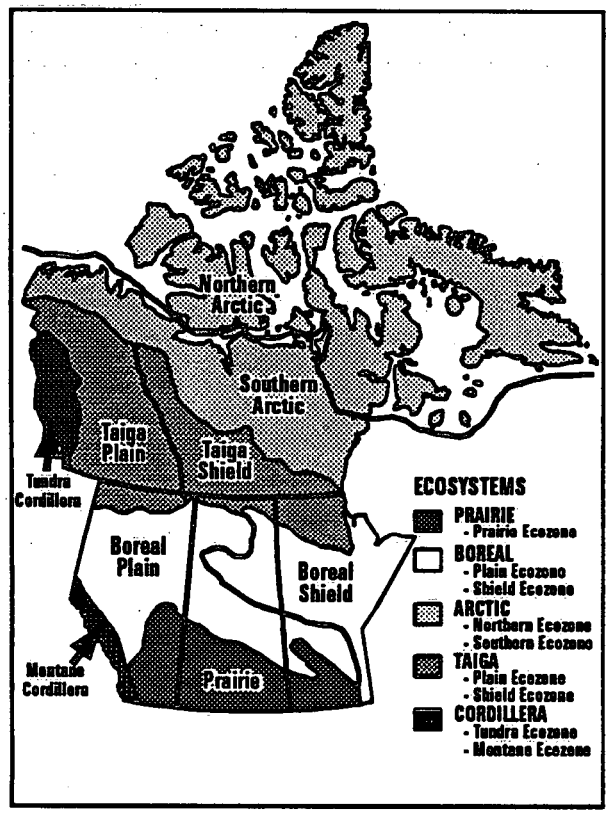
The situation becomes even more complex when the international and inter-jurisdictional responsibilities are considered. The Western and Northern Region of IWD borders with the Yukon, British Columbia and Ontario, and the states of Minnesota, North Dakota and Montana.

IWD activities have concentrated on the Prairie ecozone where more than 80 percent, or about 3.6 million, of the region's population live.

The prairie area is semi-arid with a less reliable water supply than the surrounding ecozones. On



Western and Northern Region

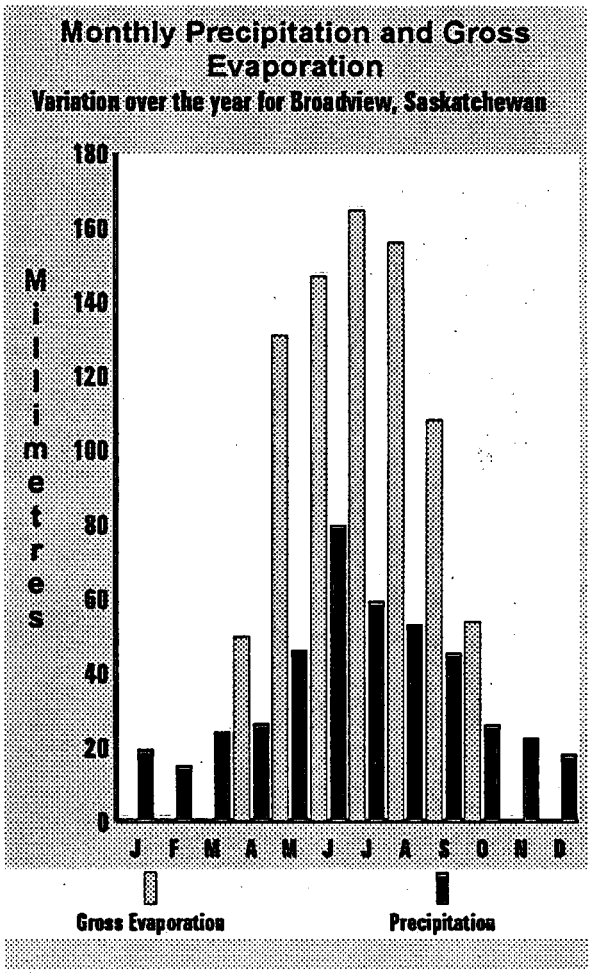


Ecosystems in the Western and Northern Region

the average, the prairies lose more water to evaporation into the air than it receives from precipitation. The continental climate of western Canada is characterized by large temporal and spatial variations in precipitation and temperature. Streamflow and water levels likewise vary, through the melting of the accumulated winter precipitation and summer rains. These semi-arid plains, the Canadian agro-prairies, have experienced severe droughts in the 1880s, the early 1890s, the 1930s, 1961, 1976-77, and during most of the 1980s. Climate change may increase the frequency and severity of droughts. Water that originates in mountains or the Precambrian Shield is generally of good quality, whereas water that originates in or crosses the prairies naturally becomes laden with sediments, salts and aquatic plants. Similarly the Shield and mountain valleys have deep rock-based lakes with good quality water, the prairies' water courses and lakes are shallow with high concentrations of salts. This generally poor water quality limits its use and results in high treatment costs.

Since the prairies were first settled, water resources have played a major role in supporting agriculture, petroleum extraction, mining, manufacturing, service industries and tourism. At the same time, the natural reliability of water supplies and its generally poor quality have been further stressed by the effects of development activities, and have been an obstacle to continued economic growth, diversification and prosperity.

Water managers on the prairies have been challenged to allocate scarce supplies among the variety of uses and minimize both the adverse effects of these uses and conflicts among them. The traditional method of approach to water management has been supply side management,



with reliance on structural solutions such as dams and stream diversions to provide a more reliable and better quality water supply. However, the unintended negative side-effects of these developments are becoming more evident. Structural modifications of the natural regime can have negative effects on fish, wildlife, water quality, and associated land-based ecosystems, and are a source of public concerns. These negative effects, in combination with the high costs of structural measures, are changing the emphasis on how our water supplies are managed. Whereas water has been traditionally viewed as a free or relatively inexpensive commodity to be used without limitation, the view is changing towards conservation of the resource, pricing to reflect the real costs storage, treatment and delivery, and reducing our reliance on structural measures. At the same time, awareness has increased about the importance of aquatic ecosystems to support plant and animal life, including human life.

IWD has performed an important role in both the traditional approach to water management and the evolving role of evaluating environmental concerns. The data collected by IWD provides the basic information required to size a culvert, to build a safe bridge, dam or reservoir, to provide safe drinking water, or to allocate the scarce resource among many competing users. This information is also critical to assess the effects of developments such as cities, pulp mills or mines; to identify safe water quality standards; and to determine the conditions necessary to sustain the physical and biological integrity of aquatic ecosystems.

Basic scientific information on the quantity, quality and use of water is needed to support economic and environmental objectives. IWD, through its Water Resources and Water Quality Branch programs, and the two National Research Institutes in Saskatoon and Burlington, provides much of this information. IWD supplements these records with information gathered by the power producers, provincial water resource and environmental agencies and agricultural interests. Water Planning and Management Branch provides information and expertise on the hydrological, social, economic, and environmental aspects of water use and developments affecting water. In the NWT, all IWD responsibilities are carried out by the integrated NWT Programs Branch.

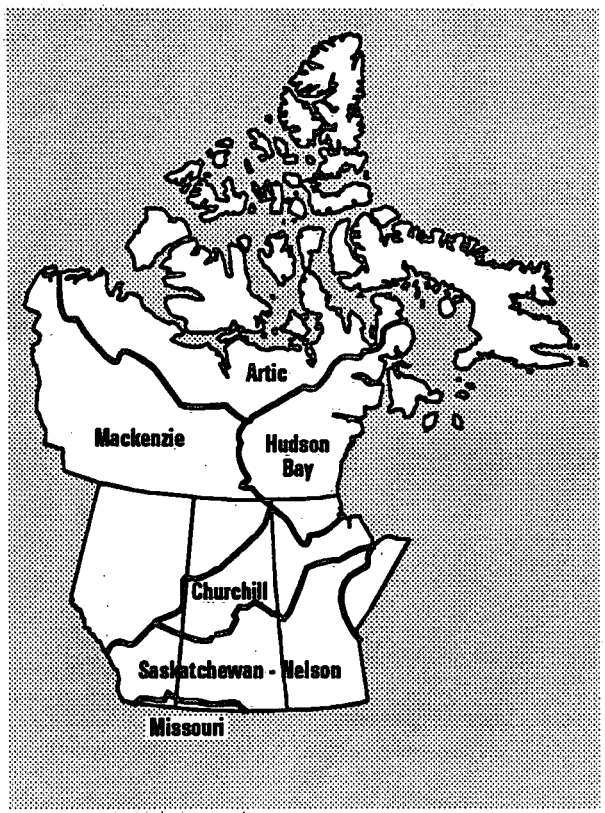
This report presents the accomplishments of IWD, Western and Northern Region over the past seven years including, when possible, the cost of the respective programs and the actual and estimated social and economic benefits of these programs. The benefits of water and water management to society are readily identifiable but difficult to calculate in economic terms. Water has traditionally been treated either as a free good or priced far below the supply cost and subsidized by all levels of government. Thus, economic benefits, in terms of what people are willing to pay for water are seldom available.

1.2 Constitutional and Legal Context

The work and accomplishments of IWD are a function of the constitutional division of responsibility over water management between the federal and provincial/territorial governments. In Canada, the provinces have primary responsibility for water management, except for the water in National Parks, Indian Reserves, and the Northwest Territories and Yukon. In the two territories, water is managed by the federal government with territorial government participation. Provinces legislate with respect to water supply, pollution control, power generation, irrigation and water-based recreation. The three prairie provinces each have agencies that monitor the state of water in their respective jurisdictions, regulate its consumption and protect users' interest through licensing. The federal government legislates in the areas of navigation, fisheries, migratory birds and some aspects of water related to public health and international waters. Since the provincial governments have direct control in water management and associated land use matters, close coordination between both levels

of government is essential to ensure that respective legislative responsibilities are met.

The federal government has broad, constitutionally-based responsibilities over international waters and assists the provinces and territories with arrangements to share waters that cross their boundaries. IWD supports the work of the International Joint Commission in administering the terms of the Canada-U.S. Boundary Waters Treaty with monitoring programs and special studies. IWD has a role in the Prairie Provinces Water Board. The Board ensures that Alberta, Saskatchewan and Manitoba receive their share of water and addresses water quality issues from eastward flowing interprovincial streams. IWD is assisting with similar cooperative arrangements for the Mackenzie River Basin among British Columbia, Alberta, Saskatchewan, Northwest Territories and Yukon. Over the past seven years, IWD has helped develop a Master Agreement to establish a cooperative inter-jurisdictional water board, and has facilitated public consultation with respect to this Agreement. This Agreement should be signed in the near future.



Major Basins in the Western and Northern Region

IWD administers the International River Improvements Act (IRIA). The IRIA requires the provinces to acquire a licence for any water development project, except for domestic or irrigation use, which alters the flow or quality of an international river. IWD is also the initiating department for environmental assessments of such projects under the Federal Environmental Assessment and Review Process.

IWD also administers the Canada Water Act. The Act is the primary legislation under which the federal government forms partnerships with the provinces and territories to address water resource management issues of mutual concern.

> *Parliament of Canada is desirous that, in addition, comprehensive programs be under taken by the Government of Canada and by the Government of Canada in cooperation with the provincial governments in accordance with the responsibilities of the federal government and each of the provincial governments in relation to water resources, for research and planning with respect to those resources and for their conservation, development and utilization to ensure their optimum use for the benefit of all Canadians.*
> *- Canada Water Act (1970)*

Part I of the Act deals with federal-provincial-territorial cooperative arrangements to establish intergovernmental bodies:

i. to maintain continuing consultation on water resource matters and to advise on priorities for research, planning, conservation, development and utilization relating thereto;

ii. to advise on the formulation of water policies and programs; and

iii. to facilitate the coordination and implementation of water policies and program.

Part I of the Act calls for federal-provincial-territorial agreements for any waters with a significant national interest. Such agreements can cover a broad range of activities ranging from the collection, processing and provision of data on the quality, quantity, distribution and use of these waters, to research, to project design and management, to the formulation of comprehensive water management plans and to the establishment of joint commissions, boards or other bodies empowered to direct and coordinate such programs. Examples of activities carried out under the Act include the South Saskatchewan River Basin Study, the Northern River Basins Study, the Flood Damage Reduction Program, the Northern Flood Agreement and the Mackenzie River Flow Forecast. The federal-provincial-territorial water quantity and quality monitoring agreements are also under the umbrella of the Canada Water Act. Programs under active negotiation or consideration under the Act are the Mackenzie River Basin Master Agreement and the proposed Bow River Basin Studies. The Canada Water Act is the legislation which allows the Minister of Environment to pursue the federal interest in water resources through partnerships with the provinces and territories.

In terms of guiding principles for federal actions on water matters, IWD has special responsibility to promote the Federal Water Policy. The 1987 Policy sets out a national strategy for managing Canada's water resources. The Policy's goals are to protect and enhance the quality of our water resources and to promote the wise and efficient use of water. Five strategies to reach these goals are employed, where constitutionally appropriate, in carrying out research and monitoring programs, and in influencing the provinces/territories, industry and the public. These strategies are:

i. water pricing

ii. science leadership

iii. integrated planning

iv. legislation

v. public awareness.

The Policy's central theme is that water in Canada has been undervalued as an economic resource and its value to the health of the ecosystem, particularly to humans. Canada has among the highest per capita water use in the world. Water is overused and abused, both as a source of supply and as a convenient means of carrying away wastes. The role of the Policy is to promote the concepts of realistic pricing and the user-pay principle as means of controlling demand and generating revenue to cover the cost of water supply and waste water treatment infrastructure.

With the announcement of Canada's Green Plan in 1990, the principles of the Policy to promote more efficient, nonpolluting use of water were restated. Nationally, a Code of Environmental Stewardship for the Government of Canada has been developed, with a Federal Facilities Water Conservation Plan to implement part of the code. A series of water awareness fact sheets have been issued through the Environmental Citizenship Program. In the Western and Northern Region, IWD helped host the February 1993 National Water Conservation Conference in Winnipeg. This conference drew about 400 people to evaluate progress in water conservation in Canada.

A key underlying theme of the Policy is the concept of integrated planning. An integrated approach takes into account the interests of all users and jurisdictions sharing a water resource. Coordination and integration among the agencies and levels of government responsible for water are necessary to ensure environmentally compatible development. Since the inception of the Canada Water Act in 1970, basin planning activities with the provinces and territories have advanced this concept.

Canada's Green Plan and the Federal Water Policy have provided the policy direction and stimulus for the adoption of an integrated ecosystem approach to planning. IWD activities

THE CODE OF ENVIRONMENTAL STEWARDSHIP

for the Government of Canada

The Government of Canada fully supports the principle of sustainable development. To reflect this commitment in all aspects of its operations and activities, from facilities and real property management to procurement and waste management, the Government commits:

To integrate environmental concerns with operational financial, safety, health, economic development and other relevant concerns in decision-making.

To meet or exceed the letter and spirit of federal environmental laws and, where appropriate, to be compatible with provincial and international standards.

To improve the level of awareness throughout the public service of the environmental and health benefits and risks of operational decisions and to encourage and recognize and recognize employee actions.

To apply environmentally respinsible management practices to hazardous substances used in operations, including biological products, specifically with regard to the acquistion, handling, storage, safety in use, transportation and disposal of such substances.

To ensure that environmental considerations are integrated into government purchasing policies and practices.

To see cost-effective ways of reducing the input of raw materials, toxic substances, energy, water and other resources, and of reducing the generation of waste and noise associated with day-to-day operations.

To acquire, manage and dispose of lands in a manner that is environmentally sound including the protection of ecologically significant areas.

require integration with the other directorates of C&P, the Canadian Wildlife Service (CWS) and Environmental Protection (EP), and a change in emphasis and approach to the type of water data collected and research undertaken. The Green Plan also provides the overall objective of achieving sustainable development.

Wise management of water is one of the foundations to economic development, both in Canada and within the region. The dominant withdrawals of water in the Prairies are by agriculture and thermal power generation. Consumption of water by agriculture in the Prairies in particular is also significant nationally. Irrigation consumes the 2 412 million cubic metres of water or about 60 per cent of Canada's water consumption.

Water is an important generator of economic activity. The economic value of water on an annual basis to Canada is estimated at $16.3 billion and the value to the Prairie Provinces is estimated at $2.2 billion. These conservative estimates do not include important values of water to support riparian forests, wildlife, and aesthetic uses, such as through enhanced property values.

IWD water programs, in terms of data, water science, and the support of water resource planning, take on considerable significance in the Prairie Provinces. The water resource base

Water Withdrawal and Consumption, 1981

Water Withdrawals (in millions of cubic metres per year)								
	Municipal	Rural Residential	Agriculture	Mining	Manufacturing	Thermo Electric	Total Withdrawal	Total Consumption
Prairies	586	75	2 337	195	535	1 944	5 672	2 107
NWT	<1	1	0	24	1	0	26	2
Canada	4 263	347	3 125	648	10 201	19 281	37 864	
Canada's Consumption	640	-	2 412	178	507	168	-	

Source: Final Report; Inquiry on Federal Water Policy, Ottawa, September 1985

within the Prairies is limited and variable and many streams are already highly utilized for agriculture, thermal power and other uses. In order to protect the environment and other economic uses, careful decision-making based upon ecosystem principles is essential to achieving environmentally-sustainable economic development.

Annual Economic Value of Water, Prairies & Canada, 1981 (in millions of dollars)

	Prairies	Canada	Prairies as a Percent of Canada
Withdrawal Uses			
Municipal [1]	636.2 [2]	3 628.0	17.5
Irrigated Agriculture	42.5	57.2	74.3
Thermal Power	16.2	169.4	9.6
Manufacturing	27.1	612.8	4.4
Total	722.0	4 467.4	16.2
Instream Uses			
Hydro-electric [3]	995.6 [4]	6 553.4	15.2
Waste Assimilation	143.6	2 272.0	6.3
Rec. Fishing [5]	330.5	2 982.1	11.1
Commercial Fish [6]	20.1	58.8	34.0
Sub-Total	1 489.8	11 866.3	12.6
Total	2 211.8	16 333.7	13.5

[1] median estimate
[2] Canada total pro-rated to Prairies on basis of population
[3] Zuker and Jenkins estimate
[4] values for Manitoba increased to include Alberta and Saskatchewan, on basis of annual hydro power generation
[5] median estimate
[6] value of freshwater catch, 1982

Source: adapted from R.A.Muller "The Socio-Economic Value of Water in Canada" Inquiry on Federal Water Policy, Research Paper Number 5, Ottawa, March 1985

2. LIFE'S THREE ESSENTIALS - CLEAN AIR, WATER AND LAND

2.1 Health and Environment

2.1.1 Drinking Water Source/Aquatic Life

Polls taken over the last decade show that Canadians are increasingly concerned about the quality of their water resources. The chemistry of life, and indeed much of the chemistry of the earth, is water chemistry. Our entire ecosystem depends on water for its survival. Many human activities are in direct conflict with water's life-sustaining role. Stresses on this essential resource are many. With the growth of urban centres, increased industrial activity and an agricultural sector heavily dependent on chemicals, the capacity of water to assimilate contaminants is being strained.

The 1991 report on the State of Canada's Environment echoed the concern of a large number of Canadians that the quality of water has been impaired in many parts of our country. Canadians, through the Green Plan consultation process, also expressed their desire to see aggressive action aimed at correcting existing problems.

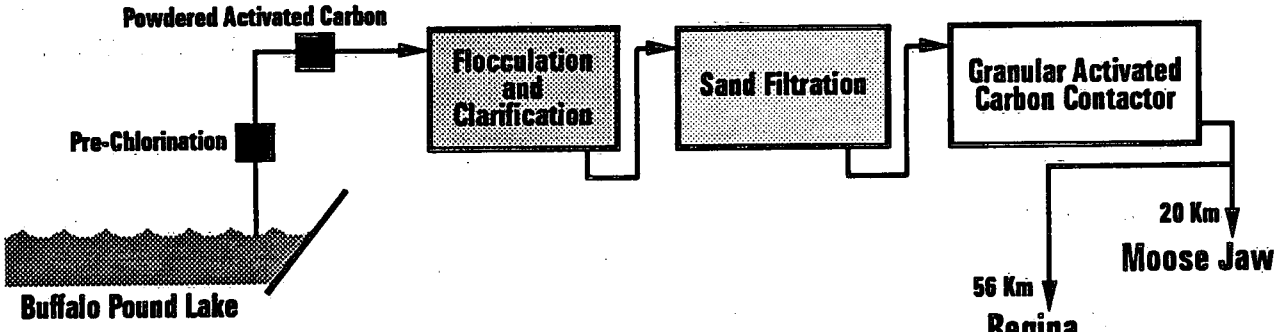
Regina-Moose Jaw Water Supply

The cities of Regina and Moose Jaw in Saskatchewan share a common water treatment plant which draws its raw water from a shallow lake, Buffalo Pound Lake, in the Qu'Appelle River system about 50 kilometres northwest of Regina. During summer and fall, the raw water supply suffers from a severe taste and odour problem caused by weed and algae growth in the lake. The problem had for a long time raised questions concerning the quality of the water supply and had reflected negatively on the communities as places to live and work.

In the early 1980s, the province of Saskatchewan was lobbied for action on the water quality problem by the administrations of Regina and Moose Jaw, by residents and visitors, by groups such as the Chamber of Commerce and by the convention and tourism industry. The federal government was under particular pressure to assist the cities, since the federal election was imminent and a federal-provincial regional development agreement was being negotiated. The most popular long-term solutions to the water supply issue for the local governments and business groups were a $100 million pipeline or a $250 million multi-purpose canal scheme. A less expensive and more environmentally sensible advanced granular activated carbon (GAC) filtration water treatment system was preferred by both senior levels of government.

However, at that time, few systems in North America had built or studied a sophisticated GAC water treatment system that utilized a water source as poor as Buffalo Pound Lake. IWD convinced the Cities of Regina and Moose Jaw to do a joint, in-depth scientific evaluation of the GAC process. The bench and pilot tests conducted for the two cities demonstrated that treatment by GAC was the most effective method of removing the organic materials that caused the taste and odour problems. The study concluded that a GAC treatment facility would be the most inexpensive and the least environmentally disruptive solution to treatment of Buffalo Pound Lake water.

The Province of Saskatchewan agreed in 1982 to help fund the construction of a GAC system. The three levels of government then developed a proposal to construct the GAC facility. IWD was the federal lead on negotiating the $15 million cost-shared agreement among the federal, provincial, Regina and Moose Jaw governments to construct the facility and the federal member of the construction management team. In 1983, the Federal Government decided to fund the project to a maximum of $5 million under the Canada-Saskatchewan Economic and Regional Development Agreement. The GAC facility created 250 person-years of overall direct employment in the depressed construction



Buffalo Pound Water Treatment Plant

and engineering industries. The Federal and Provincial governments agreed that improving the water quality would be beneficial for both economic and industrial development opportunities and the quality of life in the two cities.

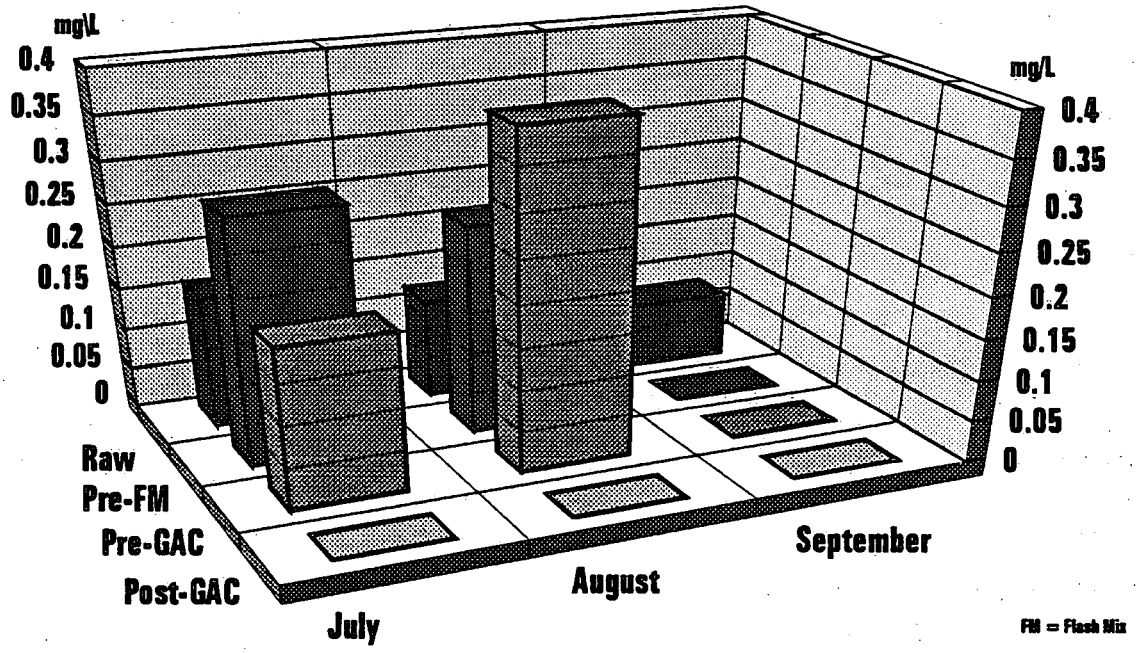
The installation of the GAC system, the first of its kind in Canada, was completed in 1986. The federal government and its partners in the GAC project agreed that the effectiveness of the GAC process should be assessed. In view of the federal government's investment in the project, IWD designed and carried out scientific investigations of the GAC process between 1986 and 1989 in partnership with staff from the Buffalo Pound Water Treatment Plant. The Environment Canada studies demonstrated that treatment by GAC greatly improves the aesthetic quality of the drinking water through the removal of taste and odour causing compounds. The GAC system also effectively eliminates many pesticides, PCB's and a large number of toxic chemicals, including halomethanes, created by the reaction of chlorine with natural organic compounds contained in the raw water.

The greatest beneficiaries of the GAC process have been the 220 000 people in the cities of Regina and Moose Jaw. The complaints about taste and odour of the treated water decreased substantially following the installation of the GAC system. The reduced complaints and reduction in taste, odour and toxins confirmed that the federal investment had been a sound one. The installation of the new treatment system has largely eliminated the previous unease by the people of Regina and Moose Jaw over the aesthetic quality and safety of their drinking water supply. Longer term economic benefits are associated with the elimination of this old perception. Regina's and Moose Jaw's water no longer has negative image to constrain the attracting of new business.

The GAC reduced the demand and associated costs for household water treatment. The total monetary saving realized through large scale treatment of raw water at the source is estimated at $300 000 annually in Regina and Moose Jaw. Health-related advantages are also derived from standardized treatment at a central facility since poorly maintained domestic treatment installations nurture disease-causing bacteria.

The GAC demonstrates federal government leadership in terms of wise resource management. Support and development of GAC technology avoided construction of large-scale water transfer schemes, saving federal regional development dollars and environmental damages from large-scale infrastructure developments. The knowledge and expertise gained and documented in several major scientific reports will benefit other Canadian municipalities who are evaluating the GAC technology for similar use. Prairie communities with water quality problems could use this locally available information on the GAC technology rather than paying for similar evaluation studies. IWD action was in the spirit of the Green Plan when technical leadership was

Lindane Removal by Granulated Activated Carbon (GAC) Treatment for Regina-Moose Jaw Drinking Water Story



provided to support better decision-making with respect to the environment.

Herbicides in Stephenfield Reservoir

Over the last decade, the public has pushed to reduce the input of pesticides to prairie streams and lakes because of the potential hazards to human health and stresses on the aquatic ecosystem. Aquatic systems of south-western Manitoba are especially vulnerable to herbicide contamination because of the intensity of agriculture, the industry's dependence on chemical weed control and the frequent absence of physical barriers between sprayed areas and watercourses. Work conducted in the early and mid 1980s by Environment Canada and by other federal and provincial agencies showed that residues of various herbicides were present in the surface waters of rural Manitoba.

If herbicides are present in southern Manitoba streams then they could also occur in municipal water supplies drawn from surface water impoundments. Herbicides also pose a threat to fish and other aquatic biota. The Manitoba Department of the Environment and Environment Canada studied the extent of herbicide residue in a southern Manitoba reservoir.

The Stephenfield Reservoir, located near the town of Carman, is representative of southern Manitoba reservoirs. This reservoir supplies water for domestic use and cattle operations, and supports a sport fishing industry worth close to $100 000 a year to the local economy.

The study was conducted in 1987-88 under the Canada-Manitoba Water Quality Monitoring Agreement at a total cost of $30 000, equally funded by Canada and Manitoba. The study was designed to answer two basic questions:

i are fall-applied herbicides transported to surface waters during the spring runoff and

ii are levels of herbicides in the reservoir present at concentrations of concern to human health or aquatic biota?

The herbicides studied were those compounds high on Agriculture Canada's priority list. All of these chemicals are toxic to mammals and present a certain degree of risk to human health

especially. Phenoxy acid herbicides such as 2,4-D, 2,4-DP and MCPA are moderately to highly toxic to fish. Trifluralin is extremely toxic to fish. Fish fry are especially vulnerable to herbicides. Some of these compounds are also highly toxic to some invertebrates. These invertebrates are often critical components of the aquatic food chain and a sudden decline in their populations can upset the delicate food web of this milieu.

The joint scientific venture between Environment Canada (IWD and EP) and the Manitoba Department of the Environment provided evidence of 2,4-D and atrazine contamination of the water supply used for human and agricultural consumption. The study also demonstrated that herbicides are transported to the reservoir by spring melt water and runoff from precipitation events.

Although the observed concentrations were within the guidelines for drinking water quality and aquatic life, they do confirm the need for ongoing vigilance. Therefore, the affected communities and health authorities have been alerted to the potential for danger to human life. Armed with the scientific information from the report, authorities can assess the treatment required for water drawn from the Stephenfield Reservoir using accepted risk assessment methodology. This will allow for the least costly course of action at the lowest risk to human health. The agricultural community has also been made aware of the situation and has been encouraged to follow environmentally sound land use practices which would minimize the contamination of the aquatic ecosystem.

Environment Canada and the Department of Fisheries and Oceans have further capitalized on the results of this study by contributing directly to the evaluation of registered pesticides and the re-registration process. This was accomplished by providing Agriculture Canada with reliable facts on the presence and abundance of pesticides in prairie surface waters. The benefit is improved protection of human and aquatic life through the banning or regulated use of harmful agricultural chemicals. The observed results may be typical of other prairie watersheds and may be applied to other similar ecosystems.

2.2 Continuing Action to Protect and Restore our Water

2.2.1 Water Quantity Monitoring and Assessments

Water commands a unique place among our natural resources. It supports other natural resources such as fish and forests; provides a medium for transportation and energy production; governs our settlement patterns; provides recreational medium; inspires artistic and cultural expression; and is essential for life.

Water generates between $8 billion and $23 billion per year of our national wealth. These estimates count only those benefits that lend themselves to economic calculations. The more subtle recreational and aesthetic benefits derived from our lakes and rivers, the appeal of natural water environments, the national identification with water and the generated tourism are difficult to measure in conventional economic terms.

The environmental consciousness of the 1960s has matured into a broader, more balanced appreciation of the need to protect the integrity of natural systems and to continue to use them for our social-economic advantage. Canadians realize that long term economic development and a healthy environment are closely related. Consequently, they pressure their governments to take appropriate actions.

In response to this pressure, governments are taking actions to ensure the maintenance and, in some cases, the re-establishment of a healthy and viable natural environment. These actions are based on the concept of sustainable development. Many governments now accept that the state of the country's water resource is one of the primary indicators of a healthy environment.

The importance of water resources to Canada's development led the federal government to conduct water quantity surveys in 1884, with

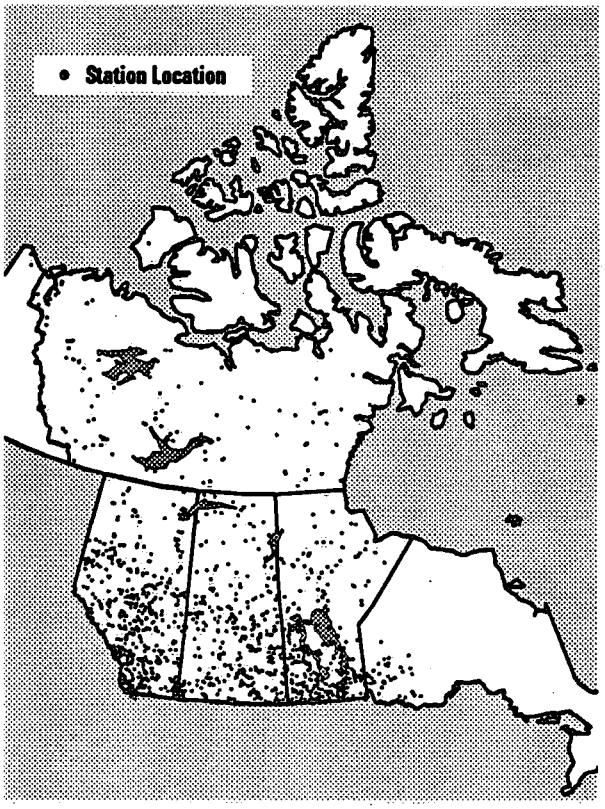
records beginning in 1892 on Lake of the Woods, 1902 in southern Manitoba and 1906 in southern Alberta. The Hudson's Bay Company's outposts had recorded lake and river levels, timing of ice formation and breakup and visual appearance for nearly 200 years before. In the early years, these federal surveys were to delineate the streams for navigation, to estimate the hydro-power potential and to determine if water supplies were adequate for irrigation.

With higher water demands from increased economic activity and immigration, a more systematic and wide-spread program to measure and record surface water conditions in Canada was needed to resolve internal and international disputes. The changing political character of the country, with new provinces and changing priorities, made water information important to protect life, property and the economy from the extremes of floods and droughts; to estimate the requirements of the aquatic and upland eco-systems; and allow sustainable economic growth. The continuous, long-term record with a broad aerial coverage is also needed to identify whether global change is occurring and what the impacts of climate change are on the interior plateau.

An accurate comprehensive knowledge of the availability and distribution of water is gained by doing water quantity surveys which include the collection, compilation, analysis and publication of streamflow, water levels, and sediment data.

Federal-Provincial/Territorial Water Quantity Survey Agreements

Today's Federal-Provincial/Territorial Agreements evolved out of the foresight and understanding that an accurate and continuous set of data on the water quantity and its seasonal and yearly variation was needed for orderly development of the country to occur. For the data to be comparative across the country, the data had to be collected under a national set of standards. Cooperative data collection arrangements with the provinces, which began in 1922, only stopped for a short period during



Water Quantity Station Locations in the Western and Northern Region

the depression. Water Quantity Survey Agreements were initiated on April 1, 1975 to replace ad-hoc arrangements. The Agreements were to reduce duplications between governments, improve operating efficiencies and provide a one-window approach for information services.

These Agreements set up the mechanism for cost-sharing between the parties under a station designation process, namely:

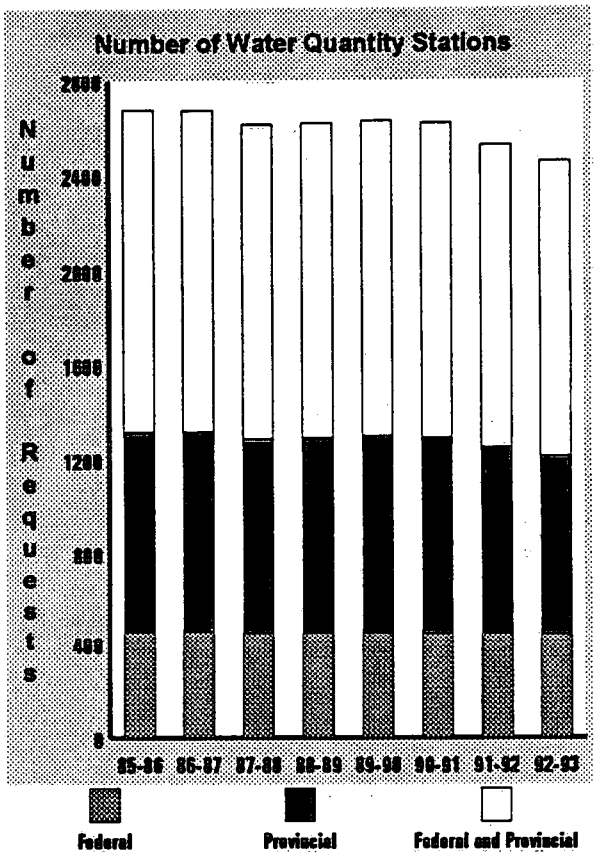
i Stations designated as Federal support programs of primary interest to Canada have 100 percent of the construction and annual operating cost paid by Canada;

ii Stations designated as Provincial/Territorial support programs have 100 percent of the cost paid by the Province/Territory; and

iii Stations designated as Federal/Provincial support joint interest programs are operated under a 50:50 cost-shared arrangement.

National guidelines for defining and designating stations and all operating procedures were established jointly between Canada and the Provinces.

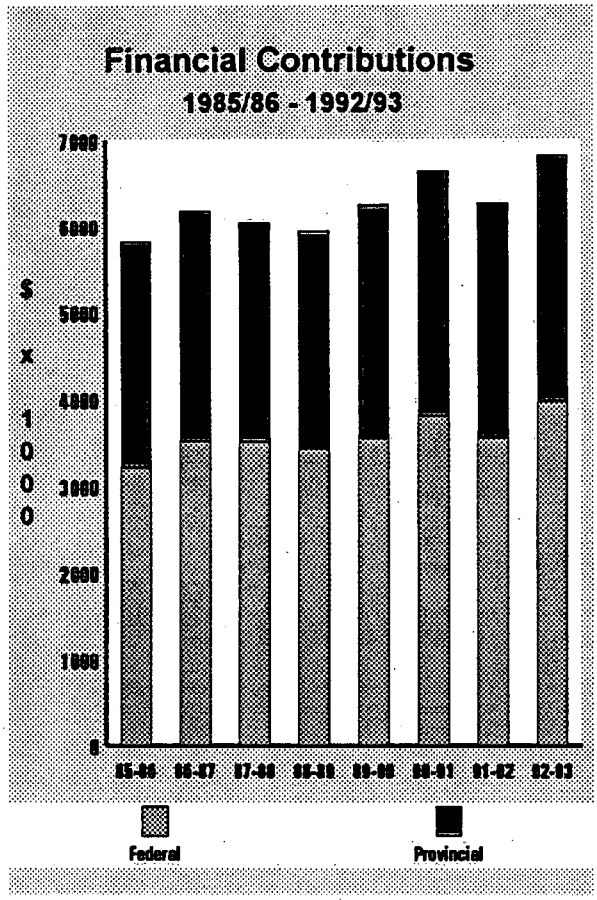
These Agreements have been highly successful and cost effective in the region because both parties are committed to excellence and fully cooperate. The total number of stations operated by IWD have declined since 1985-86 with the largest decline being in Federal-Provincial ones. The financial contribution by each party to the Agreement has increased over the period but declined if calculated in constant dollars.



Network Planning

The spacial coverage of the data network across the region can be a constraint to proper planning, project design, and assessment of ecological change. However, with effective network planning, integration and operation and with automation and simulation techniques, the data collection program should continue to provide the information required for sustainable ecosystem management.

