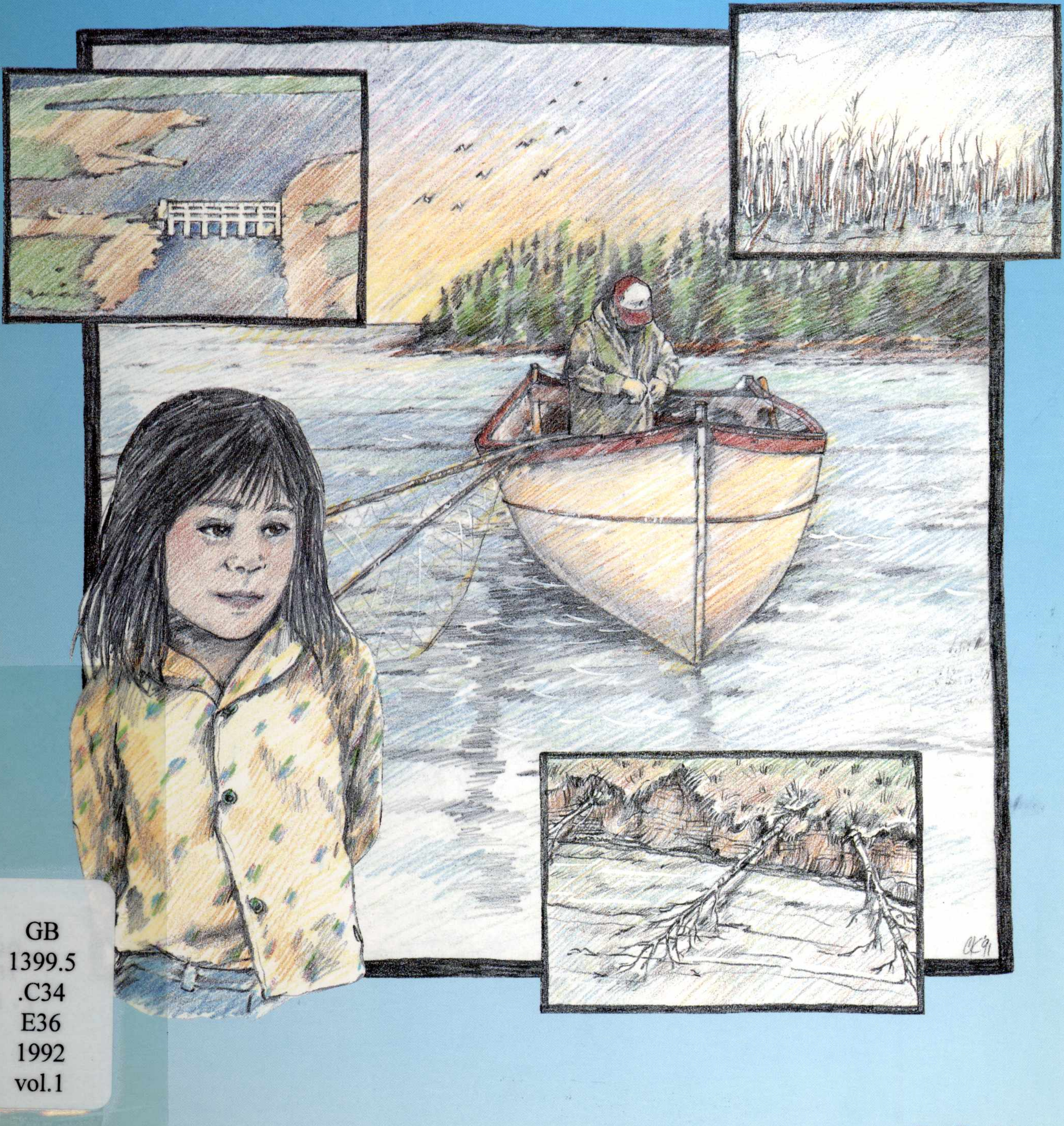
FEDERAL ECOLOGICAL MONITORING PROGRAM

Final Report
Volume 1



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FEDERAL ECOLOGICAL MONITORING PROGRAM

Final Report
Volume 1

Environment Canada
Conservation and Protection
Western and Northern Region

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CHAPTER 1

THE FEMP STUDY AREA

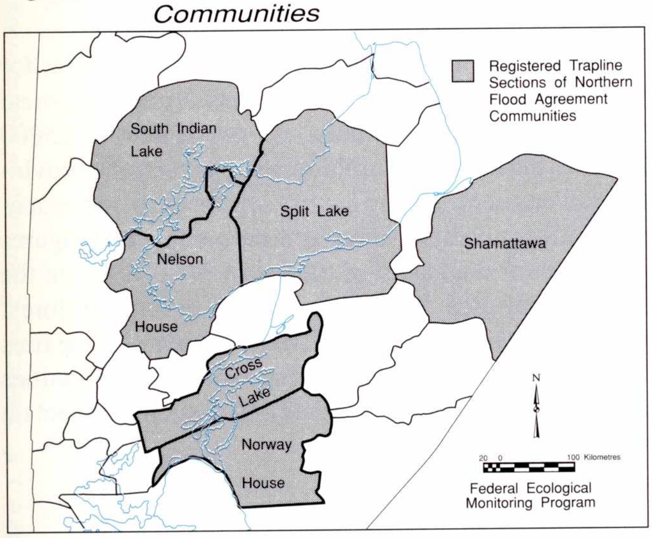
INTRODUCTION

In 1986, Environment Canada (DOE) and the Department of Fisheries and Oceans (DFO) began a joint, 5-year environmental research and monitoring program called the Federal Ecological Monitoring Program (FEMP). FEMP was an investigation of the environmental impacts of the Lake Winnipeg, Churchill, Nelson (LWCN) Rivers Hydroelectric Project in northern Manitoba. Volume 1 of this report describes the background of FEMP: the study area (chapter 1); the area's water regime, (chapter 2); the program's strategy and objectives, (chapter 3); the program's scientific foundation, (chapter 4); and the program's reporting mechanisms, (chapter 5). Volume 2 of this report describes FEMP results: the socioeconomic importance of the environmental changes to the area's native communities, (chapter 1); a compilation of the program's results for Southern Indian Lake and the Churchill River Diversion area (chapter 2), the Outlet Lakes area, (chapter 3), and the Split Lake area, (chapter 4); and the program's conclusions and recommendations, (chapter 5).

LOCATION AND CLIMATE

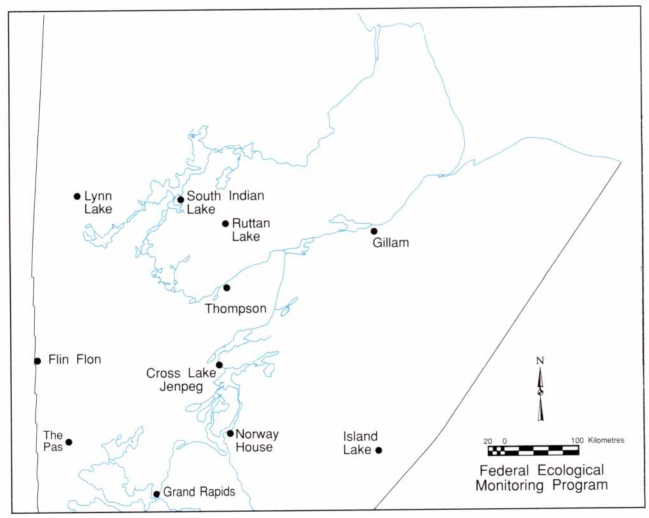
The LWCN Hydroelectric Project is a series of dams and control structures from Lake Winnipeg to Hudson Bay, on the Churchill, Nelson, Rat and Burntwood rivers. (See Map 1 at the back of this report.) The FEMP study area corresponded, approximately, to the resource areas of the 6 native communities affected by the LWCN Hydroelectric Project. (See Fig. 1.1.)

Figure 1.1 Resource Areas of the FEMP Native Communities



The FEMP study area in Manitoba's interior has a continental climate, consisting of long, cold winters and short, cool summers. The network of climate stations in northern Manitoba is limited; there are only 13 stations, at 11 locations, within and around the FEMP study area (Fig. 1.2). The ranges and extremes recorded for temperature, precipitation, snowfall, and growing degree days greater than 10°C for these 13 stations are shown in Fig. 1.3.

Figure 1.2 Location of Climate Stations in the FEMP Study Area



Footnote: There are two stations, each, at Norway House and Grand Rapids

Figure 1.3 "Normals" and Extremes for Selected Climatic Variables in the FEMP Study Area, 1970 - 1989

Normal Values	Extreme Values	
Temperature		
0.2°C to -	3.3°	Grand Rapids Hydro,1987
5.2°C	-7.0°C	Gillam, 1972
Total Precipitation		
434.0 mm to	880.5 mm	Ruttan Lake, 1983
542.4 mm	319.0 mm	The Pas, 1982
Snowfall		
110.2 mm to	332.7 mm	Lynn Lake, 1988
239.3 mm	53.7 mm	Grand Rapids Hydro,1987
Degree Days >10°C		
758.8 dd to	964.9 dd	Grand Rapids Hydro, 1988
377.6 dd	216.6 dd	Gillam, 1978

Comparison of the meteorological data for 1970 - 1989, corresponding approximately to the construction and post-development period of the LWCN Hydroelectric Project, to the "normals" published by Environment Canada (for the period 1951 to 1980) showed, that while fluctuations away from normal did occur, no "abnormal" departures occurred for any significant periods of time. There was, however, a slight tendency for stations to display more years with above normal temperatures values and a tendency for stations to record more years with below normal snowfall amounts. Fig. 1.4 shows this data for 4 of the 13 stations.

Temperature trends recorded at the 13 stations showed a high correlation, as did the number of growing degree days greater than 10°C. There were also similarities in the recorded snowfall at the 13 stations, but not to the same extent as for temperature and growing degree days. There was no agreement in recorded total precipitation among the 13 stations. (Rainfall is caused mainly by convective activity that can occur on small scales, whereas snowfall is carried by large frontal systems that can affect a wide area.) Temperature and degree days recorded at these 13 stations were thus deemed representative of the FEMP study area while snowfall and total precipitation amounts and trends were confined to typifying smaller areas.

THE BOREAL FOREST

Description

The FEMP study area is part of the boreal forest or the taiga, an area that makes up 27% of the world's total forest or 17 x 10^6 km^2 in North America. The taiga meets the tundra in western Alaska, sweeps across the continent, swinging south of Hudson Bay and encompasses most of the island of Newfoundland, an area extending some 6 200 km from east to west and 500 to 800 km north to south.

The taiga is an area of circumpolar coniferous forest consisting of remarkably few species of plants. In the taiga, the dominant trees are conifers, particularly spruce, with other trees being pine, larch, birch, alder, and aspen. An important aspect of taiga vegetation is the presence of berry-bearing shrubs (e.g. blueberry, crowberry, etc.) that are important in the lives of taiga birds, mammals, and people. Another characteristic of the taiga is the usual presence of podzol soils. Podzol typically possess a surface humus layer of slowly decomposing coniferous litter; the humus is typically strongly acid.

The boreal forest affects the local climate. Within the forest, the ambient temperature is usually somewhat higher than outside the forest and the extremes are not as wide. Also, the needles and twigs catch the wind and slow it down so that windchill within the forest is less than outside it. Because of the remarkably little wind and the usually continuously sub-freezing winter temperatures, the snow cover of the taiga is typically soft and of low density, even though varying greatly in thickness from place-to-place and from year-to-year.

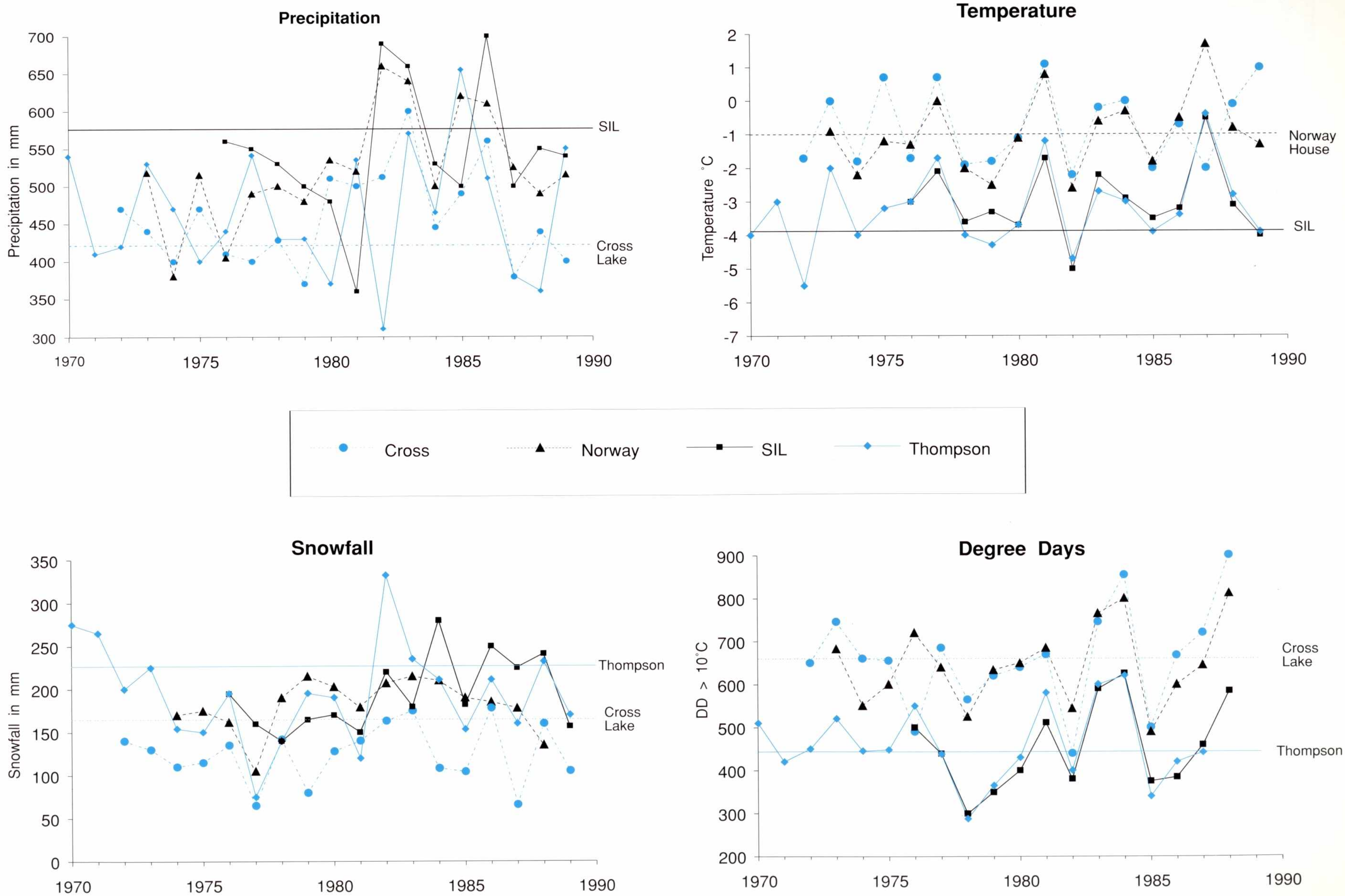
Predictions of future greenhouse-dominated climates postulate that the taiga will undergo more changes than any other forest type, possibly a large reduction in area from about 17 x 10^6 km^2 in North American to about 10.5 x 10^6 km^2, and a poleward shift in boundaries. (One estimate is that for every 1°C increase in global temperatures, there will be a northward shift in the forests of 100 km.) Such a poleward shift could result in a substantial loss of the taiga in the FEMP study area. Whether these predictions will be realized will depend on the interaction of many factors, not the least of which will be man's global response to the greenhouse effect.

Forest Fires

Because the taiga consists primarily of highly resinous coniferous trees, it is extremely susceptible to fire. Although wildfire was a regular occurrence in pre-contact times in North America, the frequency of wildfire has increased enormously since the arrival of Europeans.

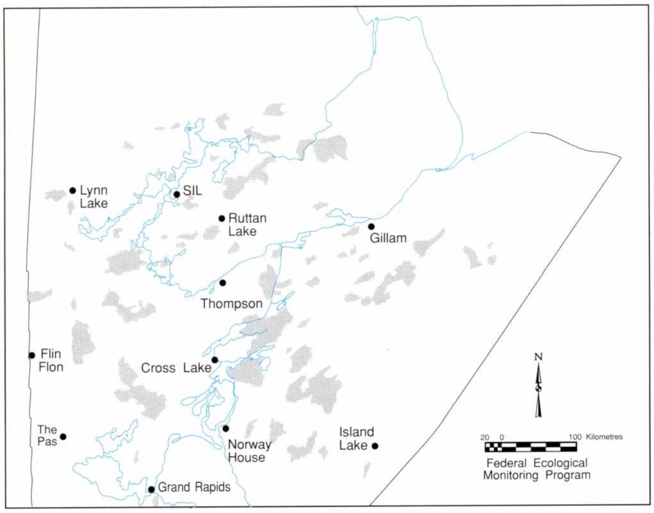
The summer of 1989 was a particularly bad year for forest fires in Manitoba, most especially in the boreal forests of northern Manitoba. Across Manitoba, 25000 hectares burned; $88.2 million was spent by the provincial government, mostly for fire suppression and evacuation. Unfortunately, there are no comparable figures available for the extent of the forest fire damage in the FEMP study area; however, as shown in Fig. 1.5, forest fires were extensive in the FEMP study area. These fires forced the evacuation of each of the 6 native communities in the FEMP study area and had a devastating impact on their resource areas.

Figure 1.4 Selected Examples of Departures from "Normals" for Selected Climatic Variables in the FEMP Study Area, 1970 - 1989



Footnote: Straight lines are the highest and lowest 30 year normals of the four selected stations.

Figure 1.5 Forest Fires in the FEMP Study Area, 1989

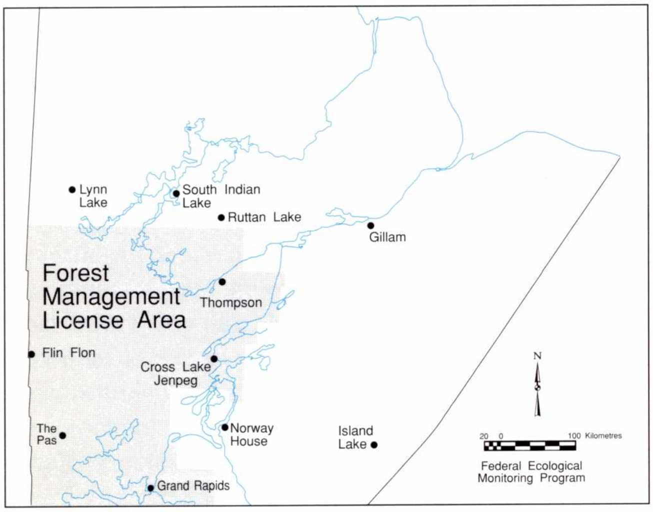


Forestry

In 1989, with the purchase of a crown owned pulp and paper mill at the Pas, Repap Enterprises Inc. was granted a forest management licence (F.M.L.) area of approximately 108 000 km^2 of Manitoba's boreal forest; this represents about 19% of Manitoba's land mass. Included in the F.M.L. area are the resource areas of 2 of the 6 native communities in the FEMP study area, Cross Lake and Nelson House (Fig. 1.6).

Repap has proposed to process the harvested timber by converting and expanding the existing manufacturing facilities at The Pas in two phases. In Phase I, the present unbleached kraft pulp and paper mill will be converted to a bleached kraft pulp mill and production increased from 400 to 500 tonnes per day. In Phase II, a new 1200 tonne per day bleached softwood (conifers), kraft pulp mill will be constructed and the 500 tonne per day pulp mill converted to produce 550 tonnes per day of hardwood (deciduous) kraft pulp. Should Repap proceed with their proposal, it will be subject to environmental impact assessments by the federal and provincial governments.

Figure 1.6 Repap's Forest Management License Area within the FEMP Study Area



Note: F.M.L. area extends below 53°N

MINING

The FEMP study area is located in the Precambrian Shield area of northern Manitoba, an area rich in metals: nickel, copper, cobalt, zinc, gold, silver, lead, and tellurium. The first major mining operation in northern Manitoba began in 1927 when Hudson Bay Mining and Smelting Co. Ltd. set up a pilot mill at what was to become the town of Flin Flon, near the Saskatchewan border. Since then, the mining industry has played an important role in the northern Manitoba economy and has been directly responsible for the creation of the towns of Lynn Lake, Snow Lake, Leaf Rapids, and Thompson. Thompson, located on the Burntwood River in the FEMP study area, has evolved from a mining town to the major service center of northern Manitoba, with a population of 15 000.

THE NATIVE COMMUNITIES

Introduction

There are 6 native communities located on the shorelines of the major rivers and lakes of the FEMP study area - South Indian Lake, Nelson House, Split Lake, York Landing, Cross Lake, and Norway House. (See Map 1.) Occupancy of the region by the predecessors of the residents of these communities dates back thousands of years.

The native people of this area have been in longer and more complex contact with European society than any aboriginal groups in Canada except for those of the Atlantic and St. Lawrence areas. Commercial exchange for fur dates from the 17th century and the area has served as a major transportation route into the interior of North America. Wage labour and the existence of a stratified occupational hierarchy have been facts of economic life in the region for at least two centuries. Since at least the 1880s, other economic developments, including commercial fishing, railway construction, mining, forestry, and white settlement, have added to the complexity of the social and economic life of the region.

Although neither wage employment nor the market system are foreign to these communities, there is typically a substantial level of economic activity that takes place outside of the market sphere. This resource-based subsistence activity does not constitute a separate and distinct economy, but rather is inextricably linked with wage labour and transfer payments.

Resource harvesting activity has traditional cultural and economic components which have continued within the mixed economics of these communities. The subsistence economy is as fundamental to the support of the communities' culture and social relations as it is to their economic structure. Extensive and intensive use of their resource areas, approximately represented by the registered trapline sections shown in Fig. 1.1, continues to take place and to contribute to the communities' cultural and economic well-being. In this sense, these "communities" extend well beyond that of their permanent settlements.

Though the framework of mixed subsistence based economies can be used in a general understanding of these northern native communities, it must be recognized that they are not identical. The degree of reliance upon subsistence and market components varies from community to community; the nature and extent of the impacts of the LWCN Hydroelectric Project on the resource base varies; and historically, the degree of isolation from industrial development has differed. Though all six communities are highly dependent on resource-based activity, there are differences among them in the importance of commercial fishing and trapping, in the presence of logging, in the degree of access to resources, and in the development of tourism facilities. Nonetheless, subsistence and access to the resource base remain significant to them all. A measure of the importance of the traditional, subsistence economy can be glimpsed from the multiple uses of fish shown in Fig. 1.7.

Figure 1.7 Traditional Uses of Fish

FOOD AND MEDICINE

Main Course: A number of different methods of preparation are: fried, dressed; baked in oven, whole, dressed; baked in open fire placed on coals, whole; barbecued, on stick in front or above fire, whole or dressed; deep fried, dressed, cut up; smoked, dressed; and boiled, ground (bone and all) to make paddies.

Delicacies: Pickerel cheeks; liver, fried from whitefish, maria, pickerel and sturgeon; fish eggs, (caviar) used as part of the mixture in bannock; sturgeon head, meat from the head gill area; sucker heads, fried or boiled.

Soup: Juice from boiled fish made into soup by adding flour or oatmeal.

Infant and Child Feeding: Juice from boiled fish used in bottles to feed infants; the tail of any fish considered the best for children because there are no bones.

Dogs: Guts and bones, whatever was not edible for humans, was fed to the dogs.