IWD operates streamflow, water level, and sediment stations throughout the Western and Northern Region, from the Arctic islands to along the U.S. border in the southern prairies. However, the demands for long term and spacially distributed water resource data are increasing from many sectors, despite current economic and financial constraints. The region's hydrometric and sediment networks must be deployed and operated as efficiently as possible, while still maintaining basic responsibilities, as well as providing reliable water data for water managers and clients.



In the present economic climate, reduced operating budgets have reduced the number of water quantity stations without adequate information or knowledge on the particular station's contribution to the overall data

collection network. The hydrometric network has also matured so choosing to eliminate a station with a large contribution to the network will reduce the effectiveness of the database.

Investigations and analyses have been carried out in the WNR for the propose of planning and adjusting the water quantity network and evaluating the sediment program. The results have served as the basis of design for many years, but this process required periodic review and updating as conditions change. The August, 1986 evaluation report, entitled "Summary Report, Western and Northern Region Hydrometric Network Evaluation and Planning Activities", recommended that the region:

i develop and maintain a process of network evaluation for the purpose of measuring the success of the federal and provinces/ territories hydrometric network against stated objectives and determine necessary adjustments.

ii develop staff capabilities in the techniques of network analysis and design.

iii maintain close liaison with cooperators, clients, and users for the purpose of identifying data and information needs, and to provide opportunities for joint activities relating to the operation and design of the networks.

Network evaluations were undertaken in each province and the territories, as recommended in the evaluation report. The intense drought of 1988, drier than any year in the 1930s, emphasized the importance of optimizing the limited water resources of the prairies for the continued good health of the region's economy. Knowledge of the size, extent and variability of the region's surface water resources is basic to water resource planning.

If existing water uses are to be managed effectively and future planning to compensate for the variable nature of the water resource is to be achieved, the hydrometric network must measure the amount of water available. The network should enable water resource managers to share water among existing legitimate users and to estimate the effects, both positive and negative, of proposed changes to streamflow.

Evaluation of the existing network and preparation of a development plan to the year 2000 required that the current water development plans be identified; that relevant concerns and issues impacting on hydrometric data be quantified; that the data requirements of regional basin planning initiatives for effective use and orderly development and maintenance of the region's water resources be recognized, and that the needs of integrated network planning be addressed. The network required for a regional hydrology data base will provide an information source to plan water resource activities for the next ten years.

The report concluded that the hydrometric network in northern Saskatchewan is inadequate with few stations measuring runoff from small drainage basins and levels of monitor lakes and reservoirs. Coordinated monitoring networks for water quantity, water use, water quality, sedimentation, ground water, and meteorologic parameters are needed. Demand is also increasing for real-time data from water resource managers concerned with the day to day management of water by provincial agencies.

Network Operations

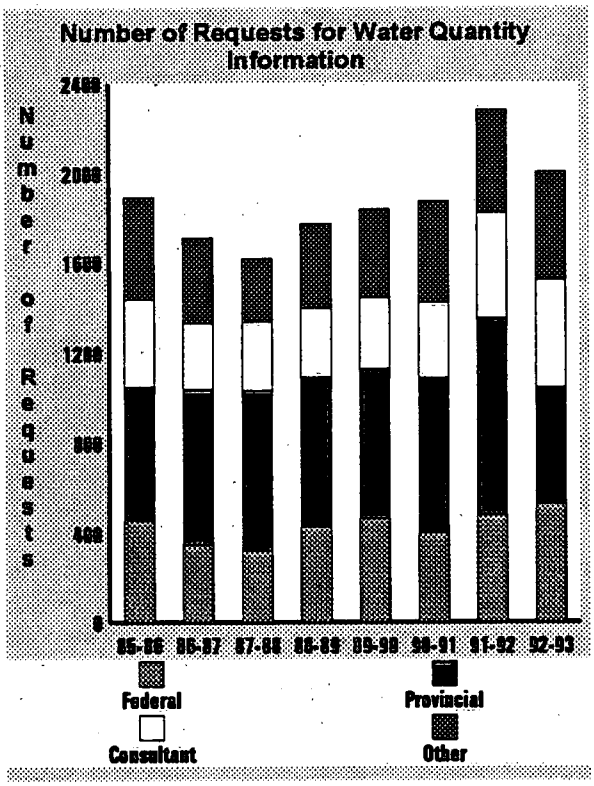
The day to day running of the network is a long term commitment to infrastructure maintenance through a construction and maintenance program and a scheduled approach to station instrumentation, data retrieval and basic data processing. The operations program continues to evolve to adjust to natural events such as floods and droughts and to the continuing demand for information. Network operations are reported on annually to provide a basic foundation for all water achievement in the region.

The construction of new gauging stations or relocation of existing stations is an required to meet the changing needs for information on the

water resource. The location of the gauging stations on the banks of streams and lakes in out of the way places makes them susceptible to damage by both natural environmental and human forces. An on-going program is required to maintain the infrastructure for the safety for employees and the general public and to ensure the continuous collection of data particularly during times of environmental emergencies, such as floods and toxic spills. The annual construction costs are about 2% of the estimated $5 million replacement cost of the gauging network in Saskatchewan. All projects are designed to have minimal impact on the environment and subjected to an environmental assessment.

Information Services

An important part of the daily operation of IWD is providing water quantity information to the public. Considering the large number of external clients who obtain this data, both as historic and real-time, the data has played a vital role in the health and safety of our lives. Water quantity data is used in the design and operation of major projects including hydro-electric, flood control and water supply dams and of smaller structures



such as bridges, culverts, municipal water supply and treatment facilities and irrigation control structures. Near real-time information is used in equitably distributing interprovincial and international waters, in ensuring safe navigation, in flood forecasting and protection, and in ice jam prediction. Information on water quantity over time is used in evaluating the environmental impacts of projects, in developing aquatic ecosystem and river basin management plans and in ensuring the viability of water-dependent wildlife especially waterfowl and fish.

The cost to Canada of damages or from over design resulting from not having this information is difficult to calculate. The under design of the spillway of a large storage reservoir because of inadequate flood flow data could cause the overtopping failures seen in Pakistan, Italy and China with catastrophic losses in lives and property. Few failures have occurred in Canada, partly due to engineering design based on the historical database. Within this region, Provincial and Territorial Flood Forecasting Systems would be ineffective without the real time data and the advise and information provided by IWD. Historical records are used by the Flood Damage Reduction Program to define and/or confirm flood levels, to designate flood zones and determine the safety of dikes. Recent flooding in the upper Mississippi and Missouri River basins shows the costs of building in the flood plain and of dike failures. Real-time data provided to operators of hydroelectric systems during all stages of flow, allows plant output to be maximized. Under the Federal-Provincial-Territorial Agreements, all data is readily available to all clients, mainly through the a national surface water data bank maintained by IWD. This continuous set of data is available in publications from 1909 to 1990 and in electronic format off IWD computers or a Compact Laser Disk (CD-ROM).

IWD offices within this region annually process an average of 1900 requests for water quantity data with peaks of 2200 direct requests. The requests are divided into 23% federal, 36% provincial, 19% consultants and 22% others,

which include researchers, educational institutions, interest groups and the general public. These numbers do not include requests that are filled through other sources such as the CD-ROM, inventories, public libraries, information centres and other federal and provincial departments.

In recent years the value of data for environmental awareness, maintenance of the aquatic ecosystem, environmental assessment and assessing climatic change and other long term trends has been understood and the number of requests for water quantity information is trending upward. Client surveys received positive feedback with a high level of satisfaction.

A sample of requests for information is provide to demonstrate the relevance of the water monitoring and assessment program to the economic competitiveness and performance in Canada. The samples reflect engineering, resource management and ecologic issues and captures the elements of dispute resolution, cost savings, inter-jurisdictional implications, improved decision making and legal considerations from both a historical and real-time perceptive. Continued availability of water resources information is crucial for far-reaching decisions on economic development and protection of the environment.

- **Station Profiles**

Hydrometric station profiles provide a summary of information including:

i the propose for the station,

ii history of the station,

iii data users,

iv data quality,

v physical changes in the basin, and

vi studies that pertain to the station.

The station profiles are reviewed and kept current on a continuing basis.

The profiles are part of hydrometric network evaluation and planning and benefit consultants, water resource managers, planners, and individuals interested in water resources. The profiles provide the user with information to evaluate the applicability of the data to a particular situation or problem.

The station profiles for all 325 active stations in Saskatchewan, completed in 1989-90, were initially distributed in two-binder sets to fourteen major users and on microfiche to another forty-one major users. Announcements were sent to 114 individuals and a display advertisement appeared in the "Professional Edge", the newsletter published by the Association of Professional Engineers of Saskatchewan.

- **Dispute over Fluctuating Saskatchewan River Levels**

Ten years of daily streamflow and water level information for the Saskatchewan River at Cumberland House was provided to the Cumberland House Band. The information was used by the Band to demonstrate the impact of Saskatchewan Power Corporation's upstream hydroelectric plant's operations on the river crossing to the Cumberland House settlement. The hydroelectric plant operators agreed to compensate the Band for past inconveniences caused by the fluctuating water levels and to improve the ferry crossing. The total cost of $250 000 was much less than the Band's request for a several million dollar bridge.

- **Protecting Ecological Integrity**

Monthly mean flows, annual maximums and annual minimums over the 1972 to 1992 period for Sundance Creek near Bickerdike, Alberta were supplied to Trans-Mountain Pipelines. These data were used to design an oil pipeline including the river crossing, pumphouse design and the hydrostatic pressure testing to minimizing the potential of breakage and hence the environmental damages from a spill. The

Alberta office of IWD fields about two requests per month from resource base companies for streamflow data at specific sites for pipeline crossing design purposes.

- **Understanding Wildlife Habitat**

A University of Calgary graduate student was supplied with monthly mean discharges and monthly maximum discharges for the Bow River at Banff for the period 1989 to 1992. The student used this information in his study of elk behaviour and, in particular, into the incidence of elk attacks on humans during high water periods. This study has the ultimate goal of better understanding to minimize human harm and protect the wildlife species itself.

- **National Park Management Study**

Wood Buffalo National Park personnel were provided with 270 station-years of water level and discharge data for water quantity gauging stations within the Wood Buffalo National Park boundaries for the development of a Park management plan. This Park contains the delta area used as a prime nesting area for the endangered Whooping Crane and as a major stop over point for other migratory birds. The Park also has a large herd of Buffalo who's habitat and grazing area is dependent on water level. Similarly small mammals and fish are utilized by natives for fur and food. The mammalian and fish populations correlate with water level changes.

- **Alberta Water Supply Studies**

Alberta Environmental Protection, Planning Division requested updated daily streamflow information to supplement data already available from IWD historical data banks for stations on Beddington Creek near Calgary, Bow River at Calgary, Elbow River at Bragg Creek, Fish Creek at Priddis, Highwood River below Little Bow Canal and Sheep River at Black Diamond. A total of 243 station years of data were used by the Calgary Regional Planning Board to assess the water supply for industrial and residential development in and surrounding the city. The data improves the economic and engineering decisions on the potential for development.

- **Fish Habitat Assessment**

F.A. Westworth and Associates were supplied with tentative daily streamflow data for March to June, 1992 for Parlby Creek near Alix for a study of Northern Pike migration. This information was provided prior to publication and computed early specifically for this agency to allow completion of their study. The results of this study were utilized in licensing of works in or near the creek, designing catch limits and protection of the species, and for a general overall scientific knowledge of a particular species.

- **Recreational Pursuits**

Rainbow and Brown, a rubber rafting company, were provided with real-time flow information for the days May 2 to June 3, 1992, for the Bow River stations at Lake Louise, at Banff, below Ghost Dam and at Calgary. These data in conjunction with their knowledge of river conditions for similar flow situations were utilized in the design of recreational rafting tours.

These rafting tours, besides providing exhilaration and excitement, are noted for exposing the public to nature and wildlife and hence are an indirect source for education and appreciation of the bio-diversity of our country. Water flow and level information is needed for the safety of the rafters and for planning the tours. During the summer months, numerous phone calls from canoeists and fishermen are received regarding existing flow and levels.

- **Bio-diversity Studies**

The Department of Biology, Laurentian University requested the entire twenty-two station years of water level data for Lake Claire. The Department was researching the changing limnology of the Lake as a result of the W.A.C. Bennet Dam on the Peace Athabasca Delta.

Long term information on water level fluctuations was essential to this study.

- **North and South Saskatchewan Rivers Flood Studies**

Monenco Engineering was provided with stage-discharge curves for ten stations within the South Saskatchewan and North Saskatchewan River basins. These curves were used by Monenco in "a flood inundation" project along the North Saskatchewan and Bow/South Saskatchewan River for TransAlta Utilities.

TransAlta, the operator of the hydroelectric power generating reservoirs and stations on these rivers, used the information to develop the most efficient operation plans for power generation while minimizing damages from flooding due to reservoir operations.

- **Pollution in Sediment Studies**

The Canada Water Resources Institute (CWRI) was provided cross-sections, stream velocities, stream profiles and flow data for Athabasca River sites at Hinton and near Obed, Alberta. Training and equipment for streamflow measurements were also provided to the CWRI crew. These data, equipment and training were provide for their study of suspended sediments particle sizes. This study will determine pollutant adherence to suspended sediments and the eventual fates of such contaminants.

- **Red Deer River Quantity Studies**

WER Engineering was provided with daily discharge data for the period of record for seventeen water quantity stations in the Red Deer Basin in Alberta. These data were being used for modelling water quality and in-stream flow needs along the river. The modelling will allow the management of flows for water supply purposes and maintain sufficient flow to preserve the integrity of the water quality of the system.

- **Time of Travel Studies**

Stream velocity information, available from streamflow measurement notes, was provided to Saskatchewan Water Resources Corporation for the South Saskatchewan River stations upstream of Lake Diefenbaker (at Medicine Hat and at Highway 41). Saskatchewan Water Corp. (SaskWater) needed the data to estimate the time of travel for specific flow conditions to improve the operation of Lake Diefenbaker.

Knowledge about the quantity of water and the time of arrival is essential for efficient, economical operation of hydroelectric power plants and for good reservoir management. Whenever water has to spill through the spillway rather than passing through the turbines, significant revenue is lost. Similarly, a delay in spilling could jeopardize the safety of the dam. Time of travel studies will help minimize spill and maximize power production with sacrificing dam safety.

- **Benthic Invertebrate Study**

Team Incorporated, of Saskatoon, were provided with specific day flow data on the Wapiti River near Grande Prairie and on the Athabasca River near Hinton, Alberta. This company was doing a benthic invertebrate survey on these rivers to ascertain levels of these entities with the respect to pulp mill operations on these rivers.

Monitoring from a Boat

Information from these studies are essential to the long term health of our river systems particularly those associated with industrial development being on the receiving end of their effluent discharges.

- **Real-Time Flow Data for Health Monitoring**

The City of Edmonton, Water Treatment Plant, has correlated the inflow of tributary streams into the North Saskatchewan River above the city to the deterioration of water quality. The City, through Alberta Environment and its Cost-Sharing Agreement with IWD, asked for dial up access to the real-time streamflow level information for three key locations. Stage-discharge curves were provided as well as measurement results to define any shifting conditions which might exist as well as monthly tentative flow information to ensure that their computations stay on track.

These data help the City to more efficiently operate its treatment plant ensuring only the proper amounts of treatment chemicals are being utilized.

- **Understanding Ecological Integrity**

A Geography Graduate Student from the University of Calgary was provided with flow data for the period of record for Milk River at Eastern Crossing (160 station years). These data were utilized in a study of the effect of stream-flow regulation on riverine cottonwood forests.

Information from studies such as these are essential for impact assessments, for potential mitigative works and for the commissioning of major river developments.

- **Minimizing Impacts of Environmental Emergencies**

Alberta Fish and Wildlife Department was provided with provisionally computed 1992 June and July daily discharges for the House River near Ft. McMurray. These data were required to assist in the clean-up of an oil spill that had occurred near the gauge.

In March, 1993, Sage Land Resources requested stream velocity information at eight sites in the Ft. McMurray area for the design of booms and placement locations in the event of future spills. Streamflow data for environmental clean-up of spills is used to prepare reactive and proactive plans. Time of travel of potential spills can determine the logical locations for clean-up equipment to minimize the impacts of spills.

- **Economic and Safe Design of River Crossings**

Alberta Transportation is provided with current and historical peak flow data at river crossing sites on an "as required" basis, usually three to four requests per month. Long term, reliable peak flow data are essential for the determination of flood frequencies, which are used in the optimum economical and safe design of river crossings.

- **Preservation of a Healthy River System**

Proctor and Gamble Ltd. have been provided with a stage-discharge rating curve and a real time water level recording instrument exists on the Wapiti River near Grande Prairie enabling them to obtain up to date flow data. In addition this company is provided with discharge measurement, when they are performed in the winter, to ensure accurate flow data is used for effluent release control.

The amount of released pulp mill effluent is licensed according to river flow. Below a certain flow value, none can be released. Therefore the company needs accurate data for efficient operation, to minimize of environmental impacts of their releases and to prevent contaminating releases when flows are too low. Similarly these data are required in the event of legal actions against companies if they contravene licensing requirements.

- **Real Time Water Level Data**

Real time water level reporting equipment has been installed on Cold Lake at the request of Esso Resources and Alberta Environmental Protection. Esso Resources has been granted a licence to withdraw water from Cold Lake for heavy oil production. All withdrawals must cease when levels fall below a certain level resulting in the shut down of the plant or the acquisition of water by much more expensive means.

- **Design of Safe Flood Protection**

GPEC Consultants were provided with daily discharge data for the 1966 to 1992 period of record for the gauging station on Kleskun Hills Main Drain. These data were provided for the design of a storm retention pond on a non-gauged stream of similar basin characteristics. When specific site data are not available, data from nearby sites of similar characteristics can be utilized for design of engineering works.

- **Water Supply Evaluations**

Alberta Environmental Protection in Peace River were provided with the daily discharge data for the period of record for the Keg River, Boyer River and Chinchaga River. These data were utilized in the assessment of sustainable water supply and identification of options for the Paddle Prairie Metis Settlement.

- **Mackenzie River High Water Advisories**

Data and advice have been provided to flood-prone communities in the NWT since 1963. IWD provides current data on water level, flows, and river ice breakup to flood watch committees in five NWT communities to ensure public safety. Flood damages have totalled about $4 million (1991$) in Hay River since 1963, about $3 million the other NWT communities of Fort Simpson (1963), Aklavik (1961 and 1982) and Fort Liard (1989). The service also reduces potential flood damages at the Norman Wells oilfield operation. However,

Mackenzie Barge Traffic

the only flood-related drowning occurred at Hay River in 1974.

IWD currently provides more data and better advise, based on data transmitted by satellite, new stations, and formal IWD procedures for flood reports and warnings to community, territorial, and federal emergency response agencies.

- **Hydro-power Operations**

IWD provides discharge and water level data for NWT water quantity stations on an ongoing or special request basis to the NWT Power Commission (NWT PC). NWT PC uses the data to determine inflow to reservoirs and manage releases in its Snare and Taltson generating stations. The NWT PC produces the greatest amount of electricity from the water available water by keeping reservoir levels as high as possible, to maximizing total head and power plant efficiency. The data also allows NWT PC to satisfy requirements of water use licenses issued under the Northern Inland Waters Act to efficiently use the available water and to reduce the cost and environmental impact of diesel power generation.

Yellowknife power consumption is currently met by a mix of 70% hydro-power and 30% diesel generation. Rate surcharges to reduce demand and pay the additional cost of diesel have been necessary during recent extended droughts. In 1981-82, surcharges increased consumer power bills by 40%. Similar conditions today could increase total

Snare River Hydro-Power System, NWT

Yellowknife grid wholesale electricity costs from about $15 million to $21 million.

- **Hydro-power site Assessments**

In April 1991, NWT PC and five consultants bidding on a contract to evaluate a small hydro project requested historic IWD water quantity data and other information for the Coppermine River basin and Bloody falls station. An economic source of power was being sought for the community of Coppermine, as well as the nearby deep water seaport to serve the proposed Isok Lake copper/zinc mine. More detailed information was subsequently supplied to the successful contractor, Acres International of Calgary, over the course of the next year.

Historic IWD data and observations on discharge, ice formation and sediment transport lead Acres to conclude that the Bloody Falls site is not suitable for hydro-power, because of head losses due to backwater from downstream ice build-ups, and heavy silting. IWD data for the previous decade enabled NWT PC to quickly reach the correct decision regarding site development, and consideration of other potential sites in the area. Data from existing or future IWD stations will likely form the basis for a future $50 to $100 million power production decision.

- **National Parks Operations**

Since 1988, the Parks Canada has requested real-time data on summer water levels and flows for Nahanni National Park. The data is used by Parks Canada to plan its spring maintenance and fuel haul trips to open the park, using its fleet of jet-boats and a jet-powered scow. During the tourist season Parks Canada uses IWD stream flow and level data to plan and coordinate canoe patrols through the Park, and help them advise park visitors on flow conditions in the park. IWD also provides the information to air charter companies operating float planes into and around the park.

IWD flow velocity and level data enabled Parks Canada to continue using a low-powered propeller scow for park maintenance tasks, until it could be replaced with the jet-powered scow. Parks Canada thrust and power specifications for the new jet scow were based on flow data and calculations performed by IWD's Yellowknife office. IWD's ongoing running record of river conditions inside the Park ensures safe and responsible use of park facilities by tourists and provides a basis for Parks Canada park operations.

- **Design of Municipal Water and Waste Treatment Facilities**

The Northwest Territories' (GNWT) Department of Municipal and Community Affairs has a mandate to upgrade water and wastewater treatment facilities in NWT communities. Information on historic water quantity and quality, as well as other back-ground material such as water temperatures, river cross-sections, and study reports are regularly requested by the department and engineering and construction companies.

IWD data was use in the design of waste treatment facilities for the communities of Arctic Red River, Baker Lake, Coppermine, Fort McPherson, Fort Simpson, Fort Norman, Fort Providence, Fitzgerald (Alberta), Grise Fiord (Canada's most northerly settlement), Hay River, Inuvik, Norman Wells, Snare River, Snowdrift, and Yellowknife.

At Baker Lake, IWD lake hydrographic studies helped the assessment of salt water intrusions

into the lake, which were causing problems in use of the lake as a source of community drinking water. At Inuvik, the IWD office developed a stage-discharge curve for a new weir controlling releases from the town's sewage lagoon.

IWD data and knowledge of local waters helps consultants design effective and efficient systems for water treatment, and ensure safe potable water and proper sanitation for small, isolated communities. The value of information provided and facilities constructed are often not appreciated, until contagious disease strike communities. The outbreak of "hamburger disease" in Arviat during winter 1992/93, illustrates consequences of poor design or operation of community facilities (800 infections, two deaths, and the closing of the community school and other social events for several months).

- **Territorial Parks**

The Semba Deh/Whittaker Falls Territorial Park is located at NWT Highway#1 Trout River Crossing. In September 1992, IWD provided Avens Associates, the contractor to NWT Department of Economic Development and Tourism, historic Trout River water quantity and related information for design of park facilities including a nature trail, foot bridge and interpretative centre. The Interpretative Centre, staffed by summer tourism season guides, contains literature on IWD water monitoring activities and methods. The IWD water quantity station will also be a point of interest on the future park nature trail.

- **School Curriculum Support**

A member of the NWT Kitikmeot Board of Education requested various water use information pamphlets and books from IWD in January 1991, to see if they could be used in eastern Arctic schools. As a result of the sample material supplied, 2000 Environment Canada Water Fact Sheets #1 to 5 and 500 other environment information pamphlets were provided to regional schools.

As a result, proper water use was introduced into the Kitikmeot Board of Education curriculum, and an Inuktitut translation of the Primer on Water was adopted as a standard text. As a side benefit, English and French texts for Environment Canada's "Primer on Water" were subsequently expanded to include specific questions and answers on northern water issues.

- **University Field Courses**

Since April 1991, IWD-NWT has provided background historic water quantity, quality, sediment and related information to the University of Colorado. This information is used by biology undergraduates to design sampling regimes for selected NWT rivers.

The sampling program is then carried out by students in a subsequent field trip to the NWT. Water flow, temperature and other data are collected, as well as information on the river's biota. A different NWT river is selected each year.

IWD's information enhances the course by providing the historical and scientific background for more detailed studies by the students. The field work provides valuable hands-on experience in an ecosystem unfamiliar to most participants. IWD data also helps to organize and schedule the course for the best trip safety and study conditions.

- **Global Warming Studies**

In 1991, the University of Waterloo requested information on the location of the watersheds drainage divides in the Mackenzie River basin, as part of its study on impacts of global warming on river flows. Copies of drainage maps for Arctic watersheds in the Yukon, NWT, and the northern portions of BC, Alberta, Saskatchewan and Manitoba were provided to the University's Department of Civil Engineering for digitizing. The information is used to study the impacts of global warming on the Mackenzie River basin by Atmospheric Environment Service (AES), the University (using its WATFLOOD Flood model), NHRI

(as part of the Global Energy and Water Cycle Experiment or GEWEX), and the World Climate Research Program.

Studies are designed to refine current climate prediction models, produce better forecasts of floods for major Mackenzie River tributaries, and detect climate changes from global warming. Results are critical to define impacts of climate change and to design coping strategies for agriculture, transport, and other sectors of Canada's economy.

- **Toxic Storage Site Selection**

In January 1989, Indian & Northern Affairs Canada (INAC) requested information for the evaluation of an application to relocate a toxic waste storage facility on Vale Island, Hay River, NWT. While the new location was not within areas identified as flood prone on 1984 flood risk maps of the community, IWD studies of a 1985 flood showed that the flood zone delineation required updating. IWD information and expertise enabled INAC to determine that the proposed site was unsuitable, saving thousands of dollars in further studies, and possible relocation of hazardous material to a site more susceptible to flooding.

- **National Park Fire Prevention**

In October 1992, IWD supplied 86 years of historic data to Wood Buffalo National Park staff for a study comparing mean annual runoff and the area burned by forest fires in park's lowland and swampy areas. The fire fuel to moisture models used by park staff worked for day-to-day analysis, but these models did not allow long term trends in water availability. Research done by Parks Canada staff showed that relationships exist between annual runoff and forest fire following year. Work is now proceeding towards a system to provide Parks staff with indications of fire potential eight to twelve months beforehand.

The NWT's Forest Fire Center has also requested IWD data for rivers below the treeline for similar purposes. The Fire Centre spends about $10 million in annual pre-season preparations and up to $50 million on fire suppression. Major savings are possible if projections of the next season's forest fire fighting requirements can improved.

- **Data for World Climate Model**

In March 1991, IWD supplied 326 years of historic water temperature data for stations in the western Arctic to the University of Washington's School of Oceanography. IWD data was combined with other data sets in a global climatological model used for prediction of seasonal weather patterns.

This model will improve predictions of ocean weather trends to allow better routing of shipping and aircraft and improved warnings of high sea surges which will reduce storm damages in coastal areas. IWD data is also being used in other models for prediction of more complex continental weather patterns.

- **Global River Atlas**

In November 1991, IWD was asked to delineate and identify NWT river with mean annual discharges exceeding 350 m^3/s by Umea University's Department of Ecological Botany, for inclusion in a world wide inventory of rivers. The inventory will be published as a reference text for researchers and students around the world.

- **Beaufort Sea Breakup Model**

IWD provided Mackenzie River Delta historic and current water quantity and temperature data and field support to the University of Alaska's Geophysical Institute in December 1989. The data was used to study the effects of river inflow on formation and breakup of sea ice in the Beaufort Sea and to develop a model to predict sea ice breakup. The study and model are directly applicable to the planning of offshore oil exploration and shipping, as well as understanding of the effects of sea ice on the climate in the northern hemisphere and forecasts of weather.

- **Nature Film Production Support**

In April 1988, IWD provided historic water quantity, quality, sediment, water use and ice thickness data and the location of IWD monitoring sites to American nature film maker Robert Perkins for planning a 1988 trip down the Back River. During summer 1989, Mr. Perkins provided IWD with observations on weather and ice breakup conditions on the Back River in return for use of IWD crew shelters while filming and writing on the area.

Mr. Perkins' book and film "Into the Great Solitude, An Arctic Journey" was shown on PBS Television and distributed overseas, generating interest by canoeists and other parties to visit northern Canada. IWD assistance produced appreciative clients and economic benefits to outfitters, air charter companies and other service companies and promoted the NWT on the world tourism market. The $88 million tourism industry is the NWT's fourth largest economic sector.

- **Artificial Island Design**

In June 1991, IWD calculated water velocities of the Mackenzie River at Norman Wells for certain dates and times for UMA Engineering of Calgary to check the reliability the meter they used to measure flows near the artificial islands at Esso Resources Norman Wells Oilfield. Independent confirmation of UMA's measurements, using IWD data, was required to confirm study results. Without IWD information, UMA would have had to do the program for another year or prepare a report with unconfirmed data. Additional IWD data was used to assess the stability of island shoreline erosion protection structures during spring breakup.

- **Fish Studies**

Data on water levels and seasonal flow conditions of the Dianna River near Rankin Inlet were requested by Fisheries and Oceans Canada staff in 1989. The information was used to plan field trips and build traps for a fish tagging program, as a part of ongoing, long-term studies of the movement and populations of Arctic Char in the eastern Arctic/Hudson Bay region. This study is used to calculate fish stocks and set limits for indigenous, commercial and recreational fishing. Effects of pollution and global climate change are also being monitored.

- **Flood Studies**

In September, 1986 a strong storm system, culminating from a combination of former hurricane Newton and former tropical storm Madeleine, developed over Montana and generated high winds and heavy rainfall. The storm moved in a northwest direction, entering southern Saskatchewan on September 24. Unusually high amounts of rain fell during the 48 hour period of September 24-26, with peak recorded amounts of over 140 mm in Canada and 175 mm in the U.S. This tropical storm was the only one ever recorded to affect Saskatchewan. The flows produced by the storm exceeded previously recorded peaks in the Milk River tributary basins of Lodge, Battle and Lyons Creeks. The high flows caused little structural damage in the agricultural area, caused considerable flooding and occasional road washouts.

IWD staff measured the flows and documented the event. The event was documented and frequency analyses were done for sixteen hydrometric stations. The results of the analysis have been valuable to PFRA for the spillway design of the Battle Creek Dam. The procedures for obtaining and interpreting the field data were documented and will now serve as a case study and training guide for field staff. A paper on this unique flood event was presented at the 24th Annual Congress of CMOS on Climate Variability - Causes and Consequences May 28 -June 1, 1990 in Victoria, B.C.

- **Sediment Issues - Deltas**

Sediment issues in the Cumberland Lake area of Saskatchewan have been important for many years. The area is part of the delta complex of the Saskatchewan River and historically has had

widespread sediment deposition. However, since 1963, the E.B. Campbell Hydroelectric Dam, about 50 kilometres upstream of the delta complex, has trapped most of the Saskatchewan River sediment load previously deposited in the delta. The delta has now become a sediment source rather than a sediment sink.

Sediment entrainment, movement and deposition within the Saskatchewan river delta floodplain and the impacts on the ecology of the delta must be better understood. Sedimentation and the resulting diverse floodplain morphology is important to producing different plant communities, closely juxtaposed, and wildlife in the delta. M.A. Carson and Associates, the contractor, reviewed the work to date that attempted to address the sediment issues in the Cumberland Lake area of the Saskatchewan River delta-complex and recommended the development of a sediment budget for the area and the use of short term monitoring stations. The report provides information for understanding the ecology of the delta complex.

- **Sediment Issues - Agriculture**

High levels of suspended solids in streams adversely affect fish performance, increase sediment accumulation that spoil fish habitat, infill channels and produce high dredging costs in ditches, canals and reservoirs and contain contaminants such as nutrients, heavy metals and organic compounds. U.S. studies have shown farmland erosion to be a major source of sediments in streams. Similar studies had not been done for the Canadian prairies thus the seriousness of the problem in this country is not understood.

This first study to examine the off-farm impacts in the prairie region of Canada was completed under contract to M.A. Carson and Associates in 1990. The study assessed the nature, extent, and effects of off-farm sediment impacts in the Saskatchewan River system including how much of the sediments originate from farmland and what are the impacts of this farmland sediment on instream and off-stream uses of water in the river basin.

The results of the study will guide IWD in focusing its sediment monitoring programs in areas where the off-farm impacts are greatest.

2.2.2 Water Quality Monitoring Agreements Canada-Alberta/Saskatchewan/Manitoba

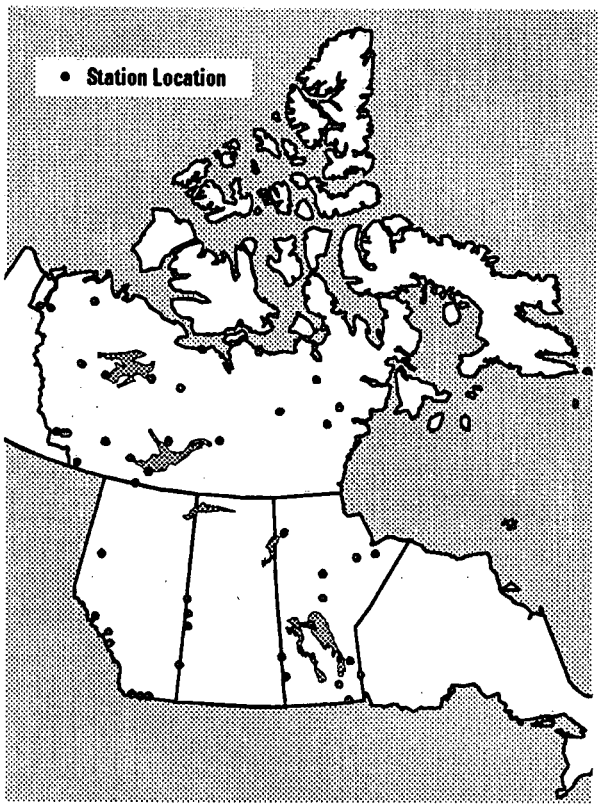
A comprehensive knowledge of the availability, distribution and quality of water is vital in the development and management of a nation's water resources. Information is also required to advise both federal and provincial agencies in support of pollution control regulations, environmental assessments, legislative formulations and international commitments. The Canadian public is increasingly demanding information on the state of their water resource.

In response to these needs, the federal Cabinet created a formal mechanism to enhance cooperative planning and implementation of monitoring activities. The framework for the collection and assessment of water quality data in a non-duplicative manner forms the basis for the Federal-Provincial Water Quality Monitoring Agreements. In the Western and Northern Region, the Canada-Manitoba Water Quality Monitoring Agreement has been successfully implemented sine 1989. Both Alberta and Saskatchewan have declined to sign similar Agreements.

Canada-Manitoba Water Quality Monitoring Agreement

This monitoring program, formalized on June 12, 1989, has focused largely on Manitoba streams which have either been adversely impacted by human activity or have the potential to be significantly affected by such developments in the future. The program was designed to provide basic information to satisfy the public's "need-to-know" in addition to contributing to sound economic development decisions in the province of Manitoba.

Under this Agreement, IWD and the province of Manitoba have jointly monitored the physical and chemical attributes of fifty-two prairie and northern rivers on a routine basis in Manitoba



Water Quality Station Locations in the Western and Northern Region

since 1989. Canada has also taken advantage of the provincial expertise and resources in bio-monitoring to obtain important data on the presence of metals and organics in fish. The Agreement has facilitated the completion of special studies, such as the Stephenfield Reservoir Pesticide Survey, which have made major contributions to our knowledge of the state of the aquatic resource.

The Canada-Manitoba Water Quality Monitoring Agreement has eliminated unnecessary duplication in the acquisition of environmental data as envisioned by the federal Cabinet in their 1982 Proposal and it has provided a formal forum for the planning and assessment of monitoring activities in Manitoba. The work-shared arrangement adopted for this particular Agreement has also simplified the financial accounting process. Overall, this approach has resulted in a more efficient way of assessing the state of the aquatic resource of the province of Manitoba.

Water Quality Sampling

3. SUSTAINING OUR RENEWABLE RESOURCES

3.1 Achieving Environmental Sustainablity in Agriculture

3.1.1 Economic Impacts of Prairie Drought

The natural prairie ecosystem evolved under semiarid conditions characterized by wide variations in precipitation, temperature, and other climatic elements. Fauna and flora accordingly adapted to extreme weather and climatic events, including droughts. Man has, during the past century, radically transformed the prairie landscape, thus the ecosystem now faces both the temporary effects of drought and the more long term influences of man.

The agricultural industry depends upon adequate supplies of good quality water for domestic needs, livestock watering, and irrigation. Reliability of water supply has always been of concern to prairie farmers. Since the Dirty 30s, when drought forced widespread farm abandonment, federal and provincial agencies have supported on-farm and community water storage projects, construction of wells, and irrigation projects thereby decreasing vulnerability to drought. Since the rural water development programs were started in 1935, 228 000 individual, group and community projects have been financially assisted.

Severe droughts, such as those in 1977, 1980-81, 1984 and 1988, however, still impose economic hardship on the farming community as a whole. Farmers in the southern prairies have responded to critical water shortages by hauling or pumping water, constructing deep wells and dugouts, moving livestock to wetter areas and reducing herd size. Finding adequate sources to pump from is a significant problem. The conjunctive use of ground and surface water has been constrained in recent years by dropping water tables. Shallow aquifer wells have been affected in many areas. Despite high cost and poor water quality, farmers are drilling deep wells to obtain additional water supplies.

Low water levels are often associated with poor quality. Farm dugouts with low water levels may be choked with weeds and algae and/or may contain higher concentrations of dissolved solids which could present health problems for livestock.

Irrigation based on small storage reservoirs, sloughs, and spring-fed streams were curtailed during the droughts of the 1970s. Irrigators with access to dependable supplies had higher costs, usually to pay for greater pumping to offset the higher evaporation rates and lack of supplemental rainfall and larger lifts from lower reservoir levels. Above normal temperatures resulted in higher demands for irrigation water and in greater reservoir draw-downs.

The 1976-77 drought in the southern prairies cost the federal and provincial governments over $10 million in subsidies and additional drought insurance payments. Electric power producers, especially Manitoba Hydro, spent an additional $100 million using coal fired thermal plants and to import power to offset reduced hydro-electric production or thermal-power cutbacks due to low water levels.

The two Interim Subsidiary Agreements on Water Development for Regional Water Development for Regional Economic Expansion and Drought Proofing, the Canada-Saskatchewan (SAW) and the Canada-Manitoba (MAW), provided for joint studies to assess economic development opportunities and constraints due to lack of water. IWD had the studies expanded to include hydropower, wildlife and non-structural alternatives. IWD was on the SAW study management board and provided technical expertise to both studies. From the studies, long-term economic and water resource development strategies and short-term drought mitigative measures were compiled. The Agreements included water storage and delivery schemes. SAW included implementation of flood damage reduction measures for their regional development

potential. The studies were underway during the more widespread 1980-81 drought.

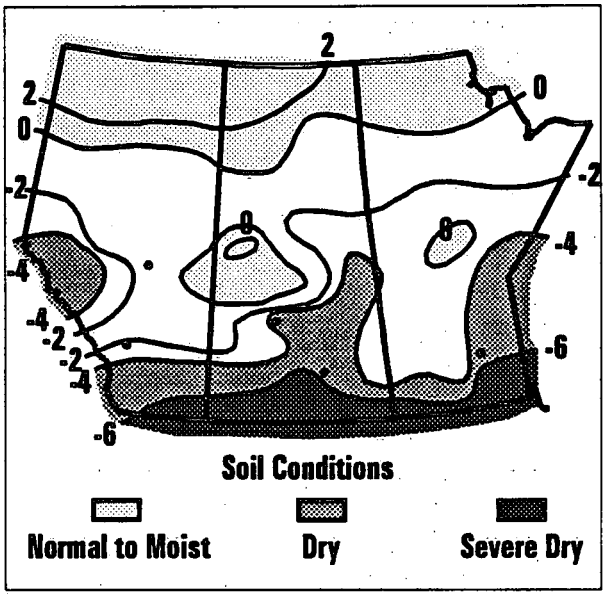
While the SAW Agreement terminated on March 31, 1984, projects approved before the termination date were implemented according to the agreement. The final report of the Subsidiary Agreement was released in 1987. Phases II and III of the Drought Proofing Studies were carried out after the agreement terminated. A total of $12.9 million was spent by March 31, 1986.

The MAW studies assessed the drought sensitivity of southern, semi-humid/semi-arid areas Manitoba and the economic and physical methods to mitigate or prevent the negative impacts of drought. These studies examined the financial implications of drought on on-farm, regional and provincial economies, the adequacy of on-farm water supplies and the physical and economic effects of drought on waterfowl, fisheries and hydro-electric production. The studies concluded that a severe drought similar to the late 1930s would cause, in 1979 dollars, $1.45 billion lost agricultural related economic activity and $50 million per year loss in hydro-electric production.

Waterfowl has, historically, adapted to periodic drought, but in recent decades the steady loss of on-farm wetlands, accelerated by drought, has reduced overall populations. Less open water during drought also concentrates waterfowl numbers which decreases nesting success and increases the number of deaths due to water-borne diseases such as botulism and cholera. Drought's major impact on the fisheries in Manitoba and Saskatchewan has been accelerated eutrophication from concentrating nutrient loading during low water levels and increased algae growth that culminates with suffocation of fish later in the season as decaying vegetation depletes oxygen levels.

Both agreements reduced the economic and social vulnerability of the agricultural areas to droughts. Both agreements included investigations and mapping of groundwater aquifers for future ground and surface water development. Eighteen Saskatchewan and fifteen Manitoba drought-prone communities were identified and six and five communities respectively had their water supplies made more secure under the agreements by constructing larger dugouts to increase carry-over storage, digging wells into deeper, larger aquifers and identifying the closest, secure water source. Non-structural activities were identified as important to reduce the physical and economic disruptions caused by drought. Farmers were encouraged to use more water efficient farming practices, such as snow-trapping, use of fertilizers and conservation tillage, to improve crop yields and reduce production costs.

Irrigation was identified as the only method of maintaining crop yield during droughts. A maximum of 200 000 hectares (ha) could be irrigated in Manitoba or about 3 percent of Manitoba's improved agricultural land. In Saskatchewan, two long term mitigative strategies were evaluated, a large 37 000 ha project and a large number of 16 ha irrigated forage plots across southwestern Saskatchewan. The impacts of farming practices on waterfowl numbers were noted and the recommendation to improve habitat for migrating birds, such as wetland replacement, were later included in the North American Waterfowl Management Plan.



Palmer Drought Index - August 1988

The 1980s continued to be dry, with the 1988 drought extending from the Gulf of California to central Manitoba, and eastward to Quebec. Canada's agricultural output decreased 12.7% in 1988, with agricultural production in Alberta, Saskatchewan and Manitoba down by 1.2%, 38.6% and 18.5% respectively. Manitoba's economy also had a 13% reduction in hydro-electric production. Alberta's agricultural industry was maintained by the large economic value of irrigation in southern Alberta and near normal production in the Peace River area. The direct production loss to Canada was estimated at $1.8 billion (1981$), or 0.4% of real GDP. These economic losses were close to those predicted earlier in the SAW and MAW studies for a severe drought.

The drought PDI, 1988 also caused economic loses in the U.S. northern plains and midwest. Due to its intensity, duration and coverage, the impacts of the 1988 drought rippled through the Canadian, North American and international economies. Agricultural economic losses were tempered by the higher product prices.

Some sectors of the environment, economy and society are more sensitive to climatic extremes. However, strategies to reduce this sensitivity are built on a knowledge of how each sector responds to and is vulnerable to drought. The Saskatchewan Research Council and Agricultural Economics Department, University of Manitoba, in their report "Some Environmental and Economic Impacts of the 1988 Drought - Saskatchewan and Manitoba", assessed these environmental and economic impacts. AES took the lead federal role in the study with support from Agriculture Canada, IWD and CWS.

The study divided the physical and economic impacts into issues/sectors of agriculture, land degradation, forestry, water resources, water-fowl, fisheries, recreation/tourism, transportation, energy and other industries. Models were used to show the different impacts under different sets of social conditions, such as those arising from past drought experiences, through technological change or due to drought relief programs. Studies of the 1988 drought will allow the design of better mitigation strategies for the next climatic disaster. However continuous information on drought vulnerability must be collected since the economy changes over time.

3.1.2 Ecological Impacts Caused by Agriculture

Non-Point Source Pollution Impacts

In Canada, many water bodies are considered unsuitable for human use because they contain prolific growths of algae and rooted aquatic weeds. In the prairie provinces, many lakes attest to this problem. The Shellmouth Reservoir (Lake of the Prairies) on the Assiniboine River is a striking example of eutrophication, or excessive productivity, which results from increased loading of nutrients (nitrogen and phosphorus).

Constructed in 1969 at a cost of $10.8 million, this artificial impoundment was designed to provide flood protection and to meet the needs of industrial, agricultural and domestic users downstream. The reservoir itself has developed into a valuable recreation and fisheries resource. Sport fishing alone generates local revenues in excess of $1.0 million per year. The lake is also used for other water sports. The Prairie Province Water Board (PPWB) has identified recreation as the most sensitive water use of the Shellmouth Reservoir.

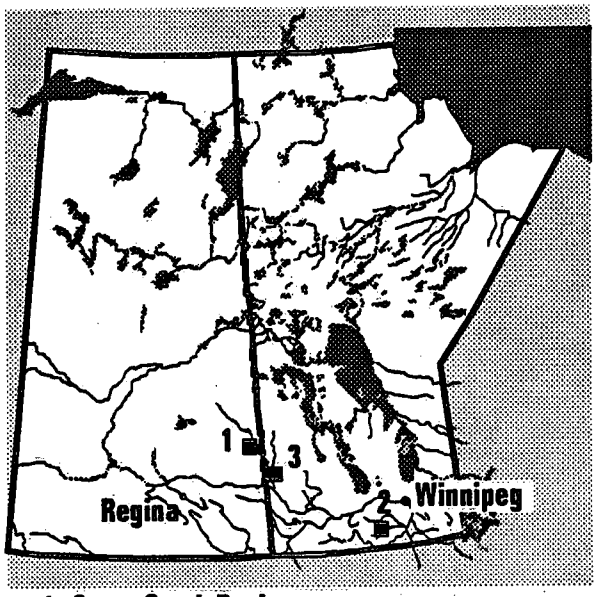
Unfortunately, in recent years, extensive blue-green algal blooms, believed to result from an overabundance of phosphorus, and the strong rotting odours from the decaying algae have reduced the recreational appeal of the reservoir. Oxygen depletion, also a result of the decay process, has become a serious threat to the fisheries.

The province of Manitoba, concerned about the sustainability of this ecosystem and its capacity to maintain healthy recreation and fisheries industries, initiated in 1991 a major study aimed at better understanding the magnitude and nature

of the Shellmouth eutrophication problem. IWD's involvement in this resource management project came at the request of the PPWB and the provinces of Manitoba and Saskatchewan. IWD conducted scientific investigations designed to assess the extent of non-point source agricultural pollution to Shellmouth Reservoir. This work, carried out between 1990 and 1993 at an annual cost of less than $10 000, was compatible with IWD's role of promoting cooperative solutions to inter-jurisdictional environmental problems.

The Stony Creek watershed in Saskatchewan was selected by IWD as its primary study area. Stony Creek, a tributary of the Assiniboine River, drains 500 square kilometres of agricultural land. The cattle farming operations situated along Stony Creek are regarded as significant sources of nutrient in the watershed. Fertilizer use on forage and cereal crops has increased over the last twenty years and is another source of nitrogen and phosphorus within the Stony Creek drainage area.

Prior to this study, the general consensus was that Kamsack, Saskatchewan, with a population of approximately 30 000 and situated a few kilometres upstream of Shellmouth Reservoir, was the major contributor of phosphorus. IWD estimated that the Kamsack sewage lagoon contributed 1066 kilograms (kg) of phosphorus per year in 1991, a relatively dry year, compared to the total non-point source loading of phosphorus of 5000 kg per year. Saskatchewan had also studied the impact of Kamsack separately. In early 1994, Manitoba is expected to complete a detailed biological and chemical survey of the reservoir. Together these three related studies will provide the basis for a basin-wide water management and land use strategy leading to long-term water quality improvements.



1 Stony Creek Basin
2 South Tobacco Creek Project
3 Shellmouth Reservoir

Sites of Impact Studies

The application of agricultural Best Management Practices in the Assiniboine River basin will reduce the input of agricultural chemicals and sediments and lead to long-term water quality improvements. Efforts to reduce the input of agricultural chemicals and sediments are long-term investments which will benefit the terrestrial and aquatic environments and provide a secure future for a recreation-based industry. A more immediate benefit of this joint work is that a sound decision on whether to upgrade the Kamsack sewage treatment facility can be made. Before the IWD study, pressure was on the town of Kamsack to improve the quality of its effluent at relatively high cost. The studies showed that remedial action would provide greater benefits to the lake.

Increase in Nutrient Input

Nutrients from Fertilizers	Quantity (Tonnes)		Percentage Change
	1971	1986	
Nitrogen	824	16 241	1 871
Phosphorus	3 111	28 368	812

Erosion Impacts Studies

The need to achieve environmental sustainability in agriculture on the Canadian prairies is critical. At stake is a multi-billion dollar a year farming industry directly employing a total of more than 200 000 people in the three prairie provinces. The technological advances that have made grain farming so productive are now threatening its own assets. Organic matter content of soil has fallen from 40 to 50% from pre-settlement levels in the prairies. The concurrent loss in soil nutrients has meant a large increase in fertilizer use.

Lake Winnipeg in Manitoba is a sink to the Red River basin, which has 80% in agricultural use, and is subjected to inputs of sediments, nutrients and pesticides generated by farming activities. Visible signs of this can be seen as increased weed growth and the presence of blue-green algae and other obvious changes in the Lake's ecosystem in recent years. The Manitoba public has expressed concerns over the possible deterioration of the fishery, recreational and tourist industries currently supported by Lake Winnipeg.

IWD started examining the impact of agricultural land use on Lake Winnipeg in 1991, soon after the Governments of Canada and Manitoba signed an agreement with the Deerwood Soil and Water Management Association to implement the South Tobacco Creek Pilot Project (STCPP). This project's impetus was the need to reduce the loss of soil caused by severe runoff erosion on farmland along the Pembina Escarpment. In 1992, at the request of the Prairie Farm Rehabilitation Administration (PFRA), the Inland Waters Directorate became involved in the planning and implementation of the aquatic component of the Pilot Project.

The South Tobacco Creek originates on the Manitoba escarpment in south-central Manitoba and is a tributary of the Red River. It is therefore believed to be one of the contributors to the sediment, nutrient and pesticide burden to Lake Winnipeg. Stream ecosystems in this watershed are also believed to be heavily impacted by farming as they are in the rest of the Red River basin.

Considerable financial support for the water quantity and water quality work conducted by IWD is provided by the Deerwood Soil and Water Management Association. IWD has also formed a joint venture with Agriculture Canada and the University of Manitoba to conduct multi-disciplinary field-scale studies to characterize the processes which govern the transport of nutrients, pesticides and other substances from small agricultural drainage basins into rivers. Fisheries and Oceans Canada are examining the role of atmospheric transport of pesticides into the basin and volatilization of agricultural biocides from Lake Winnipeg.

Recent provincial studies indicate that the City of Winnipeg, on the Red River with a population of 650 000 and an aging sewer system, also contributes large amounts of nutrients to Lake Winnipeg. The City is under pressure to upgrade its infrastructure at a projected cost of nearly $1 billion. However, the significance of the city contribution to Lake Winnipeg's nutrient loading relative to the input from agricultural sources in the drainage basin has not been established. This information gap makes it difficult to estimate how much the city's sewage infrastructure should be upgraded.

The other component of this study, launched this fall by IWD, is designed to estimate the contribution of the Red River's major tributaries to the nitrogen and phosphorus loadings into Lake Winnipeg. Whereas the Stony Creek watershed study was to examine the interaction of anthropogenic and natural processes at the individual farm level, the objective in South Tobacco Creek is to document the nature and the extent of erosion and contaminant problems on a much larger scale.

The major anticipated benefit from this work is the reduction of the impact of farming on the aquatic and terrestrial ecosystems. The implementation of agricultural Best Management Practices in the United States has

generated significant improvements in water quality. Iowa's Public Policy Center also reports that the adoption of environmentally sensible agricultural practices has in turn led to increased profitability for the farmers. Hence, the lesson for our country is that environmental responsibility and global competitiveness need not be mutually exclusive.

The implementation of agricultural Best Management Practices means the safeguarding of local jobs created by a major recreational industry which is highly dependent on a healthy Lake Winnipeg. The information collected through this study will also allow the Province of Manitoba and the City of Winnipeg to make economically and environmentally sound decisions on the future of Winnipeg's sewage treatment facilities.

The experience from the U.S. Rural Clean Water Program has demonstrated that a successful project must involve the producers, local agribusiness and conservation districts. IWD will promote "local ownership" of the project and provide education and technical assistance to the land owners over the projected ten year duration of the study. The Deerwood Soil and Water Management Association will continue to be active in this project.

Pesticides Impacts Studies

During the past decade, South, Central and North American governments have put a high priority on identifying, assessing and protecting critical shorebird habitat for species that migrate over much and sometimes the full length of the Western Hemisphere. These activities are related to the fact that many species have become endangered or threatened as the result of rapid agricultural and industrial expansion in the Americas over the last few decades.

Protecting shorebirds is part of a larger effort to maintain biological diversity which is itself a key aspect of maintaining the health of our environment. This major effort has been strongly endorsed by the Wildlife Ministers' Council of Canada which, in September 1990, adopted this country's first national wildlife policy. The policy establishes a framework for the conservation of all of Canada's wild organisms.

In 1988, the prairies of southern Saskatchewan were subject to severe drought, and many large lakes became dry. These "dry" lakes and some more permanent ones are critical staging and breeding habitat for shorebirds and waterfowl. A number of shorebird species must locate and obtain an abundant food supply from these Canadian prairie lakes in order to replenish energy reserves, and complete their annual migration from South America to their breeding areas in arctic habitats in North America. Many of these same lakes are critical breeding habitat for the endangered Piping Plover. Survival of several shorebird species is dependent on the maintenance of "healthy" lake habitat on the Canadian prairies.

A potential health threat to shorebirds is the presence of pesticides in lake ecosystems. Pesticides used on the prairies often find their way into prairie lakes, transported there through aerial drift at the time of application or by runoff. Detailed surveys of permanent lakes have been conducted in the past and there is accordingly a good knowledge base on the presence and fate of biocides and the risk they pose to wildlife in these particular habitats. There is a need to collect similar information for semi-permanent lakes in view of the lack of knowledge on the interaction of pesticides and birds in these habitats.

IWD, with the cooperation of the Canadian Wildlife Service (CWS) and Ducks Unlimited, conducted an assessment of the pesticide levels in water, sediment and aquatic biota in semi-permanent ("dry") and permanent lakes in southern Saskatchewan. The total cost of the project was $100 000. Lindane, alpha-HCH, 2,4-D and triallate were detected in many lakes. With one exception, concentrations of these pesticides were below levels that would affect habitat quality. Semi-permanent and permanent lakes did not differ in pesticide detection

frequency and levels, but freshwater lakes were contaminated more than were saline lakes.

The above results represent, overall, good news for the prairie farmers. A general conclusion of the IWD work is that the use of agricultural pesticides does not as yet represent a significant health threat to shorebirds. But the fact that several pesticides were detected in the target lakes confirms the need for vigilance on the part of the land users. This data has been communicated to Agriculture Canada so that they can revise, if necessary, the guidelines governing the use by farmers of the pesticides contained in this study. Creating awareness based on sound scientific advice is the first step in developing citizenship solutions to major environmental problems. Accordingly, this IWD initiative indirectly but strongly promotes the goals of the national wildlife policy put forth by the Wildlife Ministers' Council.

- **Herbicide Impacts Studies**

Minimal-till and zero-till agricultural practices are being promoted by Agriculture Canada and its provincial counterparts in an effort to conserve the integrity of prairie soils through the reduction of wind and water erosion. These practices are also designed to provide cover for nesting waterfowl, and thus, have been endorsed by the Prairie Habitat Joint Venture. The latter is a federal-provincial consortium of government agencies dedicated to increasing the production of ducks in the central flyway, the migratory route south from the Mississippi River north to the Mackenzie. The Prairie Habitat Joint Venture is the largest program under the North American Waterfowl Management Plan, signed in 1986 by Canada and the United States.

One of the most popular herbicides used by farmers who practice conservation tillage is glyphosate, which goes under the trade name of ROUNDUP. Research shows that glyphosate does not affect waterfowl directly. However, this herbicide could upset ecological processes such as primary or algae production in prairie ponds, which are critical feeding habitat for ducklings. Reduced algal production could limit the abundance of invertebrates, which are the most important food source for young ducks.

The loss and potential loss of biological diversity is one very serious consequence of not protecting wildlife habitat. The duck population serves as one barometer of a diversified and well-balanced ecosystem. Past farming practices, especially the drainage of wetlands and the extermination of plant species perceived as weeds, have endangered the survival of at least twenty-five animal species in Canada.

Wildlife also contributes to the financial well-being of our country. The 1991 The State of Canada's Environment report estimated that the wildlife resource has a multi-billion dollar economic value. The duck resource, in particular, is enjoyed by a great number of people in this country and also in the United States and Mexico.

IWD, with financial support from the Prairie Habitat Joint Venture, conducted a $50 000 study on prairie ponds to determine the effects of glyphosate on primary algal production. Small enclosures were constructed in three ponds in the Buffalo Moraine in south-central Alberta. These enclosures were treated with glyphosate at levels similar to those applied operationally to fields. Chlorophyll "a" concentrations, a good indicator of algal productivity, showed little negative impact attributable to glyphosate. The half-life of glyphosate was determined to be 6.7 to 17.0 days. These data and results from bioassay trials indicate that the impact of glyphosate on ponds would be minimal. Glyphosate, therefore, is suitable for use, under controlled conditions, in areas where ducks nest and rear their young.

The work carried out by the IWD provided farmers and wildlife managers with data which can be used to estimate the risk to fauna of using glyphosate near prairie wetlands. Solid scientific facts allow land users and wildlife managers to fine-tune agricultural best management practices. This scientific knowledge also makes possible the conditions appropriate for the co-existence of farming with a wildlife-based

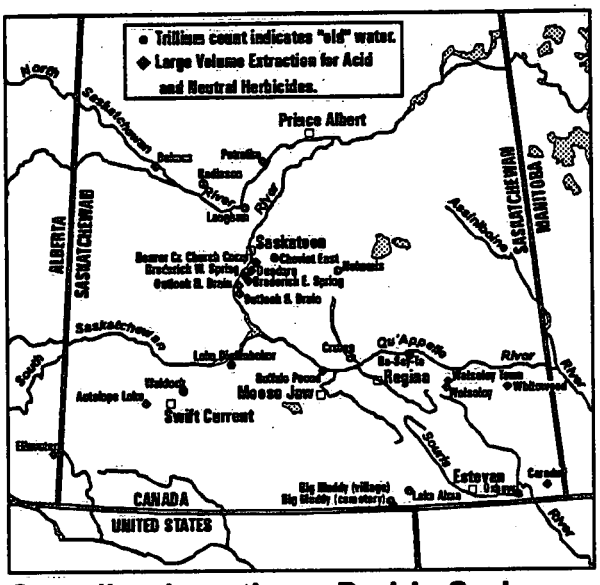
recreational and tourism industry. The 1991 State of Canada's Environment report estimated that activities related to wildlife contributed $11.5 billion to Canada's gross domestic product. Wise resource management contributes to the preservation of global diversity, in itself a priceless legacy to the environment and to future generations of humans.

- **Contamination of Prairie Springs Assessment**

A recent Environment Canada study indicates that little is known whether any of the $850 million of pesticides applied every year in Canada reach the groundwater and, if so, what their impacts are. The Western region is one of the least studied with regard to shallow aquifer contamination. Pesticide-contaminated groundwater systems can have detrimental impacts on the health of rural residents for whom shallow aquifers are sources of drinking water. Many farms use spring waters for livestock consumption therefore putting cattle at risk. Groundwater discharges into wetlands which serve as habitat and food sources for various waterfowl and other wildlife. The economic value of our wildlife resource, as estimated in the 1991 State of Canada's Environment report, is in the billions of dollars annually to this country.

Previous surveys at a few instrumented sites in Western Canada have indicated that herbicide contamination of shallow groundwater does occur and with greater frequency than was expected. Although a small number of instrumented groundwater research sites have been investigated, a large scale survey of shallow spring waters for herbicides has never been carried out in the prairie ecosystem.

In view of the human and ecosystem health concerns and in response to the knowledge gap disclosed, IWD initiated a study in 1991 to investigate whether regional scale contamination of shallow groundwaters is occurring and to what extent. The study focused on fifteen shallow prairie aquifers, located throughout the entire region of southern Saskatchewan in areas



Sampling Locations, Prairie Springs

where herbicides are used extensively. The springs typically originate within shallow glacial surface deposits and are used as human and livestock drinking water sources. All of them are also important riparian habitats.

This ongoing project has revealed the presence of herbicides in shallow groundwater. The occurrences appear to be sporadic but significant levels of several locally used "acid" herbicides were found in some aquifers. At other locations, "neutral" herbicides (notably atrazine), which have never been used locally, were found. These contaminants appear to have been transported atmospherically from remote sources. Not surprisingly, atrazine, a relatively persistent and volatile organic compound, is the most frequently reported pesticide in studies of groundwater in North America. Because of these same attributes, it also frequently appears in surface waters in many regions of the globe.

This study, conducted at a cost of $40 000, will provide health officials with an important component of the information required to assess the risks posed to human health by the presence of herbicides in rural drinking water and to recommend appropriate remedial measures if necessary. The same data can be used to assess potential impacts of shallow groundwater herbicides on livestock. This knowledge base

will also be useful to Agriculture Canada, provincial agencies, farmers, wildlife managers and other stakeholders in the development of farming practices which contribute to sustainable agriculture.

The license to manufacture and distribute atrazine is currently under review by the Commercial Chemicals Branch of Environment Canada. The current study by IWD has significantly expanded the knowledge base on the persistence and dispersive characteristics of this herbicide. By influencing the regulations which set limits on the use of atrazine, this project will indirectly contribute to the protection of ecosystem health and bio-diversity.

4. OUR SPECIAL SPACES AND SPECIES

4.1 Protecting Unique Ecological Areas

4.1.1 Long-Range Transport of Organic Compounds to the Rocky Mountain National Parks

IWD set up a network of water quality monitoring stations within Banff, Jasper and Waterton National Parks in 1972 to characterize baseline water quality conditions. This initiative was by Parks Canada to assist in their Biophysical Inventory program.

The monitoring program has been carried out at an annual cost of $55 000, half paid for by Parks Canada. The monitoring program has determined the natural aquatic levels of chemical and physical constituents in water plus it has revealed the presence of two organo- chlorine compounds, the insecticide lindane and its breakdown product alpha-HCH (also a by-product of lindane manufacturing), in surface waters. Since Parks Canada has no significant usage of either compound, the compounds presence was attributed to atmospheric transport and deposition.

Atmospheric transport is an important process for the global dispersion of agricultural and industrial chemicals. Other researchers have confirmed the presence of hexachlorohexanes, polychlorinated biphenyls (PCBs) and polyaromatic hydrocarbons (PAHs) in remote areas thousands of kilometres away from their nearest known sources.

Concerns over the long-term viability of the tourist industry convinced IWD and Parks Canada to conduct an exploratory survey of Waterton National Park in 1989. National parks are primarily set aside to protect and preserve unique ecosystems but they also provide opportunities for recreation. Large numbers of people from all over the world visit Waterton and other national parks with the Rocky Mountain National Parks being especially popular with nature enthusiasts from Europe and Japan. The success of this tourist industry, and the thousands of Canadians it employs, is closely tied to the image of national parks as unspoiled spaces and species. This image would be tarnished if the Parks ecosystem become visibly stressed.

The first IWD study revealed higher than expected levels of organochlorine pesticides and polychlorinated biphenyl (PCB) residues in fish in alpine lakes. These results heightened worries over the integrity of aquatic habitats in mountain ecosystems and human health related to fish consumption.

These preliminary findings provided the stimulus for a detailed investigation into the levels and sources of organic contaminants in national and provincial parks along the Continental Divide. Under this joint project with Parks Canada and Atmospheric Environment Service (AES) and with the cooperation of the British Columbia Ministry of Environment and Alberta Fish and Wildlife, IWD determined contaminant levels in lake trout fillets, lake water and snow from fourteen lakes in four national and two provincial parks. The $150 000 project, shared equally by the Parks Canada and IWD, was conducted from 1990 to 1992.

In general, concentrations of contaminants in fish and water were below regulatory limits and suitable for human consumption. However, more than half of the fish taken from Bow Lake in Banff National Park exceed the Health and Welfare (H&W) Regulatory Limit for toxaphene. Upon further review of the facts, H&W ruled that the fish were suitable for consumption because of the estimated low consumption rate by humans. The presence of toxaphene in aquatic biota has been attributed to a significant use of this compound within some of the parks' lakes in the early 1980s.

Fish from several lakes in the parks exceeded the Great Lakes Quality Agreement Specific Objective for PCBs (100 %g/kg) which was set to ensure protection of birds and mammals species. Using 5-day trajectories, AES traced the source of these contaminants to the northern half of the Pacific Ocean suggesting Asia as a potential source.

The study clearly demonstrated that the pristine qualities of national and provincial parks along the Continental Divide are being compromised by atmospheric pollutants from sources outside of Canada. Excessive use of toxaphene prior to the environmental awareness movement has also resulted in some stress on the aquatic eco-systems of these special spaces. Protecting these unique ecological areas is as much an international as a national problem. At stake is a huge multi-million dollar tourist industry backed by the perception of unspoiled spaces and ecosystems. A dollar figure cannot be put on the unique life forms at risk here but they represent a natural heritage which cannot be brought back once it's lost.

Some good news is that IWD's records from the Rocky Mountain National Parks indicate although lindane and a-BHC are still present in water, the levels appear to be declining. The frequency of detection of a-BHC, the more stable of the two compounds, has declined during the past decade. The most significant decline has been in the Athabasca River where the influence of lakes is low, and lowest in the Waterton River where the influence of lakes is pronounced.

4.1.2 Water Quantity Monitoring in the Rocky Mountain National Parks

IWD operates a network of eighteen streamflow stations within the Rocky Mountain parks to provide Parks Canada with the water quantity data needed to meet management objectives. These objectives include the design of bridges and culverts, snowmaking for Lake Louise and Mount Norquay, the study of the breeding area of the Harlequin Duck on the upper Maligne River, ecosystem studies, state of the environment reporting and glacier studies associated with climate change. The first station in the network was started on the Bow River at Banff in 1909. The longer-term records from this streamflow station are used to extend short-term records in similar hydrologic regions.

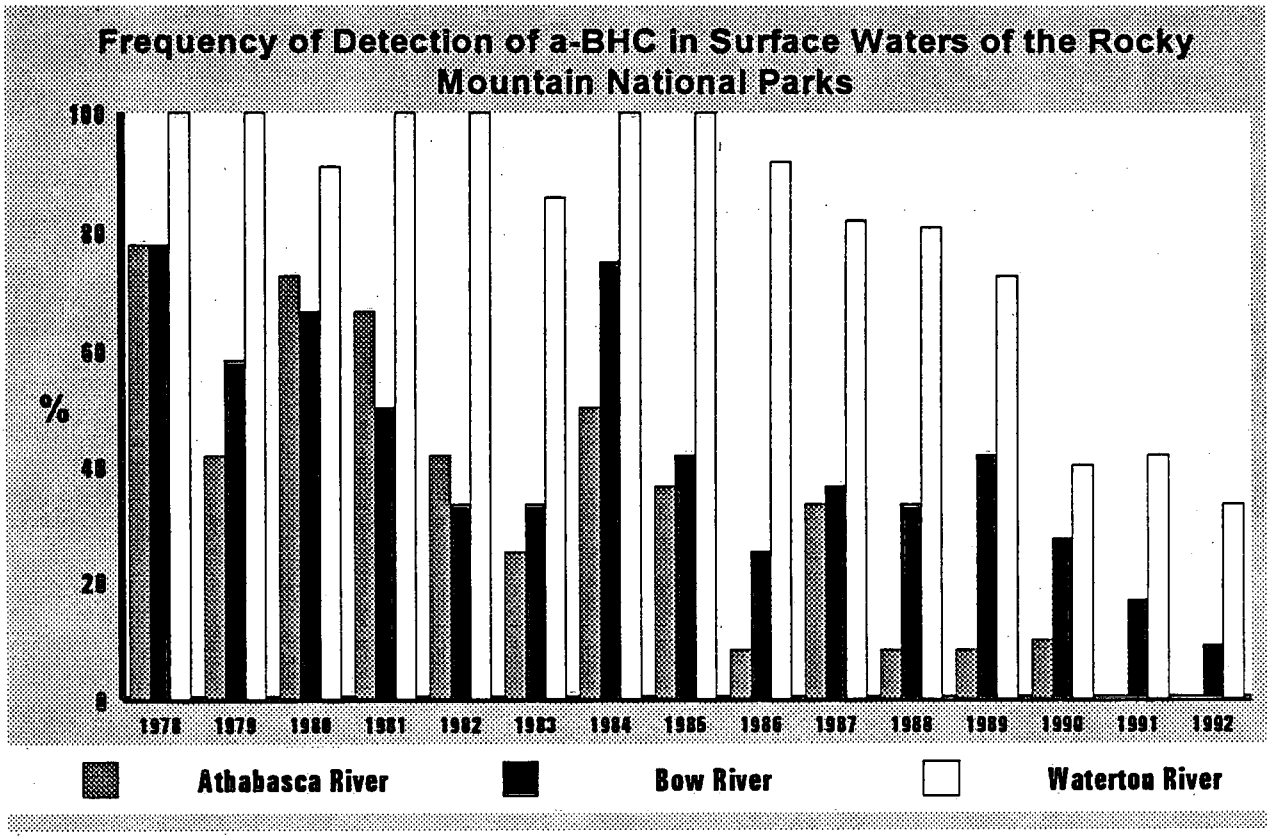
The network in the Rocky Mountain Parks costs $88 000 annually with no cost recovery from Parks Canada as at the time funds were available from within IWD. IWD feel this network is important and is being continued, with plans to pursue a cost recovery agreement.

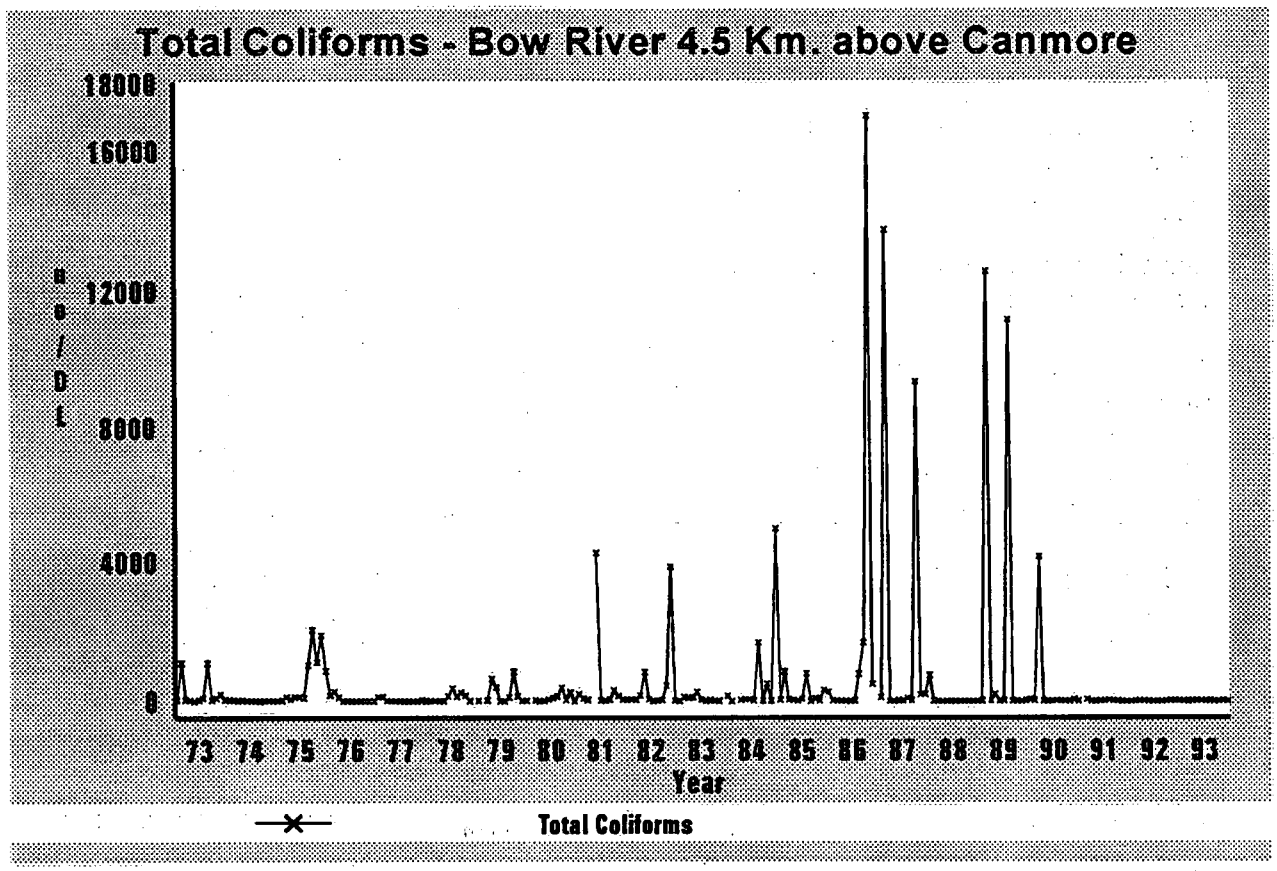
4.1.3 Waste Management in the Mountain National Parks

The rapid growth of tourism in the Rocky Mountain National Parks has led to waste management problems that threaten the public's strong expectation of a pristine setting. During the early 1980's, local residents and tourists made numerous complaints about the quality of the Bow River below the town of Banff. Authorities acknowledged that the operating capacity of the Banff sewage treatment plant had been exceeded and, at times, the plant had even malfunctioned. The undesirable aesthetic and environmental conditions resulting from this situation would have a significant long-term negative impact on the revenue generated by tourism in these areas.

Responding to these concerns and under advice from Conservation and Protection Service (C&P), Parks Canada authorized in 1986 the establishment of a $12 million state-of-the-art sewage treatment plant to serve the Banff townsite. The facility, designed under the supervision of the Wastewater Technology Centre of Environment Canada, has corrected the chronic pollution problems caused by the inadequacy of the previous treatment system. Ongoing monitoring of the receiving waters downstream from Banff townsite indicates that the new treatment system effectively removes bacterial and nutrient contaminants.

C&P's technical advice to Jasper, Waterton and Elk Island National Parks has also led to several


Frequency of Detection of a-BHC in Surface Waters of the Rocky Mountain National Parks
100
80
60
40
20
0
%
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992
Athabasca River
Bow River
Waterton River


Total Coliforms - Bow River 4.5 Km. above Canmore
18000
16000
12000
8000
4000
0
c/dL
73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93
Year
Total Coliforms

innovative and cost-effective sewage treatment solutions for park facilities and small lease holders such as lodges, restaurants and hotels. Following Banff's success, upgrading, improvements or replacements of sewage treatment systems have been instituted in consultation with C&P, at more than twenty facilities in the Mountain National Parks.

C&P advocacy and expert technical advice have played a major role in preserving the pristine state of the Rocky Mountain National Parks. Not only has a multi-million dollar tourist industry been protected but unnecessary stress on the aquatic ecosystems of these special spaces has been eliminated.

4.1.4 Prince Albert National Park

Spruce River Diversion Project

On December 7, 1960, the Governments of Canada and of Saskatchewan agreed to construct and operate a dam on the outlet of Anglin Lake in central Saskatchewan and a pumping plant to divert water from Anglin Lake to Emma and Christopher Lakes. The diversion maintains these two highly used recreational lakes at desirable levels. Since Anglin Lake is partially located within Prince Albert National Park, an agreement between the two levels of government was needed. IWD stations are used to monitor the terms of the Agreement and to bring breaches of the Agreement to the attention of the appropriate agency and to annually report on the operations of the project.

Water Quality Monitoring Program

In 1988, Parks Canada signed an Memorandum of Understanding (MOU) with IWD to collect water level data on the Waskesiu, Kingsmere and Crean Lakes and flow data on the Kingsmere River to assist the implementation of Prince Albert National Park's effective resource management plan. Under the Agreement, IWD provides the equipment and expertise to install and operate the stations and trains Parks Canada personnel on data collection. Parks Canada contributes $2000 annually to offset IWD costs to process and publish the data. Through this cost shared arrangement, IWD supplemented the national data base while providing Parks Canada with information needed for its management objectives.

4.1.5 Wood Buffalo National Park

Pine Point Dewatering

In 1983, Parks Canada became concerned with the effects of major groundwater pumping at Cominco's Pine Point lead-zinc mine on surface water levels in a wide area around the mine. Declining water levels in Wood Buffalo National Park and increased mortality for chicks of the endangered whooping crane were of particular concern.Lower pond levels allowed greater access of predators to nesting sites and reduced chick survival rates.

Monitoring of pond water levels from 1983 to 1988 by IWD, Parks Canada and the National Hydrology Institute (NHRI) showed that area drought conditions, not mine dewatering, were responsible for the lower pond water levels. Extensive underground channels in limestone rock of the area extend the effects of pumping far from the mine, however pond water levels were found to be controlled by local soil and rock characteristics.

Mine dewatering stopped in 1987, and the mine was shut down in 1988, however Parks Canada and IWD continue to monitor water levels because of the spinoff benefits from the study. Parks Canada and the GNWT Fire Centre use the information to manage Wood Buffalo National Park (WBNP) and Fort Smith area forest fires, and predict success rates for whooping crane nesting each year. This knowledge may guide future decisions on removal of eggs for incubation by other cranes.