Medicine: Juice from boiled fish was kept in a jar by some and used as medicine for certain ailments.

OTHER

Child's Toys: Air sac blown up and dried and used as a child's balloon; pebbles placed inside to make a rattle.

Glue: The gill or throat area of a sturgeon was prepared (peeled/diced/boiled) and used as a very strong glue.

Fertilizer: Guts often put into gardens to act as fertilizers.

Native Crafts: Scales of certain fish were used to ornate native crafts.

Bait: Leftover fish or guts used as bait by trappers.

Oil: Sturgeon oil was used as lamp oil and a lubricant for tanning moose hide to make the hide softer.

Source: Adapted from letters of E. Scott, Cross Lake.

Community Profiles

Five of the six native communities - Cross Lake, Nelson House, Norway House, Split Lake, and York Landing - are located on reserve lands; local governments, organized under Indian and Northern Affairs Canada guidelines, are provided by elected chiefs and band councils. The sixth community, South Indian Lake, is located on provincial Crown land and is not a reserve; its government is organized under the guidelines of Manitoba's Northern Affairs Act. South Indian Lake is the only one of the 6 native communities that is not a signatory to the Northern Flood Agreement (NFA), an important 4-party agreement discussed in chapter 3.

The size of these communities is noteworthy in that they are among the largest native communities in Canada. The total population (status and non-status) of the six FEMP study communities is presently about 14000. By comparison, the entire population of the eight Cree bands in northern Quebec affected by the James Bay Hydroelectric Project is less than that of the 5 NFA communities.

South Indian Lake

The South Indian Lake community is situated along a narrows which joins South Bay to the main body of Southern Indian Lake. Part of the community's resource area has been flooded while other areas, downstream of Missi Falls, have been permanently dewatered. The majority of the population are status Indians, most of whom have affiliation with the Nelson House Band, dating back to the early permanent settlement of South Indian Lake somewhere near the turn of the century. However, there exists little interaction between the two communities, as a result of separate development. In 1988, the total population was 845 persons. Commercial fishing, trapping, and tourism comprise the principal local economic activities.

Nelson House

The core area of the community is located along the north shore of Footprint Lake. Part of the Nelson House resource area has been flooded by the diversion of the Churchill River along the Rat and Burntwood rivers. In 1988, 1,413 persons lived on reserve out of a total band membership of 2,569. Economic activity is based on trapping, hunting, fishing, and a local service sector.

Split Lake

The Split Lake Band has three reserves located around Split Lake, with the principal settlement on the northwest shore. The community resource area is affected by both the operation of the Churchill River Diversion and by the operation of hydroelectric installations on the Nelson River. In 1988, 1,163 persons lived on reserve out of a total band membership of 1,615. Trapping, hunting, fishing, and service industries are the principal economic opportunities.

York Landing

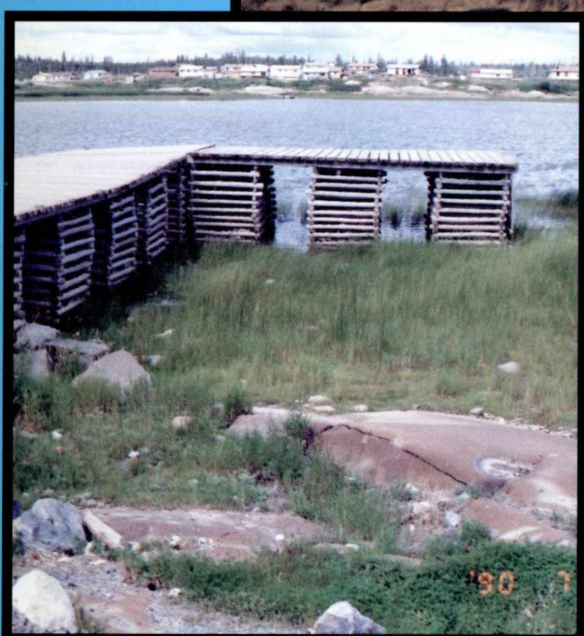
This community is located on the north bank of the Aiken River near the mouth where it empties into Split Lake. As a result of its relocation from York Factory near Hudson Bay in 1957, it has only a limited resource area, consisting of one community trapline in each of the Shamattawa and Split Lake registered trapline sections. In 1988, 9 band members lived on reserve and 326 on Crown land out of a total band membership of 538. Trapping is limited. Tourism provides additional economic activity in the operation of a goose camp near Hudson Bay.

Norway House

The Norway House reserve is located just downstream of the outlet of Lake Winnipeg. The community's resource area includes the Outlet Lakes which have been affected by Lake Winnipeg control works such as 2-Mile Channel. In 1988, a population of 2,648 lived on reserve out of a total band membership of 3,339. Commercial fishing, trapping, logging, construction, and service opportunities are the primary local economic activities.

Cross Lake

Five reserve parcels are located on the shores of the Nelson River where it enters Cross Lake. The location of the Jenpeg Dam 15 kilometers upstream from the reserve has resulted in the dewatering of Cross Lake in the summer months. In 1988, 2,337 persons lived on reserve out of a total band membership of 2,972. Trapping, commercial fishing, and log cutting are major economic opportunities.



CHAPTER 2

THE FEMP WATER REGIME

INTRODUCTION

"By the early 1600s, explorers searching for a North-West passage to India had mapped the estuaries of the Seal, Churchill, Nelson, and Hayes Rivers on Hudson Bay. In 1668, Radisson and Grossilliers traded furs at the mouth of the Nelson for great profit and within two years, the Hudson's Bay Company was formed with trading depots at the mouths of all the major rivers. At one depot, York Factory at the mouth of the Hayes River, the trade was particularly rich. It was discovered first by Henry Kelsey in 1690 and later confirmed by David Thompson in 1745, that the river leading to the depot was part of a larger system of channels that were connected to the interior of the continent. The valley of the Nelson and Churchill Rivers through the Canadian Shield was discovered and the passage from the docks of England though Hudson Bay to the western plains and mountains of the interior of North America was established" (Newbury, 1990, p. 3).

From the early days of the fur trade to the present-day hydroelectric projects, northern Manitoba's waterways have played a critical role in Manitoba's development. However, since long before the arrival of the Europeans, these rivers and lakes and their associated shorelines were, and continue to be, vital to the way of life of the local aboriginal people, providing them with transportation corridors, abundant natural resources, and a hospitable place to live.

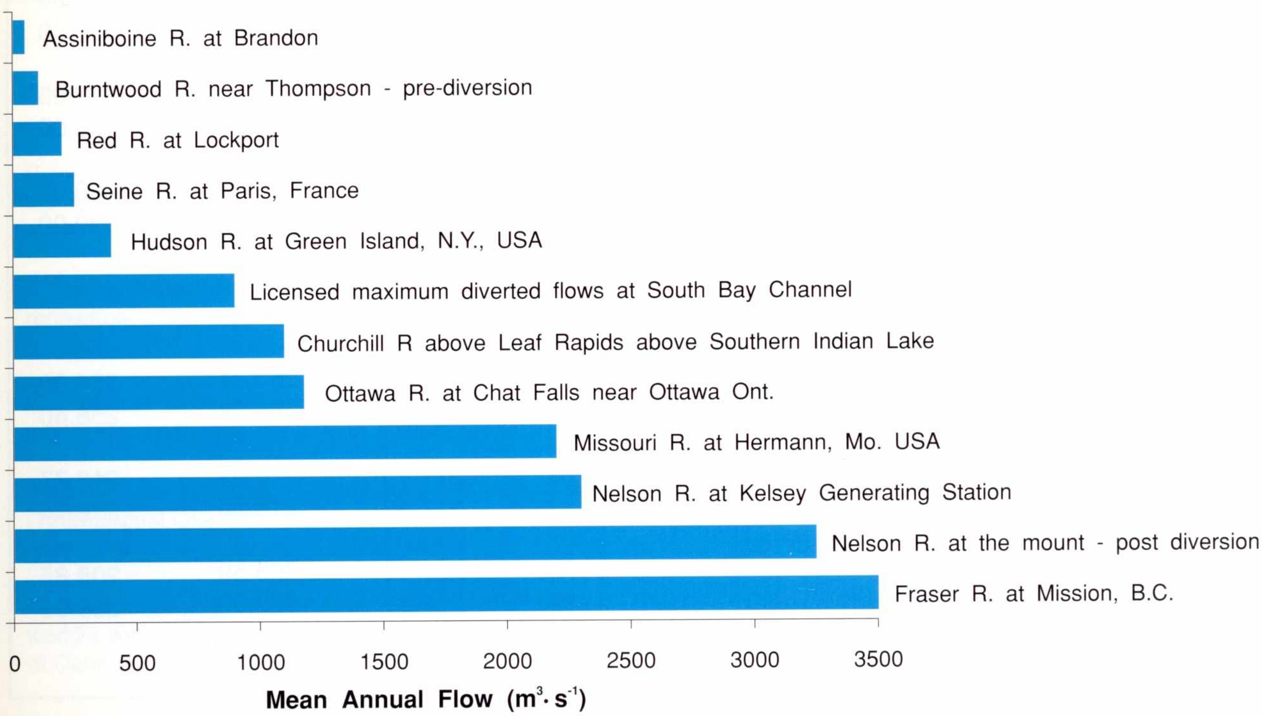
In this chapter, the natural regime of these waterways and the changes to it since the Lake Winnipeg, Churchill, Nelson (LWCN) Rivers Hydroelectric Project are discussed. A knowledge of the altered water regime is essential in understanding the FEMP results, and their implications.

THE NATURAL REGIME

The Nelson and Churchill rivers are two of the biggest rivers in western Canada, as measured by the size of their drainage areas and by their flows. Together these two rivers and their major tributaries - the Saskatchewan, Red, Winnipeg, Assiniboine, Qu'Appelle, English, and Rainy rivers - drain more than 1.2 million square kilometers (km^2) of the interior of North America. The mean annual discharges of the Nelson and Churchill rivers, along with those of other rivers selected for comparison, are shown in Fig. 2.1.

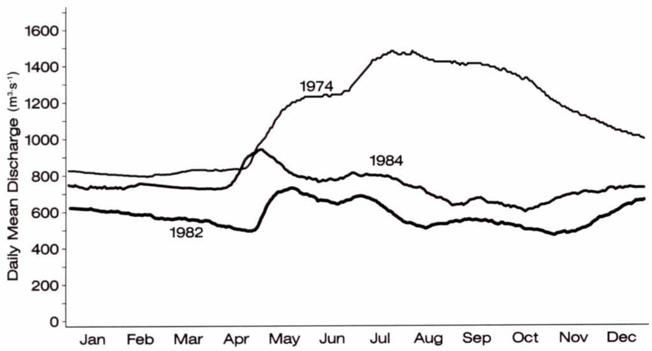
The flow of any river varies over the course of the year and between years. Factors which affect a river's natural flow include the river basin's climate, especially precipitation patterns and evaporation rates; the river basin's topography and soil permeability; the amount, type, and location of vegetation in the river basin; and the number and size of the lakes. In northern Manitoba where a

Figure 2.1 FEMP River Flows in Comparison to Other Rivers



significant amount of the year's precipitation is in the form of snow, natural river flows rise in the spring with the local runoff from snowmelt and spring rains. Fig. 2.2 shows how the Churchill River, which accumulates runoff from across the northern plains, may rise to a second peak in late June or July as the spring runoff finally arrives from the farthest western portion of the Churchill River drainage basin. Variation in flows between years is illustrated in Fig. 2.3.

Figure 2.2 Hydrograph of Churchill River at Granville Falls



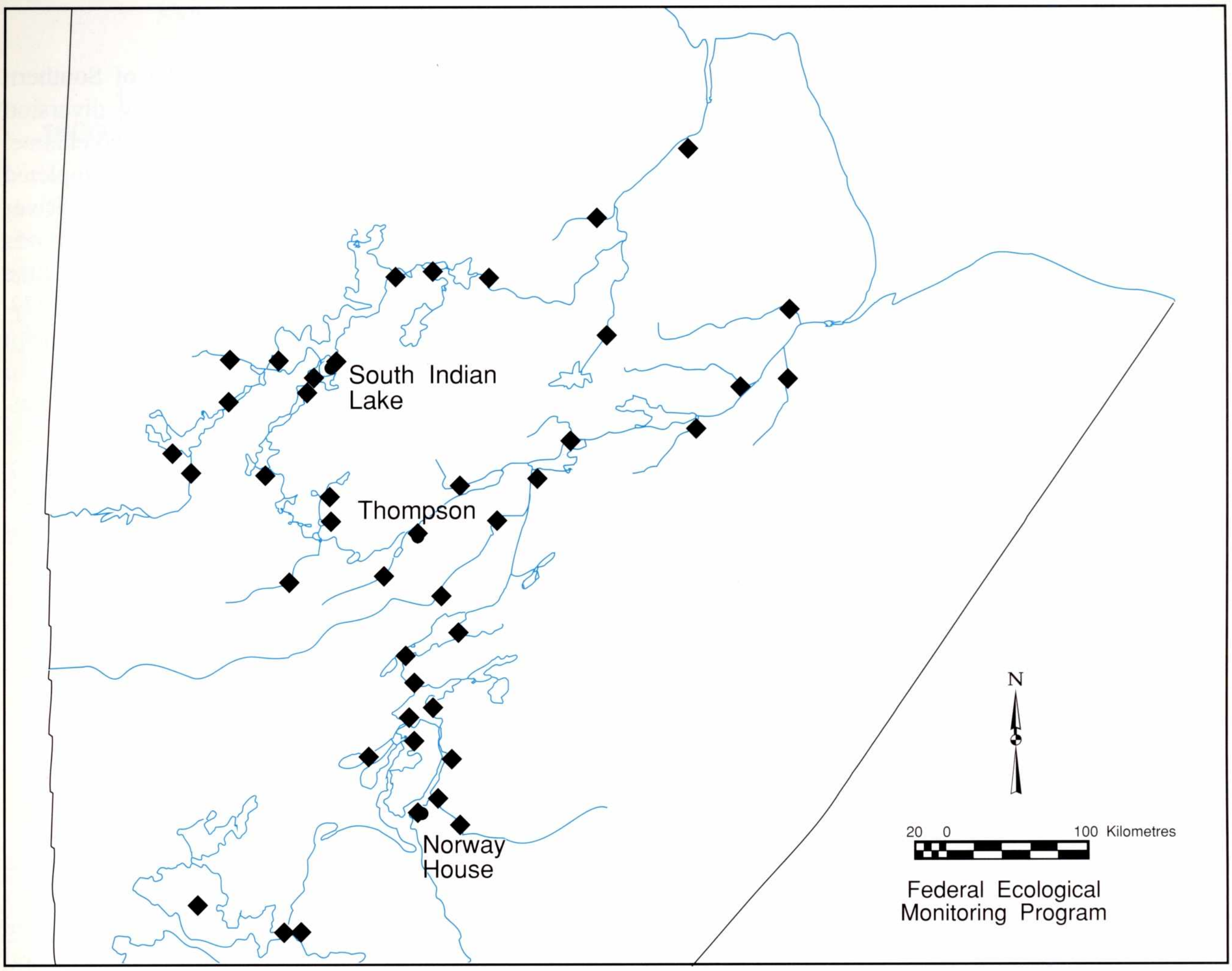
Point specific measurements of river flows and lake levels are made at a number of locations within the FEMP study area (Fig. 2.4). The hydrologic data generated from this network of sampling sites was used to calculate a water budget for the FEMP study area. One of the uses of the water budget was the determination of the changes in the water regime reported on in this chapter.

Figure 2.3 Selected Flow and Lake Level Extremes for the FEMP Study Area

Station Flows ($m^3 \cdot s^{-1}$)	**Period**[1]	**Mean**	**Min.**	**Max.**
Churchill River at Granville Lake	1951 - 1973 1976 - 1989	808.73 787.77	479.00 468.00	1700.00 1480.00
Churchill River at Fidler Lake	1960 - 1973 1976 - 1989	1152.27 302.77	665.00 40.50	2300.00 1910.00
Burntwood River at Thompson	1957 - 1973 1976 - 1989	118.16 863.39	7.79 340.00	578.00 1320.00
Nelson River at Kelsey	1960 - 1973 1976 - 1989	2490.58 1783.35	748.00 418.00	4992.00 4085.00
Nelson River at Bladder	1958 - 1973 1976 - 1989	2391.24 1994.48	697.00 721.00	4620.00 4830.00
Levels (m)				
Southern Indian Lake at South Indian Lake	1964 - 1973 1976 - 1989	255.19 257.76	254.31 256.94	256.08 258.40
Lake Winnipeg at Berens River	1914 - 1973 1976 - 1989	217.40 217.42	216.01 216.56	218.77 218.14
Cross Lake at Cross Lake	1918 - 1973[2] 1976 - 1989	207.14 206.87	205.59 205.06	208.85 208.93

[1] 1973-1976 was main LWCN construction period
[2] No Cross Lake record for 1934 - 1949

Figure 2.4 Location of Hydrometric Stations in the FEMP Study Area



WATER FACTS

- Scientists estimate that as much as one-seventh (1/7) of the fresh, liquid surface water in the world is contained within Canada's boundaries.
- Annually, Canada's rivers discharge 9% of the world's renewable water supply - 105 000 cubic metres per second.
- Canada has more lake area than any other country in the world, with 565 lakes larger than 100 square kilometres.
- By area, Lake Winnipeg in Manitoba is the world's twelfth (12th) largest lake with an area of 24 400 square kilometres.
- Canadians are the trustees of almost 25% of all of the world's wetlands, currently covering 14% of the land area of Canada.
- In 1985, the United Nations ranked Canada as the world's largest hydroelectric producer, with 15% of the global output.
- During 1987, 67% of the total power generated in Canada came from hydro sources; in Manitoba, hydro sources provided 94% of total power generated.
- Canada is one of the world's largest dam builders; Canada has built over 600 large dams, and about 60 large domestic interbasin diversions.
- Canada diverts more water than any other country in the world, more than Russia and the United States combined.
- Canada diverts water mostly to concentrate flows for hydroelectric development, especially in northern Quebec and northern Manitoba.

HYDROELECTRIC DEVELOPMENT

Hydroelectric development has had a long history within the Churchill and Nelson rivers drainage area of Manitoba, beginning with the first site developed on the Winnipeg River in 1926. Since then numerous other sites have been developed within this drainage area, both within and outside of Manitoba.

Power generation from hydroelectric sources offers a number of advantages: 1) it is an efficient source of power, with efficiencies typically well above 90% being obtained when hydroelectric power plants are operated at optimum; 2) it is an economic source of power - particularly in a province like Manitoba that has limited fossil fuels to fire thermal power plants; 3) it is a renewable source of energy; and 4) hydroelectric power plants have the ability to respond rapidly and economically to changes in power demand. This latter characteristic is the reason hydroelectric power plants are used to respond to peak power demands and to sudden demands imposed by emergency conditions in the system.

Furthermore, in the past, hydroelectricity had often been promoted as a clean, non-polluting source of energy with inherent environmental advantages over nuclear and fossil-fuel sources. This perception, reflected recently in even leading scientific journals, such as Science, further added to the attractiveness of hydroelectricity.

The hydroelectric potential of the Churchill and Nelson rivers in northern Manitoba was first identified by federal water power surveys in the early 1900s. Extensive provincial surveys beginning in the 1940s confirmed this potential, and hydroelectric feasibility studies commenced. By the mid-1950s the possibility for diversion of the Churchill River flow into the Nelson River basin, via the Rat and Burntwood rivers, had been discovered. In 1961, the Kelsey Generating Station was constructed on the Nelson River, providing 320 MW of power to the International Nickel Company of Canada mine and refinery at Thompson, Manitoba. By 1964, with the assistance of the federal government in the form of a promised 927 km direct current transmission line, it was considered economical to generate Nelson River power for sale to markets in southern Canada and the northern United States. By 1970, when the second generating station had been completed, at Kettle Rapids (1220 MW), it was decided to divert the Churchill River to supplement flows along the lower Nelson River and to build a control structure at the outlet of Lake Winnipeg. A total of nine dam sites on the Nelson River and four on the diversion route were identified.

Control structures at the natural outlet of Southern Indian Lake and at Notigi Rapids on the new diversion route in the Rat River valley, and an excavated channel at South Bay on Southern Indian Lake, were completed in 1976 to facilitate diversion of the Churchill River southward into the Nelson River. The diversion was begun at about one-third of licensed capacity in June 1976 and expanded to full operating discharge in 1977. Construction of works at the outlet of Lake Winnipeg designed to regulate levels on the 24 400 km^2 lake for dependable midwinter flow, begun in 1971, was completed in 1977 with the commissioning of the Jenpeg Control Structure and Generating Station (170 MW). Two more generating stations, Long Spruce (970 MW) and Limestone (1000 MW) have since been built on the lower Nelson River. Currently Manitoba Hydro is seeking authorization to begin construction of the Conawapa Generating Station (1100 MW). The locations of the hydro stations are shown on Map 1 at the back of this volume.

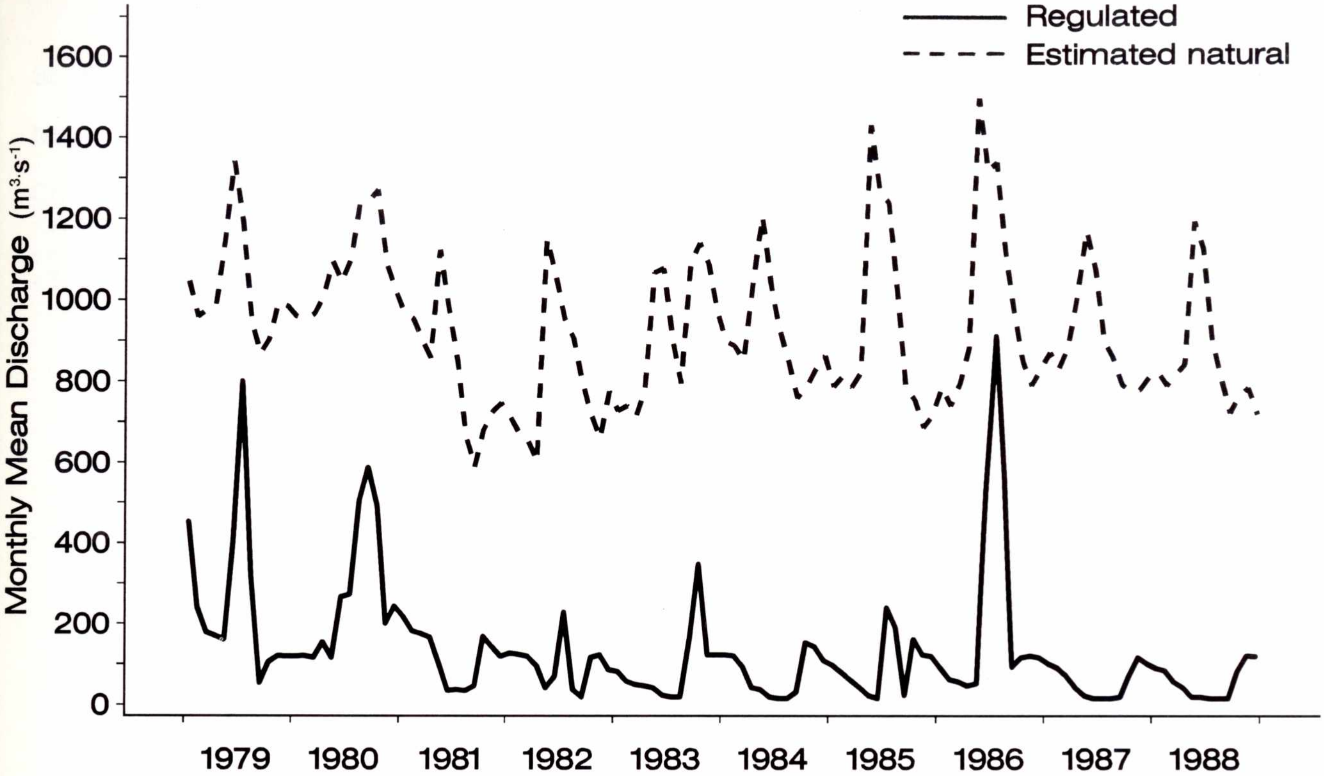
THE CHANGED REGIME

The extensive hydroelectric development within the FEMP study area dramatically altered the water regimes of the Churchill, Nelson, Rat, and Burntwood rivers. The following sections provide an overview of the type and magnitude of these changes, by area. Comparisons are made of river discharge and lake levels under regulated and estimated natural conditions for the period 1979 - 1988. A brief discussion on the ice regime concludes this chapter.