Baseline Monitoring

The Peace and Athabasca River systems are major physiographic features of Wood Buffalo National Park. Resource development on these rivers upstream of park boundaries is occurring

at rapid pace. Pulp and paper operations, in particular, will affect the aquatic ecosystem of Wood Buffalo National Park, especially the ecologically sensitive Peace-Athabasca Delta.

Under the authority of the National Parks Act, Parks Canada has the mandate to protect and preserve the pristine characteristics of waters flowing into and through Wood Buffalo National Park. IWD has long been recognized by Parks for its solid in-house analytical capabilities and recognized expertise in conducting water quality assessments and interpretation. In 1989, the Parks Canada and IWD jointly designed and initiated a monitoring program to assess and evaluate long-term changes in water quality on the Peace and Athabasca Rivers within Wood Buffalo National Park.

This baseline monitoring program will allow the reporting of significant deterioration of water quality in Wood Buffalo National Park to regulatory agencies within provincial and federal governments. The feedback will be very useful in evaluating the effectiveness of pollution control measures dictated by regulations. Regulatory agencies have the authority to tighten the existing rules and impose further limits on the release of contaminants to streams as a result of new information provided by ambient water quality monitoring. The cost for incremental improvements in industrial effluent quality can range in the tens of millions of dollars. However, the long-term societal benefits related to protection of aquatic ecosystems in Wood Buffalo National Park and the Peace-Athabasca Delta far outweigh the cost of any future water treatment upgrades. At only $20 000 a year, shared equally by the IWD and Parks Canada, this monitoring project is a value-added service to the Canadian ecosystem and to future generations of Canadians.

4.1.6 Nahanni National Park Reserve

In 1988, IWD and Parks Canada agreed to a $193 400 study to define baseline water quality conditions in Nahanni National Park Reserve (NNPR). The study responded to concerns that mining development in the South Nahanni River watershed outside the park, and deposition of global atmospheric contaminants, could degrade park water quality. The ability of Parks Canada to protect the park is limited by the fact that NNPR does not encompass the entire watershed.

During 1988/89 and 1989/90, water quality and sediment samples were collected at 13 sites in the Nahanni River watershed by IWD, Parks Canada, and Indian and Northern Affairs Canada (INAC) staff. Samples were analyzed for about 20 parameters, including heavy metals and other contaminants. The final 1992 study report, *"Protecting the Waters of Nahanni National Park Reserve"*, concluded that park water quality was in near-pristine condition (uncontaminated by human activities), but ongoing efforts were necessary to characterize baseline conditions and monitor for environmental change. An initial set of park water quality guidelines was developed to control impacts of area development on the park and to satisfy Parks Canada's policy of "no detectable change in water quality".

In August 1992, IWD and Parks Canada agreed to an ongoing $30 000 per year program to monitor water quality and contaminants in park river sediments and biota (fish). Results from 1992/93 monitoring revealed the need to update objectives for high flow conditions not observed during the initial 1988-90 study period. A presentation to the NWT Water Board in September 1992 gained board approval for full

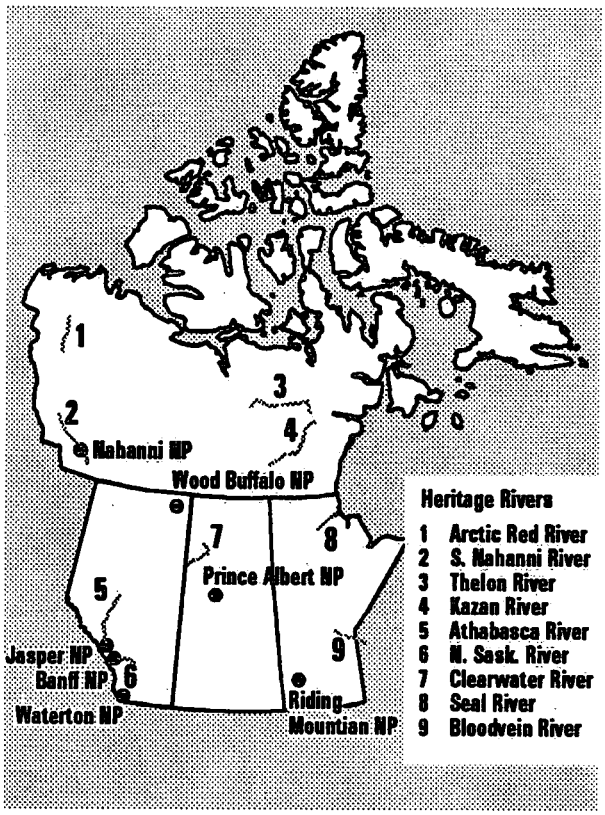
Virginia Falls, Nahanni National Park

Parks Canada participation in technical reviews of all future park area water use projects. The Nahanni monitoring program is also being considered for inclusion in Green Plan ecological monitoring networks, to support integrated ecosystem approaches to environmental management.

4.2 Building Upon Our Historical Heritage

4.2.1 Canadian Heritage Rivers

Canadian rivers have played a major role in the exploration and development of the country and hence provide a very valuable and irreplaceable part of our natural and cultural heritage. To give national recognition to the important rivers of Canada in January 1984, the Canadian Heritage Rivers System was established under a joint federal, provincial, territorial agreement. The objectives of Heritage Rivers are, in addition to national recognition, to ensure long-term management that will conserve the rivers' natural, historical and recreational values for the benefit and enjoyment of Canadians now and in the future.



National Parks and Heritage Rivers in the Western and Northern Region

IWD, in support of Heritage Rivers, has worked with the Parks Canada or the responsible provincial or territorial government to provide the environmental data and information required for the designation and future management of heritage rivers.

During the nomination stage leading up to the designation, IWD provided historical water quality and quantity data and specialized information and advice required to carry out research and analysis to prepare the management plan.

Upon designation, to ensure conservation of heritage resources and that the recreational potential is realized, IWD, in partnership with the responsible agency, maintains water quality and/or quantity monitoring programs, as required for the particular system. These include:

i Province of Manitoba: On the Seal and Bloodvein Rivers, water quantity monitoring was started in 1955 and 1976, respectively, under the Canada-Manitoba Water Quantity Agreement. Water quality monitoring was started in 1991, under the Canada-Manitoba Water Quality Monitoring Agreement.

ii Province of Saskatchewan: Two water quantity stations have been operated on the Clearwater River System, since 1973 and 1977, under the Canada-Saskatchewan Water Quantity Agreement.

iii Province of Alberta: On the North Saskatchewan River within Banff National Park and on the Athabasca River System within Jasper National Park, cost-shared water quantity monitoring has been carried out since 1970 and water quality monitoring since 1972.

iv Northwest Territories: Water quantity and quality monitoring has been carried out on the current NWT Heritage rivers (the Arctic Red, Kazan, South Nahanni, and Thelon) since the mid-1960s. This work is carried out under the Canada-NWT Water Quantity MOU and Arctic Environmental Strategy initiatives. A comprehensive environmental monitoring program was undertaken on the South Nahanni River in 1988 to develop water quality objectives designed to ensure preservation of pristine park water quality conditions. IWD and Parks Canada are also cooperating in classifying flow conditions for major rapids in the park relative to river flows. In future, current flow information will be used to predict flow conditions at rapids for use by canoeists.

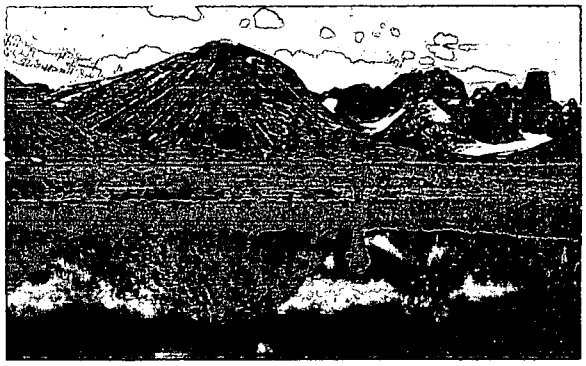
On-going water quantity monitoring provides valuable information, to managers and users of the river system of existing water flow and level conditions. This information is especially important for effective logistical planning and safe navigation in remote wilderness areas. IWD regularly provides information on historic and current river flows, breakup conditions, suitability of water for drinking and logistics to parties planning travel on Canada's heritage and other rivers. Parties are provided up-to-date information on river water levels and flow conditions either from observers and/or through telephone or satellite transmission equipment from remote gauging sites. These canoeists come from around the world to Western and Northern region's rivers because of their well-recognized "wild river or historic fur trade route" reputation. For example, in 1988 and 1989, naturalist Robert Perkins used IWD information, advice and field facilities to produce a film and book on the Back River.

In addition, since in many cases this data represents natural flow conditions, it is valued for use in the assessment and design of environmental and engineering projects in similar hydrological regions, as well as providing a baseline against which to assess environmental changes such as climate change and global warming.

Water quality data collected on Heritage Rivers is used initially to establish a baseline database. Then, through routine monitoring, changes in quality can be identified and appropriate corrective action taken.

5. CANADA'S UNIQUE STEWARDSHIP: THE ARCTIC

The Northwest Territories (NWT) covers 34% of the land mass and contains 20% of the freshwater found in Canada. The NWT contains an abundance of wildlife, vast areas of undisturbed land and, generally, pristine waters. Two thirds of the people are of aboriginal descent. To northerners, water is the life-blood of the land. Fish and wildlife species harvested by northerners are directly of indirectly dependent upon a healthy aquatic ecosystem. The changing quality and quantity of the water in the north is influenced by events outside the NWT. The gradual deposition of pollutants transported through the atmosphere, Arctic haze, climate change and bioaccumulation of chemical contaminants deposited far upstream are evidence of other jurisdictions' impacts on the north.



Pristine Conditions in the North

5.1 Data Collection

The federal government began expansion of rudimentary northern environmental data networks in the 1960s to provide information for northern development. New mines, expanding communities, construction of highways like the Mackenzie, Dempster and Liard, hydro-power development and oil and gas exploration provided impetus for growth of the NWT water quantity network. A small water quality program was also initiated in 1960 on the Slave and a few other northern rivers.

The Canada Water Act (CWA), Northern Inland Waters Act (NIWA) and other federal environmental legislation responded to public demands for a legislative and regulatory regime to properly manage and use Canada's water resources. In 1975, IWD and Indian and Northern Affairs Canada (INAC) agreed to expand the NWT water quantity network, under a federal-provincial-territorial cost sharing program. The primary objective of the program was to obtain data for a national inventory of Canada's waters, as well as water resource planning, engineering design, water management and environmental monitoring and assessment.

5.2 The Arctic Environmental Strategy: Preserving the Integrity of the North

Public demands for a more coherent, systematic balance to social concerns, environmental protection and economic development goals led to the development of Canada's Green Plan in 1990. The Green Plan committed the federal government to a broad ecosystem approach for achieving environmentally-sustainable economic development. While these principles had been part of federal river basin studies and other activities for some time, the Green Plan adopted them for integrated use in and across all government programs and activities.

The Arctic Environmental Strategy was announced in June 1991 by INAC, as the northern component of the Green Plan. The Strategy is an action plan to protect the environmental integrity of Canada's Arctic regions and work with other northern countries to develop a cooperative ethic for the Arctic. Its goal is "to preserve and enhance the integrity, health, biodiversity and productivity of our Arctic ecosystems for the benefit of present and future generations".

The Arctic Environmental Strategy addresses concerns for health and well-being of Arctic ecosystems and continuing sustainable use of resources (particularly by indigenous people). A collective approach, with responsibility shared by aboriginal peoples, other northerners, Canadians and other northern countries, is considered essential to develop better Canadian decision-making mechanisms. The objectives of the Strategy are to reduce contaminants in country foods, clean up waste, improve the northern water management regime and integrate environment and economy decisions for the benefit of northerners.

Environmental protection was recognized to be highly dependent on social behaviour, economic activity and political structures. Improvement of legislation, settlement of land claims and continuing devolution of provincial-type programs, were therefore also seen as keys to success of the Arctic Environmental Strategy.

5.2.1 Action on Contaminants

The Arctic Environmental Strategy Action on Contaminants initiative addresses increasing public awareness and concern with the impacts of contaminants on aquatic life and human health. Recent research on long range airborne transport of pollutants, contaminants in country foods and observations of environmental deterioration by long term northerners (often confirmed by results of scientific studies), demonstrates that the NWT is not immune from global activity, despite being far from source areas of pollution.

Mackenzie River Fish Tainting/Abnormalities

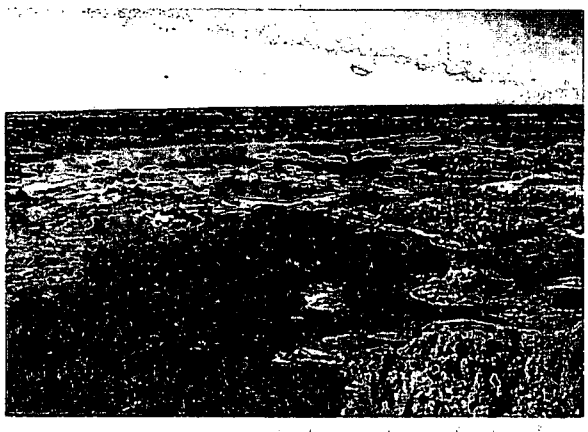
In 1985/86, soon after expansion of Esso Resources' Norman Wells oilfield to 25 000 barrels per day (annual value approximately $180 million), residents of nearby communities began complaining of abnormalities in the appearance and taste of Mackenzie River fish. A number of studies were undertaken between 1986 and 1988 by Fisheries and Oceans Canada (FOC), National Water Research Institute (NWRI) and IWD, to address concerns that the problems represented a human health hazard and investigate whether oilfield expansion (i.e. dredging for artificial islands) and operations were responsible.

Studies showed that tainting by oil, abnormalities in appearance (emaciated appearance, discoloured livers, etc.) and elevated contaminant levels in fish and sediments throughout the study area can not be attributed to the oilfield alone. Rather, the problems are due to both natural historic oil seepages at Norman Wells and Fort McMurray and anthropogenic (man-made) sources of contaminants and normal over-winter fish malnutrition.

FOC and NWRI scientists concluded that the problems are currently largely aesthetic and area fish and water are still safe to consume. Ongoing monitoring of contaminants country foods was recommended however, due to high rates of consumption by local residents and the evolving nature of oil and gas operations and new developments.

Slave River Aquatic Contaminant Studies

Proposals for major new pulp mill developments in northern Alberta raised public and scientific community concern over potential effects of hydrocarbon (from oil sand plants) and organochlorine contaminants in the Slave River



Slave River

and NWT portion of the Mackenzie River basin. The economic benefits of the $3 to $5 billion worth of pulp mill development are considerable, however safety of drinking water supplies for downstream communities (including 3200 NWT Slave River residents) and subsistence consumption and commercial use of fish (valued at about $4 million) quickly became a focus of concerns.

C&P and other agencies responded by assisting INAC with an integrated program to determine levels of key environmental contaminants. IWD-NWT, INAC and the Government of the NWT (GNWT) jointly designed a monitoring program for the Slave River in 1988. IWD assisted INAC with Slave River sediment sampling and analyses for contaminants from 1989 to 1992, contributing over $100 000 of staff time, equipment and financial support to the $1 million INAC-led program.

Study results to 1992/93 show that water, sediments and fish in the Slave River have low levels of the contaminants associated with upstream developments. Elevated levels of mercury were found in NWT fish however, as observed throughout northern Alberta and Saskatchewan. Research on the Churchill River diversions in the 1970s demonstrated that this occurs naturally, due to the geology of the Canadian Shield. When lake levels are artificially raised for use as reservoirs, mercury levels increase due to release or "methylation" of mercury from newly flooded lake shore sediments to create an additional environmental hazard. The mercury bio-accumulates in sediments and the food chain, posing a health hazard.

Health and Welfare Canada (HWC) concluded that Slave River problems are not severe and area water and fish are still generally safe to consume. HWC recommended that consumption rates of some types of fish should be restricted however and ongoing monitoring be carried out to determine whether levels of contaminants are changing. These efforts are necessary so that economic activity in the watershed is managed to ensure continued safety of water and fish for human consumption.

The study provided documentation of current ecosystem conditions, so that any future environmental changes due to discharges from upstream development such as increasing contaminant levels could be detected and monitored. NWRI and IWD assistance also resulted in the transfer of new technology for sampling of contaminants in river sediments, using large volume extraction and centrifuge sampling systems, to INAC for use in ongoing cooperative NWT contaminants studies.

Long Range Transport of Atmospheric Pollutants

The detection of environmental contaminants in marine mammals, such as PCBs in Baffin Island seals and fish of the Canadian Arctic in the mid-1980s raised public concerns over the safety of country foods consumed by local inhabitants. While contaminant levels in the NWT are generally only one tenth those recorded in the Great Lakes, high subsistent consumption rates by northerners are of concern. The potential impacts of the contaminants are considerable, due to the cultural, economic and nutritional value of country foods.

To reassure local residents on the safety of fish and water for human consumption, IWD, Indian & Inuit Affairs of HWC and GNWT Health officials participated in several scientific and community meetings on the issue. Study requirements and their human health implications were discussed, follow up work was identified and commitments made to conduct research and keep residents informed.

Evidence from northern Canada on the presence and impacts of contaminants far from their North American, European and Asian sources is important. The data helps to define the extent of the problem and convince other countries to cooperate in international efforts to reduce emissions. In 1992, HWC concluded that the health risk from consumption of contaminants in

marine mammals varies with individuals and communities but is outweighed by the nutritional value of a traditional diet based on country foods.

IWD studied the effects of contaminant deposition in the NWT from airborne sources. IWD and GNWT Renewable Resources assembled NWT water quality data, assessed the sensitivity of the northern aquatic environment to acid deposition and produced maps of the ability of terrain to neutralize acid deposition in 1987/88. Results showed that NWT waters and soils have a low buffering, acid neutralizing, capacity. The Canadian Shield, particularly east of the Mackenzie River between Great Bear and Great Slave lakes and the District of Keewatin, is particularly sensitive to acidification.

NWRI has studied deposition of organochlorine pesticides and polychlorinated biphenyls in mainland and High Arctic snow since 1986, to determine the magnitude and type of contaminant inputs. Research shows that pollutants accumulate in stable polar air masses, falling in snow throughout the winter. Deposition rates for organochlorine pesticides are higher and PCB levels approximately equal to those recorded in the Great Lakes.

With evolution of NWRI work from a research to an environmental monitoring activity, IWD-NWT has taken over snow sampling. Approximately $20 000 per year was saved by collecting snow samples during scheduled trips to IWD water quantity stations, instead of special project air charters. Ongoing monitoring of contaminants in both snow and country foods is required, to ensure preservation of the sensitive balance between acid deposition and buffering capacity, essential to the continued health and safety of northerners.

Uncertainty about the impacts of pollutants on northern aquatic life lead to 1991 Arctic Environmental Strategy commitment to systematically assess health risks to northerners, determine where contaminants are coming from and engage in international negotiations to control and restrict emissions. Agency mandates and expertise have led to concentration of INAC, GNWT Health and Health & Welfare Canada efforts on the assessment of health risks, while IWD has investigated process and source aspects.

5.2.2 Action on Water

The Action on Water initiative seeks to improve the northern water management regime through establishment of a comprehensive NWT water monitoring network, documentation of water quality characteristics, expansion of the water quantity network and measurement of changes in northern waters.

The Legislative and Administrative Framework

By 1985/86, northerners had become concerned that project-by-project resource management and regulation under the Northern Inland Waters Act (NIWA) would not protect the environment, nor the health and safety of northerners. The need to improve environmental management monitoring approaches and networks, to address this concern, was recognized through legislative change, the settlement of northern land claims and approval of the Arctic Environmental Strategy Action on Water initiative.

Since the June 1991 Arctic Environmental Strategy announcement, INAC has completed revision of NIWA into the NWT and Yukon waters acts and updated regulations for the acts. The negotiation of comprehensive land claims settlements has proceeded, with the Inuvialuit (1984), Gwitch'in (1992) and Nunavut (1993) agreements approved. IWD staff advised on environmental information commitments made in the agreements by the federal government and will assist in the operation of future monitoring networks for management of settlement area resources.

Arctic Environmental Strategy Water Quantity Network

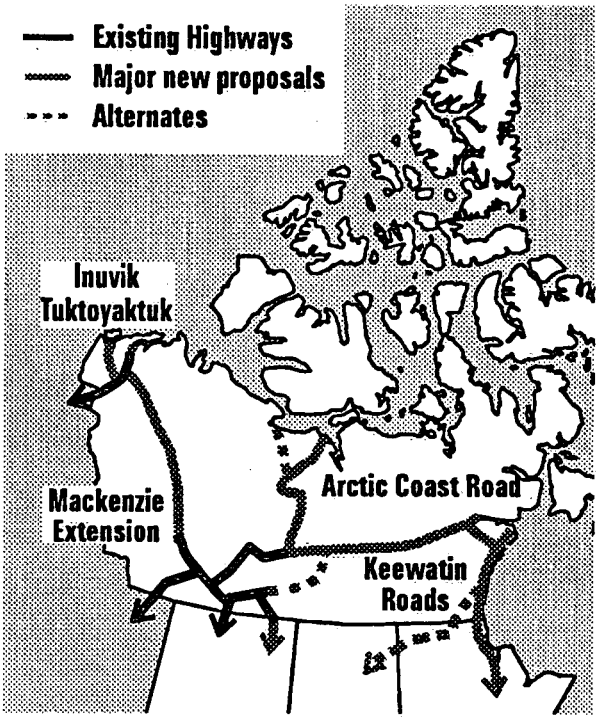
Water quantity stations have been operated in the NWT since the 1930s. The first major

commitment to an NWT water quantity network, in support of northern development, involved IWD permanently staffing its Fort Smith office in 1960. Since then, the number of stations has expanded from about 30 sites in 1960 to 143 in 1985, before being reduced to 116 sites in 1993.

Water quantity network data has strategic value to the economy of the north, in supporting industrial development and expansion of the transportation infrastructure, as well as all water-related environmental monitoring programs. Forward-looking economic development and transportation strategies, completed in 1990 by the GNWT, have identified transportation infrastructure improvements as key to long term economic growth and social stability in the NWT.

The GNWT Minister of Economic Development and Tourism has noted that the "lack of adequate roads, airports, docks and harbours handicaps our (the NWT's) economic growth. A better transportation system will create opportunities for mining, tourism, fishing, trade and travel between communities". Studies of the NWT's mining potential also identify the lack of an extensive highway network and a regional power grid as the main factor limiting economic growth and stability. This view mirrors the history of Canada's development such as the transcontinental railroads, the St. Lawrence Seaway, Trans-Canada Highway and TransCanada Airways/Air Canada.

The real value of water data becomes apparent once decisions have been made to build new roads, hydro-power stations, or water-related development projects. GNWT's Transportation Strategy proposed construction of 5 606 kilometres (km) of new roads over the 1993/94 to 2010/11 period, at a total cost of $3.7 billion. Road proposals include: Yellowknife-Arctic Coast (870 km); Manitoba-Keewatin (2572 km); Great Slave Lake-Keewatin (1200 km); and Mackenzie Highway extension to Inuvik and Tuktoyaktuk (964 km). Once completed, annual highway maintenance costs are estimated at $75 million (1990$).



Expansion of N.W.T. Road Network

Experience shows that approximately 10% of total highway construction costs are for stream crossings. If accurate streamflow data is available, approximately 10-20% of the costs for stream crossing can be saved. Historic IWD water quantity data has already been used to reduce costs and environmental impacts, through better design for fish passage, of past NWT highway construction. Historic data may have saved the NWT about $2.5 to $5 million on past highway stream crossing construction costs in the Mackenzie Valley.

The economic benefit of having adequate historic, current and future streamflow data to

Stream Crossing, Arctic Roads

Highway Construction Costs and Estimated Savings from Having Water Data in Northwest Territories

Highway	Date Completed	Length (km)	Total Cost (millions)	Savings (millions $)
A. Current NWT Highways				
Mackenzie-Wrigley	1983	348	$81	$1-$2
Dempster/NWT	1985	670	$128	$1-$2
Liard	1983	254	$57	$0.5-$1
Total		1 272	$266	$2.5-$5
B. Proposed NWT Highways (1990$'s)				
Yellowknife-Arctic Coast		870	$600	$6-$12
Mainitoba-Keewatin[1]		1 372	$1 120	$11-$22
Great Slave-Keewatin		1 200	$580	$6-$12
Mackenzie-Inuvik/Tuktoyaktuk		964	$580	$6-$12
Total		4 406	$2 880	$29-$58

Notes: [1] Includes 456 km in Manitoba, costing $410 million.

support accurate highway design and construction is estimated at up to $29 to $58 million over the next fifteen years. The mining industry has long stated that a number of mines, particularly in the area north of Great Slave Lake, only require road access to become economically viable. Future expansion and modernization of NWT roads and other infrastructure, community water supply intakes, docks, hydro-power developments and a variety of other facilities, therefore ensures an ongoing need for NWT water quantity data. The data also helps to protect the ecosystem and ensure development is sustainable, such as in the design of stream crossings to allow fish passage to upstream spawning areas.

In the absence of such information, poor design decisions often result in a high cost maintenance or replacement efforts. For example, a Liard Highway culvert stream crossing washed out in 1988, after only twelve years, will cost $800 000 to replace with culverts or $2.5 million for a bridge, as originally recommended by Fisheries & Oceans Canada. As well as the cost of a new crossing, area residents, businesses and tourists suffered from the inconvenience and additional expense of two months of road closure during the heart of the summer holiday season.

Following approval of the Arctic Environmental Strategy, IWD and INAC cooperatively designed a water quantity network covering proposed NWT highways, new parks and heritage rivers, flood warning services to

communities and other future data needs. IWD's Arctic Environmental Strategy funding of $255 000 for 1991/92 was used for a comprehensive program to locate suitable gauging sites in 34 target watersheds, install four new stations and reactivate six discontinued stations.

In 1992/93, $149 900 of IWD funds and $160 000 of INAC funds were used to install two more water quantity stations, operate the four new stations installed in 1991 and complete final assessments on thirty-two of the original thirty-four basins. Installation of four additional water quantity stations is planned for 1993/94. In addition, the entire NWT water quantity network, largely funded through IWD and INAC A-base budgets, continues to be adjusted to meet new information needs and departmental budgets.

Government and industry plans suggest that the north will continue to be a developing frontier area of Canada for the foreseeable future. Ongoing monitoring of the environment, with IWD programs forming a key role, is essential to ensure northern development is sustainable.

Arctic Environmental Strategy Water Quality Network

The presence of contaminants in the aquatic environment has raised questions about the current and future safety of NWT waters for community water supplies, the protection of aquatic life and subsistence use of country foods by northerners. IWD has had a small territorial water quality monitoring program since 1960, with the first IWD NWT water quality staff hired in 1982. Work on a IWD, INAC and GNWT water quality agreement for the NWT began in 1987. A draft Canada-NWT Water Quality Agreement and a strategy for NWT water quality monitoring were completed in September 1989. Further progress was delayed until late 1991, when the Arctic Environmental Strategy announcement provided the funding for the water quality monitoring.

In 1991/92 IWD received $25 000 to resume agreement negotiations. In 1992/93, IWD used $119 000 through the Strategy to staff two water quality positions, complete negotiations on the water quality agreement with INAC and GNWT and expand IWD's water quality program. The agreement provides a formal interagency mechanism for long term sharing of the work and cost of monitoring the quality of NWT waters. Design of the initial federal-territorial network was completed in March 1993.

Full operation of the NWT network will begin in 1993/94, following ministerial approvals. The initial network will consist of thirty-five water quality stations operated by IWD, eighteen federal, four federal-territorial and thirteen territorial sites, for more systematic assessments of the state of the NWT's aquatic environment by IWD, INAC, other agencies and public interest groups. The new water quality information will document the impacts of local and regional development and global change, help design new municipal water use and waste treatment facilities for 55 000 residents in 61 NWT communities, identify requirements for new regulatory limits on water use and effluent discharges and inform residents on the state of the environment.

5.3 Integrated Environmental Monitoring

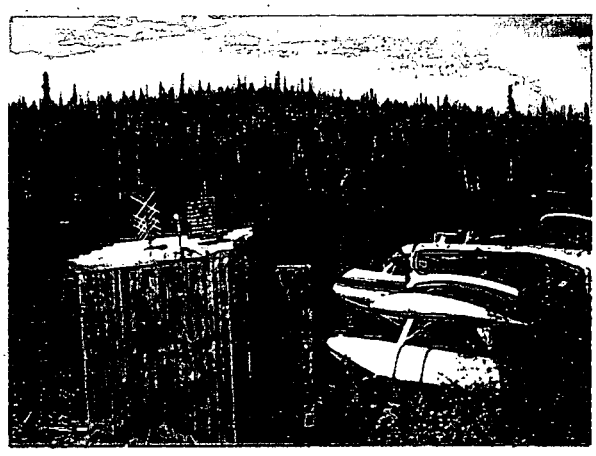
In response to public and scientific concerns about cumulative global impacts, the federal Green Plan adopted an environmentally sustainable approach to development. IWD views integrated environmental monitoring as a key means for detecting and assessing environmental changes. Integrated monitoring includes the key components of the environment, including water, land, air, vegetation and animals and what changes are occurring, why and what are the important impacts.

Besides providing better information on how the environment is changing and what the effects are, integrated monitoring can be far more cost effective than traditional single-program

monitoring in remote areas. Integration can range from simple coordination of field activities at locations common to several programs or agencies, to integration of results from several programs in interpretative resource-specific studies and comprehensive environmental monitoring and interpretative assessments.

In the NWT, IWD has integrated internal activities with work for other agencies to extend monitoring networks to high cost remote locations. NWT water quantity and quality work has been carried out by water quantity survey staff since the 1960s, rather than by separate water quantity and quality groups. IWD also cooperates with INAC, Atmospheric Environment Service (AES) and other agencies to collect climate, snow cover, water quality and other environmental information at remote locations across the NWT. As a result of partnerships, IWD currently operates six climate stations for the AES, nineteen water quality stations for INAC and more than twenty water quantity sites for other government agencies and private sector clients and the public they serve.

Since 1987/88, IWD efforts to recover the cost of these activities have resulted in revenues increasing to 4% or $110 000 of the total 1993/94 IWD-NWT budget of $2.5 million. INAC also provides $700 000 per year for Canada-NWT agreements on water quantity and quality networks. Since federal fiscal restraint began in 1984, partnerships have become the main avenue for growth in IWD's environmental monitoring networks. This planning and operational level integration enables the collection of additional information for a variety of applications such as weather forecasts, forest fire management, road construction and monitoring of environmental conditions in remote areas.



Isolated Integrated Monitoring Sites

In the past, the traditional data users such as engineers, resource managers, hydro-power companies and community planners, acquired and integrated raw data for their specific needs. These users have long requested more basic data processing and interpretation work from the data-producing agency. While no mechanism is currently in place for recovery of costs for such basic network-wide analyses, IWD-NWT produced statistical summaries of data for all NWT water quantity stations in 1986 and 1988 for use by all clients, as well as internal IWD use.

In 1991, these and other network analyses revealed that 25% of the NWT water quantity network could be closed to cut costs or to relocate gauges to areas lacking information without jeopardizing normal uses of the data. Annual savings of more than $100 000, or 4% of IWD's gross budget, were generated. Unfortunately, air charter costs to remote northern sites are high and network reductions decrease station densities, therefore increasing unit costs unless entire regions of stations are shut down. For data deficient areas like the NWT, IWD's water quantity network reductions can best be used to free resources for integrated monitoring efforts at stations in the reduced network, or fewer new sites.

Innovative IWD-NWT river basin water resources overview reports have also been produced for a wide public audience. The basin reports, for the Coppermine River (1986), the Yellowknife River (1988) and Nahanni (in progress) summarize available IWD water quantity, quality and sediment data; information on basin geology, vegetation, climate, physical characteristics; and water uses by communities, mines, hydro-power companies and recreational users. Information provided in the reports is

useful to wildlife, fisheries, recreation, economic development and tourism agencies.

5.4 Northern Oil and Gas Action Program (NOGAP)

During the 1970s, the public became concerned with potential socio-economic and environmental impacts of widespread agriculture, oil and gas, pulp and paper and other industrial development in the Mackenzie River basin. Concerns were particularly spurred by problems caused by the 1968-71 filling of B.C. Hydro's Williston Reservoir on the Peace-Athabasca Delta and potential problems with Mackenzie Delta and Beaufort Sea oil and gas exploration activity.

The Berger Commission held hearings throughout the Mackenzie Valley in 1975 and 1976, to hear concerns about the social, economic and environmental impacts of development on the area. The Commission recommended a 10-year moratorium on major northern development to enable land claims to be settled and provide northerners with time to prepare for development. The governments of British Columbia, Alberta, Saskatchewan, Yukon, the NWT and Canada responded by setting up the Mackenzie River Basin Committee (MRBC) to conduct a comprehensive socio-economic and environmental study on the Mackenzie River basin.

The major recommendations of the MRBC's 1978 to 1981 study identified a need for: inter-jurisdictional basin water management agreements; development of a basin-wide environmental monitoring network; further studies on the Mackenzie Delta and the Liard River spring breakup and sediment transport processes; and a Mackenzie River flow model to anticipate and prevent future environmental impacts.

From 1981 to 1984, a small diameter (30 cm) pipeline was constructed by Interprovincial Pipelines Ltd. to transport oil from Esso Resources' oilfield at Norman Wells to existing pipelines at Zama Lake, Alberta. The relatively small project, which was an approved exception to Justice Berger's development moratorium, renewed concern for the environment. A proposal for environmental and socio-economic studies to focus on the sensitive Mackenzie Delta was submitted to the MRBC in 1985. The proposed study did not proceed however, due to fiscal restraint, poor results from delta area hydrocarbon exploration and a downturn in worldwide oil and gas prices.

The sensitivity of delta ecosystems to disturbance of natural hydrologic and sediment regimes was well recognized however, despite the lull in exploration and development activity. Concern for the Mackenzie Delta, viewed as particularly sensitive due to widespread occurrence of permafrost, lead the federal and territorial governments to approve the Northern Oil and Gas Action Program (NOGAP) in 1982. NOGAP was proposed as a two-phase eight-year program of socio-economic and environmental research and planning studies, to help prepare for major hydrocarbon development north of 60^{o}.

IWD proposed extensive monitoring and studies of physical processes in the delta, which support the entire delta ecosystem. The studies were intended to add to the nearly fifteen years of IWD delta area environmental monitoring and research. Hydrologic and sediment regime studies were undertaken in the lower Mackenzie River and Delta area, to assist the evaluation of physical, biological and socio-economic impacts of area hydrocarbon development.

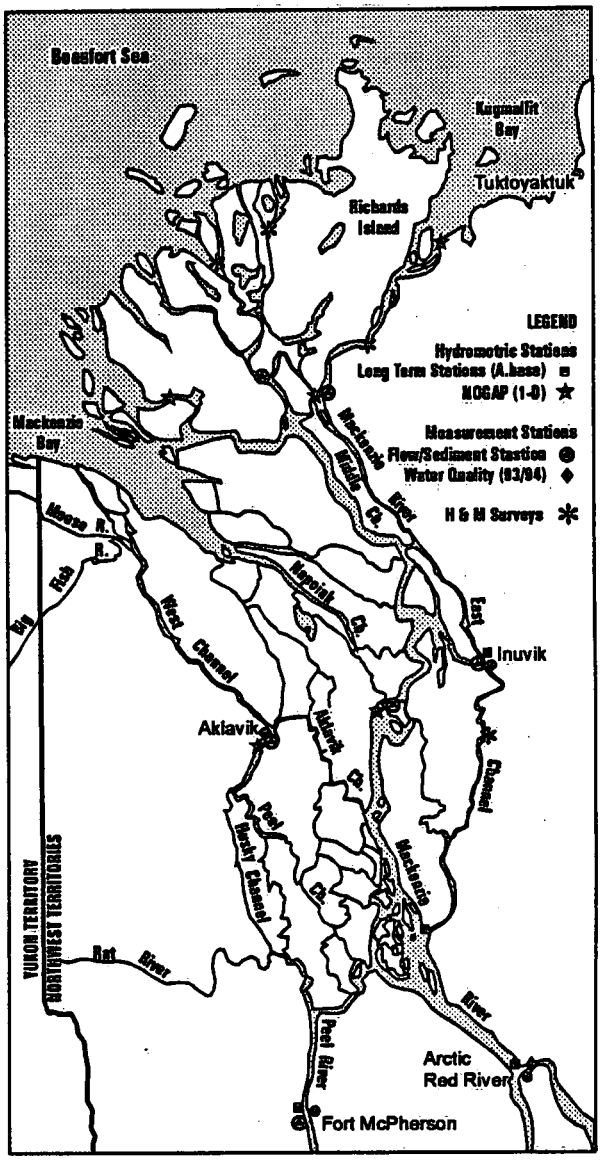
During Phase I of NOGAP (1982/83 to 1987/88), IWD expanded the delta water level network to eleven stations (1982-87), produced maps summarizing hydrologic information along the Mackenzie River and in the Delta (1986), developed a basic model of flow through the delta (1987), summarized and analyzed Mackenzie River sediment data and conducted initial sampling of hydrocarbon-related contaminants in the Mackenzie River (1987-88).

Phase II (1990/91 to 1993/94) IWD work includes $800 000 of projects to extend delta geodetic control, elevations for modelling, complete a delta flow model to evaluate changes in delta water levels and channel stability, produce the first comprehensive model of delta sediment transport, measure contaminants in delta sediments, study stability of proposed delta channel pipeline crossings and develop a delta Geographic Information System (GIS) for storage and access of information on the delta environment.

Reports of an October 1990 workshop to obtain input from cooperating agencies on study needs and a comprehensive progress report on 1991/92 sediment-related studies have been completed. Distribution of a basic interactive computer environmental monitoring information system for the delta area to interested agencies is planned soon. Other study reports, public information fact sheets, workshops and scientific papers will follow throughout 1993/94 and early 1994/95, as results of NOGAP work is submitted to senior IWD managers, other government departments, the scientific community and public.

The information will be used by IWD, INAC, GNWT and other agencies to assess proposals for development, define physical impacts on the environment and methods to mitigate their magnitude and monitor environmental change. Other agencies and project proponents will use results of IWD studies for design of development projects and other infrastructure, pipelines crossings, oil and gas collection networks, refineries, port facilities, etc. and the prediction and mitigation of impacts on vegetation, waterfowl, furbearers and fish. Results are also important for protecting tourism and the use of country foods by residents of 5 area communities.

Studies by Fisheries & Oceans Canada, the Canadian Wildlife Service, Energy Mines & Resources Canada and other agencies also depend on clear understanding of components of the physical environment being studied by IWD. IWD's hydrologic and sediment transport



Mackenzie River Delta

models are key to understanding and predicting physical changes in the delta, flows, water levels, flooding, sedimentation, erosion of channels and coastlines, etc. and possible impacts on the entire delta ecosystem, waterfowl nesting and rearing, fish stocks, furbearer habitat, vegetation, etc. If these changes and their impacts can be predicted before they occur, extensive damage to a sensitive delta ecosystem, as has occurred in the Peace-Athabasca Delta, can be avoided.

IWD NOGAP studies also satisfy basic environmental information, monitoring and

modelling needs for other potential developments and global climatic change scenarios. Study applications are diverse, including prediction of changes in flow regime due to Liard River hydro-power or major diversion projects, reductions in Mackenzie River dredging for navigation and the identification and removal of delta archaeologic sites prior to their loss through channel erosion.

Results are crucial, because changes in delta water and sediment regimes could produce major physical impacts in the delta, disrupt ocean current and water circulation patterns, reduce sea ice cover in the confined Arctic Ocean basin and cause further impacts on polar and global climate. Contaminants associated with oil and gas and other development may jeopardize consumption of area wildlife and fish by local residents, affecting subsistence and tourism economies.

6. GLOBAL ENVIRONMENTAL SECURITY

6.1 International Progress

International cooperation on water issues is exemplified by Canada and United States working together to solve common concerns along the International Boundary thereby ensuring peace, order, and fairness in international relations. In 1993, IWD contributed to Canada's foreign aid by presenting Western and Northern Region's experience in avoiding and resolving water management problems within different political jurisdictions to the 1993 Middle East peace negotiations where water quantity and quality problems need to be solved. The delegates in Geneva were presented with the evolution of the Prairie Provinces Water Board as it deals with inter-provincial streams in Alberta, Saskatchewan and Manitoba and the development of a water management agreement among British Columbia, Alberta, Saskatchewan, North West Territories, and the Yukon by the Mackenzie River Basin Committee.

6.1.1 International Organizations

International standardization is one of the key elements in a global marketplace. Among the hundreds of technical committees on the International Organization for Standardization (ISO), IWD contributes to the three related to air quality, water quality and water quantity. IWD, W&NR contributed to the Subcommittee on Notches, Weirs and Flumes during the 1980s and to the Subcommittee on Velocity Area Methods during 1992. IWD provided expertise to other countries, evaluated instrumentation and methods for possible use in Canada and influenced the international standards to the benefit of Canadian companies.

IWD has also contributed to UNESCO's International Hydrological Program and to the World Meteorological Organization's (WMO) Commission on Hydrology.

6.1.2 International Assignments

IWD has provided technical aid to several less developed countries. In the late 1980s, Bob Halliday did a short WMO assignment on flood plain management in Columbia and Robert Sauvlet undertook an assignment with the aid organization PLENTY in Lesotho. Currently, the Canadian International Development Agency (CIDA) has Diane Blachford on an environmental regulation assignment in Indonesia and Al Chomica developing a water quality monitoring program in Zambia.

6.1.3 International Partnerships

Environment Canada, represented by IWD, in cooperation with provincial and federal agencies resolves inter-jurisdictional water resource problems through ongoing dialogue with U.S. agencies along the 1650 km of boundary that W&NR shares with the United States of America.

6.2 International Joint Commission

The Boundary Waters Treaty of 1909 (Treaty) was signed by the governments of the United States and Great Britain relating to the use of boundary waters and to settle all questions between the United States and the Dominion of Canada along their common frontier. An International Joint Commission (IJC), composed of six commissioners, three from the United States and three from Canada was established to act as a single permanent body on international questions. The IJC met for the first time in 1912.

The IJC considers applications for the use, obstruction or diversion of waters that flow along and across the international boundary. The IJC also undertakes investigation of specific issues, or monitors situations, such as pollution or apportionment when requested by Governments.

6.2.1 International Boards

The work of the IJC is conducted by its international boards and task forces, the membership of which are normally selected from federal, state and provincial agencies. The board categories are divided into investigative boards, pollution surveillance boards and boards of control . The IJC has three boards which are active within the Souris-Red Rivers basin, the International Souris-Red Rivers Engineering Board, the International Souris River Board of Control and the International Red River Pollution Board. The IJC also has an Accredited Officer for the St. Mary-Milk Rivers Basin.

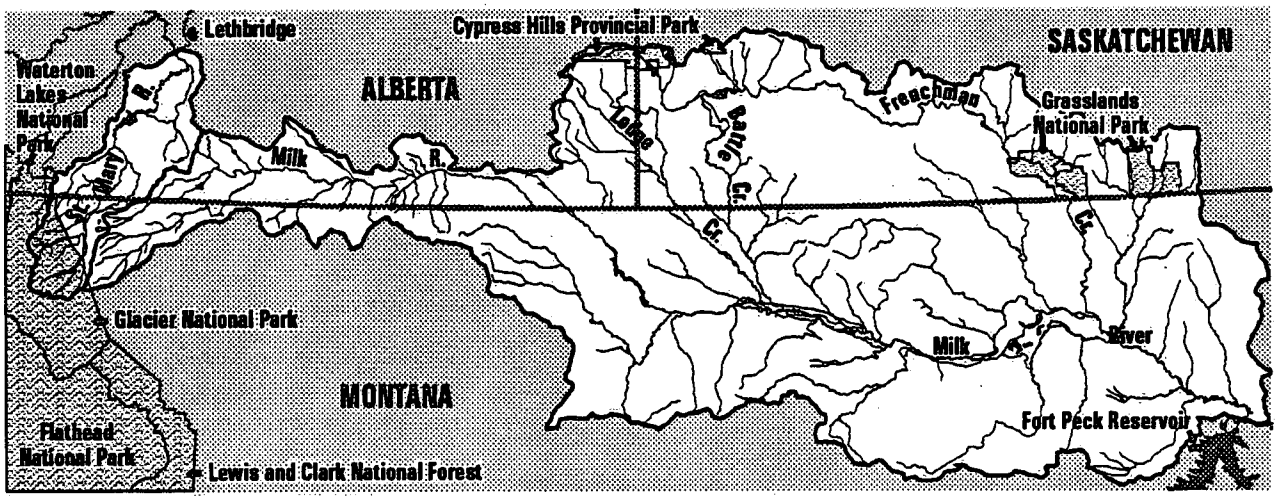
Historically, IWD plays a key role in the operation of the Souris, Red, St. Mary, and Milk Rivers boards by providing Canadian co-chairmen and an Accredited officer who give leadership to the initiatives of the IJC together with technical and logistical support.

St. Mary-Milk Rivers

In the ranching country of southern Alberta and southwestern Saskatchewan, the difference between a viable operation and a non-economic one is the ability to produce feed rather than buy it. The availability of water for irrigation is therefore fundamental.

A long simmering dispute over the waters of the Milk River was a major contributing factor to the development of the Treaty. The 1905 Winters decision which led to the definition of Indian Water Rights in the U.S. also pertained to the Milk River. The language in the Treaty was clarified by an Order of the IJC in 1921. This Order defines the apportionment of the natural flow of the St. Mary and Milk Rivers and the "eastern tributaries" which are the Frenchman River, Battle Creek and Lodge Creek. Environment Canada computes the natural flows and issues status reports every 15 days. Reports are use by water managers an users to plan their operations to maximize the beneficial use of water in both countries.

Canadian ranchers along the Southern Tributaries of the Milk River indicated a frequent lack of suitable water supplies. An ad hoc task force comprised of Canadian and U.S., Alberta and Montana officials met with Canadian and U.S. ranchers and undertook an assessment of water availability. This assessment led, in 1990, to a moratorium on water development in the Southern Tributaries in both countries.



St. Mary and Milk River Drainage Basins

- **Eastern Tributaries**

The division of the waters of the St. Mary and Milk rivers, including its tributaries, is governed by the Boundary Waters Treaty of 1909 which specifies the proportion of the natural flow to which each country is entitled. The natural flow for the Milk River eastern tributaries, which are the Frenchman River, Battle Creek and Lodge Creek, is determined on a ten-day basis to provide near real-time information for water management decisions to ensure that each country receives its share of the natural flow.

The complex and data intensive determination of natural flow every ten days requires daily stream flows and water levels at 54 locations, actual water usage in the basin, evaporation rates and precipitation amounts. This data provides the basic information needed for the natural flow computations. The information is then given to 23 individuals/agencies concerned with water management in the basin. All work is done within two days so that water managers can make timely adjustments to their operations.

The water in the basins is totally allocated to water users and in many years significant shortages occur. Water is critical to the economic well being of the residents in the basin and IWD staff frequently meet with the water users to explain the procedures used for apportioning the water and the reasons for sharing the water with the United States.

To provide the managers with the best information as quickly as possible, IWD continually seeks ways to improve the accuracy of the computations and improve the timeliness and efficiency of collecting the data.

International Souris-Red Rivers Engineering Board

Since 1948 the IJC has called upon the International Souris-Red Rivers Engineering Board, an investigative board, to conduct several studies, to gather technical information on water based issues and also to respond to references from the two federal governments. Further to the initial 1939 Reference 41R on Souris River Water apportionment, the IJC, on April 7, 1948 under Reference 58R, appointed the Souris-Red River Engineering Board to investigate a reference to the Commission on water uses and requirements in the Souris-Red Rivers Basin. Arising from these investigations, the International Souris River Board of Control and the International Red River Pollution Board were permanently established by the IJC.

The Engineering Board provides activity reports twice a year to the IJC on issues of concern within the Souris-Red Rivers basin in Canada and the United States. Areas of concern are monitored regularly to determine whether or not international action is required. In addition to formal references the Engineering Board has conducted several short term investigations on behalf of the IJC, some of which have resulted in the formation of individual study boards or bilateral arrangements between Canada and the United States.

Past studies and continuing monitoring of the Engineering Board include: Roseau River drainage project has flooding concerns in Canada; Poplar River power station and cooling reservoir in Saskatchewan has apportionment, water and air quality concerns in Montana; in North Dakota the Garrison Diversion Project raises concerns related to inter-basin biota transfer and associated economic impacts, chemistry impacts and flooding on Souris and Red Rivers in Manitoba; Burlington Dam on Souris River in North Dakota for flood control for Minot had agriculture economic, fisheries, and flooding concerns in Manitoba; the Lake Darling Dam expansion also for flood protection of Minot had economic, fisheries and flooding concerns in Manitoba; the Aux Marais-South Buffalo road dike along the international boundary between Manitoba and North Dakota has agricultural flooding and related economic concerns in North Dakota; the Big Muddy basin in Saskatchewan has apportionment concerns in Montana; Pembina River has flooding, quantity, quality and economic concerns in both Manitoba and North Dakota; Pelican Lake project in Manitoba has recreation, and Indian reserve

concerns together with water supply concerns in North Dakota; Devils Lake outlet to the Sheyenne River in North Dakota has water quality and quantity, and inter-basin transfer of foreign biota concerns in Manitoba; Red River diking in North Dakota and Minnesota has flood implications for Manitoba; as does the Red River reservoirs in North Dakota and Minnesota. Because all of these areas have significant potential impacts on the two countries they are very politically sensitive and cause very emotional situations in the immediate areas. Any activity in either country is observed closely by the Board on behalf of the IJC.

International Souris River Board of Control

The Board was established in 1959 to ensure compliance with the interim measurements for the apportionment of the Souris River which were recommended by the IJC and approved by the governments of Canada and the United States. The measures outline the rights that Saskatchewan, North Dakota and Manitoba have to the use of the Souris River. The Board is currently composed of members of the North Dakota State Water Commission, United States Army Corps of Engineers, Manitoba Water Resources Branch, Saskatchewan Water Corporation and Environment Canada.

The water of the Souris River was first apportioned between Canada and the United States in accordance with interim measures that were accepted by the two governments in October 1940. These interim measures were updated and accepted by the governments in 1959 after the construction of Boundary Dam on Long Creek. After the addition of the large storage reservoirs formed by the Rafferty and Alameda Reservoirs, the apportionment rules were modified and included in the October 26, 1989 United States and Canada Agreement for Water Supply and Flood Control in the Souris River Basin. The Board was directed to apply the interim measures as modified in its computations of natural flow.

The Board has been challenged in recent years to meet the apportionment measures under conditions of low flow on the Souris River. Deficits in deliveries to the United States have been made up by Saskatchewan in a manner that was beneficial to Saskatchewan and the wildlife and agricultural interests in North Dakota.

IWD works with participating agencies to review the apportionment calculation procedure to ensure that it accurately reflects the conditions in the Souris River basin. A total of 30 gauging stations are operated by IWD in the Souris River basin for apportionment purposes. The management of the water in the basin is important for agriculture, municipal water supply of communities of Weyburn and Estevan and numerous smaller communities, cooling water for two thermal power plants which supply over 70 percent of Saskatchewan's power requirements and flood forecasting for Weyburn, Estevan and smaller communities in Saskatchewan and for Minot, North Dakota.

The importance of timely accurate information on water quantity was illustrated when a release was needed from Boundary Reservoir to meet Canada's international commitments. This release would have caused a shortage of cooling water and partial decommissioning of the power plant and resulted in a power purchase from another utility. The accurate information on water quantity allowed Saskatchewan to forgo the release with a saving in the order of $2 million.

- **Souris River Flow Forecasting Liaison Committee**

The Souris River Flow Forecasting Liaison Committee, established in January, 1977, reviews and implements procedures for the interchange of hydrologic, meteorologic and related data between the forecasting and operational agencies concerned with flow forecasting in the Souris River basin in Canada and the USA. The Committee reviews flow forecasting methods, coordinates flow forecasts and snow survey data and recommends on standardization of techniques, forecast methodology, data transmission and communication systems. The Committee reports

annually and after each spring runoff to the International Souris River Board of Control. The committee has members from Environment Canada, the provinces of Saskatchewan and Manitoba and the USA.

International Red River Pollution Board

The Red River drains an area of 278 000 km^2 in Canada and the United States. Approximately one half of the drainage area lies in Manitoba. The Red River provides Manitobans with water for drinking, recreation, farming and manufacturing of goods. The basin have been extensively modified through numerous water diversions and storage projects, especially in the U.S., built to utilize the highly variable flows and through the drainage of agricultural land. Industrial activities within the basin and the disposal of municipal waste have also caused major impacts on the aquatic resource.

In the early 1960s, the Red River basin became the focus of concerns by the Governments of Canada and the United States over the degree of pollution and resultant decline in water quality. In 1964, the two Governments officially requested an investigation of pollution in the waters of the Red River crossing the International Boundary pursuant to the provisions of Article IV of the Treaty.

As a result, the IJC, established the International Red River Water Pollution Board (IRRPB) to which it appointed technical experts from both countries. The Commission provided detailed instructions to the Board in the form of a directive which requested that all relevant water quality information be examined, pollution sources identified and remedial measures determined. The Board includes members from the States of Minnesota, North Dakota, the province of Manitoba, the United States and Canada.

The Inland Waters Directorate, representing Canada, contributes directly to the surveillance and control activities of the Board in several important ways:

i Inland Waters Directorate Chairs the Canadian Section and has influenced the development of a scientifically valid and systematic approach to the monitoring of aquatic quality.

ii Water Quality Alert Levels, led by IWD, provide a yardstick for measuring the acceptability of water quality. These Alert Levels are important instruments of water management within the Red River basin.

iii Decisive action by the U.S. to improve the water quality of the Red River has been driven, in large part, by the information provided by IWD's long-term baseline chemistry monitoring and by its early warning continuous monitoring system located at the Canada-U.S. border. Both programs have also served as very important deterrents to further pollution.

In 1969, Water Quality Objectives were established to restore and maintain the chemical, physical and biological integrity of the waters of the Red River. Water quality objectives were necessary to secure government commitment to pollution abatement. Five specific Water Quality Objectives were developed by the Board for the international boundary and they were subsequently adopted by the IJC.

With the objectives in hand, federal, provincial and state members of the Board approached municipalities and industries to obtain commitment to comply with the international objectives. Significant improvements have since taken place in the water quality of the Red River.

Tremendous social and economic benefits have resulted from the proactive approach taken by Canada and the U.S. in dealing with serious water quality issues which were plaguing the Red River. A good example is that of bacterial quality of the water. In the 1970s, the IJC faecal coliform water quality objective was frequently exceeded at the International Boundary. As a result, the Red River water coming into Canada was unfit for human consumption and for many industrial and recreational use. The increased

expense of treating this water to make it potable or the cost of finding alternative sources of suitable water to the many communities along the Red River was in the millions of dollars annually. Following the implementation of pollution control measures by various municipalities and industries in the U.S., non-compliant conditions have diminished to virtually zero since 1984.

Numerous fish kills reported in the 1960s and 1970s were caused by low dissolved oxygen (DO) levels. High concentrations of organic matter from untreated municipal and industrial wastewater, released to the Red River, were responsible for depressed DO conditions. However, since 1981, DO oxygen at the international boundary has remained well above the objective of 5 milligrams per litre (mg/L) except for short periods in 1981 and 1984. No fish kills have been reported in the last decade.

Through the Red River Pollution Board, the Aquatic Quality Program has brought international focus and action on major issues associated with: potential foreign biota transfers into the Hudson Bay drainage (e.g. European Goldeye [Zander]) from North Dakota; water quality deterioration by draining Devils Lake, North Dakota; and, the location of high hazard waste treatment complexes in the Red River Basin, Minnesota. The Board provides a forum for discussing and finding solutions to a variety of waste management issues in the Red River basin.

6.2.2 Bilateral Arrangements

Poplar River

A 1977 Reference from the Governments of the United States and Canada requested the IJC to examine the water quality of the Poplar River, including the transboundary water quality implications of the Saskatchewan Power Corporation's (SPC) thermal power station near Coronach, Saskatchewan.

The IJC recommended that "a bilateral group, constituted as a Board of the United States and Canada, should be maintained to monitor water quality and water quantity in the Basin with particular reference to the impacts of the SPC project". In response to this recommendation, the governments signed the Poplar River Cooperative Monitoring Arrangement and formed the Poplar River Bilateral Monitoring Committee in 1980. Monitoring programs for transboundary air quality and surface water quantity and quality and groundwater quality and levels began in 1981.

The federal government enacted the International River Improvements Act (IRIA) to ensure that Canadian projects constructed on international streams were beneficial for Canada. IWD has the legislated responsibility to ensure that projects are licensed under the IRIA. The Poplar project licence included clauses relating to surface water quality and quantity, groundwater quality and levels and air quality was also included.

IWD and the United States Geological Survey (USGS) share monitoring duties for surface water at the border crossing. Surface and ground water quality and quantity monitoring related to the operation of the Coronach power station is carried out in cooperation with member agencies. The Coronach station provides over 10% of the electrical power used by Saskatchewan.

The Committee brings together scientists and water resource managers from the USGS, the state of Montana, the province of Saskatchewan and the Directorate. IWD has played a lead scientific and diplomatic role on the Committee since its inception. IWD had a significant influence on the development and the application of water quality objectives as a means of scientifically assessing and resolving water-related issues before they develop into major problems. Scientific investigations lead by IWD have also contributed to a better understanding of the impacts of the Coronach power plant and of its ancillary operations on the aquatic environment. For example, a report assessing the effect of coal dewatering and coal use on the water quality of the East Poplar River

concluded that radionuclides and metals in the receiving waters posed no immediate danger to the environment or to humans. The report also identified research questions which needed to be addressed. IWD has also assumed the lead role as far as forecasting changes in water quality. By using existing data, IWD was able to predict that the international water quality objectives for boron and total dissolved solids would be exceeded sometimes in the mid 1990s unless the current drought came to a sudden end. This information has allowed all parties involved to seek a solution to this potential problem ahead of time rather than having to react after the facts at a probably much higher cost.

IWD and the USGS are the editors, on a rotational basis, of the annual report to governments on the monitoring activities and environmental changes caused by the operation of the power station.

Souris River

Starting in Saskatchewan, the Souris River loops into North Dakota and then flows into Manitoba where it joins the Assiniboine River. Since the early days of settlement in the Souris basin, alternating periods of flood and drought have been a major concern for local residents. Water storage and distribution structures on the Souris River were envisaged at the turn of the century. Control of the variable water supply was, and is still is, seen as the key to economic prosperity.

In the 1930s large scale proposals such as the Rafferty, Alameda and Boundary dams received serious consideration. Several water management studies of the Souris River system, initiated by the IJC, resulted in a water apportionment agreement between the U.S.A. and Canada in 1959.

In 1984, the province of Saskatchewan began planning for the Rafferty-Alameda project for flood control in North Dakota and Saskatchewan and for industrial and irrigation water supply in Saskatchewan. This scheme involved using the Rafferty Reservoir as the source of cooling water for a proposed thermal electric generating station valued at $500 million.

The federal government granted the project a final license under the International River Improvements Act (IRIA) following a number of environmental reviews by various government agencies in both countries. But on April 10, 1989, the Federal Court of Canada quashed the IRIA license and ordered application of the Environmental Assessment and Review Process (EARP) to the project "as it relates to federal interests in considering an application for a license under the IRIA". Since then, a new IRIA license has been granted for the Project through the efforts of IWD.

On October 26, 1989 the Governments of the United States and Canada entered into an Agreement for Water Supply and Flood Control in the Souris River Basin. The agreement was intended to provide flood control benefits in the United States and water supply benefits in Canada in a manner that is consistent with the Boundary Waters Treaty and the Migratory Birds Convention. The United States determined that the value of the project to the United States was $41.1 million US 1985 or roughly $69 million (1993) of the $210 Million dollar water storage project in Saskatchewan.

The governments of Canada, Saskatchewan, Manitoba, the United States and North Dakota established framework for management of the water resource through the signing of the Agreement which recommended the formation of a Bilateral Water Quality Monitoring Group. Management of the Souris River is accomplished through the efforts of the International Souris River Board of Control and the Bilateral Water Quality Monitoring Group. Membership in the two groups has several common members. Meetings of the Board and the Group are scheduled for consecutive days to minimize duplication of effort.

6.2.3 Water Quality Monitoring

Article VI of the Agreement deals specifically with water quality, including the establishment

of a Bilateral Water Quality Monitoring Group. Aquatic quality of the Souris River is or has the potential to be significantly impacted in a number of ways. Municipal treated sewage discharges are the primary point source of pollution. Intensive grain and cattle farming, the artificial impoundment of water and releases from the Rafferty, Alameda and Boundary reservoirs in Canada and from two major wildlife refuges in North Dakota are the most significant non-point contributors to water quality degradation in this international stream. To ensure the protection of various water uses on the Souris River and in accordance with the Agreement, the Group, to which IWD has assigned a representative, recommended a set of water quality objectives and a monitoring plan to governments in 1991. The plan was officially sanctioned by the United States and Canada and monitoring was initiated in 1992.

IWD's contribution to the Group's activities is a very important one. Viewed as an unbiased partner and well respected for its water quality expertise, the Directorate played a key role in the development of water quality objectives. Because of this and in view of its detailed knowledge of the Souris River and of its long-term involvement in water quality monitoring in that basin, state and provincial governments specifically requested Environment Canada's direct involvement in the revised water quality monitoring program for the same reasons.

IWD developed the apportionment calculation procedure that has been adopted by the IJC and developed water quality objectives and a monitoring program in partnership with Canadian and U.S. agencies. The water quality work drew considerable praise from the U.S. State Department. IWD also documented for the first time the effects of apportionment releases from Saskatchewan reservoirs on transboundary water quality. Sufficient information is now available to predict impacts in North Dakota.

Boundary Reservoir Releases

The water apportionment commitment to the United States constitutes for the province of Saskatchewan the most significant water demand in the Souris River basin.

Typically, most of the flow in the Saskatchewan portion of the Souris River occurs during the spring. In order to satisfy the apportionment schedule established by the International Souris River Board of Control, releases from the Boundary Reservoir have to be made periodically. Boundary Reservoir was constructed on Long Creek in 1958 by the Saskatchewan Power Corporation (Sask Power) to provide a cooling water supply to a electric generating station.

In recent years, Sask Power has supplemented its surface water supply with groundwater pumped from local aquifers. Groundwater in this part of the province is particularly high in dissolved solids. Dissolved constituents such as chloride and boron, when present in surface waters at elevated levels, can have deleterious effects on aquatic biota and damage irrigated crops. There was therefore concern on the part of the Board of Control, of which both Canada and the U.S.A. are members, that releases from Boundary Reservoir during periods of drought could cause significant environmental damage and have detrimental effects on the local farming economy in the U.S. portion of the Souris River basin.

The concern was intensified by the fact that the Souris River Basin Development Authority (SBDA) had, in the early 1980s, designed the Rafferty-Alameda dams for joint operation with the Boundary Reservoir starting in the next decade. This would of course greatly complicate the development of an overall water management strategy for the Souris River basin, especially when considering a scenario of possible environmental and economic injury caused by the release of groundwater.

The latter possibility was the motivation behind the study initiated by IWD in 1989. The Directorate was also anxious to maintain the strong history of international cooperative management of the Souris River basin water resources built over several decades.

IWD saw the 1989 Boundary Reservoir release as an opportune time to investigate the effect of this release on the ambient surface water quality of Long Creek on the Souris River. The southern portion of the prairies was experiencing an extended period of drought. Through intensive monitoring at twelve sites along Long Creek and the Souris River between October 1 and November 1, IWD experts were able to assess the potential impact on downstream uses of high levels of boron and other dissolved solids contained in the Boundary Reservoir water. Boron was present at very high levels in the Boundary release water at the time of this study. Concentrations in the Souris River were correspondingly elevated, exceeding the current (1991) objectives set for the protection of certain crops for this basin by 5 times at some sites. Chloride, sulphate and sodium all exceeded their respective international objectives as well.

The IWD study also uncovered two other important sources of boron in the Souris River basin:

i open pit coal mining, and

ii improper stockpiling of ashes produced by the coal combustion process at the Boundary generating station.

The information generated by this study has prompted changes in the management of the Boundary Reservoir releases which are now timed so as to maximize the possibility of dilution of boron and other deleterious dissolved substances. Also as a result of this study's findings, Sask Power has modified its procedure for ash stockpiling in order to reduce the impact of its operation on the environment.

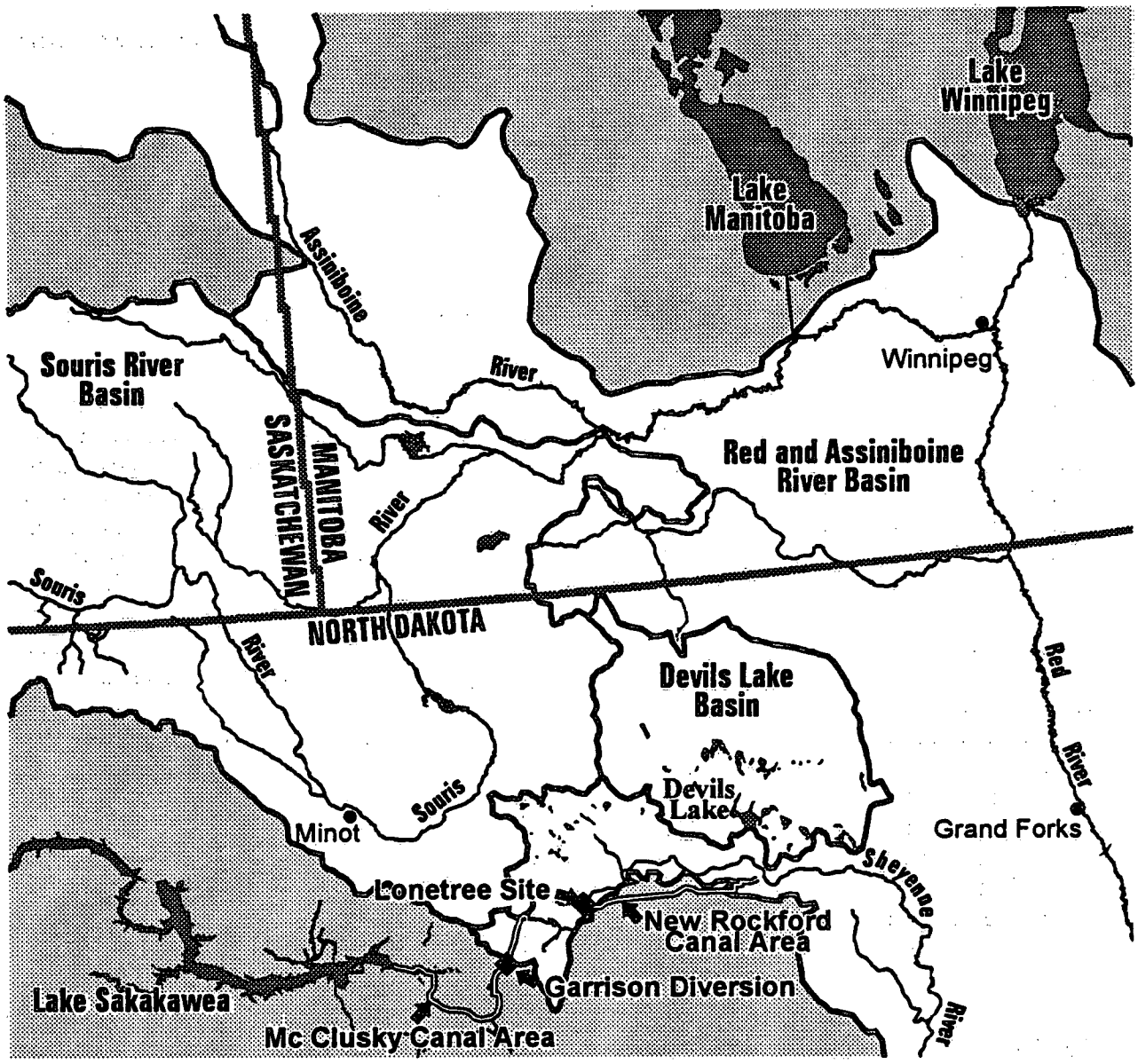
This is another good example of IWD being instrumental in resolving a matter which had the potential to damage long-standing international relationships and could have deteriorated into an onerous legal action between several jurisdictions in two countries. The instruments used by IWD to do this were its recognized scientific expertise in water resource management and its strong reputation as an impartial broker.

Garrison Diversion Project

During the 1970s and 1980s, at the request of the Canada-United States Consultative Group, the Canada-United States Garrison Joint Technical Committee (GJTC) investigated the environmental risks of the Garrison Diversion Unit (GDU) irrigation project in North Dakota on Canada. The GDU is a multi-purpose water resource project that proposes to transfer water from the Missouri River, which drains into the Gulf of Mexico, to irrigate up to 100 000 hectares and supply water to new industrial and municipal users in northeastern North Dakota. Some of the irrigated area and the industrial and municipal uses are in the Souris and Red River basins in Manitoba that drain into Hudson Bay.

The interbasin transfer of Missouri River water could result in foreign organisms such as fish and fish diseases and parasites entering the Hudson Bay basin and harming Manitoba fisheries which have a commercial and country food value of about $7 million (1993). The irrigation return flows could also degrade the quality of water entering Canada. Environment Canada, represented by IWD (co-chairman), Fisheries and Oceans Canada, and the province of Manitoba were part of the Canada-United States technical team that evaluated the relative risk to Canada of several option for a proposed link between the McClusky and New Rockford Canals, the two main supply canals for the GDU. The Consultative Group agreed with the GJTC report and concluded that any one of three options for a connection between the McClusky and New Rockford Canals are potentially acceptable, from the technical standpoint of risk to Canadian waters. They stipulated, however, that each should be subjected to further review to assure Canadian public acceptance of the final United States selection.

Canada continues to oppose project proposals that could allow biota transfer from the Missouri basin to the Hudson Bay drainage basin. IWD is



active on the Joint Technical Committee and continues to represent Canada to protect the aquatic environment. Canada is waiting for the United States to select its final option for connecting the McClusky Canal to the New Rockford Canal before further addressing the matter.

Devils Lake

The International Red River Pollution Board is presently examining a rising concerns about water level changes of Devils Lake, a closed basin in North Dakota. High lake levels threaten to cause major flood damages and low levels threaten one of North Dakota's major recreational fisheries. The solution to high levels is seen as an outlet to the Red River. Release of Devils Lake water to the Sheyenne River and the Red River would result in a significant increase in the salinity of the Red River entering Canada. The introduction of Missouri River water from the Garrison Diversion Unit to raise low levels with the outlet to the Sheyenne River

would result in biota transfer to the Hudson Bay drainage. Public concerns in Canada relate to the introduction of foreign biota, fish and fish diseases, and parasites which would damage the Lake Winnipeg fishery, and water quality effects which would increase water treatment costs for Manitoba communities. Because Devils Lake is closely associated with the Garrison Diversion Project, IWD also represents Canada's interests on this project through the Garrison Joint Technical Committee.

Pelican Lake

The Pelican Lake Enhancement Project is a government of Manitoba initiative to divert water from the Pembina River into Pelican Lake to stabilize lake levels primarily to improve conditions for recreation. The project includes a weir on the Pembina River, inlet and outlet diversion channels and two control structures. Agriculture Canada funded part of the project and was the initiating department under the Environmental Assessment Review Process. An initial environmental evaluation of the project concluded that project impacts were known and could be mitigated with known technology; therefore, the project was allowed to proceed. The project was reviewed under the Manitoba Environmental Act and a provincial licence was issued on November 1, 1990. IWD was responsible for licensing the project under the IRIA.

6.3 Reducing Atmospheric Pollution

6.3.1 Global Warming

In 1989, the Atmospheric Environment Service approached IWD and many other agencies with a proposal for a 6-year study of the potential impacts of future climate change on the water resources, ecosystems,economic activities, and communities of the Mackenzie River basin. The proposed study followed previous analyses of the impacts of climate change on the Great Lakes and single sector economic activities, such as agriculture, with a broader multi-disciplinary study designed to facilitate long-term planning to accommodate anticipated changes.

IWD supports the assessment of the physical impacts of climate by providing historic and current water quantity, quality, and sediment data, as well as applying the SIMPAC computer model for routing of flows down the rivers in the Mackenzie Basin and the One Dimensional (1-D) computer modelling of the flows and water levels of the Peace Athabasca Delta. Results of a number of IWD studies, off-farm impacts of erosion and pesticide use will also contribute to prediction of the consequences of climate change on precipitation, evaporation, and runoff, as well as other processes. IWD will contribute flow models already developed under other programs for the Mackenzie River navigation forecast and Mackenzie Delta. IWD's Mackenzie Delta hydraulic model, developed to help assess and design pipeline channel crossings, will also enable the prediction of changes in delta flow conditions and flooding characteristics due to climatic change.

Global Energy & Water Cycle Experiment (GEWEX)

The GEWEX program plans to develop a more accurate description of global precipitation regimes. Conventional meteorological and hydrological point data are the basic data source for many of the proposed Canadian GEWEX science initiatives and are the primary source of information for the development and validation of algorithms for deriving geophysical variables from remote sensors and for the validation of modelled atmospheric and hydrological parameters. IWD is providing support for the Boreal Forest Experiment and Mackenzie GEWEX Study (MAGS), under the Continental-Scale International Project (GCIP) of GEWEX. IWD will provide One Dimensional modelling of flows and water levels in the Peace Athabasca Delta for the various scenarios selected under the GEWEX study. The GCIP will develop an understanding of the terrestrial hydrological cycle and the

ability to observe and model it in scales appropriate for climate studies.

The Boreal Forest Experiment will try to determine how boreal forests and atmosphere affect each other while MAGS provides the GCIP with cold region characteristics that are missing in the Mississippi Basin, which was used as the continental scale basin to develop the models. The Mackenzie basin also provides a river with limited regulation and a point to study the role of ice cover and circulation of the Arctic Ocean. Both these projects are necessary steps to understanding the processes of global warming. IWD is also providing ground level support for the Boreal Ecosystem-Atmosphere Study (BOREAS) under the International Satellite Land Surface Climatology Project (ISLSCP) at two sites. The Prince Albert National Park site will represent the southern fringe of the forest. The site near Norway House, in northern Manitoba, will represent the northern fringe of the boreal forest area. Ground level support will include installation of a streamflow monitoring station on a small catchment basin and entering the data into the BOREAS information system.

Flow Regimes from International Experimental and Network Data Stes (FRIENDS)

FRIENDS, an International Hydrological Program, intends to establish regional hydrometric databases for continental and global monitoring and set methods of hydrological analysis using regional data sets, including an examination of the relations between low flow statistics and hydrogeology including the study of the effects on recharge of low flows. IWD is providing information and data analysis to support FRIENDS.

6.4 Decade of North American Geology

The Decade of North American Geology (DNAG) Project prepared a synthesis about the geology of the North American continent and adjacent oceanic regions. Two volumes of this encyclopedia described the occurrence and movement of water on the continent and explained the hydrologic effects of geology, physiography and climate. Environment Canada provided authoritative authors for most of the chapters in the Surface Water Hydrology volume, published in 1990, notably the chapters on Low Flows and Hydrologic Droughts and on Movement and Storage of Sediment in Rivers of the United States and Canada. The DNAG Project presents the state of knowledge of the geology and geophysics of North America in the 1980s and points the way toward work to be done in the decades ahead. The cooperative project also allowed Canadian content in an international publication series that will be used in universities throughout North America.

7. ENVIRONMENTALLY RESPONSIBLE DECISION-MAKING

7.1 Partnerships as Solutions

7.1.1 Provincial and Territorial Partnerships

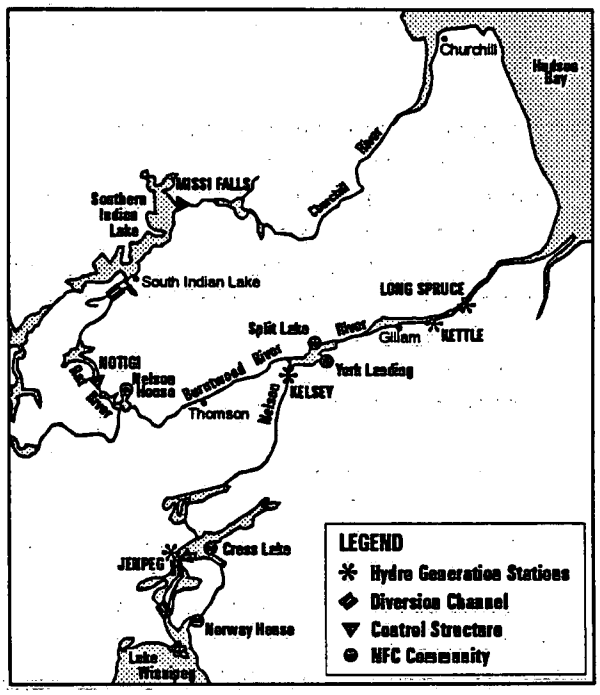
The Green Plan commits Canada to strengthening existing partnerships between federal, provincial and territorial governments and to encouraging the development of new partnerships to achieve sustainable development. A high priority is also placed on formalizing agreements with provinces to work cooperatively to fulfil our mutual environmental obligations.

Partnerships are especially significant with respect to water management in W&NR. The three Prairie Provinces have a long history of cooperation on water issues. This is illustrated by such institutions as the Prairie Provinces Water Board and participation in major river basin planning studies such as the recently-completed South Saskatchewan River Basin Study in Saskatchewan.

Because water flows across political boundaries, and given the provincial responsibility for water management, most of the work of IWD is delivered through the mechanism of federal and provincial or territorial and international partnerships. Cost-shared partnerships exist for water quantity and water quality monitoring programs and the national flood damage reduction program, for example. Partnerships will become even more essential to the delivery of IWD programs in the future.