Missi Falls

Missi Falls was the natural outlet of Southern Indian Lake before the Missi Falls Control Structure was built and the Churchill River diverted at Southern Indian Lake. The mean flow of the Churchill River at Missi Falls for the period 1979 - 1988 was 135 $m^3 \cdot s^{-1}$; without diversion it is estimated that the natural flow for this period would have been 925 $m^3 \cdot s^{-1}$ (Fig. 2.5). The long-term mean outflow from Southern Indian Lake is estimated to be about 1100 $m^3 \cdot s^{-1}$, considerably higher than the estimated natural flow for the relatively dry, post-diversion period of the 1980s. A return to wetter conditions and a contin-

Figure 2.5 Regulated and Estimated Natural Monthly Mean Discharge for the Churchill River at Missi Falls, 1979 - 1988



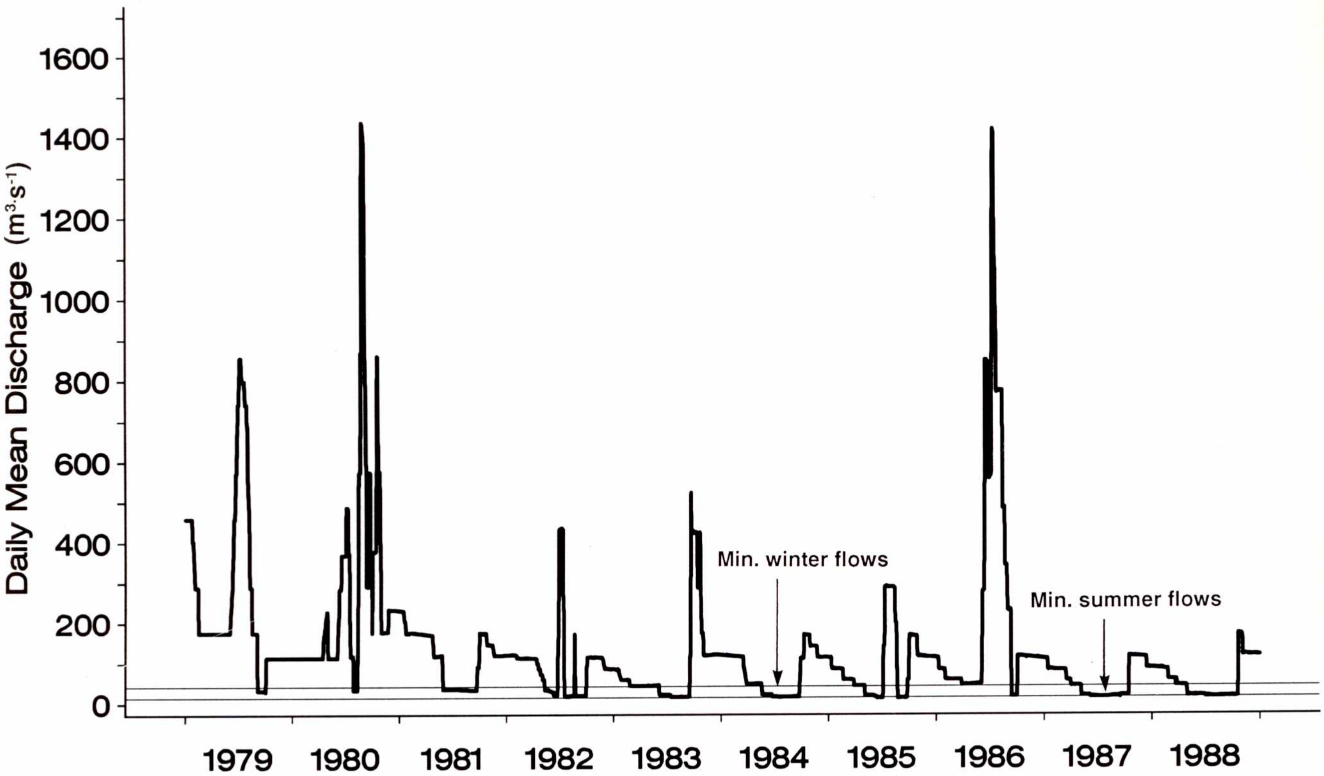
ued adherence to the currently authorized deviations to the diversion operating interim license (allowing up to 963 $m^3 s^{-1}$ under ice conditions and 991 $m^3 s^{-1}$ in open water to flow through the Notigi Control Structure) would result in the regulated long-term mean at Missi Dam being close to 200 $m^3 s^{-1}$.

For the most part, the operating range at Missi Falls, since diversion, has been between 13 and 200 $m^3 s^{-1}$, with occasional spills to concur with the terms of the interim license regarding high levels on Southern Indian Lake. Without diversion, it is estimated that the natural range of daily discharge at Missi Falls for the period 1979 - 1988 would have been between 600 and 1700 $m^3 s^{-1}$. In the period 1979 - 1988, there were two years, 1980 and 1986, when the regulated discharge exceeded 1400 $m^3 s^{-1}$ for a few days; in approximately half of these years, the peak flow was less than about 300 $m^3 s^{-1}$. Minimum flows each year since diversion have usually been close to the licensed lower limits of 14 $m^3 s^{-1}$ during the open-water season, and 42 $m^3 s^{-1}$ during the period of ice cover.

Maximum and minimum discharges are neither at the same season nor of the same duration as before diversion. Under regulation, large peak flows occurred most often during the June to September period but have occurred even in January. The relatively gradual rise and fall of this large river has been replaced by dramatically higher rates of change (Fig. 2.6). A change in discharge of up to 280 $m^3 s^{-1}$ is allowed in any 24 hour period under the operating license; in practice, this rate was met or exceeded in 1980 and 1986 when discharges at Missi Falls were quickly and briefly raised from under 100 to over 1400 $m^3 s^{-1}$. In creating the 1980 peak, the daily mean flow was increased by 1400 $m^3 s^{-1}$ (from 30 to 1430 $m^3 s^{-1}$) in 16 days in August and dropped by almost 1100 $m^3 s^{-1}$ (equivalent to the long-term mean flow) in a 7 day period in early September.

Regulation of Missi Falls discharges has had a profound effect on the lower Churchill River. For example, three of the larger lakes along the lower Churchill River, Partridge Breast, Northern Indian, and Fidler, have been reduced in area by 39 to 76%. While not part of the main FEMP study area, some limited study of the effects of the changed water regime along the lower Churchill River was conducted and is reported on in Volume 2 of this report.

Figure 2.6 Daily Mean Discharge for the Churchill River at Missi Falls, 1979 - 1988



Southern Indian Lake

The damming of the natural outlet of Missi Falls raised the water level of Southern Indian Lake by approximately 3 m, and increased the lake's area from 2082 km^2 to 2377 km^2. This change in area of 295 km^2 resulted primarily from the flooding of surrounding land (187 km^2), with the remaining area consisting of the incorporation of nearby lakes by flooding (Fig. 2.7). A composite Landsat image of Southern Indian Lake (Fig. 2.8) illustrates the extent of flooding in the vicinity of the South Indian Lake community.

The original operating license for Southern Indian Lake reservoir stipulated a maximum annual range of 0.6 m; since the early 1980s Manitoba Hydro has annually requested, and received from the province, permission to operate with a range of 1.5 m. In practice, the annual operating range since 1981 has been 1.2 to 1.4 m.

The outflow from Southern Indian Lake that has been diverted from the natural outlet at Missi Falls now exits Southern Indian Lake via a man-made channel that connects the southern end of the lake with the Rat River. Direct measurement of the flows at this man-made outlet had, until recently, not been possible, because site characteristics prevented the use of conventional stream flow measurement techniques. However, recent technological advances have provided a viable alternative means of streamflow measurement at this location (as discussed in chapter 4) and a monitoring site employing this technology has now been established, with financial assistance from FEMP.

Churchill River Diversion Route

The Notigi Control Structure, located about 90 km south of Southern Indian Lake, controls the flows down the Churchill River Diversion (CRD) route. Discharge at the Notigi Control Structure is currently limited by annual operating permits to 991 $m^3 \cdot s^{-1}$ under open water conditions and to 963 $m^3 \cdot s^{-1}$ under ice cover conditions, and is further constrained by licenced limits for water levels in Footprint Lake and for the Churchill River Diversion at Thompson. Between 1979 and 1988, mean flows at Notigi were 825 $m^3 \cdot s^{-1}$ compared to an estimated natural flow for this period of 31 $m^3 \cdot s^{-1}$. (Fig. 2.9).

Figure 2.7 Changes in Lake Surface Areas in the FEMP Study Area

LAKE	Pre-development Areas (km^2)		Post-development Areas (km^2)	Changes in Area (km^2)	
	(1)	(2)	(3)	(4)	(5)
Southern Indian Lake	2082	2190	2377	295	187
Notigi Reservoir	153	182	733	580	551
Churchill River Diversion					
- Wapisu Lake	45.1	46.8	66	20.9	19.2
- Footprint Lake	22.0	62.0	76	54	14
- Threepoint Lake	45.0	46.0	64	19	18
- Upstream of Wuskwatim Lake	4.9	6.2	17	12.1	10.8
- Wuskwatim Lake	50.1	53.2	64	13.9	10.8
- Opegano Lake	7.2	7.2	8	0.8	0.8
- Burr Lake and Wapishtigau Brook	1.4	1.6	6	4.6	4.4
- Birch Tree Lake	5.0	5.8	16	11	10.2
- Mystery Lake	9.0	9.0	12	3	3
- Apussigamisi Lake	14.3	14.3	22	7.7	7.7
TOTAL	204	252.1	351	147	98.9
Outlet Lakes Area					
- Playgreen Lake	691	NA	674	-17	NA
- Little Playgreen Lake	91	NA	89	-2	NA
- Kiskittogisu Lake	273	287	303	30	16
- Kiskitto Lake	173	NA	176	3	NA
- Nelson River above Jenpeg	36.0	36.0	84	48	48
TOTAL*	309*	323*	387*	78*	64*
Kelsey Reservoir					
- Sipiwesk Lake	403	434	496	93	62
- Archibald, Cauchon and Prud'homme lakes	113	124	167	54	43
- Lower Kelsey Reservoir	69	69	101	32	32
TOTAL	585	627	764	179	137
Split Lake	279	NA	280	1	NA
Stephens Reservoir	46	96	288	242	192

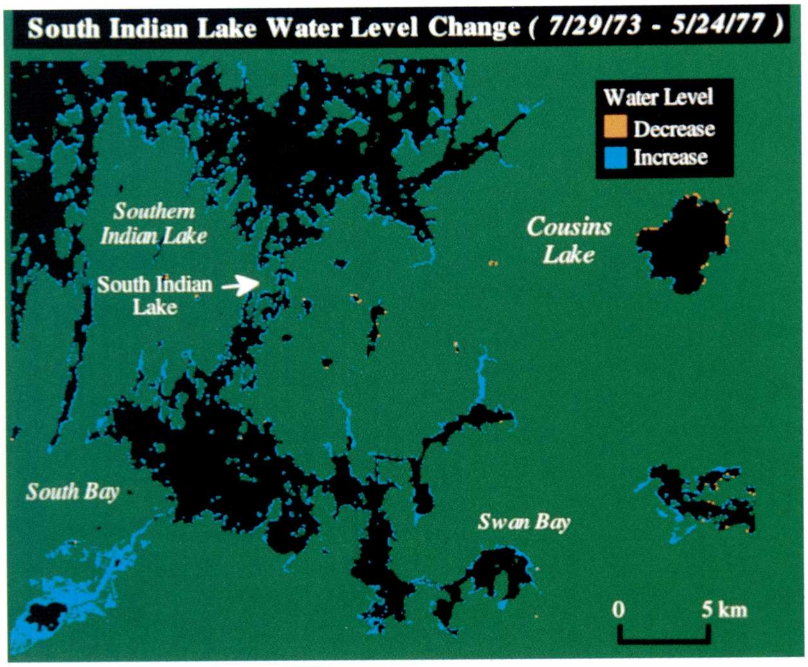
Note: Lake surface areas can vary depending on discharge. Lake areas in this table were calculated for discharges that were considered representative for each lake for the pre- and post-development periods.

Area (1): Original area of lake
Area (2): Original area of lake, plus all nearby lakes incorporated by flooding
Area (3): Area of lake after hydroelectric development
Area (4): Change in area of lake, Column (3) - (1)
Area (5): Area of flooded land, Column (3) - (2)
NA: Not Applicable, no increase due to development
*: Kiskittogisu and Nelson River above Jenpeg Dam only

Source: G. McCullough, 1991.

The Notigi Control Structure created a 15 m head and a reservoir with a post-development area of 733 km^2 (Fig. 2.7) Notigi Reservoir was created by incorporating a number of pre-development lakes, such as Karsakuwigamak, Rat and Notigi, with a pre-development surface area of 182 km^2, and by the extensive

Figure 2.8 Composite Landsat Image of Southern Indian Lake



flooding of terrestrial areas, totalling 551 km^2.

At Thompson, further downstream along the CRD mean flows for the period 1979 to 1988 have been 888 $m^3 \cdot s^{-1}$ compared to an estimated natural flow for this period of 93 $m^3 \cdot s^{-1}$ (Fig. 2.10). Regulated flows for the post- development period so far have been approximately 9.5 times what would have been the natural flow of the Burntwood River for this period. If the recent deviations authorized to the diversion operating interim license continue, there is a potential for annual mean discharges at Thompson to be approximately 1040 $m^3 \cdot s^{-1}$.

Before diversion, about one-quarter of the annual runoff at both Notigi and Thompson occurred in May and over half in the three months of May, June, and July. Although the annual range at the Notigi Control Structure is now typically between 200 and 500 $m^3 \cdot s^{-1}$, there is no longer any simple seasonal pattern to the rise and fall of the river. The pre-diversion

Figure 2.9 Regulated and Estimated Natural Monthly Mean Discharge for the Churchill River Diversion at Notigi, 1979 - 1988

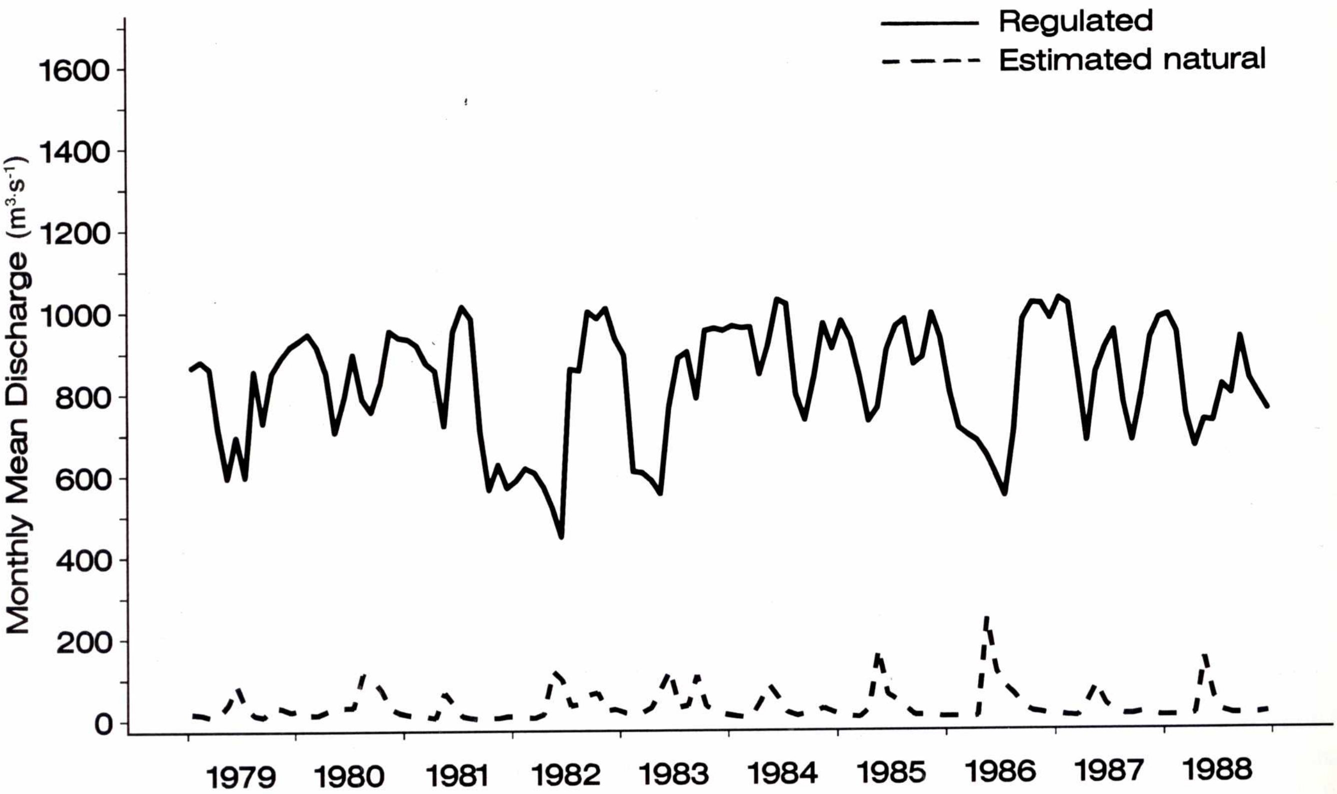
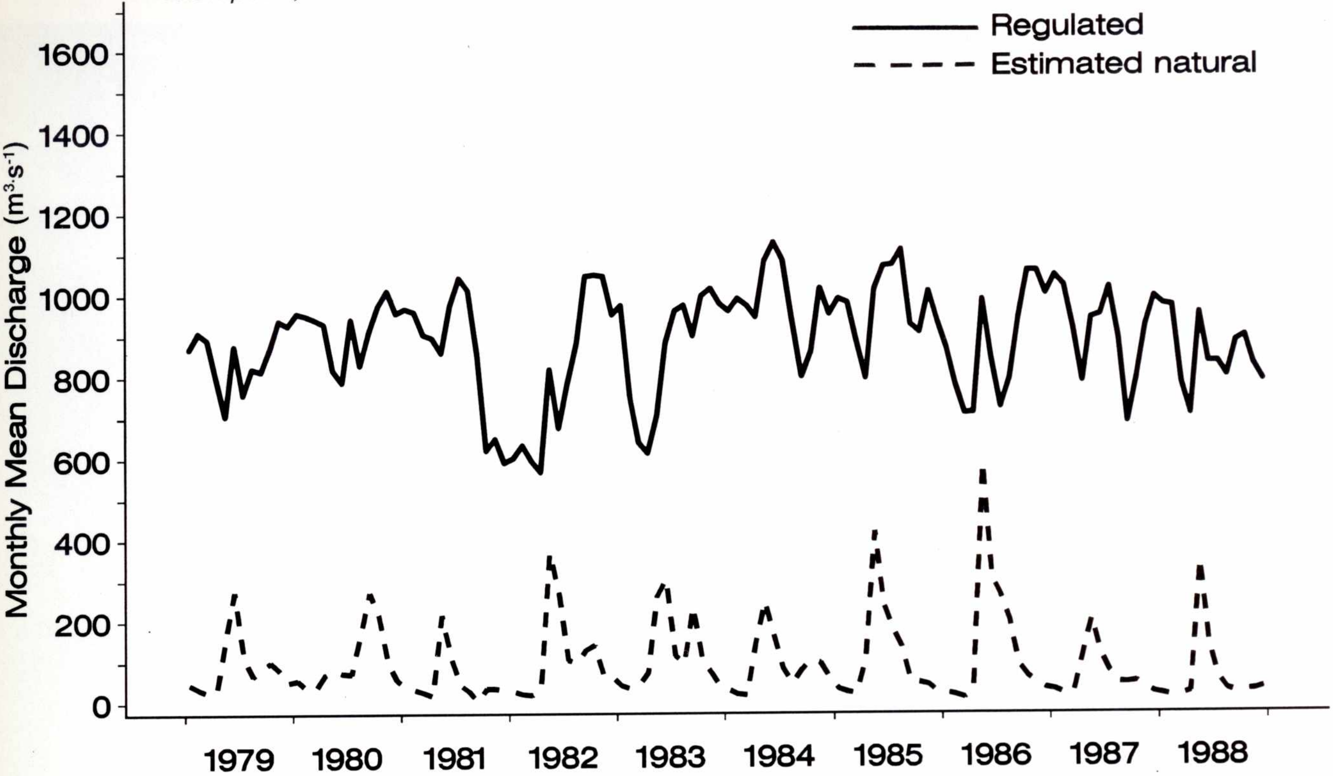


Figure 2.10 Regulated and Estimated Natural Monthly Mean Discharge for the Churchill River Diversion at Thompson, 1979 - 1988



spring runoff peak no longer occurs. The hydrograph of mean daily flows presents a picture not of a river occasionally flooding above a dominant base flow condition, but rather of a river consistently returning to an upper range of 850 - 1000 $m^3 \cdot s^{-1}$ after occasional drops in discharge. While these drops in discharge occur most commonly in March and April, they can occur in any season. The day-to-day range of releases at the Notigi Control Structure have been less than at the Missi Falls Control Structure, with only a few occurrences of a change in discharge greater than 100 $m^3 \cdot s^{-1}$ per day (Fig. 2.11).

The water levels of the lakes and river channels along the CRD reflect the changed flow regime. Examples of the increases in surface areas for some of the lakes along the CRD are given in Fig. 2.7. The most continuous water level record along the CRD has been kept on Footprint Lake at Nelson House. Fig. 2.12 shows the regulated and estimated natural monthly mean lake levels for Footprint and Threepoint lakes. Fig. 2.13 illustrates the extent of flooding at Footprint Lake, as estimated from a composite Landsat image.

Outlet Lakes Area

Lake levels on Lake Winnipeg are controlled by a dam 80 km downstream, at Jenpeg, and several ancillary channels and structures. The 2-Mile Channel was excavated near the natural outlet of Lake Winnipeg to improve the hydraulic efficiency of outflow. A second channel, the 8-Mile Channel, diverts a large but unmeasured proportion of the Nelson River through Kiskittogisu Lake, bypassing the north half of Playgreen Lake. To prevent very widespread flooding of the peatlands to the west, the outlet of Kiskitto Lake into the Channel below Kiskittogisu Lake is dammed, and the drainage from Kiskitto Lake and watershed is diverted north into the Minago River, which reenters the Nelson River below the Jenpeg Dam. The head at Jenpeg Dam is 7.6 m; flooding has been limited mostly to the channel region within 20 km of the dam.