Northern Flood Agreement

Manitoba Hydro, a provincial Crown Corporation, is mandated to provide for the "continuance of power adequate for the need of the province"... Until the 1960s, Manitoba's need for electricity was supplied by the power plants in the southern half of the province. Thereafter, the Corporation shifted attention to the north for additional power supply. Attention was targeted at the Lake Winnipeg, Churchill and Nelson Rivers area with a total potential design capacity of 8400 mega-watts. The Lake Winnipeg, Churchill-Nelson Rivers Hydroelectric Development Project (LWCN) involved regulation of Lake Winnipeg and the diversion of about 75% of the flow of the Churchill River at South Indian Lake through the Rat and Burntwood Rivers to the Nelson River with the potential for developing fourteen generating stations on the river system. The period of construction that followed in the early 1970s provided significant impetus to the provincial economy. The resulting economic and stable electricity rates were a major factor in helping Manitoba develop one of the most diversified industrial economies in Canada. In addition to export sales of electricity, spin-off benefits include a world-wide reputation in research and development in the area of long distance transmission of electricity. The latter has provided opportunity for private consulting firms to make inroads into the international market for this expertise.



Northern Flood Agreement

Construction to date has included channel improvements at the outlet of Lake Winnipeg, the diversion of the Churchill River to the Nelson River, and five generating stations; the Kelsey, Kettle, Long Spruce, Jenpeg, and Limestone. The remaining potential sites will not be developed and operational until well into the next century. While the benefits to Manitoba from this development are significant, the impact on the natural environment and the local communities has also been large.

In 1977, the landmark Northern Flood Agreement (NFA) was signed by Canada, Manitoba, Manitoba Hydro and the Northern Flood Committee (NFC) - an organization representing five native communities in the LWCN area; Cross Lake, Nelson House, Norway House, Split Lake, and York Landing. The objective of the NFA, an open-ended, open-funded, legally binding contract, is to ensure that all persons represented by the NFC who are adversely affected by the LWCN receive fair and equitable treatment. In 1976 and 1977 detailed proposals were formulated for a coordinated ecological monitoring program, however, largely because of the signing of the NFA,these proposals were never implemented. Only one study was undertaken as originally proposed, a federal- provincial study of increased mercury in the Churchill River diversion area, initiated in 1983 under the Canada-Manitoba Mercury Agreement.

Canada-Manitoba Mercury Agreement

A key component of the LWCN Project is the diversion of the Churchill River into the Nelson River which became operational in 1977. This diversion resulted in extensive areas of flooded terrain, eroding shoreline, and other environmental impacts, along the diversion route. While some of these impacts were predicted, one significant impact that was not predicted was an increase in the mercury levels in the fish along the diversion route. Elevated levels were identified as a result of routine sampling of commercial fish caught from the diversion lakes in 1977 and 1978. From ensuing discussions between officials from Canada and Manitoba, in 1978 and 1979, two questions emerged:

i Was mercury a problem in the environment of the Churchill River Diversion? and

ii If mercury was a problem, what was the relationship to the hydroelectric development project?

While these discussions were underway, concerns about the potential effects on the health and economic livelihood of the local Cree population led to the filing of Claim 12 under the NFA, in April 1981, and to a cooperative federal-provincial initiative, the "Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion".

The four year Agreement, signed on March 10, 1983 and made retroactive to April 1, 1982, was allocated a budget of $760 000, cost shared equally between the governments of Canada and Manitoba. The objectives of the study were to:

i further investigate mercury levels in the water, sediments, and the aquatic food chains along the diversion route;

ii determine the source(s) of mercury input to the diversion system;

iii research the mechanism(s) whereby the mercury was released and entered the food chain;

iv assess the significance of these phenomena to future water management activities; and

v advise the public of the purpose, progress, and results of studies undertaken.

The research and monitoring programs involved several federal and provincial agencies, key being Environment Canada (represented by IWD), Fisheries and Oceans Canada (FOC), Health and Welfare Canada (H&W), and Manitoba Departments of Environment and Workplace Safety and Health, Natural

Resources, and Health. The final report, along with eighteen technical appendices, was released in March 1987.

In summary, conclusions reached by the study were:

i The mercury in the area came from natural sources, with the bedrock being the ultimate source.

ii Mercury levels in the soil, sediment and water were within the normal ranges for unpolluted areas.

iii Post-impoundment mercury levels in fish from diversion lakes were elevated in comparison with Canadian guidelines, with pre-impoundment levels, and with mercury levels in fish from other non-flooded lakes. Levels also varied according to species and size and lake of origin.

iv Levels in blood in the majority of the people tested were within the normal range. Concern was raised, however, because a number of women of child-bearing age had levels above the upper limit of safety.

v Levels in fish eating mammals were elevated in comparison to other Manitoba regions but below toxic levels.

vi Elevated levels in fish resulted from increases in the rate of methyl mercury production which is controlled by bacterial processes.

vii The most important factor affecting methyl mercury production is the amount and type of flooded material.

viii The oxygen level is the most important of a number of other environmental factors examined to determine their effect on methylation rates.

ix Decades may be needed for mercury methylation rates and levels in fish to return to pre-impoundment levels.

x Elevated mercury levels in fish following a reservoir impoundment is a widespread problem. Many factors appear to influence the levels which makes it impossible to predict the severity of the problem at any given reservoir, especially without any previous experience in the same geographical area.

The study resulted in the following recommendations;

i The results of the study be made widely available.

ii In addition to the on-going commercial fish monitoring program, periodic monitoring of the domestic and sports fishery be continued until the mercury levels reach acceptable values.

iii Fish management activities should be implemented to the maximum extent possible as a means of mitigating the mercury problem.

These recommendations led to the establishment of consumption levels for some fish species and are the basis of the ongoing process of compensation negotiation under the Northern Flood Agreement. The study also gave recognition to the necessity of monitoring pre-impoundment mercury levels in fish as an essential part of reservoir planning, and to the need of considering elevated mercury levels in the costing of impoundment facilities.

The study represents a milestone in research and monitoring in that it proves conclusively, for the first time anywhere, that mercury levels increase due to water impoundments, and further delineated the methylation-food chain processes. Because of its significant scientific value, the study has drawn wide responses from around the world.

Federal Ecological Monitoring Program

In December 1981, the NFC filed Claim 18, which alleged that Canada, Manitoba, and

Manitoba Hydro had failed to meet certain contractual obligations of the NFA, including a failure to implement a "...long-term coordinated ecological monitoring and research program [that] would allow evaluation of impacts on the bands and their members and communities..." and that "...this failure has resulted in the fact that the NFC and the bands and their members have suffered severe loss and damage."

As a result of Claim 18, the Federal Government authorized the expenditure of funds by a number of departments for research and studies. Environment Canada received $1.8 million under the Canada Water Act as its share of funding to implement a program of environmental research and monitoring called the Federal Ecological Monitoring Program (FEMP). This program was directed towards meeting some of the federal obligations under NFA. To ensure coordination of the Program with other NFA ecological programs, a four-party Program Advisory Board (PAD) was established, comprised of Manitoba, Manitoba Hydro, Canada (IWD) and the NFC.

Through discussions with PAD, four objectives were formulated for FEMP:

i to the extent possible, determine pre-project conditions in the FEMP study area;

ii measure post-project conditions in the FEMP study area;

iii increase our understanding of the significant factors that could affect future ecological conditions in the FEMP study area; and

iv advise the public of FEMP results, ensuring that this information is presented in formats appropriate to the intended audiences.

To address the first three objectives, six subject themes were selected with the geographical focus on the immediate vicinity of the six native communities.

i Water Quantity and Quality: The diversion of approximately 75% of the Churchill River flow into the Nelson River has brought about dramatic changes in the flow patterns downstream. For example, the mean flow of the Burntwood River at Thompson increased from an average of 93 m^3/sec under estimated natural conditions to an average of 888 m^3/sec under regulation, while the mean flow of the Nelson River at Kettle Dam increased from 2170 m^3/sec under estimated natural conditions to 2980 m^3/sec under regulation. Furthermore, the alteration in seasonal distribution of flows has shifted 7% of the combined annual delivery of the Churchill and Nelson rivers to Hudson Bay from the open-water season to the ice-covered months of November to May. Large daily fluctuations, especially in the winter, further impact on the use of the river by animals and people. Major effects on the surface areas of lakes include extensive flooding and/or lowering of water levels at different locations. With limited pre-project information, a full water quality assessment at all sites was not possible, however, generally, existing water quality met Canadian Water Quality Guidelines (CDWG) for drinking water, recreational use, and protection of aquatic life, with some exceptions, mainly due to extensive siltation because of bank erosion.

Additional broad data collection was not required since it would not enable any further understanding of pre- to post-project changes in water quality. However, some localized work during medium and high flows with continuing monitoring at Thompson to assess long term changes and at future dam sites to develop baseline conditions was recommended.;

ii Sediment and Morphology: Increased erosion of shorelines, with increased floating vegetation and standing debris, was noted. On average, 50% of shoreline recession was identified as caused by erosion rather than inundation. Along the diversion route, erosion was not as serious

a problem as predicted; however, without extensive field studies, projection of future erosion rates is subject to considerable uncertainty. It was recommended that a classification system be developed to characterize shoreline types and field investigations be undertaken to determine sediment sources and sinks.:

iii Mercury: A model was developed based on rates of methylation and demethylation which indicated a slowly accelerating rate of decline in net production of methyl mercury, the predominant form of mercury in the fish. Net rates are expected to decline by 50% in about 60 years,with an additional 20 years required before pre-development values are reached. Direct measurements of mercury in water using improved measurement techniques indicated total mercury concentrations to be similar to those in unaffected reference lakes, with values substantially lower than upper limits in CDWG, and methyl mercury concentrations generally higher than in reference lakes. It was found that the same major metabolic group of bacteria was responsible for methylation and demethylation, in flooded and non-flooded sites and that oxygen availability and sediment deposition may be relevant factors. It was concluded that it will be difficult to develop mitigative measures, and that additional research is required to develop preventative or remedial procedures.

Recommendations are: investigations be continued on the microbial process, and on transport mechanisms; regular periodic monitoring of fish consumption be instituted; future proposed developments include research and monitoring activities as well as preventative measure experiments; burning of organic material be evaluated as a preventative measure, and; studies to assess the role of sediment deposition in the production of methyl mercury be undertaken.;

iv Fisheries and Aquatic Life: A substantial decrease in the quantity and quality of whitefish, caused by physical restrictions to migration and to pike population dynamics, was noted. Surveys of benthic invertebrates, an important food source for bottom feeding fish, were conducted in selected lakes, and generally showed a direct relationship to an increase or decrease in productive lake area. Recommendations are to complete and/or undertake follow-up studies on fish and benthic organisms, carry out a morphological analysis of whitefish, and initiate a pilot study to evaluate methods for moving migrating fish over major dams.;

v Waterfowl: Broad conclusions about waterfowl populations could not be drawn because of the limited number of surveys undertaken. Recommendations are that additional scientific surveys be conducted to enable an assessment of future trends. However, the data collected will not enable any further assessment of changes caused because of the LWCN.; and

vi Resource Harvesting: The analysis of limited existing data on resource use, by NFC communities, indicated a number of socioeconomic impacts, however it did not reveal the full suspected range of adverse effects. Conclusions are that until a comprehensive social impact assessment (SIA) is conducted, it is impossible to fully understand the implications of biophysical changes. Recommendations are to conduct a SIA that is community based, not only in implementation and execution but also in design and control.

Realization of the fourth FEMP objective, advising the public of FEMP results, required the determination of appropriate communication products based on the complexity and the importance of the material to be communicated and on the needs of the intended audiences. On this basis, three communication products were produced. The first product was the FEMP

Report Series, in which a series of twenty-five reports presented the interim findings of FEMP; the primary audience for this series was PAB. The second communication product was a videotape entitled "Changes" that was produced in Cree and English versions; the primary audience was the residents of the native communities. The third communication product was the FEMP Final Report, which provided complete documentation of FEMP's history, objectives, methods, and results; the intended audience was the general public. This report series comprised of Summary Report and two volume Final Report was released in May 1992 and given wide distribution.

As a scientific investigation, the FEMP successfully addresses an array of environmental issues, with far reaching implications for future decision making in the effected area. The study results form the basis for ongoing compensation negotiation under the NFA. The FEMP also has the distinction of taking an integrated and holistic approach to understanding ecosystems and to addressing and anticipating environmental impacts.

Copies of the Report have been provided to PAB for their review and appropriate action.

Prairie Provinces Water Board

The Prairie Provinces Water Board (PPWB) was formed on July 28, 1948 by the signing of a formal Agreement by Alberta, Saskatchewan, Manitoba and Canada. This Board's mandate was to advise on the best use of interprovincial waters and to recommend allocations between provinces. In 1969, Canada and the three prairie provinces ratified the Master Agreement on Apportionment which dealt with the allocation of flow and considered the quality of eastward flowing interprovincial rivers. At that time, under Schedule C, the Board was reconstituted and given the responsibility to administer the Agreement. The PPWB consists of a member from each province and two federal members.

Under water quantity, the 1969 Master Agreement on Apportionment directs "...that the Prairie Provinces Water Board shall monitor and report on the apportionment...". In the early 1970s, initial work to define the monitoring requirements was undertaken by IWD, under a cost-shared contract with the PPWB. These studies focused on methods to calculate natural flows and to forecast streamflows for the five major eastward flow interprovincial streams. IWD both developed procedures and reviewed studies for the Committee on Hydrology of the PPWB. Iwd also evaluated the need for apportionment monitoring of twenty small interprovincial streams, categorizing them into high, medium or low priority. In 1993, stream flows are monitored by IWD at 103 locations to calculate and apportion natural flow including 14 boundary crossings. The PPWB also maintains a database of water demands in the basins of the eastern flowing streams.

For water quality, Schedule C of the 1969 Master Agreement on Apportionment directed the Board "to review water quality problems, particularly such problems located at the interprovincial boundaries, and to recommend to the parties hereto, appropriate management approaches for their resolution..." , "to develop recommendations on other water matters, in addition to problems on water quality, referred to the Board by any party hereto..." and "to promote through consultation and the exchange of information the integrated development of water resources of interprovincial streams".

One major goal of the PPWB is "to foster and facilitate interprovincial water quality management among the prairie provinces and the federal government". Canada saw in this cooperative approach a consultation mechanism by which a long-term water quality management philosophy based on "anticipate and prevent", rather than the more costly "fix and cure", strategy could be promoted. Such an approach would therefore have important political, economic and social redeeming value. A clear demonstration of success is the fact that since the inception of the PPWB in 1948, provincial governments, who have primary authority for the management of water resources, have

always complied with the Board's recommendations.

The Board and the provinces, in 1973, adopted a common set of water quality objectives for all interprovincial monitoring sites. The concept of this First Order Minimum Long-Term Water Quality Network, closely tied to water quality issues, was officially endorsed by the Member Agencies in 1978.

Since 1974, the IWD has conducted monthly or quarterly surveillance of aquatic quality for the PPWB at eleven interprovincial river reaches. The resulting long-term historical database provides an excellent and unique description of water quality for prairie rivers. Interpretive tools developed with the assistance of IWD, such as trend analysis, have made it possible to use the database for forecasting purposes and identifying potential aquatic quality issues. Special studies aimed at particular issues have contributed significantly to the understanding of the state of aquatic resources at transboundary reaches of major prairie streams. In 1992, the Board, given the increasing importance and the complexities of both water quality and water quantity issues, re-defined and re-asserted its roles and responsibilities in the area of interprovincial water quality matters. The result was the 1992 Agreement on Water Quality, signed by the federal and the three provincial member governments, which promotes a preventive and proactive ecosystem approach to interprovincial water quality management.

Water quality and quantity information provided by the PPWB program formed the basis for a protection strategy developed for Lake Diefenbaker in the mid 1980s. Situated on the South Saskatchewan River downstream of the Alberta-Saskatchewan border, Lake Diefenbaker is arguably the most valuable water resource in Southern Saskatchewan. This artificial reservoir, built from 1958 to 1967 for the storage and control of the fickle natural prairie water supply, impacts directly on the lives of over 350 000 people within and outside of the South Saskatchewan River drainage basin. The city of Saskatoon draws its potable water from the river downstream from Lake Diefenbaker. Significant deterioration in water quality within the reservoir would result in additional water treatment costs for the city and its industries. Similar problems could affect the already highly eutrophic Buffalo Pound drinking water supply to Regina and Moose Jaw which depends on regular supplements from Lake Diefenbaker. Lake Diefenbaker pumps in excess of $5 million dollars a year into the local economy thanks to the highly prized recreational opportunities it offers. Like most prairie lakes, Diefenbaker is vulnerable to eutrophication and its impacts. In the case of Diefenbaker, taste and odour problems, deterioration of the fish stock and the loss of recreational appeal would be the most deleterious consequences and would therefore have enormous social and economic repercussions for that region of the prairies.

PPWB's advice often plays a major role in the environmental assessment of proposed new developments. In the early 1980s, Board data for the Saskatchewan River clearly showed that a Ducks Unlimited waterfowl enhancement project on the Cumberland Marshes would depress dissolved oxygen levels downstream with damaging consequences to fish. The Board's intervention was successful and adjustments were made to the project to optimize flow so as to protect aquatic life on the Saskatchewan River. Damage to the fisheries would have meant a significant loss in revenue from tourism for this area of Saskatchewan as well as a decrease in the recreational appeal of this stream for area residents.

Thanks to advance knowledge provided by its surveillance data and a well designed contingency plan, the PPWB has been able to alert municipalities to potential water-related health hazards. This has allowed these communities to appropriately respond and prevent costly emergencies.

The value of avoiding costly inter-provincial and federal-provincial conflicts and of making the correct resource management decisions cannot be estimated exactly. But over the long term, the financial and social consequences of

correcting past mistakes, resulting from a shortage of reliable scientific information or a lack of consultation, can easily be in the hundreds of millions of dollars. On that basis alone, Canada's contribution of $220 000 a year to the water quality monitoring program of the PPWB has been a very well placed investment.

- **Battle, Lodge, Middle Creeks**

Since Battle, Lodge, and Middle creeks are interprovincial streams flowing from Alberta to Saskatchewan the flows are apportioned between the provinces according to the PPWB Master Agreement.

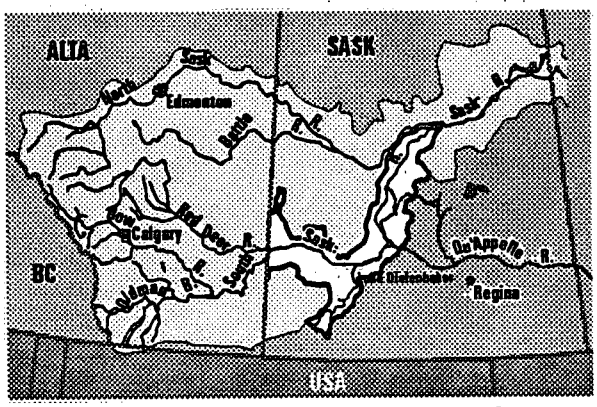
IWD developed the procedures to be used in the apportionment of these streams, collects the necessary streamflow and water level information from 11 locations and determines the apportionment shares for each of Alberta and Saskatchewan. The area is short of water in many years and in the past ten years of drought there have been shortages for agriculture, municipal and domestic purposes. The importance of the water to the economic viability of the area is paramount therefore the public has tremendous interest in the apportionment of the water.

South Saskatchewan River Basin Study

The South Saskatchewan River Basin provides the largest supply of fresh water in southern Alberta and southern Saskatchewan. Upstream hydroelectric developments in the province of Alberta store spring snow-melt for winter power production. Irrigation developments, which began in the early 1900s, have increased in size and represent a major use of water. Water storage for irrigation also takes place during peak runoff periods, although some projects on the Bow and Oldman rivers divert water throughout the irrigation season. The effects of these projects are reduced spring peaks and summer flows and increased winter flows in the South Saskatchewan River.

The South Saskatchewan River system in Saskatchewan has also undergone many changes throughout the last 100 years as agricultural development and urban settlements have grown. The most significant change occurred in 1968 when the South Saskatchewan River Project was completed and Lake Diefenbaker was formed. This lake, formed by the Gardiner Dam on the South Saskatchewan River at Cutbank and the Qu'Appelle Arm Dam, extends about 230 kilometres (km) west from Gardiner Dam. This multi-purpose reservoir supports irrigation, hydroelectric generation (187.5 megawatts), recreation, industrial and municipal water supply. Other benefits include river flow regulation and flood control. The project would cost more than a billion dollars to construct today.

The operation of the lake has changed the annual pattern of flow in the South Saskatchewan River below the dam. For example, prior to the creation of Lake Diefenbaker the peak flow generally occurred at Saskatoon in April, June or July when the spring runoff from the foothills, plains or the eastern slopes of the Rocky Mountains reached the city. Low flows occurred during late summer and in the winter. Now, peak flows at Saskatoon often occur during the winter months when the reservoir is being drawn down to generate hydroelectric power and when power demands are highest. The spring runoff is now stored as much as possible in the reservoir which results in peak flows near the power plant capacity of 425 m^3/s during the winter, flows occasionally in excess of this in spring and low flows,



South Saskatchewan River Basin

sometimes falling to the minimum desirable flow of 43 m^3/s, in the summer and early fall.

During the operational history of the reservoir spillway overflows have occurred four times. On these occasions the annual peak flow at Saskatoon was the result of the spill. This will be the case whenever spills occur. Spills will most often take place during June or July. Lake Diefenbaker is not operated as a flood control reservoir but normal operations have a significant effect on the peak flows that reach Saskatoon during high flow years.

Lake Diefenbaker has become the focus for development in the Saskatchewan portion of the basin. As an example, in 1986, Canada and Saskatchewan signed a five year, $100 million irrigation development agreement which led to sizable development around the lake. While further developments were being considered in both Alberta and Saskatchewan, several drought years in the 1980s occurred. These droughts caused increased water demand, reduced supply and increased concern about the possible impacts on Lake Diefenbaker to support this continued development. The importance of the water in the basin to existing and potential future users was needed. Also, in 1984, the province of Alberta developed a strategy for the use and management of water in its portion of the basin through its South Saskatchewan River Basin Planning Program.

The Canada-Saskatchewan South Saskatchewan River Basin Study was the result of the concern for future uses and was undertaken to provide the information required to guide water management. The end result of the Study was to ensure the water resources of the basin would meet the needs of existing and future users.

The five year, $1.6 million study agreement was signed in May 1986, was shared equally between SaskWater and Environment Canada (represented by IWD). The Agreement identified three objectives for the study:

i document the current and emerging water and related issues in the South Saskatchewan River Basin in Saskatchewan;

ii carry out an assessment of the water and related issues of the South Saskatchewan River Basin and their current and future uses; and

iii develop a framework for the conservation and management of the waters in the South Saskatchewan River Basin in Saskatchewan which allows for the evaluation of water resources projects.

The study results were released in August 1991 and documented in a series of reports including a final report supported by seven technical appendices: Issues Documentation, Water Quantity, Water Quality, Water Use, Environment, Water Management and The Framework Plan. The appendices were based on detailed studies reported in more than 60 technical reports.

The first objective, the identification of current and emerging issues, involved extensive public consultation, and a wide range of specific and common issues were identified. These involved water quantity, water quality, drought effects, health of the environment diversion, water supply and land management.

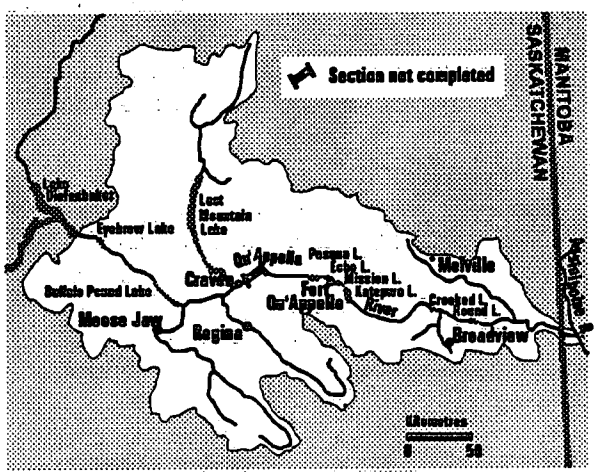
The second objective involved the assessment of the water and related resources from four different perspectives: water quantity, water quality, water use and the environment. Development of the framework plan, the third study objective, had three components: development of management strategies, provision of a consistent way of evaluating water resource development proposals and an implementation plan based on a cooperative multi-agency approach to ensure basin management strategies were adapted and that the project evaluation procedures were maintained and used. Each strategy was addressed from a short term and long term planning perspective. Based on the planning exercise, 15 recommendations were developed,

organized into three groups: public involvement, water management and research. These recommendations were assigned to agencies according to their respective responsibilities.

Since release of the study recommendations in August, 1991, considerable progress has been achieved in implementing the recommendations. For example, a public information newsletter is being developed to assist the public in understanding the water management issues in the basin and to seek their input. A water conservation strategy is being developed, particularly for those parts of the basin where water shortages are most prevalent. The Prairie Provinces Water Board has implemented the water quality objectives established by the study and the water quality monitoring results from the study to determine nutrient objectives for the South Saskatchewan River at the Alberta-Saskatchewan boundary. Several municipalities are constructing regional water supply systems as recommended in the study.

Qu'Appelle River Basin

The Qu'Appelle River basin covers an area of more than 50 000 square kilometres in Saskatchewan. The meandering Qu'Appelle River, a major tributary of the Assiniboine River in Manitoba, links seven major recreational lakes and provides a source of domestic and industrial water to several communities.



Qu'Appelle River Basin

The Qu'Appelle River under natural conditions, like most prairie rivers, is an intermittent stream with runoff from snowmelt as its major source of flow. Extreme yearly and seasonal variations in water supply have historically given rise to cycles of flood and drought in the valley. As a result, water management in this interprovincial prairie basin poses a challenge.

Under the Canada Water Act, the 1975-84 Canada-Saskatchewan Subsidiary Agreement on the Qu'Appelle Valley the channel capacity was increased between Last Mountain Lake and the Saskatchewan-Manitoba boundary. The increased maximum channel capacity can convey greater volumes of water through the Qu'Appelle system without flooding valuable valley land. The 1976 Saskatchewan Department of the Environment report "The Qu'Appelle Conveyance Study" estimated flood damage reduction benefits of $1.74 million. Work was also done on control structures at the outlet of several lakes to stabilize the lake levels to improve recreational benefits and fish habitat. By the 1984 expiration of the Agreement, only 40 percent of the conveyance improvement work was complete.

In 1984, IWD and the Saskatchewan Water Corporation signed a five year, equally cost shared $4.8 million Canada-Saskatchewan Qu'Appelle Conveyance Agreement to complete the remaining channel improvements and to mitigate pike and walleye habitat losses due to the reduced frequency of normal flooding cycles. Under this Agreement, and a subsequent $0.55 million Agreement Extension to March 31, 1992, fish nursery facilities were completed in 1992 and another 30 percent of the conveyance work. The channel modifications were not completed because the province was unable to secure agreements with valley farmers for rights-of-way and for compensation from lost irrigation opportunities. A future agreement will be required to complete the remaining 30 percent of the channel modifications to further reduce potential flood damages.

The completion of the pike and walleye fish mitigation works has sustained sport fishing in

the Qu'Appelle lakes. Sport fishing brings an estimated $9 million into the basin annually and accounts for an annual average of 300 000 angling days. Recreational anglers will experience no reduction in angling success because the fish nursery facilities constructed under the Agreement will replace the reduced pike and walleye spawning success lost through habitat and flood frequency and duration changes.

Completion of channel construction work will make it possible to exercise greater flexibility in Qu'Appelle River Basin control options. Water can be conveyed through the Qu'Appelle system, from Craven to the Saskatchewan-Manitoba boundary, at three times the rate as previously, without flooding some 6000 ha of valuable farmland. A decreased risk of flooding benefits the residents of the two Indian reservations, Piapot and Muskowpetung, as well as some thirty private landowners by reducing losses from flooding of hay lands and buildings.

A new control structure constructed at the outlet of Katepwa Lake, last of the chain of Fishing Lakes, and improvements made to the outlet structures at Crooked and Round lakes, provide better control of lake levels to the benefit of over 2000 cottagers and an estimated 320 000 days of recreational lake users annually.

In addition, enhanced Qu'Appelle River Basin management will benefit basin residents by providing an assured water supply of a suitable quality and at a sufficient rate to meet water demands for municipal, agriculture, and industrial uses; making possible a reasonable drawdown rate for Last Mountain Lake in order to use the lake as a flood storage reservoir to protect downstream valley residents.

Increased basin operating efficiency also ensures that Saskatchewan's commitment to Manitoba under the terms of the Prairie Provinces Water Board Master Agreement on Apportionment will not be jeopardized by the inability to convey required quantities of water to Manitoba without flooding Qu'Appelle Valley agricultural land. On the average, Qu'Appelle water accounts for 40% of the annual flow of the Assiniboine River below the confluence of the two rivers. The Qu'Appelle, therefore, provides a proportion of the water supply for municipal, agricultural, and industrial uses in southern Manitoba, including cooling water for the Brandon, Manitoba thermal power plant.

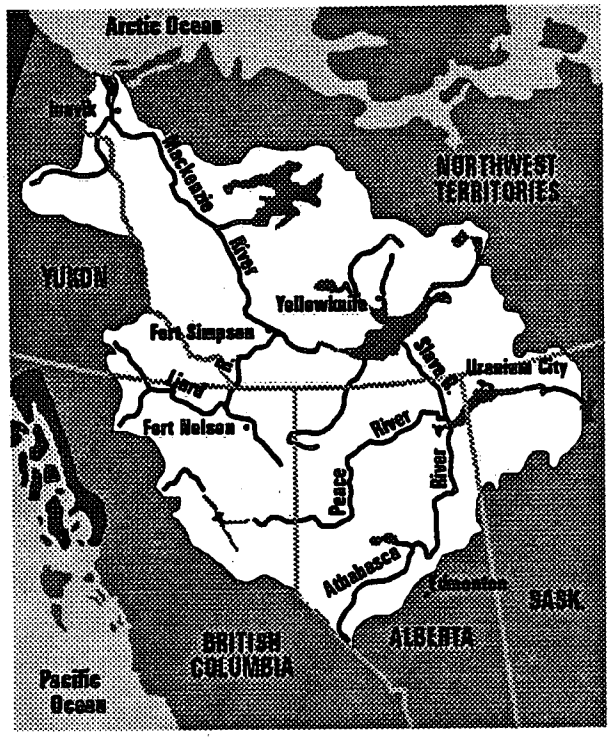
Since the Qu'Appelle River is an interprovincial river flowing from Saskatchewan to Manitoba the flows are apportioned between the provinces according to the PPWB Master Agreement of which Canada is a signatory. IWD monitors the streamflow and water levels at 21 locations to ensure compliance with the Agreement and to provide information for water management and flood forecasting. Approximately 30% of Saskatchewan's population lives in the basin and rely on the water resource for agriculture, municipal supply, and recreation.

Mackenzie River Basin

The Mackenzie River Basin is one of the world's great river systems and the Mackenzie River itself is the largest and longest in Canada. The basin encompasses portions of British Columbia, Alberta, Saskatchewan, Northwest Territories and Yukon.

Unlike most great rivers, where development starts at the mouth and proceeds upstream development in the Mackenzie Basin started upstream in British Columbia and Alberta where most of the basin's population is concentrated. The Mackenzie is also unique in terms of the number and nature of jurisdictions it encompasses, and the dramatic social, economic and cultural differences which exist between various parts of the basin.

The area south of 60^{0}, in British Columbia, Alberta and Saskatchewan, is part of the modern industrial economies of the provinces with economic activity centred around large scale hydroelectric development, oil and gas, mining and pulp mills. By contrast, the downstream part of the basin in Northwest Territories is characterized by a sparse population and traditional lifestyles dependent on the



Mackenzie River Basin

maintenance of a pristine river system and the fish and wildlife it supports. Because development started and remains concentrated upstream, this downstream part is subject to the cumulative effects of all upstream development.

The jurisdictions are also unique. Three provinces with constitutional powers over most aspects of water resources. Two territorial governments in the middle of the process of devolution with the federal government though Indian and Northern Affairs Canada (INAC) still the resource owner. The process of Aboriginal land claims and self government is also at various stages throughout the basin and Treaty 8 straddles all five political jurisdictions.

- **Mackenzie River Basin Committee**

To ensure that a coordinated and cooperative approach was taken by the responsible jurisdictions, for the management of the water resources within the Mackenzie River Basin, the Mackenzie River Basin Committee (MRBC) was established in April 1972. The MRBC is an intergovernmental body appointed by the Ministers of B.C., Alberta, Saskatchewan, the GNWT, the Yukon, INAC and Environment Canada. The MRBC provides for ongoing information exchange on water resource matters and on developments in one jurisdiction which may affect another. Since 1988 the MRBC has been working on a Master Cooperative Water Management Agreement for the basin. The Agreement addresses water management issues such as minimum flows, flow regulation and water quality, at jurisdictional boundary crossing points and the overall preservation of the integrity of the aquatic ecosystem of the basin. When signed a permanent board will be established to implement the Agreement. The agreement contains guiding principles for cooperative water management between the jurisdictions and a dispute resolution mechanism. The specific obligations of one jurisdiction to another are contained in seven bilateral subagreements between adjacent jurisdictions to be appended to the Master Agreement.

This agreement has been extremely difficult to negotiate due to the vastly different interests and needs of each of the parties and due to the special interests and status of First Nations. The potential for conflict and litigation is high in this basin for these reasons. What has kept the process going is the belief that the known terms of a negotiated agreement are preferable to the uncertainty and experience of litigation.

The Committee has completed a draft agreement acceptable at the officials level which has also been subjected to and influenced by several rounds of public consultation, with significant aboriginal representation. At present, the board to be established by the Agreement would have five Aboriginal members. Further consultation with Treaty 8 is required before the agreement can be forwarded to the Ministers for approval.

IWD has been a key player in the development of the Master Agreement. The Regional Director General, Conservation and Protection, Western and Northern Region represents Environment Canada on the MRBC and IWD provides the permanent secretariat and produces the annual report. Staff of IWD have provided technical

and professional support to the bilateral fact finding committees which develop the bilateral sub-agreements to the Master.

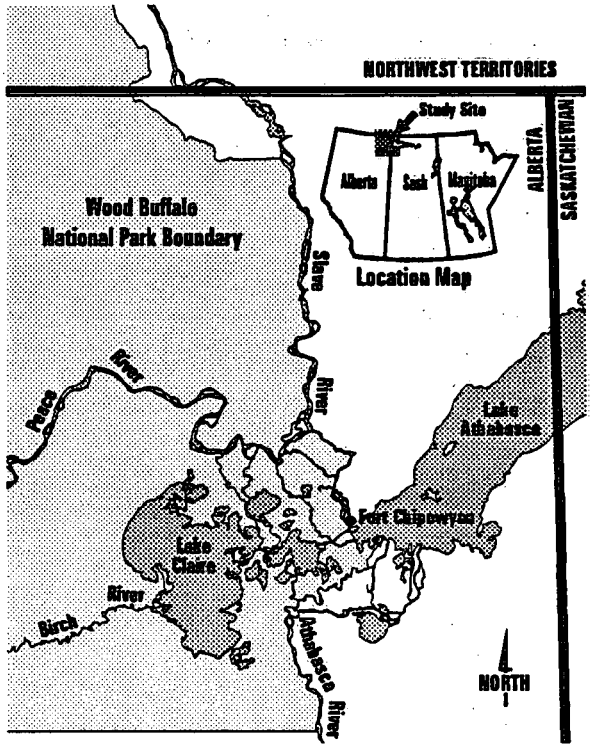
The Secretariat has prepared resource material on the subject of inter-jurisdictional agreements and international and Canadian water law for the committee, coordinated the all-party legal review of the Agreement and a large part of the public consultation process.

The Canada Water Act is the enabling legislation under which Environment Canada would sign the Agreement and the management board would be established. The signing of this important agreement and creation of the Board will provide a mechanism for resolving inter-jurisdictional issues and disputes in the Mackenzie Basin. This goes a long way towards avoiding the expensive and protracted litigation which has characterized inter-jurisdictional river basins in the United States and elsewhere.

- **Peace-Athabasca Delta**

The Peace Athabasca Delta is one of the largest fresh water deltas in the world. The Delta area is extremely flat, and under natural conditions, its headwaters lakes and perched basins are flooded periodically by ice jams on the Peace River. Vegetation of the delta is composed of sedge and grass meadows with lush vegetation in shallow lakes. The large waterfowl staging and nesting areas are critical to the survival of migratory birds. Maintenance of unrestricted channel conditions is vital to the migration and spawning of fish. Hunting and trapping by local residents depend upon the productivity of the natural ecosystem.

The construction and use of the Williston Reservoir on the Peace River by British Columbia for hydro electric power generation since 1967 has resulted in a large change to the river's hydrologic regime. Flood frequency along the Peace River has been reduced. Higher winter flows caused by releases for hydro production has reduced the frequency of ice jams in the lower Peace River. Ice jamming no longer has its natural major influence in



Peace-Athabasca Delta

directing flood water of the Peace River into the northern reaches of the Peace Athabasca Delta. This lack of water has changed the ecosystem of the region. The area of surface water has been reduced and the type and extent of vegetation has changed. Vegetation critical to the animals in the delta has decreased by over 45 percent and further reductions are predicted. These changes have also affected Wood Buffalo National Park. The decline in the numbers of ducks and muskrats has resulted in a decline in economic activity for the people living in the area.

In September 1974, the Governments of Canada, Alberta and Saskatchewan agreed to construct remedial works in the Peace-Athabasca Delta to partially restore water levels adversely affected by the W.A.C. Bennett Dam in British Columbia. The agreement called for the establishment of the Peace-Athabasca Delta Implementation Committee (PADIC) to oversee construction of the works and to monitor the effects of the restoration efforts on the delta ecosystem. The Committee was directed to

report on the results to the Ministers representing the parties to the agreement.

IWD and Parks Canada were members on the Implementation Committee (Canadian Wildlife Service was an advisor). IWD, in cooperation with Alberta Environmental Protection, operated the hydrometric network needed for the hydrodynamic modelling of water levels, did the hydrodynamic modelling of the Delta water levels, and provided scientific expertise.

The PADIC, in its final report to the ministers on April, 1987, made the following recommendations:

i The network of hydrometric stations necessary to supply data to the hydrodynamic computer model of the Peace-Athabasca Delta should be operated.

A sound hydrometric data base is a prerequisite for any engineering, ecological or social research programs related to water levels on the delta. Hydrometric data are required for input to the hydrodynamic model. The results of the model are needed for biological studies, analyses of natural hydrologic occurrences, such as the Cree Creek breakthrough, and consideration of remedial measures.

ii A long-term biological monitoring program which focuses on vegetation responses to water levels should be implemented.

Previous biological monitoring programs described relationships among water levels, vegetation communities and wildlife populations of the Peace-Athabasca Delta. A longer-term biological monitoring program for the delta is required to evaluate changes in the major habitat types, as they relate to water levels.

iii A sampling program to document the age structure of the delta goldeye population should be undertaken.

Analyses suggest that the weirs may have blocked goldeye spawning migrations in some years. Data are required to determine if this has affected the goldeye population of the delta and whether a fishway should be built at the Riviere des Rochers weir.

iv The growth of Cree Creek should be monitored. The diversion of water from the Athabasca River drainage basin through Cree Creek to lakes Claire and Manawi would affect the hydrology and ecology of the delta. The size and rate of growth of the Cree Creek breakthrough are needed for the hydrodynamic model, for biological studies and for consideration of remedial measures.

Subsequent to termination of the PADIC, an historical flood occurred on the Peace River in 1990. The flood did not recharge the perched basins which are vital to the health of the Delta. This event emphasized the importance of ice jams as the natural means of periodically recharging the Delta lakes and their perched basins with water.

Parks Canada took the initiative in re-activating activities in the Delta. In April, 1993 a Memorandum of Understanding (MOU) was signed by Environment Canada, B.C. Hydro and Power Authority, Alberta Environmental Protection (AEP), the Mikisew Cree First Nation, the Athabasca Chipewyan Band and the Fort Chipewyan Metis Association. The $1 million MOU does not include internal costs for the hydrometric network and hydrodynamic modelling, which are borne by IWD and AEP. The Ecosystem Plan under the MOU has fourteen individual projects and is scheduled for completion by March 31, 1996.

In 1993-94 dollars, the IWD share of the hydrometric network required to support the hydrodynamic model has been $64 000 annually. Estimates for the hydrodynamic modelling, conducted by IWD, Ottawa, for the PADIC would be in excess of $100 000. An estimate for the hydrodynamic modelling costs for the current MOU would be $50 000. In

addition to these fixed costs, IWD and CWS had expenditures for management and scientific advice.

Various weirs have been placed on the outlet channels from the delta in an effort to return the hydrologic regime closer to its natural state of water levels within the delta with some margin of success. However, further remedial measures are needed to result in high spring water levels in the headwaters lakes of the Peace Athabasca Delta. The Inland Waters Directorate will continue to monitor levels and flows which will be used in computer modelling of the delta and the interconnected river systems not only to simulate the historical natural flows and levels within the delta, together with the levels resulting form the weirs but also to account for the changing delta conditions caused by the continuing erosion of Cree Creek. Further remedial works will be investigated by authorities from Wood Buffalo National Park, Alberta and federal agencies, and local individuals and interest groups in an effort to restore the aquatic based ecosystem of the Peace. Proposals for remedial works will be computer simulated to evaluate the hydrologic changes that are so critical to the major migratory bird pathway across North America. The life of the local aboriginal people is entirely founded on hunting and trapping within the delta. The continuance of the life style of these people depends directly on the success of this work.

- **Northern River Basins Study**

Development of the multi-billion dollar forest industry has emerged as a major economic pursuit in the Province of Alberta. Proponents have exalted the social benefits of increased employment in areas of traditionally high unemployment as well as strengthening the provincial economy. Two characteristics of the industry, that of cutting large tracks of forests and of processing (milling and pulping) timber have come into direct conflict with traditional peoples who live off the land and water, and the biological resources which these support, within Alberta and the Northwest Territories.

In 1989, Alberta and Canada established an environmental review panel to examine the environmental issues and make recommendations concerning the potential impacts of the proposed Alberta-Pacific Forest Industries Inc. Pulp Mill for the County of Athabasca #12. In its 1990 report, the panel noted several deficiencies in our understanding of impacts of pulp and paper mills and in particular, the cumulative environmental effects of multiple developments.

Officials from the governments of Canada, Alberta and the Northwest Territories and aboriginal leaders signed an Agreement on September 27, 1991 to scientifically examine the state of the aquatic resources in the Peace-Athabasca-Slave River Basins and the cumulative effect of industrial, agricultural and municipal development. The Northern River Basins Study, originally an $12.3 million Green Plan initiative, was reduced to $11.38 million as a result of the December 1992 Federal Economic Statement. The Study officially started in late 1991. The Study focuses on contaminants from pulp and paper mills, municipalities and other industrial sources, the effects of flow regulation, and the determination of cumulative effects of developments.

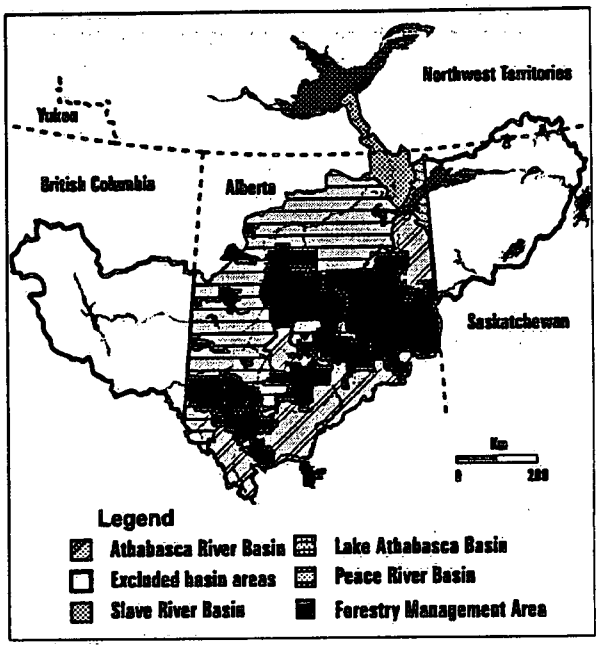
The Northern River Basins Study is a flagship ecosystem initiative within the WNR that directly addresses Canada's Green Plan. In addition to being one of the Green Plan deliverables, it is delivering upon citizenship involvement, partnerships, sustainable development philosophies, and applying ecosystem perspectives. People in the basin are taking responsibility, through the Study Board, for making better decisions about the protection of their environment. Long term (future generations) versus short term gains are prominent in the minds of the traditional people.

Advocating an ecosystem approach, a 25-member Study Board has placed the sustainability of the environment at the centre of its vision for the Study area. The multi-stakeholder Board represents the federal, provincial, and municipal governments,

industry, indian bands, environmental groups, and the general public. The Board has developed sixteen questions to guide the Study. Fourteen of these are scientific. The members have worked together to define a common vision and mission; involving local communities in the study and integrating local traditional knowledge with scientific investigations. An independent science advisory committee and eight study components are established to oversee and conduct the investigations.

Conservation and Protection has made a major four and one-half year commitment to co-chairing the Study Board (C&P WNR Regional Director General), directing the science program (two C&P WNR science managers), conducting monitoring and research (as many as twelve C&P scientists), and interpreting results. Scientists from the IWD, CWS and EP and from the National Water Research Institute and the National Hydrology Research Institute have brought their expertise to the Study. Through its involvement with the Study, C&P is developing and testing new technologies which help provide future tools relating to: cumulative effects, information management, education, computer assisted communications, effects of contaminants on the food chain, nutrient enrichment, predictive models, taste and odour control for drinking water, and ecosystem indicators for assessing ecosystem health.

The Study is a social experiment bringing diverse interest groups to the same table with empowerment over the direction of the Study and expenditures. Societal groups are strongly represented and must work hand-in-hand with industry. They, collectively, will have to define the boundaries for what is acceptable for the ecosystem on one hand, and for economic growth on the other. The Study is focusing on environment-economy relationships and will attempt to determine ecosystem (including society) values and goals against which development will be measured in the future. Traditional people are integral to the Study and new relationships will be forged for cooperation in managing the ecosystems.



Northern River Basins Study - Alberta Forestry Management Areas

In its twentieth month of study (June 1993), scientific findings are now beginning to be reported. Twenty reports, five volumes of contaminants data, and several bulletins and newsletters have been released to the public. The gap between scientists and the public is already narrowing as measured by the expressed confidence of the people, at two science forums, eight community gatherings, and many Board and committee meetings; and, by the parity achieved between seven bio-physical science study components and a Traditional Knowledge Study Component.

The long term water resource management challenges for the basins will be met with a more informed and involved community throughout the basins and new long lasting partnerships. Results from the Study have the potential to dictate how the forestry industry will evolve in northern Alberta while safeguarding the integrity of the ecosystems upon which humans rely. The Study will recommend alternatives for basin-wide ecosystem management and regulations for improved control of industrial and municipal effluents. At stake are: the safety of drinking water supplies for 140 000 people; the health of

indian and other people whose subsistence depends on good quality drinking water and healthy populations of fish, waterfowl, fur bearers, and other game; the diversity and integrity of terrestrial and aquatic ecosystems in Wood Buffalo National Park and the Peace-Athabasca-Slave delta and other locations in the basins; the safety of humans who use the rivers as traditional transportation routes; and, viable (long term) local economies.

7.1.2 Other Partners - ENGO's, Industry, the Public

Churchill River at Sandy Bay, Island Falls Measurement Program, July 23-25, 1985.

The Churchill River, flowing from Saskatchewan to Manitoba, has a great economic importance to both provinces for hydro power generation. The water is worth literally millions of dollars! This factor together with the need under the PPWB Master Agreement to share the flow on the river between the two provinces means accurate flow data is crucial.

Flow information on the Churchill River at Island Falls represents one of the longest hydrometric records in Saskatchewan. However, until IWD installed a streamflow gauging station in 1974, the flows were determined by the power utility based on power production and knowledge of the hydraulic characteristics of the structures at the Churchill River Power Company site. The records from the station showed consistently higher flows than determined by the utility.

After several studies by consultants (commissioned by Saskatchewan and Manitoba) and because of the importance of resolving the discrepancy, IWD was contracted by Saskatchewan Power Corporation (SPC) and SNC, a consulting firm, to plan and conduct an intensive measurement program in 1985. The measurement program was carried out in July 1985. A detailed analysis of the measurements confirmed the accuracy of the data from the IWD streamflow gauging station and indicated that SPC should review their method of calculating river flows at the Island Falls Generating Station. The excellent work done by IWD ended a long standing debate between the two provinces on which data to use in apportioning the water.

This is a good example of the IWD's role as a mediator in disputes between the provinces or other jurisdictions. IWD's expertise in collecting water quantity and its professional, unbiased approach has long been recognized in the water resource community.

Atmospheric Environment Service and IWD MOU

The Atmospheric Environment Service (AES) provides weather forecast services to northern communities, shipping and aircraft companies, tourists, other government departments, and the general public. Prior to 1989, AES was dependant on facilities located at communities and only two (2) remote sensing weather stations. Hunters and trappers, tourists (canoeists), exploration companies and government agencies had to conduct business despite poor accuracy of forecasts and unpredictable weather conditions. The safety of people working or travelling in remote areas was reduced, by the absence of a well-distributed network of NWT weather observation stations.

Cooperation with IWD provided AES with access to the W&N Region's well established network of remote water quantity stations equipped with data collection recorders and satellite transmitters. Signing of the AES/IWD agreement in 1989 authorized the co-location and operation of automatic weather stations at selected IWD water monitoring sites. AES provided and installed the required meterological sensors and IWD field staff serviced and maintained equipment during regular field trips. Two NWT sites were installed in 1990, three more in 1991, and two in 1992. In addition, one northern Alberta site is operational, and others are planned for additional NWT sites and in Saskatchewan.

The eight existing AES/IWD remote sites provide real time weather data for use by AES, other government agencies, and the private sector. The information has increased the reliability of weather forecasts, particularly in the Keewatin and Central Arctic, and improved the reliability and reduced air charter costs for government, exploration, and tourist agencies. IWD has saved an estimated $20 000 annually in the NWT, by using information on weather conditions to schedule trips to periods of greater safety and more reliable site access.

Integrated NWT Environmental Monitoring

IWD has strengthened existing partnerships and forging new ones throughout the past seven years. Partnerships with Canadian Coast Guard (Mackenzie River Forecast MOU, 1991-), AES (operation of weather stations in remote sites, 1989-), and Public Works Canada (data for river dredging evaluations, 1988-), and IWD research institutes (research on small watersheds and contaminants, 1992-) have been put on a longer-term, more formal financial and administrative footing.

IWD, the Canadian Wildlife Service (CWS) and Parks Canada have also discussed joint monitoring of waterfowl nesting areas, bird sanctuaries, and existing and proposed parks, to define relationships between hydrology and wildlife populations, support operation of parks, and characterize local environmental conditions. The cooperative monitoring efforts offer more effective use of staff and financial resources in remote areas, to address specific or general environmental issues and problems. Joint future efforts are currently being considered for the proposed Wager Bay national park, and the Arctic Islands (Banks, Baffin, and Ellesmere).

7.2 Environmental Information: Key to Decision-Making

The Green Plan stated that to make Canada environmentally friendly, individual Canadians must know how they affect the environment and what they can do to lessen their impact.

A healthy environment will help foster a strong economy.

C&P has informed the public on the environment directly through mailing and public displays or through support of national campaigns or other organizations. IWD supported financially and with personnel major efforts such as National Wildlife Week, Environment Week and the CWRA national conference "Waterscapes". Regional conferences and workshops were also supported including provincial chapters of the Canadian Water Resources Association (conference on erosion and a proposal for water resource education materials), Soil and Water Conservation Society (staff support and conference presentations), and the Canadian Water and Waste Water Association and the Water Studies Institute. IWD, continues to distribute environmental information to the public by participating in various public events and programs. In 1992, IWD, participated in the Agri-Mex '92 in North Battleford, Earth Day (April 22) Public Display, Environment Week Activities and National Wildlife Week. The Regina National Wildlife Week Committee organized a Wildlife Festival, geared towards families, which included puppets, music, talks, workshops and displays to promote environmental awareness. IWD, also cooperated with Industry, Trade and Technology on investigating the potential for ecotourism in Saskatchewan. IWD, also committed funds and advise for a television series on water efficient landscaping.

The effectiveness of our programs in changing public attitudes and perceptions about the environment is difficult to measure. For example, providing environmental information to the public through workshops, conferences and environmental events may only be an index of our effectiveness, particularly if a post-event questionnaire assessment is not undertaken. Changes in consumer habits, such as water conservation, may be attributed to advertising campaigns in addition to the environmental messages provided by the department. This is one area which is being addressed.

7.2.1 State of Environment Reporting

When the Canadian Environmental Protection Act was passed in 1988, it became a legislated requirement for the Government of Canada to provide information to the people of Canada on the state of the Canadian environment. As part of this mandate, the department released the Second National State of the Environment Report in April, 1991. This report was widely distributed and has been favourably received by environmental groups. IWD staff prepared the chapter on Prairie Grasslands, with the collaboration of other components of Environment Canada. This publication has become a standard reference document at universities and at many secondary and post-secondary schools.

IWD data and information have also been widely used by Manitoba and Saskatchewan in the preparation of their State of the Environment reports released in 1990.

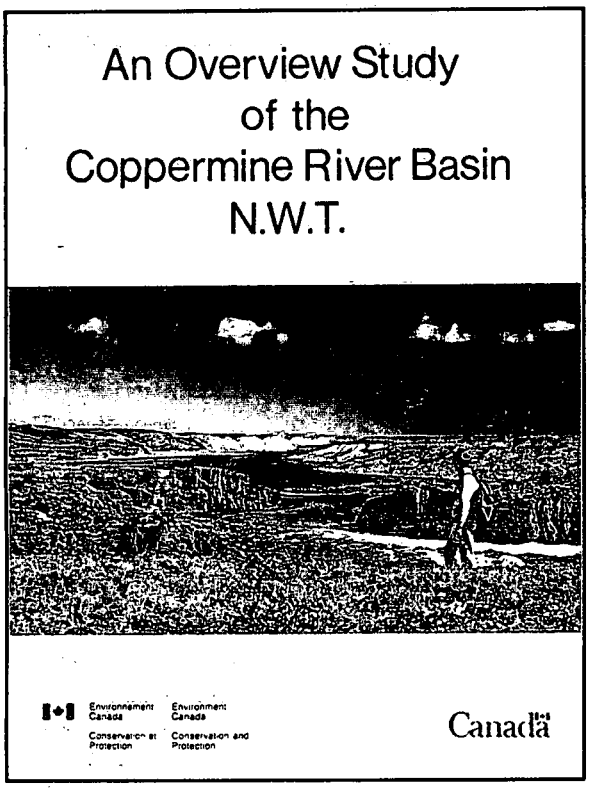
7.2.2 NWT River Basin Overview Reports

Knowledge of environmental conditions is quite limited for much of the NWT, because people are concentrated in a few communities, road access is limited, and travel costs are high. IWD is one of the few agencies that regularly visits remote locations to collect environmental information. Besides traditional engineering and water management applications (design, construction, and operation of water-related structures for about 800 km of roads, 61 communities, 5 mines, 5 hydro-power plants, etc.), information from IWD is also of interest to the growing northern tourism and recreation industry (1992 value estimated at $88 million).

IWD began producing overviews on the NWT's water resources in 1984, to provide summaries of available information on water quantity, quality, and water use. Reports completed to date include the Hay (1984), Coppermine (1988), and Yellowknife (1990) rivers. The Hay River overview was completed to support transboundary water management negotiations between Alberta and the NWT. The Coppermine River overview summarized information for canoeists, hydro-power, community, and mining interests. The Yellowknife River overview provides information useful for resolving competing basin interests by the City of Yellowknife (municipal water supply), cottagers, boaters campers and sports fishermen, recreational users, mining, and resource managers. A South Nahanni River basin overview (a popular NWT canoeing destination and national park) is currently being prepared, and planning has commenced for a joint IWD, Parks Canada and INAC overview on the watershed containing the proposed Wager Bay National Park.

Basin overviews have been well received by the public, recreation and tourism sectors, because of their attractive, informative, easy to read format. Parks Canada, INAC, and various GNWT departments (Economic Development and Tourism, Renewable Resources, etc.) have used overviews to support decisions, and promote or inform themselves and their clients on the environment. Reports have supported park proposals and planning (Nahanni and Wager Bay national parks, Yellowknife River/Ingraham Trail land management planning, etc.), mini-hydropower evaluations, and other uses. Mineral exploration companies and consultants involved with the 1992/93 NWT diamond exploration rush (expenditures estimated at $40-$50 million) have also made extensive use of information in Coppermine and Yellowknife river basin overviews.

The cost of overview reports has ranged widely, depending on the amount of information already available. Where no new information is required (the Hay and South Nahanni rivers), costs include 4 to 6 months of staff time, plus $5 000 to $10 000 for report production, printing, and distribution. For areas where additional information is required to broaden the scope of information available (Coppermine and Yellowknife rivers), up to $60 000 has been spent to obtain additional environmental information.



IWD has received requests for similar basin overview reports for other NWT rivers, to support a variety of interests. Requests include: the Thomsen River for Banks Island park, waterfowl and muskox population studies; Back, Kazan, and Thelon rivers for recreation and tourism; Peel River for NWT-Yukon transboundary waters negotiations; and Arctic Red and other mountain rivers for heritage river and/or wild river canoeing interests. Perhaps the greatest internal benefit from overview reports is their marketing value for little known, and poorly appreciated, environmental monitoring programs and information of the IWD.

7.2.3 Assiniboine River Basin Sediment Study

A comprehensive analysis of sediment data in the Assiniboine River Basin was completed by consultant Dr. P. Ashmore. The analysis includes an assessment of the existing data base with respect to; concentration, load, yield, routing, data coverage and adequacy. The study also evaluates other data bases of use in interpreting the sediment regime, particularly hydrology, land use, soils, surficial geology and geomorphology. While the former serves to characterize the sediment regime, the latter takes an ecosystem approach to evaluate the information content of the data base.

The result of the work has been to advance the scientific knowledge of sediment processes in the basin of relevance to fisheries, water quality, sedimentation, and land use practices. The study also provides an assessment of the adequacy of the sediment network and the operation, with the result that one station was discontinued.

7.3 Environmental Citizenship

Environmental Citizenship is a departmental priority and is the key to the success of the Green Plan. IWD upholds this initiative and has incorporated citizenship as a key element in its program design and delivery, as clearly demonstrated throughout this report, by providing data, information and advice on a wide range of topics and developing partnerships with both government departments and private agencies.

The following lists highlights of other projects and activities of IWD in this area:

7.3.1 Environmental Partners Fund (EPF)

In the NWT, Green Plan efforts to protect the environment and clean up wastes has been split between the Environmental Partners Fund and INAC's Environmental Action Program. Due to it's maximum project funding limit of $200 000, the Environmental Partners Fund has generally attracted proposals for larger projects. INAC's Environmental Action Program (EAP), with a $10 000 limit, has dealt with smaller projects.

Since the EPF was announced in June 1991, twenty-three applications have been received for $1.3 million worth of NWT projects. IWD has participated in the screening of all NWT projects and chaired the NWT EPF Screening Committee in 1991/92. EPF has contributed $193 623 towards the $422 984 spent on ten approved NWT projects. The EPF has supported outpost camp and community cleanups (Garry

Lake, Hall Beach, Diana River/Rankin Inlet, Mary River, Trout Lake, and Fort Good Hope), establishment of a recycling depot in Yellowknife, and provision of reusable diaper services in Arctic Bay.

In the same period of time, INAC's EAP has attracted about 240 applications (about 50 every six months), and provided $571 135 of funding to the 170 projects approved. Small scale cleanups, environmental education, and development of nature trails and other environmental awareness facilities have accounted for the majority of EAP projects.

7.3.2 Water Conservation

Water shortages have occurred frequently in small prairie communities and in rural households, causing local economic losses and social problems. These water shortages are caused by over demand of existing supply sources, poor design of wells and reservoirs, usually severe drought or lack of an adequate source of water. In larger communities, water shortages build over a number of years as demands on the existing supply infrastructure increase through population growth and increasing per capita use. Since governments subsidize the cost of infrastructure, expanding the water supply puts an increasing burden on the local, provincial and federal taxpayer. Water conservation is one method to reduce the demand on the water supply system, thereby increasing the life of the existing system and freeing up money for other uses. In the Prairie Provinces, reducing water demands also has environmental benefits by lowering water withdrawals from streams and aquifers and reducing wastewater discharges.

Realistic water pricing, appliance replacement or retrofit, and education are three common methods to encourage water conservation. One of the two goals of the 1987 Federal Water Policy was to acknowledge the real value of water and call for the wise and efficient management and use of the resource. Canada's Green Plan calls for the use of economic instruments to include environmental costs and for better environmental education to create an environmentally educated population.

In order to advance the aims of environmental citizenship in the water conservation area, IWD actively sought strategic partnerships with business and industry, municipalities, professional associations and the voluntary sector. A Water Conservation Workshop held in May, 1991 in cooperation with the Saskatchewan Institute of Applied Science and Technology was the catalyst for water conservation in the prairie region.

Representatives from Saskatchewan municipalities, provincial agencies and industry attended while the speakers came from Middleton, N. S., Waterloo, Ontario, Regina, Saskatchewan, Vancouver, B. C., the provinces of Alberta and Ontario and Environment Canada. The workshop participants included some of the leading water conservation authorities in the prairie provinces. IWD, also assisted the University of Saskatchewan Extension Department and the City of Regina with their Xeriscape Conference which was aimed at municipal officials, grounds keepers and landscape architects.

Informational talks on water conservation have been also given over the past 4 years to various groups that include schools (3), university extension courses (2), women's groups (2), open forums (2), the Saskatchewan Conservation Educators Network in Moose Jaw, the University of Lethbridge (geography department, mechanical department), University of Regina (education dept.), towns of Okotoks, Cochrane, Hanna and Banff in Alberta, Assinboia, Avonlea and Gravelbourg in Saskatchewan, Morris and Gimli in Manitoba, the Alberta Water Resources Commission. Briefs on water conservation were given to the City of Regina, IWD, staff judged for the Regina Home Builders Association "Woody Awards" for building excellence, including environmental areas. IWD, staff also appeared on CTV Regina, at the request of the City of Regina, and on CBC Radio, Winnipeg to

promote water conservation. Media interviews (2) and university faculties (2).

Water conservation is also being pursued in other regions and by the federal government to "get our own house in order". Water conservation is included in the C-2000 program of Energy, Mines and Resources and in programs of Agriculture Canada. The Provinces of Alberta, Saskatchewan and Manitoba have included water conservation in recent statements on sustainable development.

These discussions, especially the May 1991 Moose Jaw Workshop, resulted in the development of a water conservation pilot project by IWD and the town of Morris, Manitoba, in cooperation with Agriculture Canada and the province of Manitoba. The intent of the pilot project is to provide tangible evidence of the economic benefits to the community of water conservation and appropriate water pricing, as a starting point to encourage other small Prairie communities to institute water conservation. Preliminary results suggest that the residents of Morris may realize annual water and energy savings of $70 to $140 per household and that expansion of the water treatment system can be delayed for up to 17 years at an annual savings of $235 000. The Morris case study highlighted local economic benefits to the taxpayer and will be promoted to municipal officials in other prairie communities.

Three Saskatchewan towns, Assinboia, Gravelbourg and Avonlea, also began water conservation programs after the 1991 workshop. These programs, led by Agriculture Canada (PFRA), resulted in water use reductions up to 25 percent. The extra capacity in Avonlea allowed the town to supply domestic water via pipeline to area farmers. The reduced water use in Assinboia allowed the water supply system to meet demands during the recent drought conditions without large expenditures for new wells or regional pipelines.

IWD has a good working relationship with the water conservation sections of Alberta Environmental Protection and Alberta Agriculture. IWD was invited to explain water conservation at the Water Education Institute program put on by the Friends of Environmental Education Society of Alberta (FEESA). IWD also informally met with officials of Calgary, Edmonton, Banff, Cochrane and Lethbridge. The Cochrane, Alberta water conservation program is a case study to show the savings for wastewater treatment.

In 1990, the federal government spent in excess of $12 million on water and sewer charges in the National Capital Region. The Interdepartmental Advisory Group on Water Conservation at Federal Facilities (WCFF) was started by Environment Canada to reduce water costs to suit the new, fixed budgets. Through the WCFF, IWD made contact with the departments of Public Works, Agriculture, Corrections, Defence, Indian and Northern Affairs and Transport to hold water audits and information sessions at federal facilities within the region. A water conservation and treated water replacement program to produce budget savings is now underway at the Prince Albert Correctional Centre. The Regina airport is undertaking an energy audit, including water savings to reduce airport building costs.

Environment Canada was instrumental in organizing "Every Drop Counts: Canada's First National Conference and Trade Show on Water Conservation" at Winnipeg on February 4-6, 1993. This national conference promoted and enhanced public awareness of water conservation, from decision makers in business and to the community level. This conference also brought together those people involved in conservation programs to discuss those programs that are successful. IWD provided staff for the registration and information desks, led workshops and acted as rapporteurs, and provided a catalogue of public information materials on water conservation. In summary, the net gains from the conservation initiative has been decreased water use both in the public and private sectors.

7.3.3 Information Products

Client surveys have indicated that water data and information would be of much greater use if it could be obtained in a more summarized and non-technical format. To meet this demand, IWD has a series of projects which include:

Fact Sheets

- **Hydrological/Morphological Studies**

Hydraulic and morphologic surveys are designed to make better use of existing hydrometric data, to expand our understanding of gauge sites and to study large scale river morphologies. These studies and the increased Branch expertise in river studies will be important to clients and to the Department's responsibilities for environmental impact assessment. The information displayed in the fact sheet defines the character of a specific river reach with respect to water transport, hydraulic resistance, channel and basin geometry, and bed stability. This information is important for technical and management decisions in the design, construction and evaluation of engineering and environmental projects.

Hydrological and morphological fact sheets have not been produced for Alberta since IWD has been involved in a similar program of the Alberta Research Program since the 1960s. The Alberta Research Council program has produced informational sheets for most of the province. IWD has produced hydrological fact sheets, which contain statistical interpretations of the streamflow data, such as flow duration curves, low and high flow frequencies and hydrograph interpretations, and hydraulic parameters of the gauging site, and sediment station analysis reports, which contain the information of the fact sheets plus a compilation and interpretations of sediment data. Hydrologic Fact sheets are available for:

1) Crowsnest River at Frank
2) Pincher Creek at Pincher Creek
3) Lee Creek at Cardston
4) Waterton River at Waterton Park.

Since 1989, IWD five hydraulic and morphologic fact sheets have been published in the Saskatchewan District and one in Manitoba.

Saskatchewan:

1) Qu'Appelle River Below Loon Creek
2) Qu'Appelle River Below Craven Dam
3) Beaver River Near Domtosh
4) Qu'Appelle River Near Welby
5) McDonald Creek Near McCord

Manitoba:

1) Red River at Emerson

The information contained has proved valuable to public, private, research, educational and consulting institutions in making technical and managerial decisions in the design, construction and evaluation of environmental and engineering projects.

From the very positive feedback, the IWD project will be continued and expanded to include all the Region. Future sites will be selected based on the results of client surveys.

- **Mackenzie River Forecast**

IWD-NWT's first NWT Fact Sheet provides a summary of the procedures, products, and uses for the public water level forecast, prepared daily by IWD since 1963 during the open water navigation period on the Mackenzie River. The Fact Sheet was distributed widely within the river transportation industry, to air charter companies, communities, and government agencies in July 1992, generating further interest in forecast products and services. The information provided through the forecast has proved valuable to all river users.

State and Distribution of Water Supplies

A Monthly Runoff Conditions Report for Manitoba and Northwestern Ontario, designed to provide water managers and the general public with an overview of the current state and distribution of water supplies, is prepared and

distributed by the Manitoba Office. The report also provides a comparison of current trends to historical information for major lakes and streams used for social and economic purposes. It has proved valuable for the effective management, especially of storage reservoirs, and impacted aquatic ecosystems, during both high flows and "severe drought" conditions. This pilot project will be expanded to include all of Western and Northern Region.

In the NWT, the public is interested in availability of real time information and warnings of high water events (particularly the annual spring breakup period), for added safety in remote areas. In 1990, IWD tested procedures for monitoring and reporting high water conditions to government, public and private sector emergency response organizations. The procedures were formally adopted by IWD-NWT in 1991, and distributed to other federal and territorial external agencies.

IWD field staff deal directly with local community Flood Watch Committees and GNWT Emergency Measures Organization representatives, providing advice and information needed to ensure the safety of residents of flood-prone communities and their property. The Yellowknife IWD office monitors NWT-wide conditions and submits NWT material to WNR and Headquarters Environment Canada, GNWT, and W&N Region Emergency Planning Canada offices, to enable coordinated responses to major community flood events.

The initiative was so successful that the program was extended to include high water events on all monitored NWT rivers and lakes in 1992. Reports on critical conditions, which are distributed daily by facsimile to emergency response agencies and the media, enable appropriate action to be taken (advice on impending floods, evacuations, etc.).

Since begun in 1977, IWD has provided water quantity data to the end of June and October for the Prairie Provinces Water Supply Conditions Report compiled by PFRA. This water supply and soil moisture conditions report summarizes conditions on the prairies and indicates the adequacy of surface and groundwater supplies and of soil moisture and climate for pasture growth and crop production. This report is widely distributed from the Minister of Agriculture to the local and regional media.

Wilderness Water: A Guide to Wilderness Drinking Water

Most Canadians turn to the great outdoors for recreation and relaxation. Many of these nature enthusiasts seek tranquillity in Canada's wilderness environment, often in remote areas . Water "clean enough to drink" is a vital ingredient of the wilderness experience. But, safe water is not a guaranteed commodity, even in the unspoiled wilderness. Even the cleanest-looking water can be contaminated with bacteria, viruses, fungi, protozoan cysts, worm eggs and various other parasites which can cause illness. *Giardia*, a microscopic protozoan spread by animals and people, is of primary concern to outdoor enthusiasts because it is so hard to destroy.

Because of the popularity of wilderness activities and the potential for health problems associated with drinking untreated natural water, IWD and Health and Welfare Canada jointly published a pamphlet dealing with the use and purification of wilderness water.

"Wilderness Water: A Guide to Wilderness Drinking Water" states that Canadian wilderness waters are generally of excellent quality, but that to ensure an enjoyable outdoor experience, be prepared to boil, chemically treat or filter all water. The publication then describes easy-to-use, low-cost procedures which can be used by hikers, bikers, cross-country skiers and other seekers of back country pleasures to purify wilderness waters. The pamphlet also describes some simple preventive measures which back country users can take to minimize their impact on the environment.

"Wilderness Water" has received wide dissemination through the Parks Canada

distribution channels. There have also been requests from various sources throughout Canada for several hundred more copies. Condensed versions have also been produced in nature publications such as "Fish'n Canada".

Through a public understanding of the dangers, associated with consuming untreated waters costs of subsequent medical care will be reduced.

Water Resources Monitoring Network Map

Saskatchewan user demand led to the publication of a two map topographic series, one of the province and a second of the eastern tributaries of the Milk River, which shows active and discontinued streamflow, water level and sediment stations, and drainage boundaries. From the time of their initial distribution in 1991, the maps have been an extremely popular product with all sections of the community. For example, one school board requested fifty copies of the map to provide to its teachers for use in the classroom curriculum.

Interactive Computer Games

With increased use and popularity of computer games, IWD staff in the Saskatchewan Office, designed and developed two interactive software programs for obtaining educational information on the environment. One game, called Freddie Fish, is presented in an arcade style, and requires the player to move a fish along a river system, consuming edible products to maintain the energy level while avoiding environmental hazards and dangers. The second game called EnviroFacts, is a group of question and answer games, provided with voice, sound and graphics, related to geography, water, weather, pollution and nutrients. During 1992, the games were displayed at Enviro Expo, Globe '92 in Vancouver, British Columbia, a Farm and Home Show in North Battleford, Saskatchewan and National Wildlife and Environment Week.

Since these games have proved to be well designed systems and extremely user friendly, plans are to convert them to an IBM run-time version and to a Nintendo type system to allow wider public use.

"A River Under Siege"

To capture the imagination, mainly of the young environmentalists, this pictorial brochure, prepared by the Regina IWD Office in 1990, takes the reader on a journey along a river and identifies each ecosystem and the potential environmental dangers, because of human intervention.

The greatest demand for this brochure has been from public and junior high school level, the Saskatchewan District developed a physical working model of a river basin which demonstrates the interaction of water and the land. Originally displayed as part of Environment Week, it was donated in 1992 to the Saskatchewan Science Centre, for use in a new permanent exhibit, "The Living Planet".

River Basin Model

The Saskatchewan District developed a working model of a river basin as part of an Environment Week display at the Saskatchewan Science Centre. The model demonstrated various aspects of the hydrologic cycle and some of the demands for water in a basin. The model was very well received and made such an impression on the staff of the Science Centre that IWD was invited to donate the model to the Saskatchewan Science Centre for use in a new permanent exhibit, "The Living Planet". The model provides the focus to exhibit which was completed about a year ago. The exhibit demonstrates the interaction of water, land and air. A large proportion of the visitors to the Science Centre are elementary school children and the exhibit increases their awareness of the environment and its complexities.

Environmental Education

Changes in public attitudes about the environment, and the effect of human activities on it, are vitally important to achieve sustainable development and protect the ecosystem. IWD

has, because of the very specialized nature of its work, recognized the need to be actively involved in environmental educational programs. IWD efforts at environmental education have concentrated on showing the relevance of programs, while participating in science fairs, school visits, career days, and Environment Week activities.

To attract top quality technology graduates to staff positions, field training and classroom instructions in hydrology and hydrological practices have been provided annually to students at Red River Community College, Winnipeg, and Keewatin Community College, Thompson, Manitoba, The Institute of Applied Science and Technology, Moose Jaw, Saskatchewan, Lethbridge Community College, Lethbridge, Alberta and Arctic College, Thebacha Campus, Fort Smith, NWT. In addition, staff have served on program advisory committees responsible for curriculum development, program implementation and career planning and employment.

As a result of these activities, many graduates are now employed by IWD and other public and private agencies, as water quality and quality technologists and a knowledgeable contingent of summer and co-op students are available for term employment.

Presentations on environmental awareness are made on a regular basis to educational Institutions, throughout the Region, to supplement regular educational programs and at Career Days and Science Fairs and Forums.

The Saskatchewan Region makes annual presentations to third year environmental engineering students at the University of Regina, while Saskatoon Laboratory staff participate in junior high school programs.

The Alberta Office makes regular presentations, including conducting field trips, at Langevin and Waldort Schools in Calgary and Edwards School in Airdrie.

Public Information

In the NWT, staff have acted as judges in Yellowknife School Science Fairs, made presentations at Career Days in Fort Smith, Fort Simpson, Inuvik and Yellowknife, at the 1992 NWT Student Environmental Conference and at the Yellowknife Catholic Schools Annual Teachers Conference and entered a "water Awareness" float in the 1992 Yellowknife Santa Claus parade.

In addition, IWD staff participate actively in public forums, such as the 1991 Waterscapes in Saskatoon, Saskatchewan, provide technical training as given to the Manitoba Cross Lake Indian Band to conduct bacteriological testing of their drinking water supplies, so increasing local awareness and responsibility, membership on the Rotary Club of Calgary, Environmental Committee, and on the 1993 National Scout Jamboree Organizing Committee to name a few.

During the annual Environment and Wildlife Weeks, IWD plays a very active role through cooperative public displays and projects with other Environment Canada services and government agencies; promotes the goals of the Environmental Partners Fund through distribution of information and provision of advice to applicants and serving as Members on the Screening Committee. In the NWT, mall displays have highlighted information on environmental monitoring programs and conservation initiatives, and careers with IWD.

Special efforts include provision of Environmental Awareness books as prizes for

NWT Environment Week poster contests in High Arctic communities in 1990 and 1991, emphasis on non-traditional roles for women in 1991, and planting of trees and other plants donated by the department at Yellowknife's Northern Frontier Visitors Association centre in 1992.

7.4 New Science

7.4.1 Environmental Surveys and Modelling

Safe development and use of oil and gas reserves in the Mackenzie Delta/Beaufort Sea area requires broader environmental information and models of environmental and biological processes. Without this knowledge, sensitive delta ecosystems and terrain, and their use by northerners for subsistent lifestyles, can not be fully protected from major disturbance and serious impacts from development.

IWD initiated studies on models of water flow, sediment transport deposition and channel stability, and contaminant levels and pathways, to assist management of impacts from developments in the delta, as well as in upstream areas. NOGAP model work since 1983 is based on environmental data collected by IWD since 1972, socio-economic and environmental research for the Mackenzie River Basin study (1978-81), and long-term research by NHRI, NWRI, and other agencies.

IWD-NWT applications of new science for NOGAP include: use of electronic survey equipment to measure distances and elevations rather than conventional land survey techniques, location of survey sites using Global Positioning System (GPS) equipment, and surveys of river channels using new hydrographic survey equipment. Improvements in equipment and computer software have made the surveys and specialized survey products feasible for IWD regional offices, as well as specialty survey and study groups.

IWD abilities to model the Mackenzie Delta have taken a major step forward since 1985. Systematic IWD data collection and study efforts since the early 1970s, improved geodetic control, and extensive surveys of delta channels in 1985 and 1992 have supported the development of a one-dimensional hydraulic (flow) model of the Mackenzie Delta. A simple version was tested in 1987/88, and improved further in 1991/92 and 1992/93. Model estimates of water levels, flows, and velocities are now feasible for any delta location, for use to assess channel erosion, lake and land surface flooding, and impacts of development in the delta.

Development of sediment regime and contaminants and pathways models are planned for 1993/94 and the future, to provide a capability for comprehensive evaluations of physical impacts on delta ecosystems before they occur, rather than afterwards. IWD's physical models will help researchers and resource managers evaluate impacts of development on the entire delta ecosystem (wildlife, waterfowl, fisheries, water quality, and contaminants), and the socio-economic consequences for area residents. NOGAP delta models and study results will be distributed within the research and resource management communities for follow up applications in physical, biological, chemical, and socio-economic fields.