In the 10 year period from 1979 to 1988, the mean flow through Jenpeg Dam was 1505 $m^3 \cdot s^{-1}$ or 82% of 1829 $m^3 \cdot s^{-1}$ flowing via the Nelson River into Cross Lake; the remaining 18%, or 324 $m^3 \cdot s^{-1}$, flowed through Sea River Falls in the East Channel of the Nelson River. The annual mean regulated flow for this period was not significantly different from what it would have been under estimated

Figure 2.11 Daily Mean Discharge for the Churchill River Diversion at Notigi, 1979 - 1988

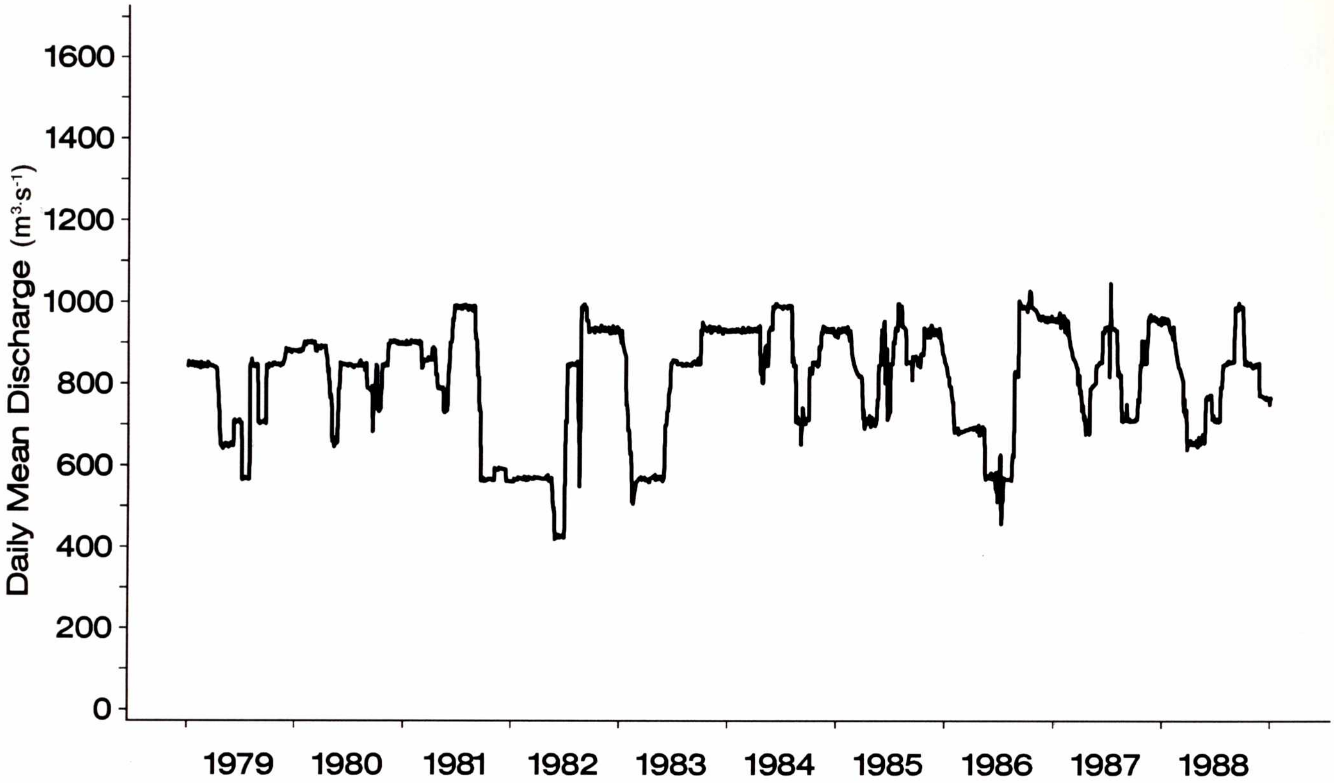


Figure 2.12 Regulated and Estimated Natural Monthly Mean Level for Footprint and Threepoint Lakes, 1979 - 1988

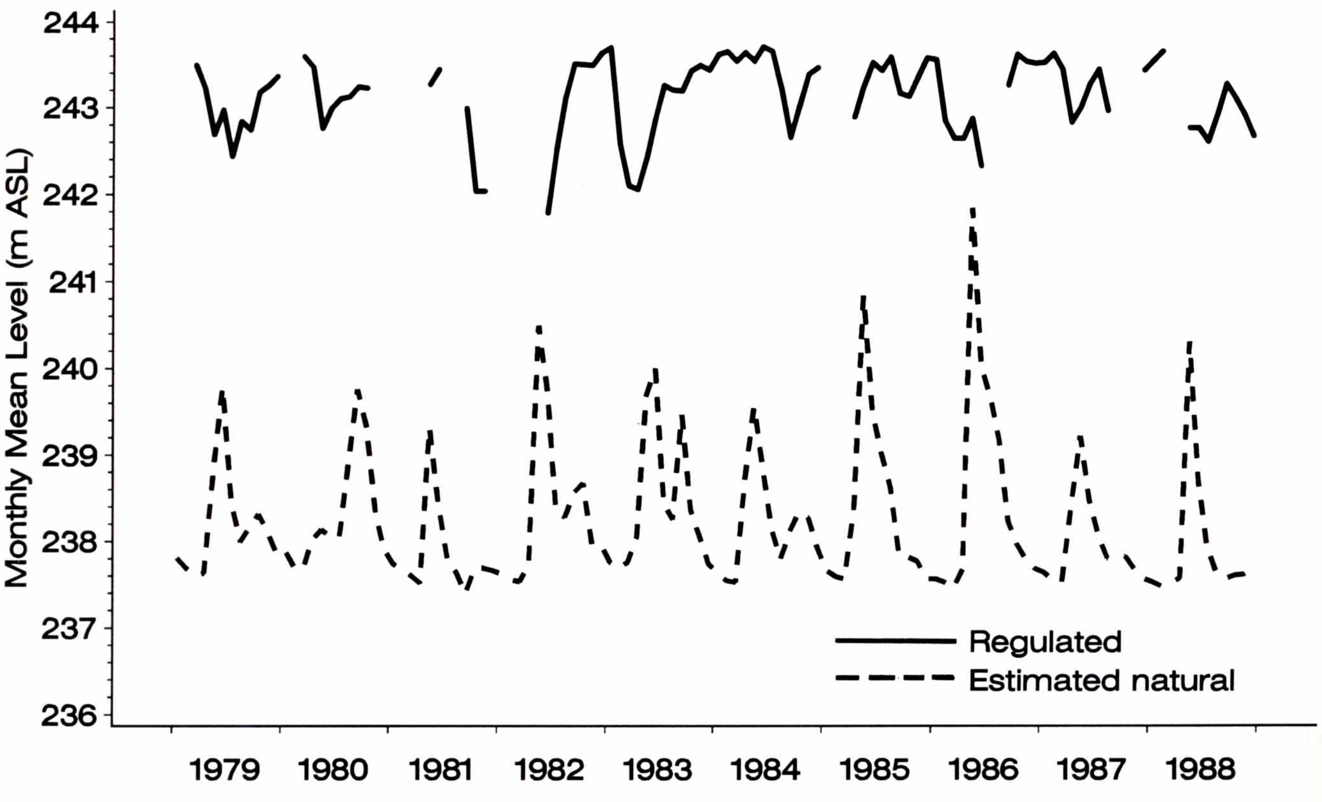
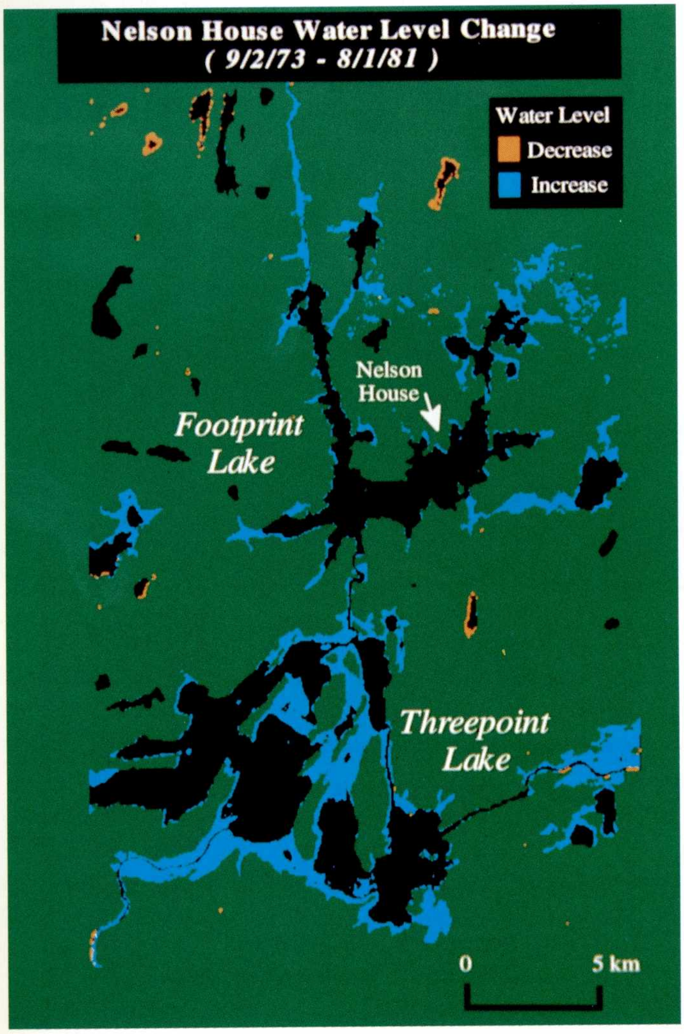


Figure 2.13 Composite Landsat Image of Footprint Lake



natural flow conditions for this same period. However, the flow for this period was considerably less than the long-term mean Nelson River flow at these stations of about 1975 $m^3 s^{-1}$, since, as noted previously, the 1980s were a dry decade in comparison to the long-term record. The effect of the altered flow regime on the surface areas of the Outlet Lakes is shown in Fig. 2.7.

The seasonal distribution of the flows in the Outlet Lakes region, and through the rest of the Nelson River, has been dramatically different than what it would have been if it had not been regulated at Jenpeg Dam. Without regulation, the peak flows of the Nelson River into Cross Lake would have occurred most commonly in June or July. Since 1979, the peak flow has occurred between October and December except during the summers of 1979 and 1986 when water had to be released at Jenpeg to prevent unusually high runoff from raising Lake Winnipeg above its natural range. For the period 1979 to 1988, the mean June - August discharges into Cross Lake were 670 - 770 $m^3 s^{-1}$ lower than they would have been under estimated natural conditions for this period. In the December to February period, they were 520 - 750 $m^3 s^{-1}$ higher than natural (Fig. 2.14).

The water level of Cross Lake reflects the changed flow regime, as shown in Fig. 2.15. The seasonal level fluctuations have been strongly reversed, causing 300 km^2 of lake bottom to be intermittently dewatered. (The area of Cross Lake, from 1979 - 1988, varied from under 300 km^2 to over 600 km^2.) The Landsat image shown in Fig. 2.16 shows the dewatered Cross Lake in the summer of 1984. A composite Landsat image for the Norway House area is shown in Fig. 2.17.

Nelson River

Four dams have been built to-date on the lower Nelson River - Kelsey Dam, located upstream of Split Lake, and 3 dams downstream of Split Lake - Kettle, Long Spruce, and Limestone. (A composite Landsat image for Split Lake is shown in Fig. 2.18.) Kelsey Dam impounded the river 16 m at the forebay, causing extensive flooding reaching upstream 150 km to Sipiwesk Lake, which was raised 1 to 2 m. The extent of the flooding caused by Kelsey Dam, as illustrated by changes in lake surface areas, is shown in Fig. 2.7. The monthly mean discharge record at Kelsey Dam (Fig. 2.19) shows seasonal shifts of magnitudes similar to those at Cross Lake.

Kettle Dam, with a forebay head of 30 m, created the new 288 km^2 Stephen's Reservoir, flooding approximately 242 km^2 beyond the pre-development Nelson River's channel (Fig. 2.7). Long Spruce and Limestone dams, each with a 24 m head, are run-of-the-river impoundments generally within high riverbanks and consequently have not caused major flooding.

At Kettle Dam, the first of the series of lower Nelson River dams where flows have been augmented by the addition of the diverted Churchill River flows, the mean discharge for the period 1979 to 1988 has been 2980 $m^3 s^{-1}$, 37% more than the 2170 $m^3 s^{-1}$ that it would have been without the Churchill River Diversion (Fig. 2.20). The long-term mean flow at Kettle, without diversion, has been computed to be 2276 $m^3 s^{-1}$. Given the current operating regime, limited by regular deviations to the interim license, there is a potential for diversion of 940

Figure 2.14 Regulated and Estimated Natural Monthly Mean Discharge for the Nelson River at Jenpeg and Sea River Falls, 1979 - 1988

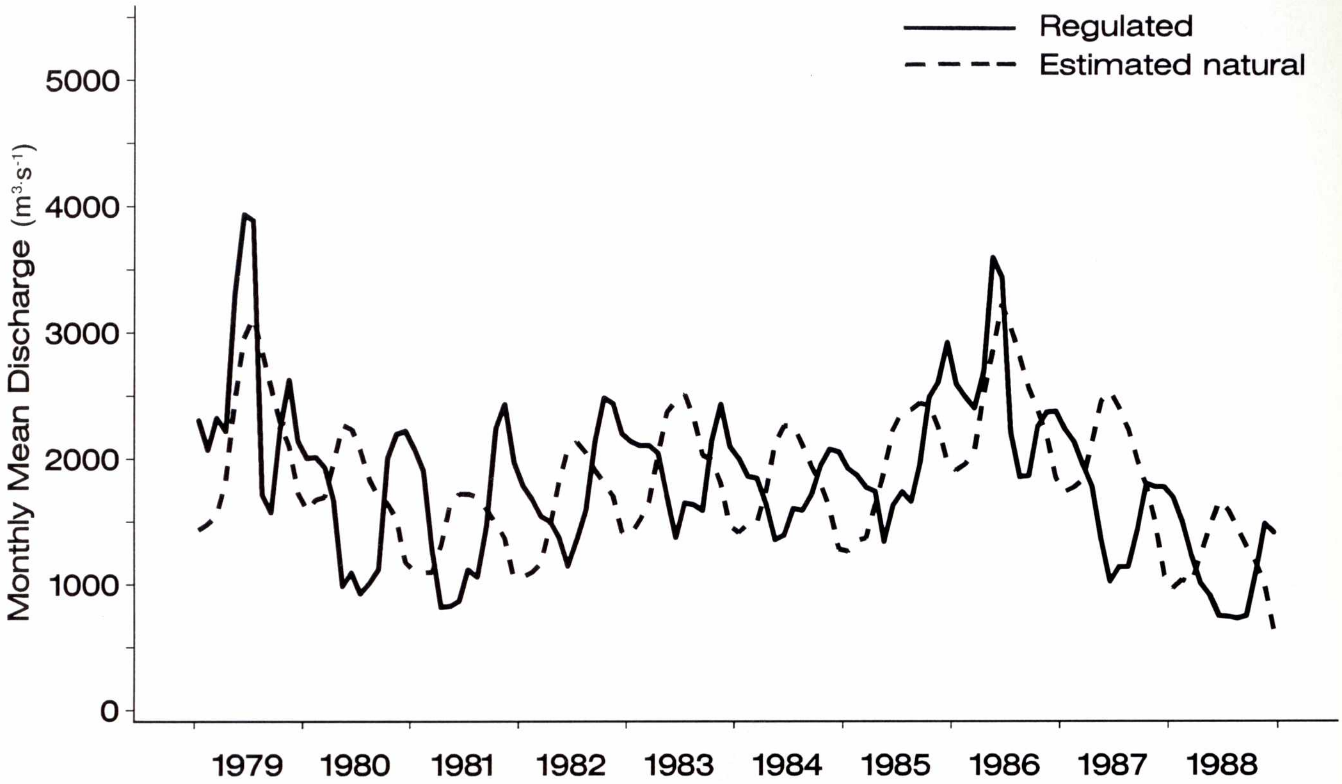


Figure 2.15 Regulated and Estimated Natural Monthly Mean Level for Cross Lake, 1979 - 1988

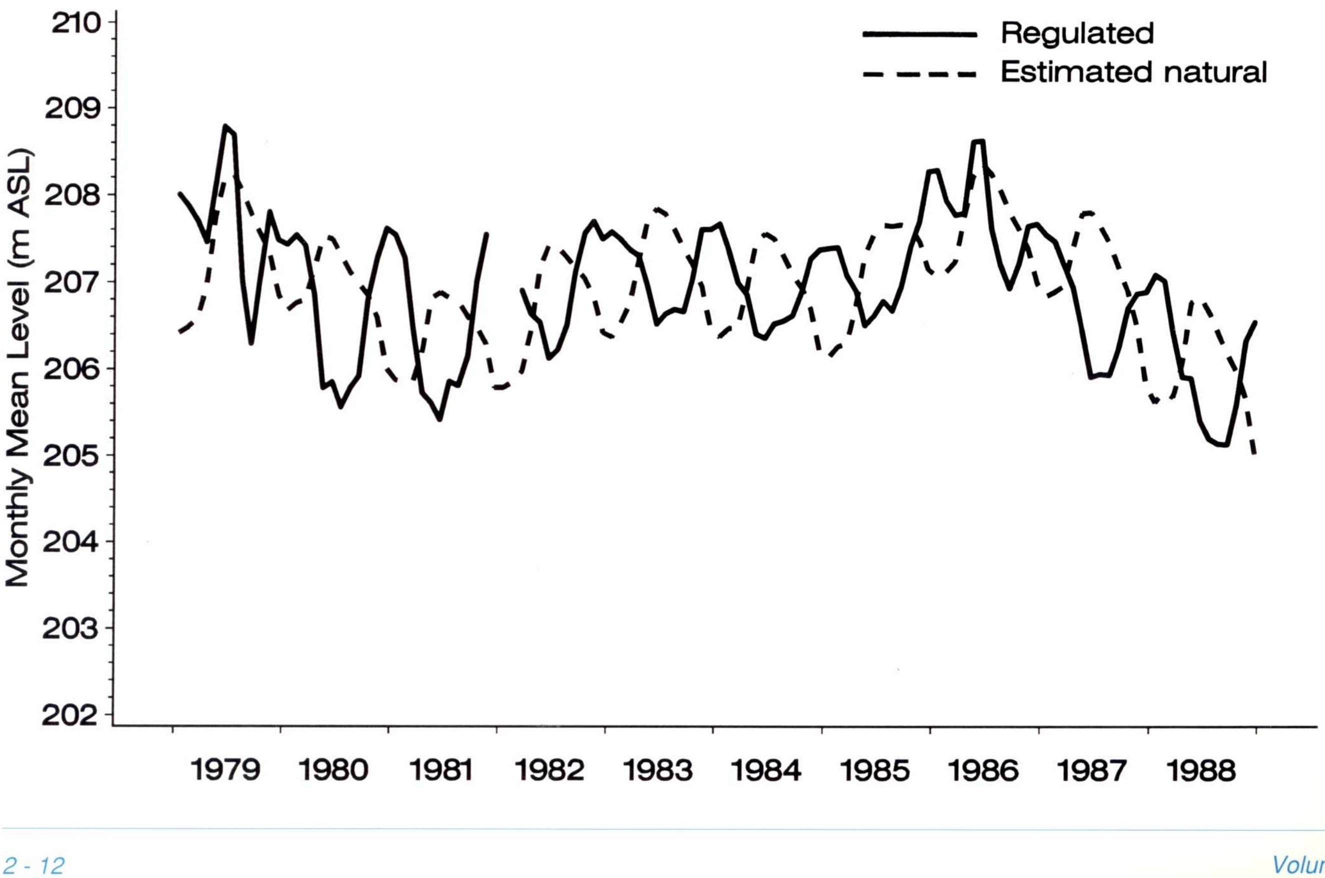


Figure 2.16 Landsat Image of Cross Lake, 1984

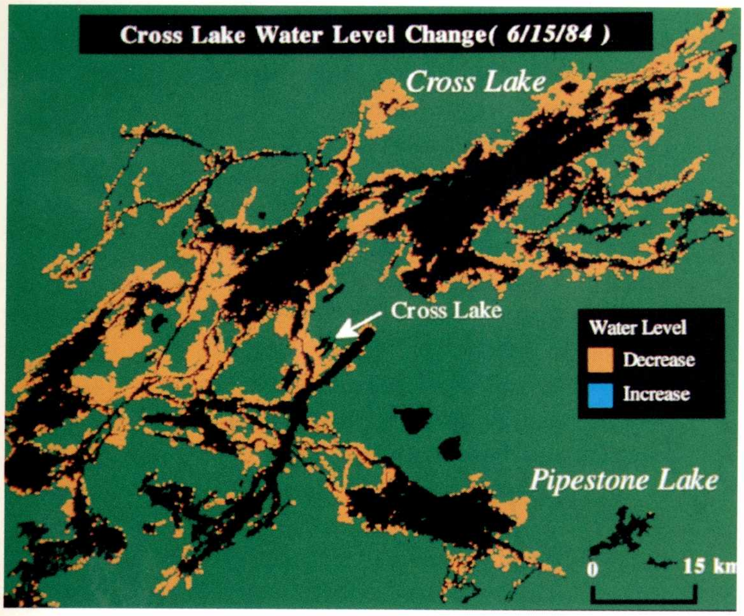
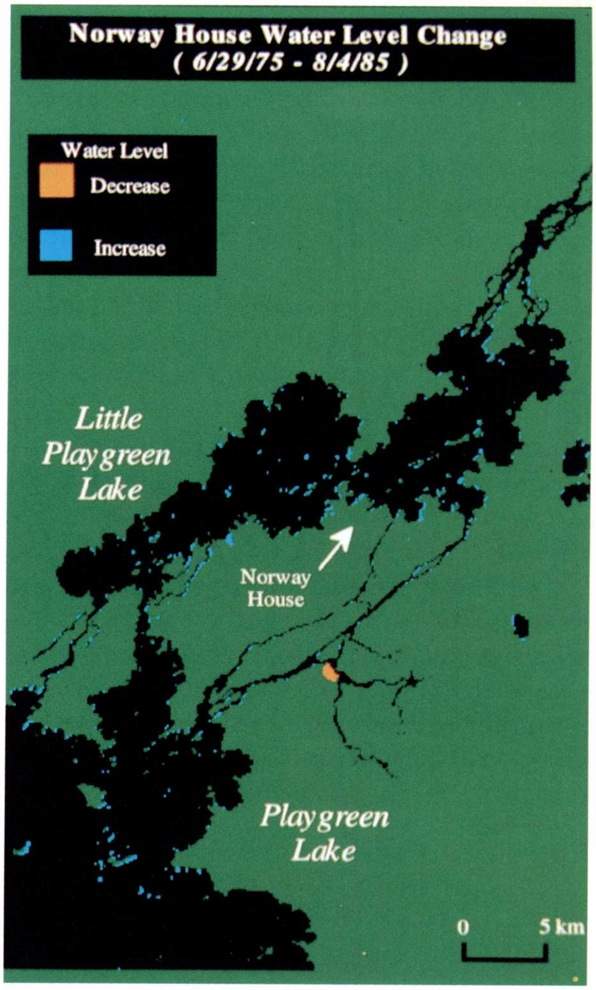


Figure 2.17 Composite Landsat Image of Norway House Area



$m^3 \cdot s^{-1}$ into the Nelson River above Split Lake. Hence, the long-term mean will more likely be near 3220 $m^3 \cdot s^{-1}$ or about 8% higher than the mean post-diversion flow so far.

Without regulation at Jenpeg Dam and the diversion of the Churchill River, the lower Nelson River would have peaked in May or June, at flows from 1000 to over 2200 $m^3 \cdot s^{-1}$ above the low flows of the previous January

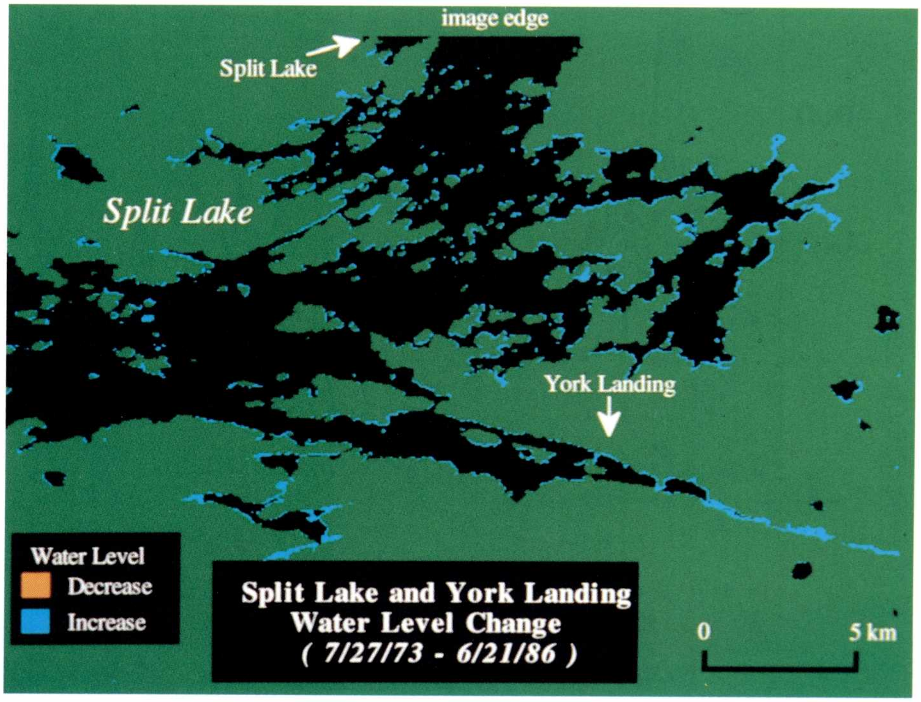


Figure 2.18 Composite Landsat Image of Split Lake

Figure 2.19 Regulated and Estimated Natural Monthly Mean Discharge for the Nelson River at Kelsey Dam, 1979 - 1988

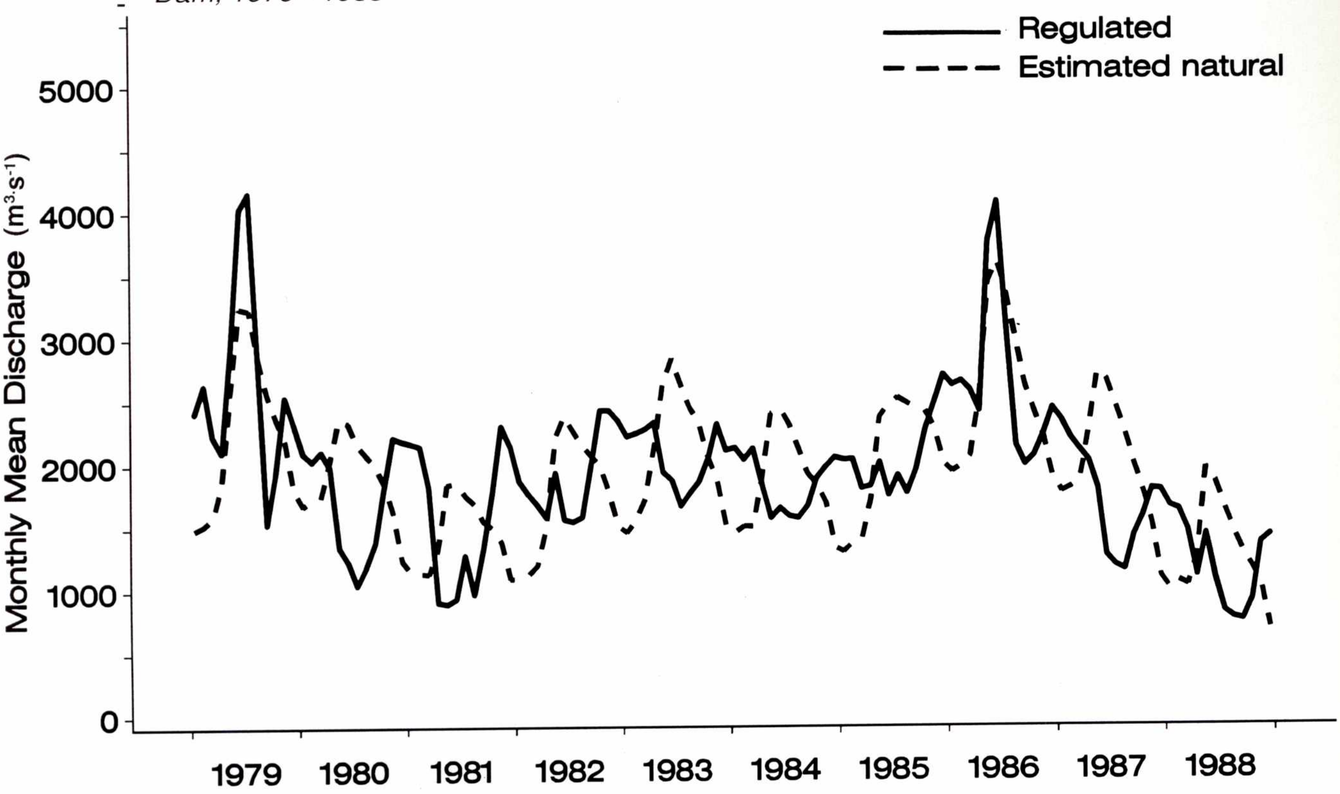
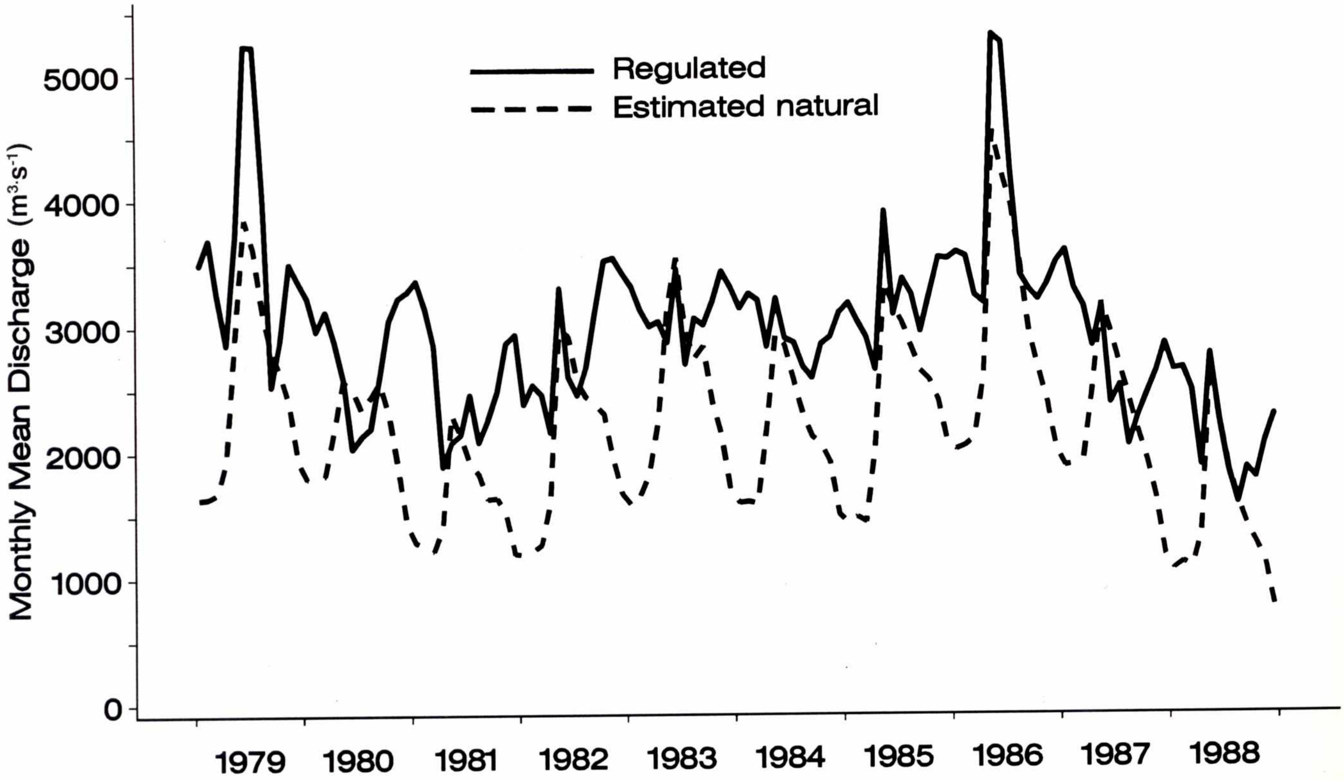


Figure 2.20 Regulated and Estimated Natural Monthly Mean Discharge for the Nelson River at Kettle Dam, 1979 - 1988



or February. Under the regulated regime the annual peak discharge typically has occurred from November to January, although exceptions were common. The 1979 and 1986 high releases at Jenpeg Dam produced major spring peaks at Kettle Dam, with flows in both years over 5000 $m^3 \cdot s^{-1}$. Much smaller, and very brief, spring peaks were due to local and diversion flows.

Despite the reversal of the seasonal pattern of the lower Nelson River flows, the diverted Churchill River water has caused even the regulated low summer flows to be as high as, or higher than, what they would have been otherwise. Mean June to August flow has on average been approximately 190 $m^3 \cdot s^{-1}$ more than without regulation and diversion, while the mean for December to February has been 1610 $m^3 \cdot s^{-1}$ higher.

It is interesting to note here that the overall effect of the regulation of the Churchill and Nelson rivers for hydroelectric production has been to reduce the amount of water delivered to Hudson Bay in the open-water period. For the period 1979 to 1988, it is estimated that, under natural conditions, an average of 47 km^3 would have flowed past Missi Falls and Kettle Rapids from June through October each year; under regulation, this was reduced by 15% to 40 km^3. The difference of 7 km^3, 7% of the combined annual delivery to Hudson Bay of the Churchill and Nelson rivers, has been shifted to the ice-covered months of November to May.

Perhaps the most dramatic effect of regulation on the lower Nelson River flows can be seen in the day-to-day regime. At Kettle Dam, for the period 1979 - 1988, most of the day-to-night drops in hourly mean discharge were over 2000 $m^3 \cdot s^{-1}$ in winter, and were commonly almost 3000 $m^3 \cdot s^{-1}$ in summer. Upstream at Kelsey and Jenpeg dams, such large day-to-day fluctuations never occurred. The maximum 24 hour change in daily mean discharge was less than 1000 $m^3 \cdot s^{-1}$. Such large day-to-day fluctuations are not the norm even for a large river like the Nelson. For example, the largest 24 hour change in daily mean flow at Bladder Rapids, below Cross Lake, for the pre-development period 1959 to 1974 was under 400 $m^3 \cdot s^{-1}$.

The variability in the short-term discharge on the lower Nelson River is tied to the weekly pattern of energy usage by Manitoba Hydro consumers. In general, discharge at Kettle Dam, and all downstream dams, is quickly raised each morning to coincide with the beginning of the working day (Fig. 2.21). High discharges are maintained until late afternoon or evening, when the discharge is dropped back down to a daily low in the early hours of the morning. After the Friday night drop, the discharge fluctuates at low values throughout most weekends, only to be raised back to weekday levels on Monday morning.

Figure 2.21 Hourly Mean Discharge for the Nelson River, 1984 . . . *continued next page*

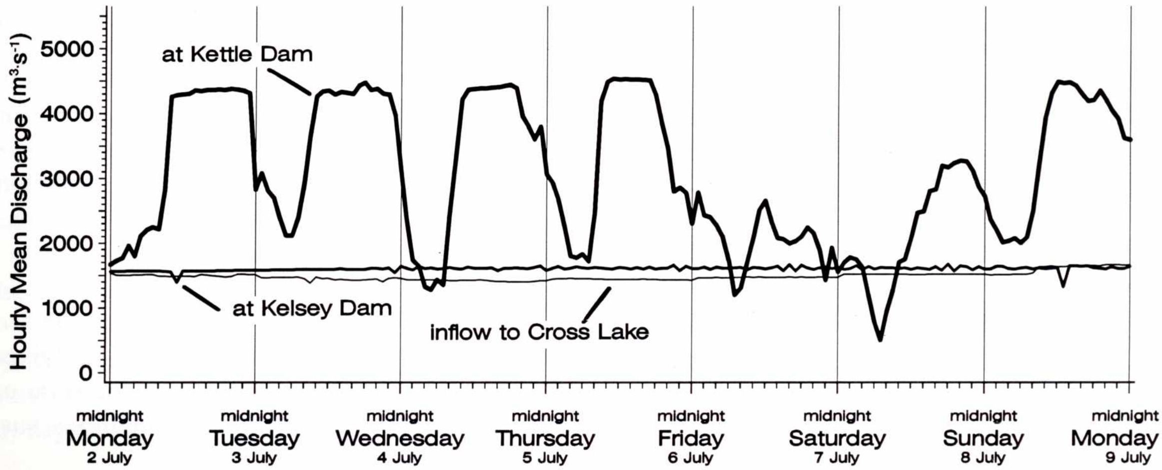
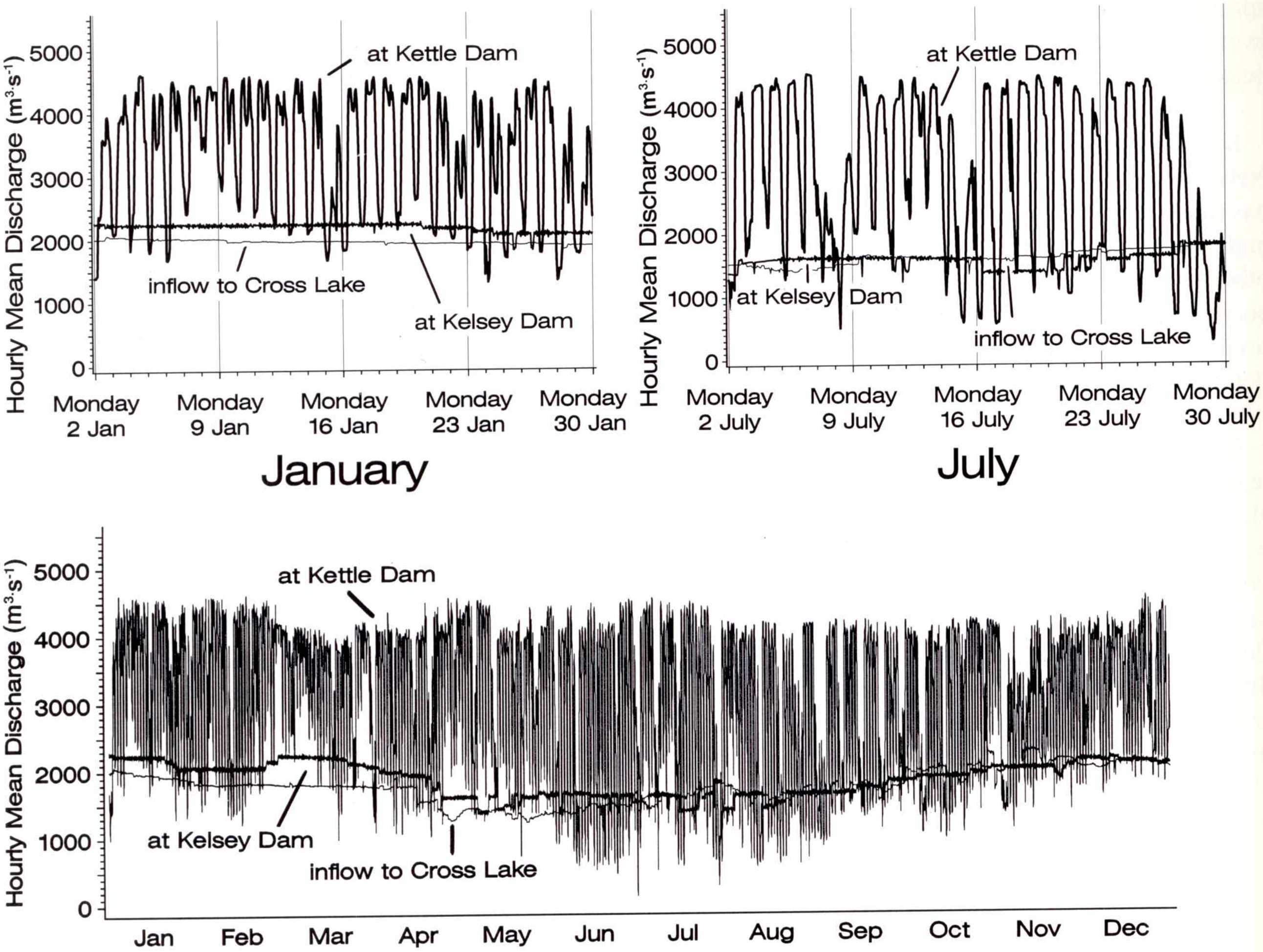


Figure 2.21 Hourly Mean Discharge for the Nelson River, 1984 . . .continued



Ice Regime

The long, cold winters that are experienced in the FEMP study area means that for a substantial part of each year, the lakes and rivers of the Lake Winnipeg, Churchill and Nelson rivers system are ice covered. As illustrated in Figs. 2.22 to 2.25, the ice cycle is governed by: 1) meterological conditions, such as air temperature, precipitation, and wind; 2) hydrologic conditions, such as water temperature, velocities, and levels; and 3) by lake and river morphology, such as shoreline configuration, water depths, and natural and man-made obstructions. In particular, it is the inter-relationships of these three major factors that determine the progress of the ice cycle from freeze-up to break-up.

The linear chain of events shown in Fig. 2.22 is by necessity a simplification; in nature, the cycle proceeds through a series of feedbacks. For example, during the freeze-up period, the actual development and persistence of a complete ice cover can take a relatively long time, with repetitive periods of freezing and thawing, even to the point of no ice cover.

It should also be noted that not all of the sequences shown in Fig. 2.22 occur on all the lakes and rivers in the FEMP study area. For example, an ice skim can only form under very quiet, windless conditions, such as on small shallow lakes or in the bays and inlets of larger lakes. Under such conditions, the skim can form across the whole surface of a lake overnight and then thicken through the growth of black ice and possibly snow ice. This type of freeze-up could occur in the still-water areas of the larger lakes and reservoirs of the FEMP study area (e.g. Notigi Reservoir), but would be unlikely on the smaller lakes and central areas of the larger water bodies, due to their riverine nature.

The influence of man-made factors, such as hydroelectric dams and river regulation, on the ice cycle is clearly shown in Figs. 2.23 to 2.25. For example, ice conditions on those river stretches upstream of a dam differ from those found downstream of a dam. The presence of a dam defines the lodgement point for that stretch of river, delaying the freeze-up downstream of the dam and advancing the freeze-up for some distance upstream of the dam. During winter, slush ice may be a problem downstream of the dam, while upstream of the dam, very irregular ice cover near the riverbanks may occur as a result of reservoir fluctuations. In the spring, the stretch of river downstream of a dam may experience a quiet thermal break-up of ice, while upstream ice jams may occur which, with high spring discharges, can cause extensive flooding.

As noted in the previous sections, one common characteristic of the regulated river regime is the large fluctuations that now can occur in comparison to what was the norm under natural flow conditions. Unlike open water conditions, monthly or even daily measurements of water levels and velocities may be insufficient to characterize the condition of lakes and rivers under ice cover. Short-term fluctuations, which in the FEMP study area can sometimes occur hourly, can have a dramatic effect on the ice cover. In particular, under-ice currents can result in thin ice that diminishes the strength and stability of the ice cover (Fig. 2.24).

The ice regime is both affected by and can cause physical changes to the environment. Examples of the latter include the scouring of shorelines by the movement of large, thick ice sheets; the gouging of river beds by the keels of moving ice sheets containing pressure ridges; and the occurrence of floods due to ice jams.

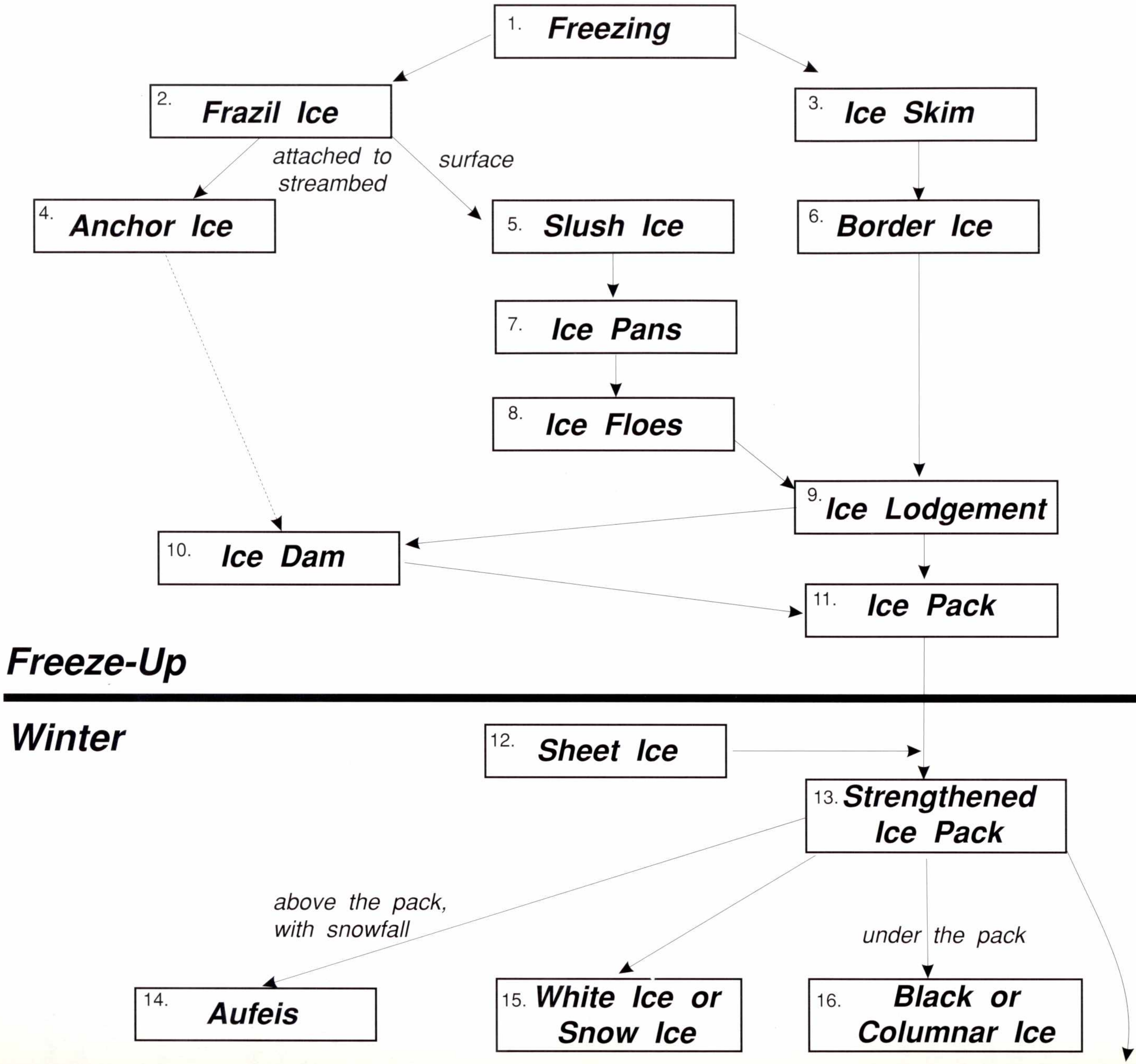
Physical changes to and by the ice regime can have a profound effect on the wildlife and people who live near and are dependent on the area's water resources. Perhaps, the most pervasive effect of changes to the ice regime is the effect on transportation. Over-ice transportation, or the trafficability of the ice, is dependent upon the weight bearing capacity of the ice (see Fig. 2.26) and upon surface ice conditions, such as the presence of slush ice and pressure ridges. Surface ice conditions are also particularly important to recreational uses of ice, such as ice skating and dog sledding. In addition, wildlife harvesting, whether for income, food, or recreational purposes, can be impeded by changes in the ice cover.