7.4.2 Geographic Information Systems

Geographic Information Systems (GIS) is software that combines tabular information with graphic data to model geographic reality. The primary use of GIS is to manage information, analyze data and communicate visually different views of the same data for different audiences. The analytical powers of GIS can allow us to refine and optimize development, not merely inventory it. GIS will allow us to move into an era of sustainable growth. Inadequate information and analytical capability have kept us from entering that era before. Data gathering and input represents about 80% of the total cost to build a GIS system. Traditionally data is owned by whomever paid to have it developed, therefore the owner should embed information

in each GIS file identifying data sources, level of accuracy, etc.

Water is both an integral part of the environment and an economic commodity. Protecting the environment and ensuring the sustainable use of our water resources requires an understanding of the complex relationships that exist among water, land, air, wildlife, and human activity. In understanding these complex environmental relationships and resolving related problems, data from diverse sources can be used more effectively in combination than separately. The ability of GIS to combine and analyze large volumes of disparate spatial and attribute data to create new information makes them a particularly valuable tool.

Potential exists within IWD to apply GIS capabilities to problem solving and decision making in areas such as: assessment and monitoring of environmental impacts; integrated basin planning; state of the environment reporting. IWD has developed a GIS capability to monitor the International River Improvements Acts license for the Rafferty/Alameda Project in southern Saskatchewan and to monitor and display ecological information for the Northern River Basins Study. The mapping capabilities are also being investigated to reduce the long-term cost of updating the flood hazard maps prepared under the Flood Damage Reduction Program. IWD provides GIS support and technical assistance to CWS to monitor land use changes. As examples of the GIS work undertaken to date, the following can be cited.

Souris River Pilot Project

To explore the capabilities of GIS, a contract was let in 1990 to acquire a variety of digital data for the Souris River basin. The data, in digital form, included topographic maps, information on hydrometric, water quality, sediment and meteorologic monitoring networks, water uses, land cover derived from satellite imagery, and land capability. The data was then used as a vehicle to improve our understanding of all aspects of GIS - hardware, software, data management, and human resource requirements. The knowledge and experience gained through this project has been invaluable in applying GIS to the Northern Rivers Basin Study.

South Saskatchewan Land Cover Mapping

The land cover mapping from satellite imagery that was done as part Souris River Pilot Project was very successful and attracted the interest of several other federal and provincial agencies. This interest has resulted in a joint project to map the agricultural portion of Saskatchewan. The participants in the project are IWD, PFRA, Saskatchewan Research Council (project leader) and Central Surveys and Mapping Agency (representing Departments of Agriculture and Food, Environment and Resource Management; and the agencies are Saskatchewan Wetland Conservation Corp., Saskatchewan Crop Insurance Corp., and Saskatchewan Property Management Corp.)

When completed, the digital land cover data will be a key component of the GIS data base for the province. The data will be compatible with similar data available for Manitoba and a proposal is being developed to map the rest of Saskatchewan. The province of Alberta has expressed an interest in the work.

Northern River Basins Study

The Northern River Basins Study has accumulated vast amounts of information that is linked to specific parts of the basin. Atlas GIS was used to organize, manipulate and analyze this information much more quickly than in previous studies. This vector-based GIS allows the study to other data that is geographically connected to provide answers and to relocate where the information was collected. For example, the location of fish, water quality, streamflow velocities and land use sampling can be geographically compared to identify site-specific or regional problems.

7.4.3 Water Quantity Data Acquisition Modernization - Project 2000

Modernization of the IWD water quantity data acquisition network was identified as required, in October 1988, in response to increased client demands for more high quality environmental products and services. It was identified that to meet these requirements, within current fiscal restraints, would require the replacement of outdated single purpose mechanical equipment with high tech electronic systems. The objective of the initiative was to modernize the collection, processing, analysis and dissemination of water quantity data so by the year 2000 have in place a national system capable of providing real-time data and an information/advisory system providing a wide range of client oriented information products. In 1992/93 the objective was enlarged to include all environmental data collected by IWD in keeping with the concept of integrated monitoring and an ecosystem approach. Implementation of Project 2000 was divided into four phases:

i Preliminary Planning and Startup

ii Preparation of pilot project proposals

iii Implementation of pilot projects

iv National Implementation.

IWD played a significant role in the undertaking of Phases I and II, between 1989/90 and 1992/93, by bringing specialized knowledge, information and experience gained from many years of field operations.

Significant advances in information dissemination/delivery, environmental sensing technology and computational and interpretative application were accomplished which allowed Phase III to proceed on schedule.

In 1990 the IWD Alberta office was awarded the three year pilot project. The major activity under Phase III was the implementation and operation, on a small scale, of a field study to identify and resolve problems encountered with the introduction of the prototype fully integrated modern technological systems, before initiating large scale nationwide changes (Phase IV). The effects on human resources, program management, program operations, and integration potential and impacts would be evaluated.

Project implementation began in late 1990, but due to late delivery of some field equipment, installations at 56 sites in Alberta, focusing on field and office environmental data collection and processing, was completed in the fall of 1992. A sub-component involving 20 sites, focusing on the real-time collection and dissemination of environmental information for decision making was awarded to Saskatchewan District in 1992. Full implementation in Saskatchewan is planned for 1993.

After one and a half years of Alberta pilot implementation, all sites are fully equipped with the new technology, but not all are operational. Problems identified, and many of which have been resolved in-house, range from use of new equipment that is still evolving -- from prototype to production models, insufficient bench-testing, delivery of power and pressure system failures, to staff training on the operation and use of new specialized equipment and development and implementation of enhanced prototype versions of software and hardware support.

From the first two years of the Alberta Pilot Study the following guidelines can be used for future planning:

i additional time is required for the Alberta Pilot to fully identify and evaluate impacts of modernization on an operational program;

ii planning for installation and training must take into consideration the workload associated with other tasks assigned to the individuals;

iii initial training requirements are fairly extensive, and must be supported and provided;

iv equipment delivery schedules must be well planned;

v bench-testing of field equipment is a necessity, and facilities and time must be available for this;

vi when introducing modernized technology to an operational program, the expected results must not be oversold. Everyone involved needs time to gain confidence with the technology and its impacts.

In summary, to modernize a network the size of Canada's in whole or in part, and to adjust to the human resource impacts, will not be accomplished quickly. Also, development of the new technology will not stand still, and we will see ongoing enhancements, although the rate of change should level off.

Another program undertaken to make the collection of water data more efficient involved the redesign of the rotor of the Price Current Meter. The Price Current Meter is the most commonly used device in North America to measure stream velocities. The rotor has traditionally been constructed of brass with a nickel or chrome plating. The meters are individually calibrated.

Recently, rotors that are constructed of plastic have attracted interest because of their lower cost and the possibility of batch calibration. Batch calibration offers the advantages of reducing costs and allows damaged rotors to be replaced without the need for calibration.

The report analyzed performance data for both metal and plastic rotors. The results indicated that the standard metal rotor is more accurate than the tested plastic rotors and that modifications are required to the meter assembly to provide improved accuracy in flow situations where vertical velocity components are encountered. Proposed modifications to allow for fibre optic pick-ups will lead to a decrease in accuracy.

The project is another part of IWD's continuing effort to improve data collection methods, reduce costs, and maintain consistent standards for the data nationally.

7.5 Legislative, Regulatory, and Market Tools for Change

7.5.1 Regulatory Reform

The key deliverable for economic instruments is the water conservation initiative. The foundation for water conservation is the promotion of realistic water pricing, which sets the stage for incentives for wise and appropriate use and management of water.

IWD is conducting ongoing development of economic valuation tools appropriate for use in the Northern Rivers Study, and the potential Bow River Study and Red-Assiniboine Initiative. Research papers have been prepared in developing methodologies to evaluate economic implications for water level fluctuations (Lake Diefenbaker), and these techniques need to be modified for use in consideration of the economic values associated with instream use of rivers for fisheries and other recreation uses, and native food fishery uses. These issues are key study objectives within the three studies mentioned above.

An opportunity also exists for WNR to assist in implementing a pilot project for emissions trading for sulphur dioxide in Alberta. The Canadian Council of Ministers of the Environment (CCME) funded two studies on the practicality of such an approach, and draft reports are nearing completion. There appears to be strong support form industry in Alberta for a trading program, particularly from the Canadian Association of Petroleum Producers. However, delays and problems have arisen due to the lack of commitment on the part of the provincial government, the lack of enabling legislation, and the setting of a provincial or regional emission

cap. Once the CCME report is finalized, discussions should be renewed with the province to determine the possibilities for a pilot project, and how to address provincial sensitivities prior to involving other partners, such as the petroleum industry.

8. STARTING IN OUR OWN HOUSE

8.1 Federal Environmental Stewardship

8.1.1 Environmental Stewardship

IWD is committed to the Code of Environmental Stewardship. Every effort is made to incorporate environmental considerations into their operations and practices. IWD staff have decreased the environmental impact of their office and field operations. Paper reuse began when used computer paper was taken home or donated as drawing paper to schools in the 1970s. Reuse of envelopes by staff was also done before it was fashionable. In the mid 1980s, fine white paper was collected and recycled by office staff in Regina and Winnipeg. Winnipeg's recycling program now includes all C&P Services in the Federal Building. Regina's program began with the IWD office then spread to the rest of C&P services and PFRA. Green Teams projects and programs have made the four "R"s of reduce, reuse, recycle and reclaim part of normal operating procedures. These programs include increased awareness of energy and water conservation and on waste reduction, the reuse of materials before recycling such as envelopes and paper, the recycling of materials such as laser printer toner cartridges, white bond and secondary paper such as coloured paper and cardboard, metal and glass containers such as pop and milk cans, oil drums and waste oil, batteries, mercury, and silver. The Alberta District has organized twelve environmental stewardship workshops for staff. Guest speakers were brought in on topics such as Recycling Initiatives and Stewardship, Energy in the Home, Calgary Environmental Management System and Household Chemical Clean-Up. The NWT replaced the IWD and Environmental Protection Service vehicles with a shared unit.

These initiatives have increased staff awareness of their environment and the small changes in business practices that have environmental benefits. Also a dollar saved through conservation is a dollar earned, which can be applied against other activities.

8.1.2 Environmental Assessment and Review Process

The Department conducts environmental impact assessment of project proposals to ensure that its responsibilities under the federal EARP Guidelines Order are fulfilled. IWD contributes its expertise in water resource management in order to encourage the efficient use of fresh water and to protect and enhance the quality of the water resource. IWD is a member of the Regional Environmental Assessment Coordinating Committee, which meets several times each year. In addition, IWD coordinated the Hydropower Sub-committee activities. In the 1980s, IWD setup a standard methodology for Initial Environmental Screenings of projects undertaken by the directorate. Initial screenings have been done as a matter of course for new and reconstructed water quantity and quality monitoring stations and other field support facilities.

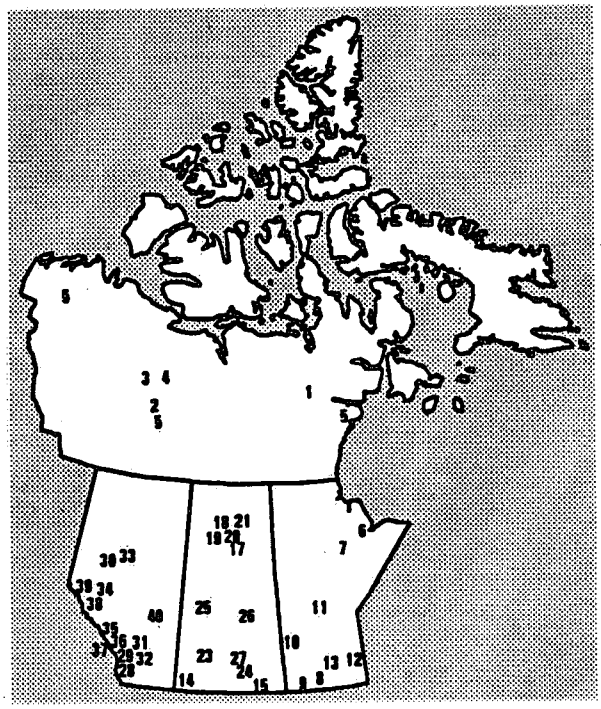
IWD has had primary responsibility of coordinating the Department's review and comment on major water resource development proposals. These have included the Rafferty-Alameda dam, B.C. Hydro Site C and, Milk River dam, Three Rivers (Oldman) dam, Manitoba Hydro Conawapa dam, Pelican Lake enhancement project and the Pembina Valley Regional Water Supply project. IWD has also contributed to the Departmental review of a number of other projects including pulp and paper mills, uranium mines, power transmission lines, oil and gas pipeline expansion, and petroleum extraction. IWD contributed advice to other departments as well as provincial governments on several hundred minor projects during the past seven years.

IWD acted as the Departmental lead on two projects for which Environment Canada was

designated as a federal initiating department under the Guidelines Order. These two projects were the Rafferty-Alameda dam project and the Pelican Lake Enhancement project. The Department had a decision-making responsibility for these two projects as each required a permit under the International River Improvements Act; an act administered by IWD. The permits for the projects require that the licensee meet a number of conditions set out in the licence. Inland Waters Directorate has the responsibility to ensure that the terms of the licence are met by the licensee.

Environment Canada contributed to a Canada-United States agreement to permit the province of Saskatchewan to jointly construct the Rafferty-Alameda Project in Saskatchewan with North Dakota and U.S. federal agencies. In 1988 the government of Saskatchewan applied to Environment Canada for a licence for the proposed Rafferty-Alameda Project under the International River Improvements Act which it received. In 1989, the federal court quashed the licence and it charged Environment Canada with the task of complying with the Environmental Assessment and Review Process (EARP) Guidelines Order in considering the application. In order to respond, IWD, in cooperation with Fisheries and Oceans, Manitoba Natural Resources, National Museum of Canada, Canadian Wildlife Service, Canadian Coast Guard, PFRA, Saskatchewan Water Corporation, and Souris Basin Development Authority (and others) prepared an Initial Environmental Evaluation (IEE) of the project from a federal perspective. IWD prepared the project introduction, the hydrology, and contributed to the summary sections of the report which was submitted to the federal Minister of Environment. The IEE provided the foundation for a renewed federal licence for the Project.

The public panel review exercise undertaken for the Three Rivers (Oldman) Dam resulted in recommendations for federal government involvement in a completed project. IWD in cooperation with the province of Alberta, will have responsibility for monitoring and analysing



NWT

1 Urangesellschaft/Kiggavik
2 Hepture Res./ Colomac
3 Metall Mining / Izuk Lake
4 Echo Bay / Lupin
5 NORAD (multiple sites)

Manitoba

6 Conawapa
7 Limestone
8 Pembina Valley Regional Potable Water Supply
9 Pelican Lake Enhancement Project
10 Repap Manitoba Inc./ mortification and expansion
11 North Central Transmission Line
12 Pine Falls Transition Authorization
13 St. Andrews Lock and Dam rehabilitation

Saskatchewan

14 Battle Creek Cam
15 Rafferty/Alameda Dams project
Uranium Mine developments
17 McClean Lake
18 Midwest Joint Venture
19 Cluff Lake
20 McArthur River/Cigar Lake
21 Rabbit Lake/Collins Bay
22 Seabee gold mine
23 Luck Lake irrigation development
24 Boundary Dam Mine Extension
25 Meadow Lake Pulp Mill
26 Nipawin Pulp Mill
27 Qu'Appelle Conveyance

Alberta

28 Westcastle Four Seasons Resort
29 Oldman River Dam
30 Alberta-Pacific Pulp Mill
31 Little Bow Project/ Highwood Diversion Plan
32 Pine Coulee Project
33 Daishowa Canada Ltd. Pulp Mill
34 Hinton Pulp Mill Expansion
35 Kan-Alta Golf Course
36 Three Sisters Golf Resort
37 Rivers Bend Golf Course
38 Cardinal River Coal Ltd.
39 Smoky River Coal Mine extension
40 Buffalo Lake Stabilization

Major Projects with Initial Environmental Evaluations, Western and Northern Region

the hydrologic changes brought about by project construction. IWD will also evaluate the effectiveness of the mitigation measures related to the project.

In the NWT, the general public, native northerners, and environmental groups are actively concerned and committed to protection of the environment. First-level FEARO screening of projects for their environmental and socio-economic impacts is handled by DIAND's Regional Environmental Review Committee (RERC). IWD, together with Environmental Protection and the Canadian Wildlife Service, has participated in reviews of North American Air Defense Modernization (North Warning System) in 1986, Neptune Resources Ltd.'s Colomac gold mine and Urangesellschaft Canada's Kiggavik proposed uranium mine in 1988, and the proposed Metall Mining Corporation's Izok Lake zinc-copper mine in 1992/93.

On occasion, IWD has assisted proponents collect specific water resources data on a cost-recovery basis to support project design and the evaluation of environmental impacts. IWD measured flows and available hydraulic head at the Burnside River outlet of Contwoyto Lake. A permanent Contwoyto Lake streamflow gauging station was established in 1991. The information was requested by Echo Bay Mines Ltd. to assist with evaluation of hydro-power potential for their Lupin gold mine. In 1992, outflows from Izok Lake were measured for Metall Mining Corporation and a stream flow gauge installed for operation in 1993/94. The information was requested to assess drainage of a lake and diversion of runoff for an open pit mining operation.

9. EMERGENCY PREPAREDNESS

9.1 Environmental Emergencies

9.1.1 Flood Damage Reduction Program (FDRP)

Flooding is a natural phenomenon that results from an increase in streamflow beyond the point where the normal stream channel can contain the water. The water leaves the channel and spreads out over the adjoining floodplain. Floodwater may occupy the floodplain for hours or for several weeks, depending on the severity of the flood.

Flooding, Hay River, NWT

In spite of the potential peril, people have been attracted to floodplain. These areas provided a source of drinking water and food, level land and aesthetically pleasing sites to build on and service and a means of transportation. As the development of floodplain increased, the damage caused by flooding has also increased. Protective structural measures such as dikes, dams and diversions, while successfully protecting many flood-prone areas, can give a false sense of security and actually encourage more active floodplain development. When the structural protection system fails, the damage from the flooding, risk to public safety and social disruption, will be greater than if the structures had never been put in place.

Canada has been facing rising compensation payments and the inability of structures to alleviate the problem of flooding. Between 1970 and 1988, Emergency Preparedness Canada has provided financial assistance for 33 flood disasters. About $440 million (1988 dollars), or about 75% of all natural disaster assistance, has

Flood Disaster Payments in Prairies & NWT, 1983-1986

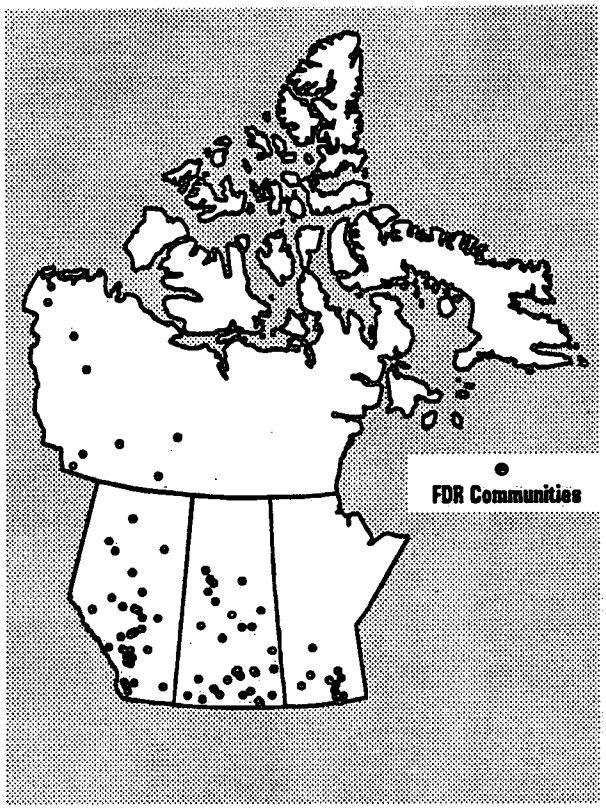
Province	Year of Flood	Audited Total	Federal Share
Manitoba	1984	$1 656 780	$301 190
	1986	$2 893 389	$908 395
Saskatchewan	1983	$4 229 195	$1 121 298
Alberta	1986	$16 400 000	$9 922 425
Northwest Territories	1985	$618 000	$618 000
	1986	$49 710	$49 710
	1989	$555 960	$555 960

been paid out to victims of major flood events by the federal and provincial/territorial governments, through cost-shared arrangements. This figure represents only a fraction of the true costs borne by individuals, businesses and industry, and provincial and municipal treasuries. The over $16 million paid in 1986 for damages in Alberta is an example of assistance payments made in the Western & Northern Region.

In an effort to provide a coordinated, cost-effective approach to flooding, a federal Cabinet Directive was issued in 1974 to address concerns with respect to the high human and financial costs associated with floods during the spring of 1974. During that spring, floods were experienced throughout Canada, and federal disaster assistance payments amounted to over $100 million. The federal government wanted to reduce the chances of high disaster assistance payments in the future and reduce the potential for federal investments to be made in areas with a high risk of being flooded.

The Flood Damage Reduction Program (FDRP) was created, under the Canada Water Act, to provide for federal-provincial agreements to map and designate flood risk areas in communities. Under the terms of the Flood Damage Reduction Program more than 120 communities in the Prairies and NWT have been identified as being susceptible to significant flooding . Of these, flood risk mapping of areas which are exposed to high flood risk has been completed for 70 communities.

Flood risk mapping of Indian Reserves is being implemented under the National Environment Canada and Indian and Northern Affairs Canada (INAC) Memorandum of Understanding (MOU). Under the MOU, a combined historical flood review and planning study was completed for the Red Earth Reserve in Saskatchewan in 1988/89. Flood risk maps were prepared in 1987-88 for projects in Manitoba at the Sioux Valley and Lizard Point Reserves. Base maps for two additional reserves were completed in 1992/1993 with the completion of the flood risk maps scheduled for 1993/1994.



Flood Damage Reduction Communities in the Western and Northern Region

Once mapping is complete the federal and provincial governments then encourage local municipalities to institute floodplain zoning and development measures to minimize future damage to the community. These measures may include leaving areas with recurring flood problems as open space, and floodproofing existing and new buildings.

Upon designation, communities would agree to institute flood plain zoning and development controls to reduce damage to future developments to remain eligible for federal disaster assistance. Provinces were to provide appropriate technical advice and supporting legislation. Other federal agencies (outside Environment Canada) also signed the Flood Damage Reduction (FDR) Agreements to commit themselves to ensuring that inappropriate federal investments did not occur within these flood risk areas.

Under the studies component, the flood damages of a community are calculated and structural

Calculated Average Annual Flood Damages for some Prairie Communities

Community	Average Annual Flood Damages
Alberta	
Calgary	$5 400 000
Saskatchewan	
Eastend	$136 900
Regina	$875 000[1]
Lumsden	$319 000[1]
Weyburn	$28 100[2]
Estevan	$10 300[3]
Roche Perce	$4 200[3]
Oxbow	$270[3]
Manitoba	
Riverton	$108 700
Melita	$13 100
Wawanesa	$6 500
Souris	$5 200

[1] Estimated if dyke fails
[2] Original damage estimate was higher prior to Weyburn dikes and channel dredging
[3] Rafferty-Alameda dams will eliminate most flood damages at downstream communities

solutions are examined to determine the most cost-effective method of reducing future flood damages. Both Manitoba and Saskatchewan have participated in this program while Alberta has conducted its own studies for some communities. Not all communities included in the flood hazard mapping component are included in studies agreements because only communities with viable structural solutions are considered.

Manitoba was one of the first provinces to join the National Flood Damage Reduction Program with the original agreement being signed on December 21, 1976. The program is implemented through the following agreements: General Agreement, Mapping and Studies Agreement, Flood Forecasting, and Flood Mitigation Projects Agreement. Sixteen communities have had flood risk areas mapped and designated under the program.

Amendments to extend the General Agreement and the Mapping and Studies Agreements to 1996 were signed in 1989-90, providing additional funding of $700 000 (federal share: $350 000), and the development of a low-cost maintenance phase for the program. Total expenditures to March 31, 1992 were $2.65 million.

The Canada-Manitoba Flood Protection Projects Agreement, originally signed on March 10, 1983 and amended on May 22, 1985, provided for the upgrading of the ring dikes at eight communities in the Red River Valley, the construction of flood mitigation measures for Ste. Rose du Lac and a ring dike to protect the water treatment plant at Souris and the construction of an emergency communications network and permanent and emergency pumping facilities. Total expenditures under the agreement were $6.851 million with Canada's share being 45 percent. The Agreement expired on March 31, 1991. The average annual damages to the communities were estimated as $2.9 million prior to construction of ring dikes and as $1.2 million after construction. Therefore, annual flood damages are expected to be reduced $1.7 million as a result of this program.

The original agreement with Saskatchewan was signed on April 13, 1977. In March 1987, new Flood Damage Reduction Program Agreements were signed with the province after a five year period where little technical work was completed due to the provincial review of the

program. Since that time all technical work has been completed for communities where base maps were completed under the original agreements. Twelve communities were designated bringing the total designations in Saskatchewan to sixteen. A Regina floodplain management study was also completed. Total expenditures to March 3, 1992 were $1.9 million.

In the NWT, nine of sixty-one NWT communities are subject to periodic flooding from local rivers or ocean storm surges. Personal damages and losses from flooding of NWT communities have been rising, exceeding $2.5 million since 1963 ($4.8 million in 1991$). Environment Canada, INAC and GNWT therefore agreed in May 1979 to reduce flood damage compensation by undertaking the Canada-NWT Flood Damage Reduction Program. Flood risk areas were subsequently mapped and designated in nine NWT communities between 1981 and 1988.

The most flood-prone community, Hay River, was designated in May 1984. Costs totalled about $250 000 (1977-84$), including $200 000 for previous engineering and mapping studies and $43 000 for flood risk area maps and other designation expenses. The communities of Fort McPherson, Aklavik, Fort Simpson, and Fort Good Hope were designated in 1985, with Fort Liard, Fort Norman, and Nahanni Butte following in September 1987, and Tuktoyaktuk in 1988, at a total NWT program cost of $355 459.

The designations are supported by community by-laws and special federal construction standards, which prohibit construction in flood prone areas without suitable flood proofing measures. While the program does not significantly reduce flood damages to existing structures exempt from compliance with flood proofing standards, it does restrict further development and damages. For example, compensation for the 1963 Hay River flood ($690 000 of damages) would be $2.7 million in 1991 $, plus damages to any further development in the area since 1963 (an additonal $2 to $3 million).

Where extensive future community development is anticipated, the designation can have a major impact. A 1986 INAC evaluation of risks from storm surges in the Beaufort Sea indicated that Tuktoyaktuk is highly susceptible to flooding. If major oil and gas development proceeds in the Beaufort Sea/Mackenzie Delta area, the population could increase from under 1 000 to more than 15 000, an expanded paved airport runway would be needed (estimated cost $60 million), and municipal and industrial facilities costing billions would be necessary. Proper design of the community, or relocation to a less flood prone site, will save millions in future damages.

Alberta was a relative late-comer to the national FDR Program in 1989. The Program is very much in full swing, with roughly a $1 million program expected annually until 1995. A number of significant designations are planned for 1993-94, including Calgary, which has the largest unprotected downtown, urban flood plain in Canada. The program in Alberta has a high national priority to complete, given the economic growth potential of the province and the need for guidelines to focus growth away from flood hazard areas.

A Canada-Alberta Flood Risk Mapping Agreement was signed on April 5, 1989. The nine-year, $5.5 million agreement will build on existing flood risk mapping for seven communities and enable new flood risk mapping for forty-five communities. Progress has been significant on the technical study reports for twenty communities completed and four communities designated. An historical flood study of the Driftpile Reserve was completed. Total expenditures to March 31, 1992 were $3.619 million.

Mapping activities are almost completed, and a few flood designations remain. The present issue is to support a minimal program to protect federal investment already made in the existing flood maps and designations and to have the provinces complete the mapping and designations of flood risk areas. Since hydrological conditions could change over time

and economic developments could occur to alter flood risk boundaries and add new (unmapped) areas to communities, program continuity is important. Program continuity is also necessary to maintain provincial technical expertise, to complete the mapping, to monitor flood plain developments, and to conduct minor re-mapping and map extensions.

Some $8.3 million has been spent to conduct engineering and cartographic work to develop the flood risk maps since the program began in 1975. But the investment pays off substantially over the long term. For example, as the gradual redevelopment occurs in Calgary, the $1 billion value of homes in the floodplain will either be flood proofed or new developments will occur in flood-free areas of the city. Although Calgary is a dramatic example, benefits will be experienced in the other communities in the program as well.

In one community in particular, in the Pilot Butte Creek area of Regina, Saskatchewan, the long term benefits of the program were realized in just one year. In the late 1970s, developers prepared and submitted plans to build homes on lots in close proximity to the creek. With the aid of the flood hazard maps, provincial and city agencies were able to change the development plans, to set homes back from the Creek to create open recreational space and to identify land fill requirements to raise the homes.

In 1983, an intense summer rainstorm caused many millions of dollars in flood damages to many areas of Regina. If the original development plan had been in place, the Pilot Butte Creek area would have experienced damages of about $1 million. These damages would have greatly exceeded the $24 000 cost of flood hazard mapping, and the $70 000 cost of earth fill for the low-lying areas. The damages in just one flood event would have been ten times greater than the mapping and filling program. For the 75 year lifetime of the housing development, several more flood events of at least the same magnitude could be expected to occur, repaying the costs of the program many times more.

The effect that flood hazard mapping had on development in the Pilot Butte Creek area demonstrated the tangible benefits of minimizing the exposure to flood hazard through mapping and land use controls. The FDR Program has illustrated Canada's commitment, as outlined in the Green Plan, to

Summary of Flood Damage Reduction Program
Western and Northern Region, Conservation and Protection

Province or Territory	Agreement Signed	Communities			Total Expenditures to March 31, 1993	Date Completed
		Total	Mapped	Designated		
Manitoba	Dec. 21, 1976	22	19	18	$2.8 million	1995
Saskatchewan	April 13, 1977	26	24	15	$2.1 million	1995
Alberta	April 5, 1989	65[1]	18	4	$3.0 million	1994
N.W.T.	May 2, 1979	9	9	9	$0.4 million	1989
Total		122	70	46	$8.3 million	

[1] All Alberta communites in the program will not be completed. Priorities will be set by the Steering Committee. The province will request an extension to the mapping component.

environmentally responsible decision-making through strengthening existing environmental partnerships. Federal-provincial cooperation to improve land use in flood-sensitive areas and promote non-structural solutions to flood problems is an example of sustainable development in action.

9.1.2 Flood Forecasting

The designation of flood risk areas can not reduce danger to existing property and warn residents of impending floods by itself. While forecasting is a responsibility effectively handled by provincial forecast centres, real time water quantity network data and advice provided by IWD plays a vital role in forecast centre operations.

Each year, IWD staff assist provincial forecasters identify areas of potentially high flows and establish special flood monitoring and reporting mechanisms for some 200 IWD-operated stations. This information, together with data from Atmospheric Environment Service weather stations, Alberta Forestry fire towers, and other sources, is used to produce forecasts during critical flood situations. These cooperative efforts have ensured that the public was advised on critical flow and water level conditions on the North Saskatchewan (1986), Slave Lake (1988), the Liard River (1989), in western Manitoba (1990), and the Peace River (1992), and effective emergency measures could be taken by local, provincial/territorial, and federal agencies. Upon request, IWD will also assist provinces and territories develop new flood forecast systems to deal with region-wide or community-specific situations.

In the NWT, IWD cooperated with INAC and GNWT, in responding to flooding in Hay River, which occurred without warning in the middle of the night on May 6, 1985. More than $600 000 of property damages occurred and lives were jeopardized. Environment Canada and INAC cooperated in funding a special $90 000 1987-90 study of ice jam flooding and options for forecasting floods by the University of Alberta. The GNWT Department of Municipal and Community Affairs funded a follow up evaluation of flood protection structures for the community in 1992.

The University of Alberta study revealed that long and short range forecasts of maximum spring breakup water levels are practical. A forecast model, together with special IWD breakup monitoring, community flood watch efforts, and data from a new stream gauge 80 km upstream on the Hay River, was subsequently adopted as the basis for flood forecasting and warning services in the community. No decisions have yet been made on additional community flood mitigation measures.

Annually, IWD offices in Fort Smith, Fort Simpson, and Inuvik closely monitor spring breakup and provide information on high water to the communities of Hay River, Fort Simpson, Fort Liard, and Aklavik. The latest information on water levels and trends, position of ice jams, and breakup is passed on to Flood Watch Committees, as well as territorial and federal emergency measures organizations, for their use.

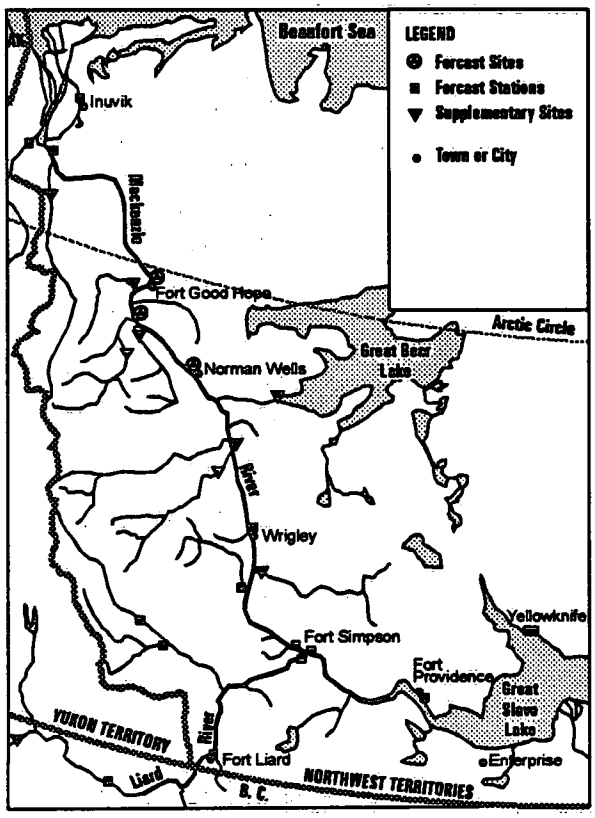
Due to the absence of a territorial flood forecast centre, IWD has assumed greater responsibility in providing essential information and advice on river hazardous conditions in the NWT. In 1990, a new IWD-NWT High Water Event Reporting system was therefore set up and tested, to improve the efficiency of advisory/reporting services to local flood watch committees, emergency response agencies, and within Environment Canada. Real time data from IWD's satellite reporting stations and water level readings by contract observers, supplemented with daily weather information from AES, is provided to government agencies and affected communities via facsimile. The system was formalized with Emergency Measures Canada and the GNWT Emergency Measures Organization in April 1992, as the basis of ongoing services.

In 1992, daily reports were issued during the critical breakup period for the Liard, Hay, and Mackenzie rivers to sixteen recipients, including river communities historically affected by major

floods and government agencies. These reports helped both local and other agencies monitor conditions more closely and take more effective emergency response action, resulting in positive responses from flood watch committees and operators of Esso Resources Ltd's. Norman Wells oilfield.

Mackenzie River Flow Forecast

Without a well developed road system in the NWT, marine transportation plays a major role in delivery of construction materials, fuel, groceries, and goods to Mackenzie River and Beaufort Sea communities. Much of the heavy equipment, fuel, and other supplies to support major projects such as Beaufort Sea oil and gas exploration, Mackenzie Highway construction, expansion of Esso Resources' Norman Wells oilfield, and Norman Wells-Zama Lake pipeline construction, was delivered by river barges. River transportation companies require current water level information for critical points on rivers, in order to plan trips and load barges to maximum safe capacity for clearance of obstacles to navigation.



Mackenzie River Forecast Network

IWD, in cooperation with the transportation industry, initiated a water level observation network on the Mackenzie River in 1963. In the late 1960's, the Mackenzie River was one of the first operational applications of new satellite data transmission facilities in Canada, due to the remoteness of most forecast stations. The basic low water forecast capability set up at that time was operated with little change and general client satisfaction until 1988.

In 1988, major summer floods produced significant losses of goods and river navigation aids. The forecast did not provide adequate warning of the event or height of peak water levels, for administrative, such as holiday weekend timing, and technical, inaccurate flood forecast method, reasons. Forecast clients complained that, with twelve to twenty-four hours warning of the timing and magnitude of the flood, much of the $920 000 of damage and losses to facilities along the river could have been prevented.

River transportation is a significant sector of the NWT's economy. More than thirty vessels and one hundred and twenty barges worth about $233 million are operated by the largest barging company on the Mackenzie, Northern Transportation Company Ltd. (NTCL). The Canadian Coast Guard spends $2 million each year to operate two navigation support vessels worth $14 million and maintain river navigation aids. The GNWT's Department of Transportation spends $4 million each year operating five ferries worth $23 million on Mackenzie Valley river crossings. GNWT economic figures show that 90 000 tonnes of cargo valued at about $200 million was moved in 1991. In the past, tonnages moved have been up to four times greater, due to major development projects.

In addition to groundings due to low water levels and shifting gravel bars, barge trains often have to be broken down when moving through points of difficult navigation on the river. The

forecast helps minimize costs incurred, by providing information to guide loading of barges and navigation. Abnormal losses of navigation aids during 1988 floods, as well as losses and damages to material stored on docks and the value of shipping, demonstrate the value of the forecast to economic activity in the north.

In response to concerns from Transport Canada and a number of other forecast users (commercial aircraft charter companies, GNWT ferry services, and local communities), IWD upgraded the forecast between 1990 and 1993 to handle flood situations, at a cost of about $50 000. The new forecast system includes software for automatic retrieval of real time data from IWD's water quantity network, uses special area weather forecasts prepared by AES, incorporates known flows from gauging sites, and routes these and ungauged area flow estimates down the Liard and Mackenzie rivers. The forecast now provides an accurate one to four day forecast of water levels during all flow conditions for five locations on the Liard and Mackenzie Rivers system.

Current annual forecast costs include IWD forecast operation expenditures of $55 000 per year for additional stations, special site visits, and other maintenance, forecast preparation and distribution plus $25 000 for development and testing. The Canadian Coast Guard has supported forecast operations and improvement through a cost-sharing agreement with IWD since 1991/92. In addition, Coast Guard, the Canadian Hydrographic Service, GNWT Marine Services, and other agencies expressed their interest during 1992/93 for a long-term forecast agreement to ensure that it meets future navigation needs.

Manitoba Flood Forecasting

The Manitoba Flood Forecasting Advisory Committee, with IWD membership, was established in February, 1986 to provide technical review, assessment and scrutiny of flood forecasts prepared by the Manitoba River Flood Forecast Centre, which was established under the Canada-Manitoba Flood Forecasting and Flood Mitigation Agreement. The Committee provides advise and coordination on hydrometeorological data, analysis and predictive systems in support of flood forecasting.