Fish and wildlife can be directly affected by changes in the ice regime in a number of ways. For instance, a change in water levels and consequently a change in ice cover can expose the eggs of fall spawners, such as whitefish, to fatal temperatures, while delayed breakup can delay the spawning activity of spring spawners, such as pike. Fish may also be affected if increased frazil ice production in large open water areas is sufficient to block fish gills. Large open water areas, which are characteristic of river stretches downstream of a hydro plant, can be beneficial to some animals such as otter and mink, which exhibit a preference for natural open water areas; however, such areas may interfere with the migration paths of moose and other ungulates.

Developing a detailed understanding of the ice regime over the large FEMP study area and of the changes to it since the hydroelectric projects was considered to be beyond the scope of the FEMP. However, it is evident that a significant feature of the changes to the ice regime is that a reasonably consistent and predictable natural cycle has been replaced by an unnatural one - one that will be difficult to predict, in part because it will be dependant upon the future power demand requirements.

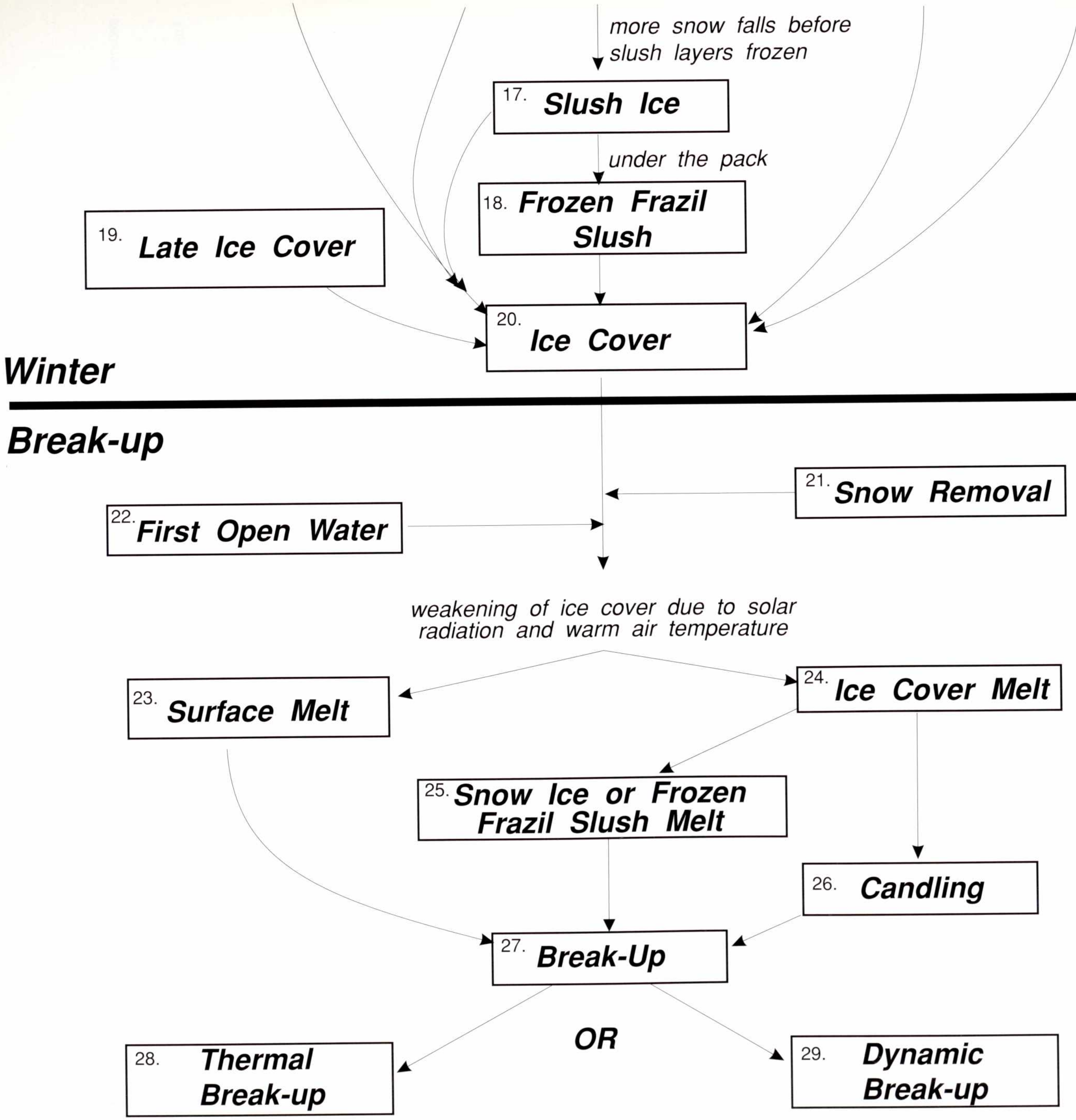
Some predictive ability may be possible with respect to the important issue of changes in ice cover thickness, if detailed bathymetry were available to relate to water level records and most importantly if some form of very accurate sub-surface temperature monitoring could be achieved. The possibility of setting up a forecast - monitoring program for critical transportation routes could be investigated; however, the intensive information requirements to develop such a forecast preclude its application for large-scale regions, if reasonable accuracy of forecast is desired.

Figure 2.22 The Ice Cycle



1. Water temperature reaches 0°C
2. In turbulent areas, small particles of ice form
3. In very quiet areas, a skim of ice forms
4. Frazil deposits form on streambed
5. Particles eventually reach surface forming slush ice
6. Ice grows in thickness and laterally
7. Congeals in cold temperatures to form ice pans
8. Pans meld together to form large ice floes
9. Ice floes and border ice joining to form ice pack
10. Ice may accumulate beneath to form a freeze-up dam
11. Pack will advance upstream, occasionally may collapse reducing in length, but increasing in thickness

12. Sheet ice may form in interstices of ice pack
13. Increased pack strength
14. Under certain conditions, water is forced onto top of ice pack and freezes
15. Slush layer, caused by water from cracks saturating lower snow layer, is subsequently frozen
16. Freezing of water under the pack through the growth of candle-like crystals



17. Several layers of slush and thin solid ice layers
18. Any slush ice under ice pack will be incorporated into ice cover as it thickens
19. Formation of late ice cover over open water, eg. rapids

21. Snow cover on ice melts
22. Open water appears first in areas of thin or late ice
23. Melting of ice at surface (slow process)
24. Melting within ice cover
25. Melting of snow ice or frozen frazil slush, takes very much longer to decay
26. Melting of columnar ice producing candle-like separate columnar grains; structural decay and decrease in strength
28. Ice cover melts in place
29. Movement of ice fragments and water downstream; if movement is the result of an ice jam release, flood waves can occur

Figure 2.23 Freeze-Up Concerns

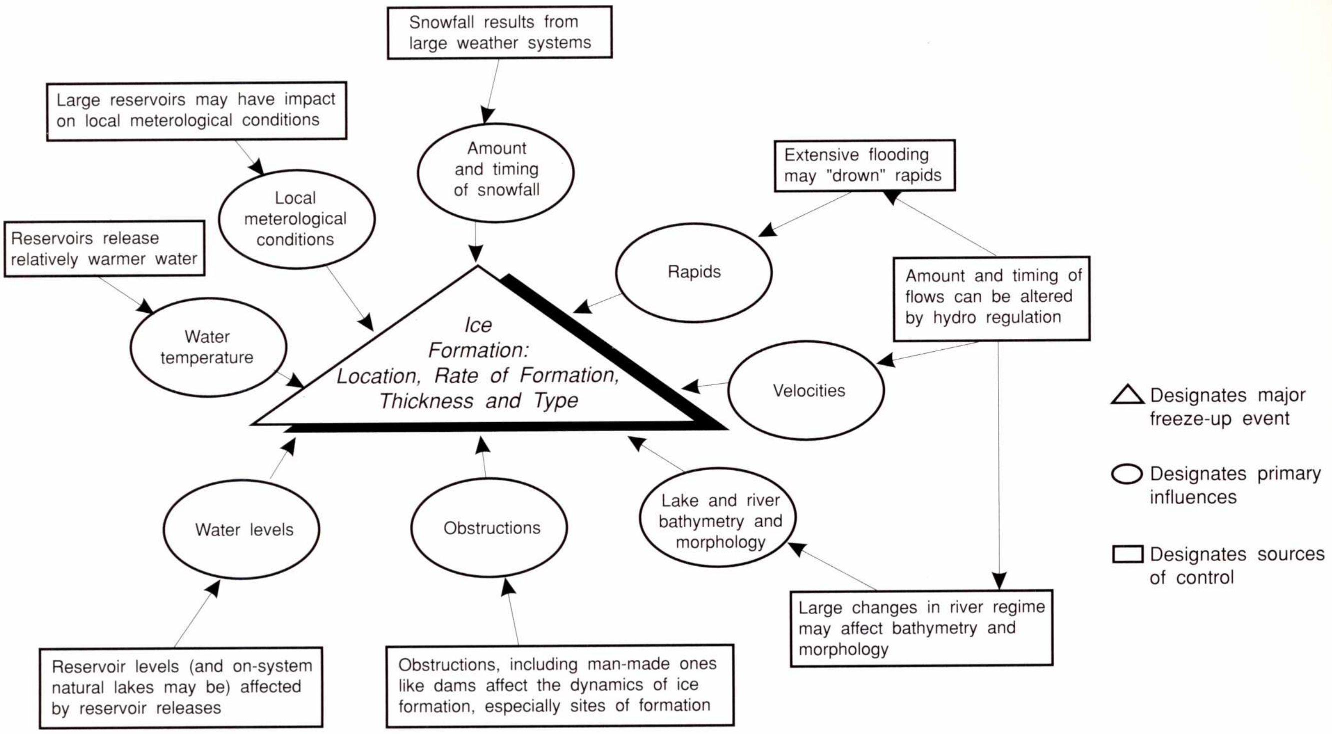


Figure 2.24 Winter Ice Concerns

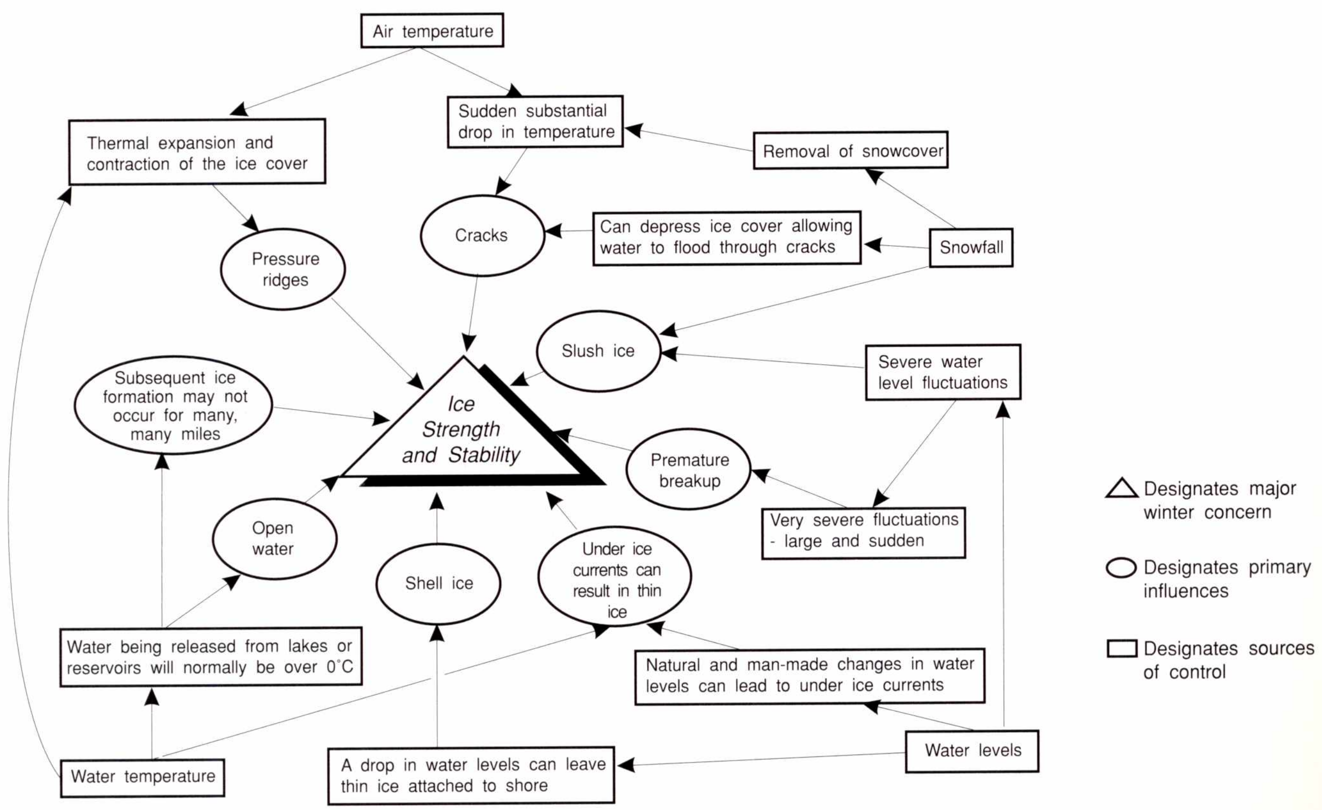


Figure 2.25 Break-Up Concerns

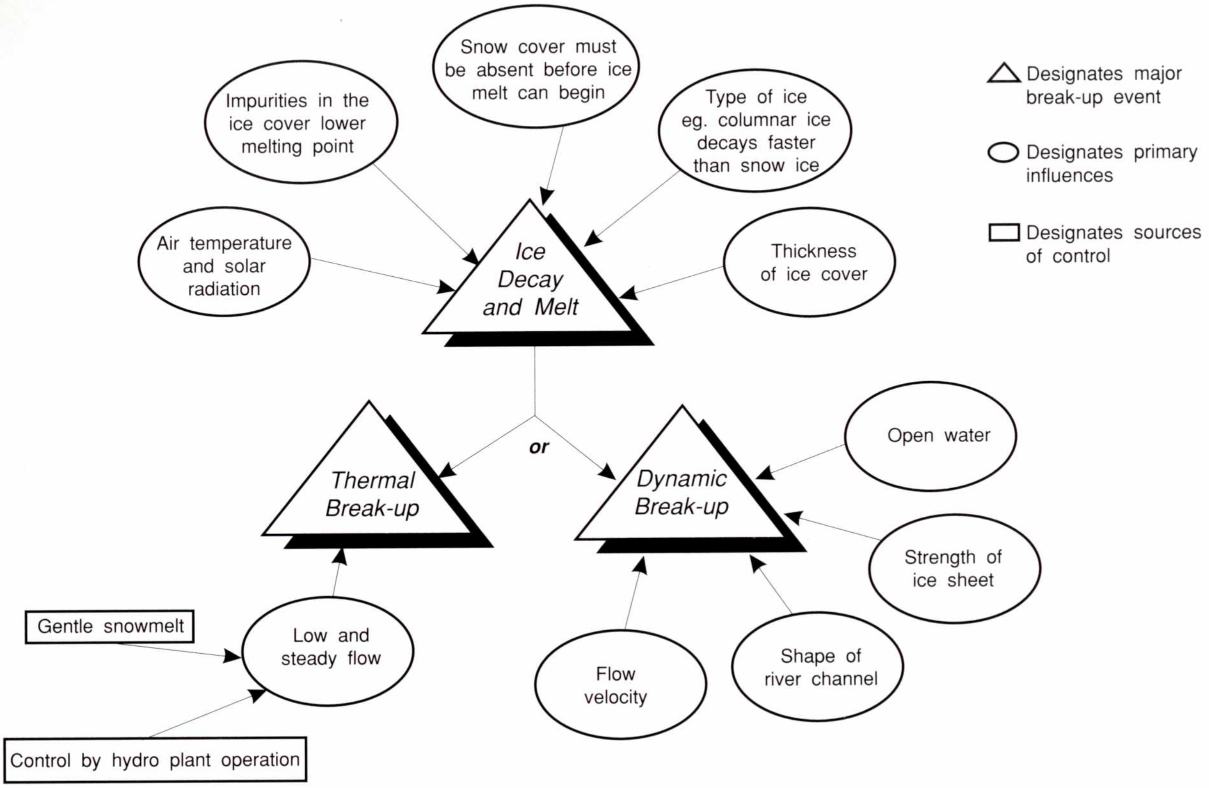


Figure 2.26 Weight-Bearing Capacity of Ice

SUMMARY

The natural regime of the Churchill and Nelson, Rat and Burntwood rivers has been dramatically, and perhaps irrevocably, altered by hydroelectric development. The diversity and magnitude of the changes in river flows and lake levels are summarized on Map 2 at the back of this volume.

The greatest perturbations to the water regime occurred during and immediately after the construction period of the early to mid-1970s. Future, although smaller, perturbations can be expected as continued adjustments are made to Manitoba Hydro's operating regime and as future hydro dams are constructed and put into operation. Over time, the water regime will become stabilized and achieve a new steady state, albeit one that will be considerably different from the natural regime which existed before the LWCN project.

CHAPTER 3

PLANNING FEMP

The Federal Ecological Monitoring Program (FEMP) was planned within the framework of the historical, legal, political, socioeconomic, and environmental conditions that existed at the time. The intent of this chapter is to briefly describe these conditions that collectively determined FEMP.

NORTHERN FLOOD AGREEMENT

The governments of Canada and Manitoba, recognizing the overall interest and conflict over the use of the water and related resources in the LWCN Hydroelectric Project area, initiated the Lake Winnipeg, Churchill, Nelson (LWCN) Rivers Study in 1971. The objective of this four-year study was to determine the effects that the regulation and diversion projects were likely to have on water and related resource uses and to make recommendations for enhancing the overall benefits with due consideration for the protection of the environment. One of the 47 recommendations (Rec. #10) of this study was "that appropriate government departments and agencies develop and implement a long term coordinated ecological monitoring and research program to allow impact evaluations and to assist in the ongoing management of the affected area".

In 1976 and 1977, detailed proposals were formulated for multi-discipline, multi-agency, coordinated ecological monitoring programs which would address LWCN Study Rec. #10 (Hecky et al. 1976; JIAWG 1977). These proposals were never implemented, largely because of the signing, in 1977, of a landmark agreement called the Northern Flood Agreement (NFA).

The NFA is an open-ended, open-funded, legally binding contract signed by Canada, Manitoba, Manitoba Hydro, and the Northern Flood Committee (NFC) - an organization representing the five Indian bands whose members live on reserves in the LWCN Hydroelectric Project area - Nelson House, Split Lake, York Factory, Cross Lake and Norway House. The objective of the NFA is to ensure that all persons represented by the NFC who are adversely affected by the LWCN Hydroelectric Project receive fair and equitable treatment.

The NFA contains twenty-five articles and eight appendices dealing with a range of topics including land exchange, community infrastructure, employment, and environmental impacts. Two articles of particular relevance to FEMP are Article 17.5 which states: "In particular but without limitation, monitoring of adverse effects of the Project pursuant to the Lake Winnipeg, Churchill and Nelson Rivers Study Board recommendations shall be planned and implemented so as to provide such information as may be necessary to give effect to this Agreement," and Article 18.2 which states: "Canada and Manitoba recognize that the Project is intended to benefit all citizens of Canada, and most particularly of Manitoba, on the one hand, and that the resource users have been and may continue to be adversely affected on the other hand, and that it is in the public interest to ensure that any damage to the interests, opportunities, lifestyles and assets of those adversely affected be compensated appropriately and justly."

Article 24 of the NFA establishes an arbitration process, by which "...any claim or matter in dispute submitted by any person..." can be heard by an arbitrator. 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." This claim was the impetus for FEMP.

FEMP, therefore, was a partial fulfillment of Canada's obligations under a legal contract, a sharp contrast to most government environmental programs that are implemented as a result of legislation or government policy. The NFA is, however, a difficult agreement to interpret and implement due to its complexity, breadth of scope, and the imprecision of many of its clauses (e.g. "eradicate mass unemployment and poverty"). The recent demise of a senior 4-party process, commonly referred to as global negotiations, intended to resolve outstanding commitments of the NFA illustrates this difficulty.

PROGRAM ADVISORY BOARD

As noted previously, Rec. #10 of the LWCN Study recommended the implementation of a long-term coordinated ecological monitoring and research program. However, until 1985, the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion was the only fully coordinated monitoring and research program to be implemented. Other environmental programs conducted in the LWCN impact area were single discipline and/or single agency programs.

In July 1985, Manitoba and Manitoba Hydro set up a two-party Program Advisory Board (PAB), to manage their biophysical monitoring programs. In September 1986, following the initiation of FEMP, the two-party PAB was expanded to a 4-party board, with members from Canada and the NFC, to facilitate the coordination of all programs. The 4-party PAB was a self-created coordinating mechanism; it had no official status to manage FEMP.

At the time, PAB was unique in that it was the only established mechanism for 4-party dialogue on any of the NFA provisions. Its creation offered the promise of a coordinated (and, ideally, a fully integrated) comprehensive ecological monitoring and research program. The 4-party PAB provided an opportunity whereby the direction and progress of FEMP, and its equivalent provincial and Manitoba Hydro programs, could be reviewed within the context of: (1) its success in addressing those environmental concerns of greatest interest to the NFA communities, as expressed by the NFC; (2) its contribution to an improved understanding of the environmental impacts of the LWCN project; and (3) its scientific merits.

The face-to-face contact which PAB provided in its more than 30 meetings facilitated: (1) spirited discussions of environmental issues; (2) information dissemination (e.g. production of a sediment atlas, FEMP Report #89-3); (3) field coordination (e.g. shared collection of water quality samples); and (4) data comparisons (e.g. an interagency comparison of field and laboratory procedures for the collection of suspended sediment data, FEMP Report #89-4). Unfortunately, however, the promise of the 4-party PAB was only partially realized; with only limited cooperative, and no truly integrated activities undertaken, the PAB process could be more appropriately described as an exercise in joint unilateralism. The lack of a formal structure, a common budget, and a shared vision on how best to realize PAB's objectives prevented the full attainment of its original purpose. Shortly after the commencement of the global negotiations process, PAB disbanded.

FEMP - AN ENVIRONMENTAL IMPACT ASSESSMENT?

An environmental impact assessment (EIA) is a systematic method of identifying potential environmental consequences and their impact on people, their livelihood and way of life. Ideally, an EIA should be conducted at a stage early enough to have an influence on the project development, before actions are taken that will result in an irreversible commitment of resources. In fact, a significant environmental impact has been defined as one which should be considered in project decisions (Beanlands and Duinker, 1983).

Traditionally, an EIA compares measured pre-project environmental conditions (or at least conditions that existed during the construction period) with anticipated post-project conditions. With the commencement of FEMP approximately 10 years after construction of the major hydro projects, it was the post-project conditions that were measured and, because of limited pre-project data, the pre-project conditions were often estimated. Hence, FEMP was not a traditional EIA.

FEMP was, however, guided by the principles of an ideal EIA, one that is developed and implemented within an ecological framework. These principles include: (1) the determination of a program focus, a process commonly referred to as scoping; (2) the recognition of the important interrelationship between socio-economic effects and environmental impacts; (3) the need for a sound scientific foundation for EIAs; and (4) the development of a program strategy and explicit objectives. Post-project monitoring, the major FEMP activity, is increasingly becoming an integral part of EIAs (Sadler 1986). For example, in Canada, Bill C-13, first introduced in June 1990, strives to improve the current environmental assessment process by requiring, for the first time, follow-up and monitoring plans for major projects. Thus, while not a true EIA, FEMP embodied many EIA attributes.

SCOPING

The NFA and Claim 18 firmly established that the purpose of the proposed ecological monitoring and research program had to be the evaluation of the impacts of the LWCN Hydroelectric Project on the bands and their members, but these documents did not provide any guidance on the direction or focus for this program, nor was such guidance provided in the policy statements or other correspondence prepared by the NFC. This material tended to concentrate on legislative requirements and conceptual frameworks (e.g. mandates, processes, etc.), rather than on program specifics (e.g. study priorities). For example, the NFC emphasized the need for "joint, collaborative and coordinated action," (March 9, 1986 letter to Manitoba Hydro), for "professionally developed scientific and environmental data," (May 20, 1986 letter to Manitoba Hydro), and for "full disclosure of all adverse effects of the project and their likely cumulative impacts over time," (NFC Guiding Principles - Discussion Phase I).

To address federal responsibilities under the NFA, FEMP clearly had to assume a community focus. Consequently, FEMP projects were limited to investigations of only those environmental conditions that were perceived to have had a direct impact on the bands and their members. For example, FEMP did not investigate the environmental impacts of the LWCN Hydroelectric Project on Hudson Bay; nor did it investigate the contribution of the extensive terrestrial flooding, caused by the hydro projects, to the production of greenhouse gases.

The scope of FEMP was further defined by examining relevant socioeconomic and scientific factors, as discussed in the next two sections. Pragmatic considerations were also important, such as : (1) the federal government's role in environmental monitoring and research; (2) the desire to avoid duplication of studies being conducted by the province and Manitoba Hydro; and (3) the limitations imposed by budgetary and temporal constraints.

Scoping is widely recognized as essential in environmental impact assessments, since no monitoring program, no matter how vigorously conducted can examine, let alone predict, all the effects of large-scale developments (Sadler 1986). Scoping was equally important to FEMP, since it could not have effectively monitored all of the post-project impacts of the hydro projects in northern Manitoba. However, scoping, by narrowing the focus of environmental studies, limits the depth and breadth of our understanding of the natural system and of changes to it; this contributes to the uncertainty of our predictive abilities with respect to the expected future regime and with respect to the impacts of changes in the environment on its dependent socioeconomic systems.

SOCIOECONOMIC CONSIDERATIONS

The relationship between social values and the scientific focus of environmental assessment studies is generally recognized and accepted in Canada. The "problems to be overcome seem less related to the importance of social values than their early identification and translation into appropriate environmental studies" (Beanlands and Duinker 1983, p. 3). This process involves two distinct but closely related components: (1) evidence of causality between observed ecological conditions and the project; and (2) an understanding of the social values of the people affected by the project.

By definition, evidence of causality is required to classify an observed ecological condition as a project impact. However, our knowledge of species ecology (Rosenberg et al. 1987, Suzuki 1988) and of the effects of reservoir changes on the higher tropic levels, like fish, (Hecky et al. 1984) is inadequate for a comprehensive assessment of impacts in a complex and severely altered environment, such as the aquatic environment in the FEMP study area. Indeed, we are still in the process of establishing these linkages. An excellent example of this was the determination of the process by which methyl mercury levels increased in fish following extensive flooding.

Characterization of an ecological condition as a significant effect of the project depends upon the magnitude of the impact, its severity, spatial and temporal characteristics. Further, characterization of a project effect as adverse, beneficial or neutral introduces a valuation concept, usually an economic valuation, which is "primarily anthropocentric and ethnocentric so that it is the value of the affected resource to man in a particular social context and not to the ecosystem as a whole which is determinative" (CEARC 1988, p. 3). The social context in which this valuation occurs in Canada is that of the dominant social group, a European-descendent, urban population living in southern Canada. However, the value of water in its natural state to this dominant social group differs from that of native groups, for whom water issues transcend strictly economic, environmental or recreational concerns; they are a matter of identity (Barton 1987). This difference in valuation of water is further compounded by differences in cultural expression, differences which have not been recognized in the implementation of government programs in the communities in the FEMP study area (McKerness 1989 a).

When FEMP began in 1986, there was insufficient information about the relevant social values of the communities in the FEMP study area to enable their "translation into appropriate environmental studies." Nor was it possible to "translate" the results of past environmental studies into a full understanding of their implications on the socioeconomic well-being of the residents of these communities. For example, lack of information on domestic fish consumption patterns in the communities prevented a full understanding of the socioeconomic effect of elevated mercury levels in fish following flooding.

PAB members recognized the inadequacies of the existing socioeconomic information and individually and collectively tried to address this need. For example, in 1986 the NFC identified four research tasks for socioeconomic assessment and monitoring: (1) a literature search; (2) an audit of results from other similar cases; (3) scoping requirements; and (4) community participation. Subsequent discussions eventually led to the formation of a socioeconomic sub-committee of PAB to examine possible terms of reference for an NFA-specific social impact assessment and monitoring strategy, and to discussions with the Canadian Environmental Assessment Research Council regarding their possible contribution to this process. Unfortunately, this initiative was not pursued.

In 1988, DFO hosted a workshop to "determine the feasibility of doing a retrospective analyses of the biophysical social and economic impacts of the Lake Winnipeg, Churchill, Nelson (LWCN) Rivers Hydroelectric Project on the commercial and domestic fishing practices of the five communities signatory to the Northern Flood Agreement". One of the products of this workshop was DFO's sponsoring of a study to examine resource harvesting data to assess their suitability for use in a social impact assessment. The other product was a study to synthesize the available information on the physical, chemical and biological impacts of the hydro projects on the aquatic ecosystems in the FEMP study area.

DFO worked closely with the NFC in developing the terms of reference for both studies. NFC involvement was recognized as critical to the identification of the specific project-related socioeconomic concerns of the community residents and in facilitating direct community participation in these studies. The results of these studies, which are presented in Volume 2 of this report, were only available near the end of FEMP and were therefore of only limited value in developing the focus for FEMP. However, the open and continual dialogue with the NFC during the planning of these studies increased the sensitivity of FEMP to community needs.

The difficulty experienced in incorporating socioeconomic considerations into FEMP, and at a stage early enough to influence FEMP's direction, is an example of the well-known and documented difficulty in conducting social impact assessments (SIA) and cumulative effects assessments (CEA). Reasons for this difficulty include: (1) an inherent situation of complex causality, where the impact is a joint effect of characteristics of the perturbation and the existing systems and conditions; (2) high uncertainty about social values; (3) the need for an improved understanding of ecological science; and (4) the lack of suitable assessment methods, including the integration of possible linkages (Sonntag et al. 1987, SCC 1988).

SCIENTIFIC PROCEDURES

All environmental studies have to be based on sound scientific procedures; otherwise, such studies run the risk of "degenerating into an exercise in public relations and government lobbying" (Beanlands and Duinker 1983, p.21). The need for sound scientific procedures was especially critical to FEMP to ensure an objective investigation in a situation complicated by an often adversarial political and legal climate.

Scientific principles which guided FEMP included: (1) the establishment of objectives which were scientifically realistic; (2) the explicit statement of all assumptions; and (3) good research design, including testable hypotheses and appropriate statistical treatment of data. An especially important decision was the selection of the appropriate level of scientific standards.

The scientific rigour with which environmental studies should be conducted has been the object of some discussion (e.g. Rosenberg et al. 1981, Couch et al. 1981). Scientific standards can vary from the extreme rigour required for advanced scientific research to the other extreme where the "science" involved is reduced to a gathering of "experts" to produce their best guesstimates (Beanlands and Duinker 1983). Given that the impetus for FEMP was the NFA, and not the pursuit of scientific research, and that NFA Article #23.2 places the onus on Manitoba Hydro to establish that its development did not cause nor contribute to an adverse effect, it can be argued that extreme scientific rigor was inappropriate for FEMP. However, the other extreme of providing guesstimates, was equally inappropriate.

The magnitude of the environmental changes that have occurred as a result of the hydro project and the importance of this environment in the daily lives of the approximately 14 000 local inhabitants warranted the use of the best tools available to improve our understanding of these changes. It was important to understand not only those changes that had already occurred, but also those that are expected to occur as the system restabilizes from the impact of past hydro dams and dams scheduled for construction. A secondary use of this improved understanding is to add to the general knowledge of post-development environmental conditions, a subject that has often been characterized on the basis of unverified predictions (Beanlands and Duinker 1983).

Thus, it was decided that FEMP must be implemented with a strong emphasis on scientific rigour. This process included: (1) selection of well-qualified project leaders; (2) review of proposed FEMP projects, in part to ensure that specific project objectives were in accordance with FEMP objectives; (3) compilation and review of all existing relevant scientific information, including some data collected through concurrent non-FEMP programs (e.g. preparation of an annotated bibliography, FEMP Report #87-1; compilation of a water quality data base; etc.); (4) technical review of project findings; and (5) annual examinations of FEMP's progress and of its future direction. The selection of scientific methodologies, the critical step in this process, is discussed in chapter 4 of this volume.

STRATEGY

The factors discussed in this chapter, and those discussed in more detail in chapters 4 and 5, formed the basis for the FEMP strategy. In particular, 5 principles were formulated to guide FEMP, as follows: 1) FEMP must address federal obligations under the NFA, with respect to environmental monitoring; 2) FEMP projects must be designed and implemented on the basis of sound scientific procedures; 3) input into the planning and implementation of FEMP must be actively solicited from PAB and, to assist them in this task, interim findings must be provided to them; 4) the environmental and related socioeconomic concerns of the community residents, as expressed by the NFC, must be important considerations in the planning and implementation of FEMP; and 5) FEMP findings must be presented in formats that are appropriate for the intended audiences, especially the native communities in the FEMP study area.

FEMP OBJECTIVES

The objectives of PAB, namely: 1) "to determine project-induced ecological and socioeconomic changes, impacts and adverse effects within the affected resource areas of the NFA communities"; and 2) "to provide an information base to assist in the design and implementation of appropriate compensation, mitigation and/or remedial works and measures for adverse effects," guided the formulation of FEMP objectives, which were as follows: 1) to the extent possible, determine pre-project conditions (e.g. by examining historical data and interpretative reports on the ecological conditions in the FEMP study area, and by using remote sensing techniques); 2) to monitor post-project conditions; 3) to increase our understanding of the significant factors that could affect future ecological conditions in the FEMP study area, such as the recovery time of present impacts (e.g. mercury) and the determination of potential impacts from future planned developments; and 4) to advise the public of FEMP results, ensuring that this information is presented in formats appropriate to the intended audiences, and most especially to the native communities in the FEMP study area.

Together, FEMP objectives #1 and 2 addressed, at least partly, PAB objective #1 by assessing changes in the ecological conditions since the LWCN project. FEMP objective #3 was a response to PAB objective #2, in recognition that the long-term effectiveness and cost of compensation, mitigation and remedial measures will be affected by future ecological conditions and therefore such conditions must be estimated to ensure the selection of the most appropriate measures. FEMP objective #4, by ensuring that the salient FEMP findings are presented in a comprehensible manner, was essential to the fulfilment of both PAB objectives.

DEPARTMENTAL ROLES

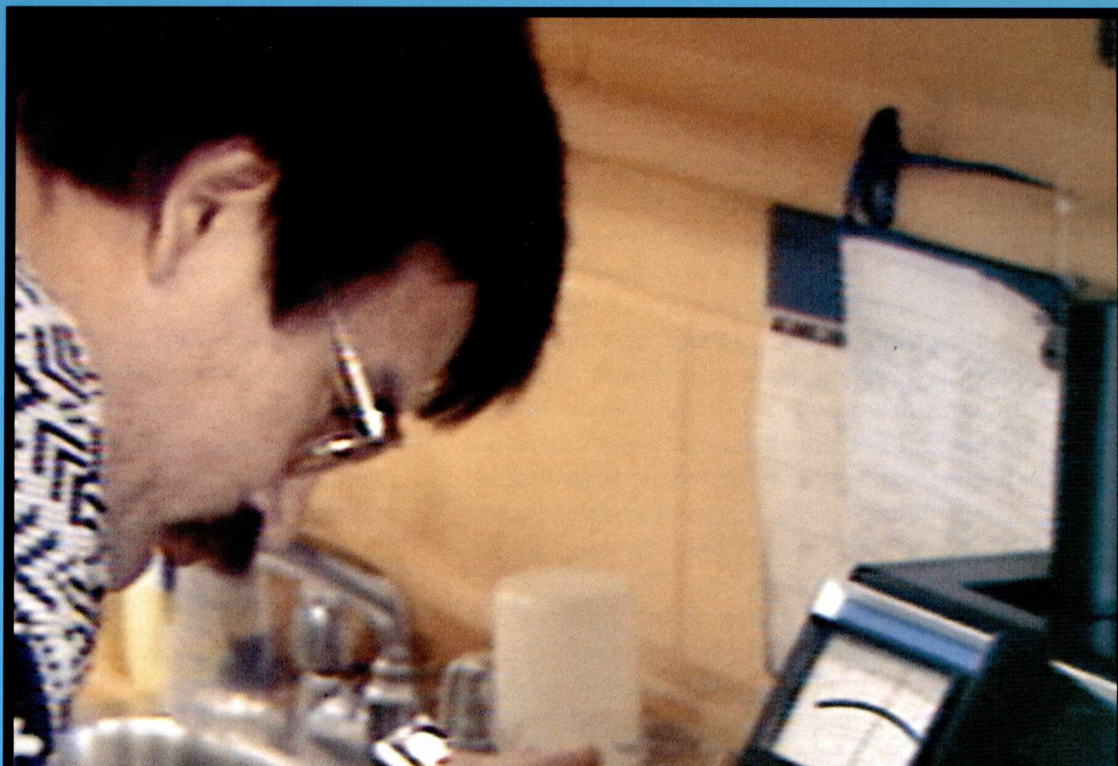
FEMP was a cooperative program of Environment Canada (DOE) and Fisheries and Oceans Canada (DFO) and consequently, it reflected the departmental mandates, expertise, and historical involvement in the FEMP study area of these two departments. DOE's focus was on the water resources and migratory birds, with the geographical areas of focus being the immediate vicinities of the native communities in the FEMP study area. DFO's focus was on fisheries and fish habitat and, as a result, their geographical areas of focus were primarily Southern Indian Lake and Playgreen Lake, lakes which support major fisheries in the FEMP study area.

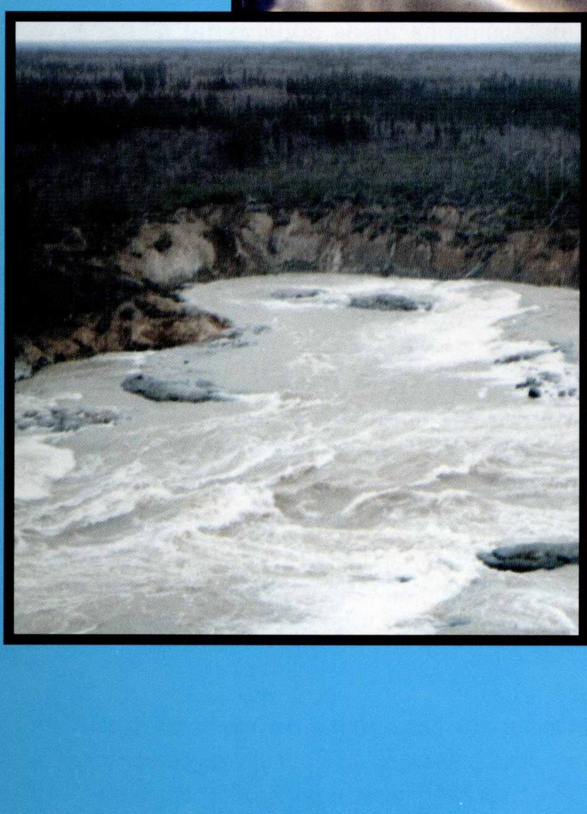
DOE and DFO also differed in the approaches they took to solicit community input into their programs. DFO sought NFC advice on their planned FEMP activities. For example, DFO did not pursue their intention to conduct an intensive investigation of Playgreen Lake, similar to DFO's case study of Southern Indian Lake, because of lack of NFC support. Instead, DFO conducted only a limited study of Playgreen Lake and sponsored two studies that, at least partly, addressed NFC's concerns about socioeconomic adverse effects. DOE also maintained regular dialogue with the NFC, especially via the PAB meetings, but it also tried to obtain direct community participation in some of its FEMP projects. For example, as part of the FEMP waterfowl projects, hunters from Norway House and Nelson House were interviewed and some of these individuals were taken on the aerial surveys.

The distinguishing characteristic, however, of the DOE and DFO roles in FEMP was the strong collaboration between the departments. Numerous tasks were jointly planned, undertaken and/or cost-shared, such as: (1) mapping the FEMP study area; (2) assessing the quality of various data bases (e.g. sediment data); (3) conducting mercury studies; and (4) preparing FEMP reports. This close and effective working relationship, which was developed during their participation in the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion, was further enhanced by the shared commitment of these same individuals to FEMP.

Figure 3.1 Chronology of Key Events

early 1900s -	federal water power surveys identify hydroelectric potential of Churchill River.
1940s -	extensive provincial surveys beginning in the 1940s confirm this potential, and hydroelectric feasibility studies commence.
mid 1950s -	discovery of possibility for diversion of the Churchill River flow into the Nelson River basin.
1960s -	feasibility studies by Manitoba Hydro indicate that a high-level impoundment of SIL and diversion of Churchill River water into the Nelson River would optimize electric generation benefits relative to all other possible system configurations.
1961 -	construction of the first power station on the Nelson River, the Kelsey Generating Station.
1970 -	first published predevelopment impact assessment, a response to strong public resistance to the high-level impoundment scheme; subsequently Manitoba Hydro opted for a low level impoundment.
1975 -	completion of a federal-provincial study which studied the environmental effects of the LWCN hydro project.
1976 -	completion of control structures at Southern Indian Lake and Notigi, and of the excavated diversion channel from Southern Indian Lake.
1977 -	completion of construction works at outlet of Lake Winnipeg and the commissioning of the Jenpeg Control Structure and Generating Station.
1978 -	ratification of the Northern Flood Agreement, an agreement intended to ensure that all persons represented by the NFC who are adversely affected by the LWCN project receive fair and equitable treatment.
1981 -	the NFC filed Claim 18, under the NFA, alleging that the other 3 NFA parties had failed to meet certain contractual obligations of the NFA, including a failure to implement a long term coordinated ecological monitoring and research program.
1983 -	the signing of the first (and to date only) federal-provincial post-development agreement to study an environmental impact of the LWCN project, mercury in the Churchill River Diversion area.
1985 -	the province of Manitoba and Manitoba Hydro set up a two-party Program Advisory Board (PAB) to manage a biophysical monitoring program within areas of provincial interest.
1986 -	Environment Canada and the Department of Fisheries and Oceans began their biophysical monitoring program; PAB was expanded to include representatives from the federal government and the NFC.
1988 - 1990	discussions took place under the auspices of a senior level, 4-party committee to resolve outstanding issues of the NFA.





CHAPTER 4

FEMP SCIENCE

INTRODUCTION

Scientific rigour was emphasized throughout FEMP to ensure that information was obtained and analyzed in an objective, accurate, and logical manner. A wide variety of scientific methodologies were employed, reflecting the diversity of scientific disciplines encompassed by FEMP and the continuing advances being made in our ability to measure environmental parameters. Some of these methodologies are highlighted in this chapter. The chapter concludes with an example of the need to understand the cause of observed changes in the environmental parameters and in particular the importance of discriminating between natural and anthropogenic effects.

SATELLITE REMOTE SENSING

Satellite remote sensing is one of two principal visual remote sensing techniques, the other being aerial photography, in which information about an object, area, or phenomenon is obtained through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation. Historically, remote sensing consisted of aerial photography from various airborne platforms. With the advent of space flight and improvements in computer technology, satellites began collecting digital imagery of the earth's atmosphere and surface.

Beginning in July 1972, a series of five Landsat satellites were launched, of which the last two are still operational. These satellites provide two different types of remote sensing images: Multispectral Scanner images (MSS) and Thematic Mapping (TM) images. Higher spatial and spectral resolution is provided by TM images, however these images are more expensive to purchase than MSS images and have only been available since 1982.

To assist researchers in determining the amount of useful satellite imagery in the FEMP study area, a remote sensing catalogue of the area was produced (FEMP Report #87-3). This catalogue consists of: 1) a user guide; 2) a complete listing of all available remote sensing; and 3) guidance on the quality of the MSS images [e.g. maps that show the cloud-free area (less than 50% cloud cover) on all images].

The Landsat MSS system records four segments, or bands, of the spectrum of reflected light, two that are different wavelengths of infra-red light and two that correspond approximately to blue-green and orange-red light. Infra-red light is strongly reflected from most of the terrestrial surface of the earth, but is mostly absorbed by water; hence, it is very powerful in discriminating land from water in satellite images. Visible light is also generally absorbed by water; however, suspended material in water tends to reflect light in proportion to its concentration. Thus, the visible light record on Landsat MSS images can be used to estimate suspended sediment concentrations in large lakes and impoundments. Both applications were used in the FEMP study.

The ability to distinguish land from water in satellite images was graphically illustrated in the colour enhanced Landsat images shown in chapter 2. It was also invaluable in determining the changes in surface areas of the FEMP lakes that were recorded in Fig. 2.7.

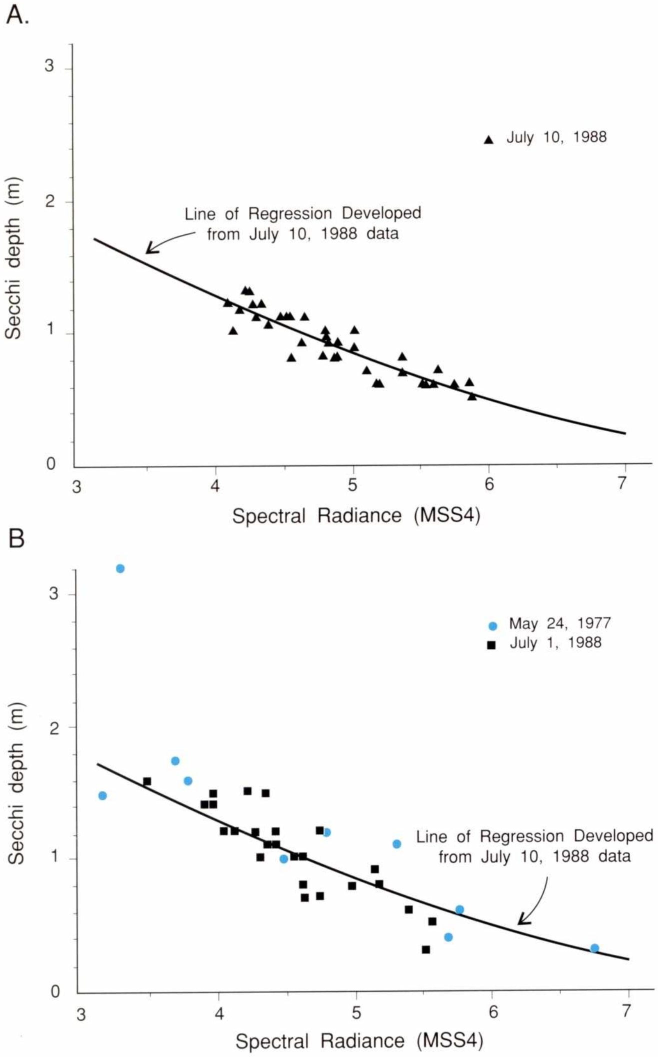
The principle that water absorbs visible light in proportion to its suspended sediment concentration was used to develop a model to determine suspended sediment concentrations in the FEMP study area. There has been only intermittent records of suspended sediment concentrations in the FEMP area; the large size and isolation of this area have precluded extensive on-lake monitoring programs. Suspended sediment data are particularly limited for the pre-development period. Successful development of a Landsat-based suspended sediment model would enable increased spatial and temporal coverage.

A series of physical measurements were taken at sites throughout Southern Indian Lake (SIL), coincident with the satellite overpasses of July 1, 1988 and July 10, 1988. Secchi disc measurements, as well as suspended sediment concentrations, were taken since there is a long record of such measurements at SIL and previous research has shown a relationship between Secchi disc measurements and suspended sediment concentrations. A satellite image from May 24, 1977 was also obtained, along with Secchi disc values that had been measured on May 23 and May 25, 1977. All sample site locations were identified relative to distinctive land features (e.g. bays) and marked on National Topographic Service map sheets for comparison to the satellite images.

Information from the Landsat satellite images was corrected to adjust for known potential sources of differences between images, such as differences in atmospheric contributions of light (e.g. smoke). Corrected values from the images were then compared to different forms of the Secchi disc data (e.g. log of Secchi disc data) to determine the best relationship, as determined by statistical analysis (Fig. 4.1.a). A comparison of the model developed from the July 10, 1988 data with the observed values from July 1, 1988 and May 24, 1977 is shown in Fig. 4.1.b.

Clearly, the model shows promise as a means of estimating Secchi disc measurements from Landsat images, and consequently, of suspended sediment concentrations. However, additional research must be conducted to fully verify this model, both temporally and spatially. A major temporal consideration is the fact that the spread of Secchi disc data was much greater historically (e.g. in 1977, the range was 0.2 to 4.2 m), a time when SIL was generally less turbid, than it is now (e.g. in 1988, the range was only 0.5 to 1.3 m). In this regard, historical Landsat MSS images and Secchi disc data available for SIL will be used to improve the model. Similarly, the spatial universality of the model must be tested. For example, one method to test the model across space is to apply it to Split Lake, a lake for which there is a set of 5 ground samples, associated with a Landsat image. If verified by further testing, the Landsat-MSS Secchi disc data model could provide a valuable tool for assessing suspended sediment concentrations, since 1972, over the entire FEMP study area.

Figure 4.1 Relationship between Observed Secchi Disc Values and Spectral Radiance in Landsat MSS Band 4, for Southern Indian Lake

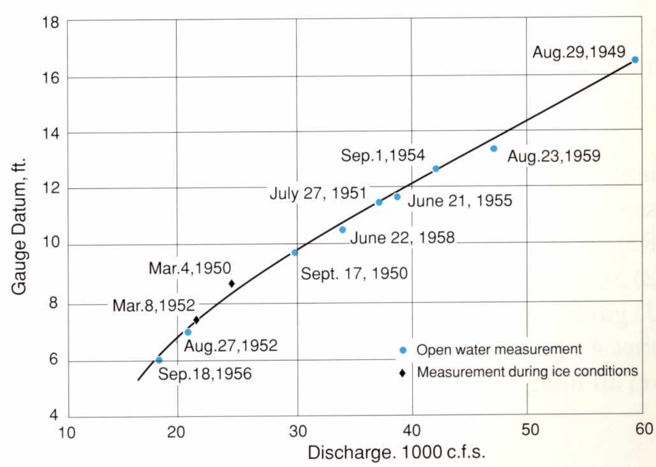


MEASURING DISCHARGE FROM SOUTHERN INDIAN LAKE

Streamflow data are usually derived from continuous or frequent (daily) records of water level or stage and periodic measurements of discharge. Derivation of streamflow data in this manner is made possible because, for most streams, there is a unique relationship between the water level of the stream at a particular location and the flow of the stream passing that location. This relationship is known as a stage - discharge curve. An example of such a curve is shown in Fig. 4.2.

For most stream stations, a simple rating curve is adequate. Periodic discharge measurements are made to determine whether or not the relationship is changing. Changes may occur at varying intervals depending on the characteristics of the stream bed, the velocity of the stream,

Figure 4.2 Stage - Discharge Curve for Churchill River above Granville Falls



the composition of the banks, and the severity of ice conditions. If the relationship changes, sufficient discharge measurements must again be made to define the new relationship.

At the South Bay diversion channel, which was constructed to divert the Churchill River at Southern Indian Lake, a unique relationship between water level and discharge does not exist. As a consequence, derivation of discharge using the traditional means of a stage - discharge curve was not possible here. Until recently, discharge at this site had to be estimated on the basis of measurements taken at the Notigi Control Structure.

In the late 1980s, direct measurement of the discharge from the South Bay diversion channel became possible with the installation of an Acoustic Flow for Remote Areas (AFFRA) Unit, purchased through FEMP. AFFRA, the product of recent, affordable technological advances, uses ultrasonic principles to measure water velocities, water depths, and velocity of sound in water. An example of water velocities and stage recorded by the AFFRA unit at South Bay is shown in Fig. 4.3. The water velocities are multiplied by cross-sectional area to provide water discharge and the velocity of sound in water is used to compute water temperature.

The same electronic circuitry used to transmit, receive and time velocity pulses is also used to measure depth of water above vertically mounted transducers. Traditionally, water level measurements, whether they are made downward from above the water surface or upward from below the water surface, have been prone to inaccuracies primarily due to changes in the temperature of the pulse transmitting medium, i.e. air or water, which changes the velocity of sound. With AFFRA, this is not a problem. The velocity of sound in water is a continuously measured by-product of the water velocity measurement.

The uniqueness of AFFRA in comparison to all other flow measuring systems, in its price range, is that it can provide velocity and stage data at a site on a continuous basis. This provides the means to compute discharge under any type of existing flow conditions. The fact that stage is measured from the bottom up permits the measurement of the "effective stage" under ice conditions, i.e. the stage associated with the area of flow. All other conventional stage sensors are pressure sensors under solid ice cover conditions. Hence, they measure the sum total of water, ice and any accumulation of snow, water or debris on the surface of the ice. This property of total pressure sensing, makes conventionally sensed stage virtually useless in determining discharge under variable backwater conditions due to ice effects. The AFFRA unit, however, provides accurate measurements under both open water and ice covered conditions.

Persistent difficulties in the satellite transmission of the data generated by the South Bay AFFRA unit, which were experienced in the start-up period, have now been overcome. Data from this site will be incorporated into the hydrologic monitoring network for the FEMP study area.

MEASURING SEDIMENT DEPOSITION

Impoundment of Southern Indian Lake by 3 metres raised the focus of wave energy above a generally stable shoreline of water-washed bedrock and long, sand and pebble beaches into glacio-lacustrine silts and clays. Three to four million tonnes per year were added to the lake by erosion in the early years after impoundment, about 15 times the natural riverine load. While sediment discharged from the lake has increased four times, most of the new load has been deposited either as near shore deposits up to 1 metre thick, or in deep water where 5 to 10 centimetres (cm) of post-impoundment sediments have been measured.

One method used to measure sediment deposition is the analysis of core samples extracted from the lake bottom. For example, new data on post-impoundment sedimentation rates have been based on a preliminary set of samples taken in 1987 as part of the FEMP sediment studies, in selected areas of Southern Indian Lake (SIL) and analyzed at 2 cm intervals for radioactive lead (^{210}Pb) and radioactive cesium (^{137}Cs) content.

Most ^{137}Cs in sediments is a product of deposition related to atmospheric testing of nuclear weapons. The rate of atmospheric ^{137}Cs fallout peaked in 1963; hence ^{137}Cs peaks in lacustrine sediments, such as those found in SIL, are considered to mark sediments deposited in the period 1962 to 1965. In SIL cores, this marker should be in sediments just below the pre-impoundment/post-impoundment interface. As shown in Fig. 4.4, ^{137}Cs does show a sharp peak in most cores, at depths ranging from 5 to 11 cm.

Figure 4.3 Measurements of Velocity and Stage at Southern Indian Lake Diversion Channel, by the AFFRA Unit

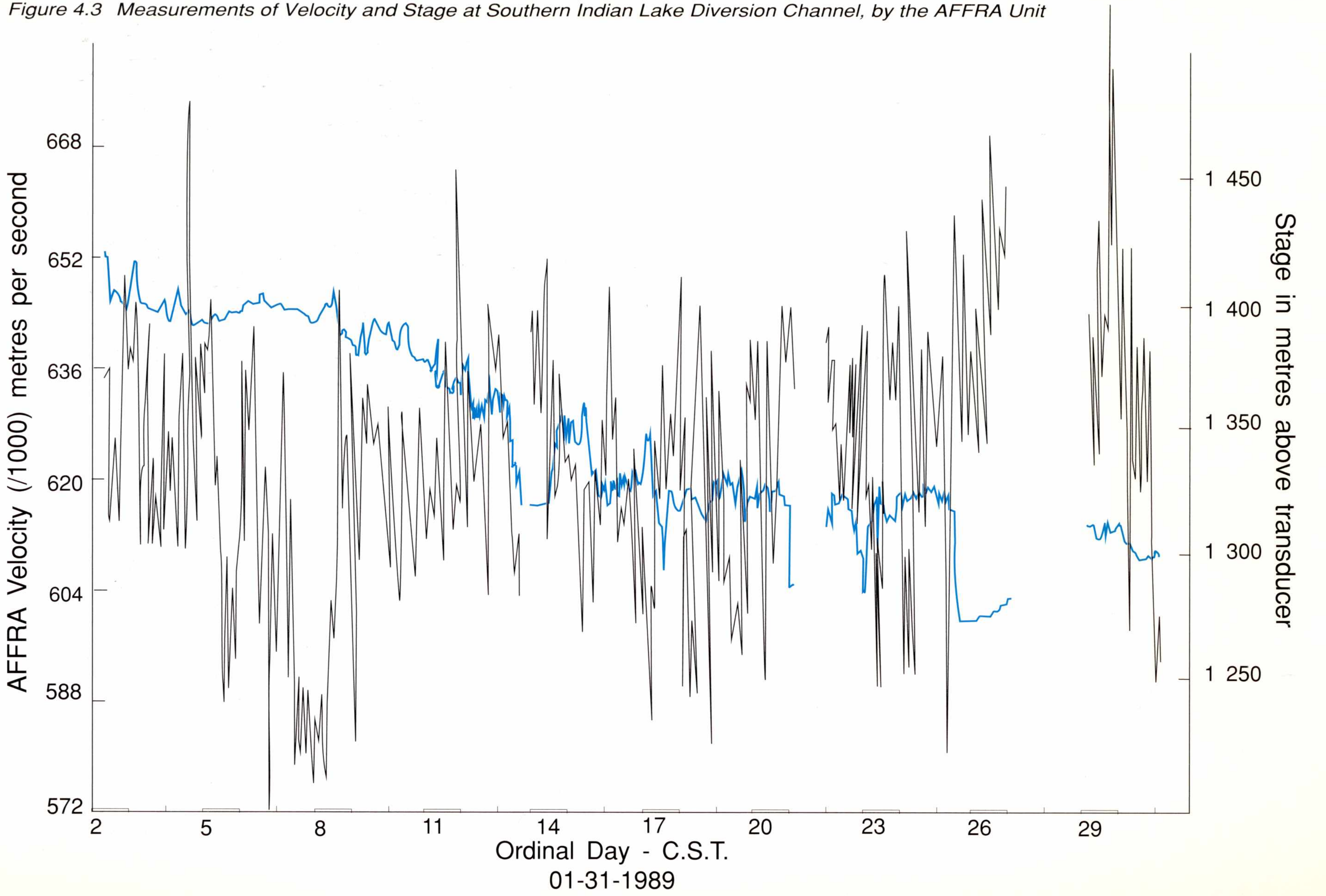
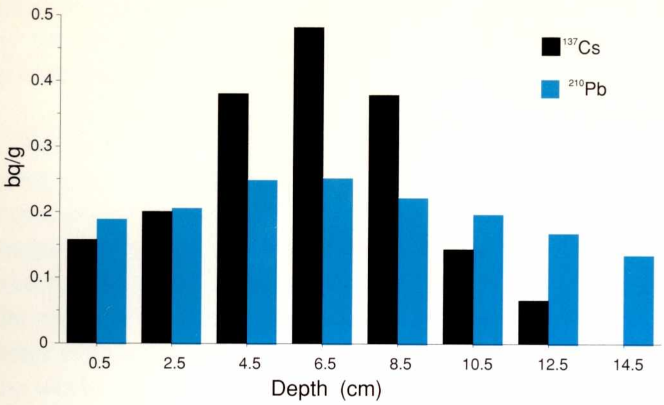


Figure 4.4 ^{210}Pb and ^{137}Cs Content in Sediments Plotted against Depth below the Sediment/Water Interface, Southern Indian Lake



^{210}Pb is a natural product of radioactive decay of uranium and, for given regions, is deposited at a fairly constant rate from the atmosphere into lakes, and then into lake sediments. Although ^{210}Pb production by radioactive decay also occurs within sediments, the rate of ^{210}Pb deposition from the lake waters into the sediment is generally well in excess of this internal ^{210}Pb production. Hence, because ^{210}Pb decays with a half life of 22.2 years, where the total sediment deposition rate is constant in the long term, the concentration of ^{210}Pb in the sediments decreases in a predictable way from the sediment/water interface downward into the sediments. (For example 44 year old sediments should contain only half as much excess ^{210}Pb as the 22 year old sediments above, and so on down.) Such a constant decay curve does appear to be found in SIL sediments below 5 to 11 cm depth. There is generally a prominent break in the curve in this depth range which coincides with the ^{137}Cs peak. (See Fig. 4.4.) ^{210}Pb levels in sediments above this break are lower and may be indicative of a higher total sedimentation rate relative to ^{210}Pb deposition; in any case, the break in the decay curve is interpreted as marking a sharp change in sedimentation rate. The coincidence of the peak in ^{137}Cs concentration curve with the break in the ^{210}Pb curve are strongly supportive evidence that the latter is a marker for the pre-impoundment/post-impoundment sediment interface in SIL.

MEASURING MERCURY LEVELS IN WATER

Mercury in the FEMP study area has been an important issue since the discovery, in the late 1970s, of elevated mercury levels in fish from the lakes along the Churchill River Diversion route. In the early to mid 1980s, federal and provincial scientists investigated this issue under the auspices of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion (CMMA). The major conclusion of the CMMA study was that increases in the net rate of methyl mercury production, which occurred in areas of flooded terrain, had resulted in elevated mercury levels in fish. It was also concluded that there was no evidence that flooding had caused an increase in mercury concentration in water of any of the reservoirs studied.

When the CMMA studies were conducted, the best analytical methods then available were not sensitive enough to detect very low levels of mercury in water. A surrogate method, that of measuring mercury concentrations in plankton, was used to provide a relative measure of mercury concentrations in water. Through this method, it was found that mercury levels in the flooded reservoirs and control lakes in the CMMA study area were similar, and both were comparable to mercury levels reported for other uncontaminated water bodies elsewhere in the world.

Since the completion of the CMMA study there have been improvements in the analytical methods to detect mercury in water. In 1986, direct measurement of total mercury concentrations in water became possible, and in 1989, a highly sensitive method was developed to detect trace levels of methyl mercury in water, the form of mercury that accumulates in fish. Using these methods, measurements of total and methyl mercury in water were conducted, as part of the FEMP mercury studies, to address the concerns of the area's residents about mercury levels in their drinking water and to improve our understanding of mercury dynamics in the aquatic environment, such as mercury speciation and spatial distribution.

The direct measurements of total mercury concentrations in water conducted under FEMP confirmed the CMMA conclusion, based on mercury analysis of plankton, that total mercury concentrations were not higher in reservoirs than in a reference lake (Fig. 4.5). However, reservoirs did have higher concentrations of methyl

Figure 4.5 Mercury Concentrations in Water in Northern Manitoba Lakes and Reservoirs, 1989

		Total Hg (ng·L^{-1})		Methyl Hg (ng·L^{-1})	
Granville	- nearshore	1.44	(0.70-1.82)	0.021	(0.013-0.033)
	- offshore	1.50	(0.66-2.37)	0.023	(0.020-0.038)
Southern Indian					
Methyl Bay	- nearshore	1.18	(0.71-2.37)	0.034	(0.028-0.045)
	- offshore	1.60	(0.73-3.15)	0.017	(0.014-0.023)
Notigi West		1.07		0.046	
Burntwood River at Thompson		2.10		0.027	(0.023-0.031)
Stephens	- nearshore	1.77	(1.07-2.70)	0.037	(0.027-0.044)
	- offshore	1.28	(0.81-1.73)	0.054	(0.041-0.060)

mercury than the reference lake. In both the reservoirs and the reference lake, methyl mercury accounted for only a very small portion (approximately 1 - 5%) of the total mercury concentrations in water.

The range of methyl mercury concentrations in the Burntwood River at Thompson was not appreciably different from that at Granville Lake. This suggests that methyl mercury produced in the flooded reservoirs upstream does not travel as far as Thompson, 130 km downstream of the Notigi Control Structure. Additional measurements of methyl mercury in water, especially at sites located within 130 km of an upstream reservoir, would be needed to determine the actual limit of downstream transport of methyl mercury in the FEMP study area.

MEASURING BACTERIA LEVELS IN WATER

A limited bacteriological study of the recreational and potable waters in the 5 NFC communities was conducted, in 1987, as part of the FEMP's water quality studies. At this time, concerns were expressed by community residents about ongoing problems in the bacteriological program routinely conducted in their communities by Health and Welfare Canada (HWC), such as limited sampling frequency, lengthy delays in the receipt of results, and the lack of guidance on the meaning of the results. To alleviate these problems, a community-administered bacteriological assessment program was proposed; as a consequence, a FEMP pilot project was conducted in Split Lake, in 1988, in conjunction with HWC.

Four simple, inexpensive bacteriological tests were selected for assessment in the pilot project. A small basic laboratory was established in the basement of the Nursing Station at Split Lake and equipped with the necessary supplies to perform all four tests. Mr. V. Spence, a community health representative, was trained in the sampling and analysis procedures. Mr. Spence is a Split Lake resident who had no previous experience with the type of field and laboratory techniques used in this program. Tests were conducted of the bacteriological quality of drinking water from a number of locations (e.g. the water treatment plant and distribution system, water barrels in private residences) and of the recreational water at a number of beaches near the community.

The pilot project clearly demonstrated its value in providing timely analysis of the bacteriological quality of the community's drinking water and in identifying possible sources of contamination, enabling corrective measures to be taken. For example, samples taken from one of the two water delivery trucks showed frequent contamination; this knowledge increased awareness of the need for proper handling and cleaning of the water trucks. The pilot project also identified where improvements could be made in the methodology, such as greater quality control and the need for additional training.

The results of the pilot project were so promising that it attracted the interest and support of the International Development Research Centre (IDRC) in Ottawa. The IDRC's support and the increasing community commitment to this project has escalated community involvement to a three-man team of investigators, trained sufficiently to maintain and report on the bacteriological quality of the community's drinking and recreational waters. Furthermore, the IDRC is proposing to create a fund for the long-term support of this program and to consider the development of a separate laboratory facility which could be used for a number of environmental assessment options.

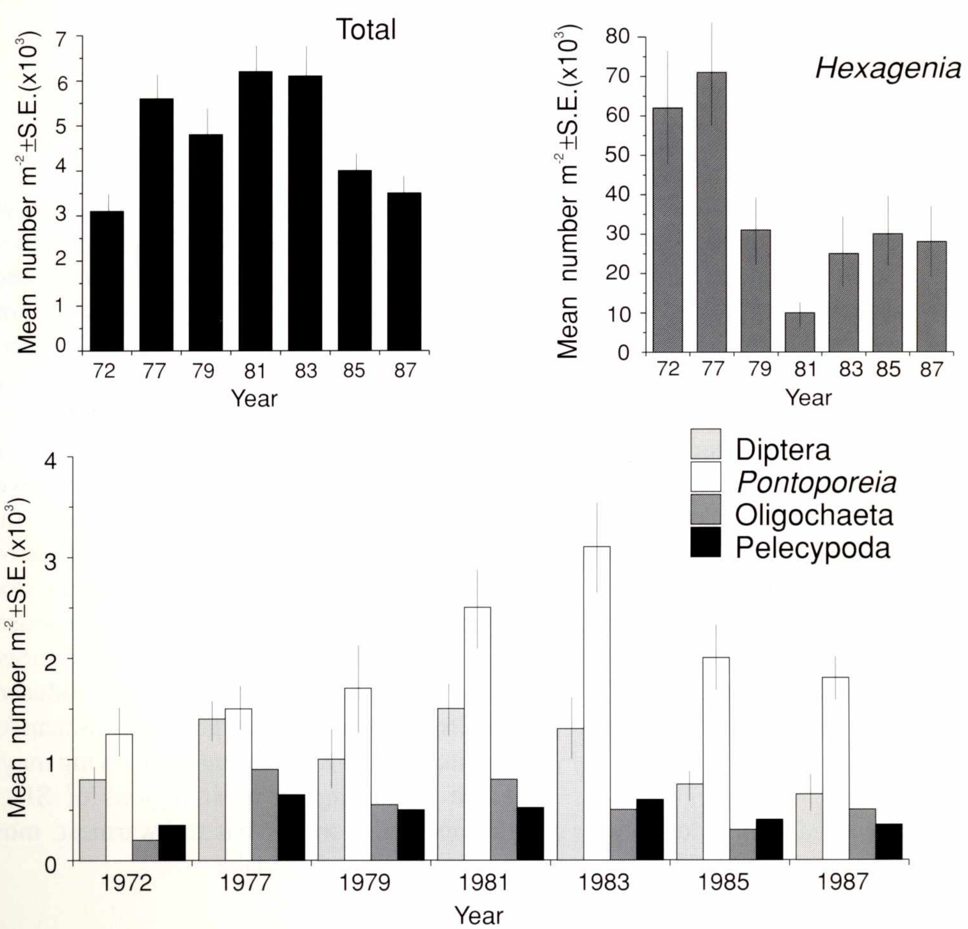
The community-administered bacteriological assessment program has given the community the training and experience with the scientific tools needed to develop an understanding of the bacteriological quality of their waters. The success of the program in Split Lake offers the exciting possibility that it can be implemented in other isolated communities in Canada and elsewhere in the world where the bacteriological quality of the water is a concern.

BURROWING MAYFLIES IN SOUTHERN INDIAN LAKE

New reservoirs typically experience a trophic upsurge, an increase in the aquatic biomass, immediately following impoundment. This results from an initial input of nutrients and organic matter originating from newly flooded land. The subsequent depletion of this material then results in a decrease in the aquatic biomass to near or below pre-impoundment levels.

In Southern Indian Lake (SIL), the only biotic group to show this pattern was the benthic macroinvertebrates. The four most abundant benthic groups, the immature flies (Diptera) the freshwater shrimp (Amphipoda; *Pontoporeia brevicornis* grp.) the aquatic worms (Oligochaeta), and the freshwater clams (Pelecypoda) all responded similarly, thus creating the overall pattern shown in Fig. 4.6. However, an opposite pattern was observed for burrowing mayflies (*Hexagenia limbata* and *H. rigida*). Lakewide standing stocks increased slightly following impoundment, but fell dramatically

Figure 4.6 Benthic Invertebrate Abundance in Southern Indian Lake, 1972 - 1987



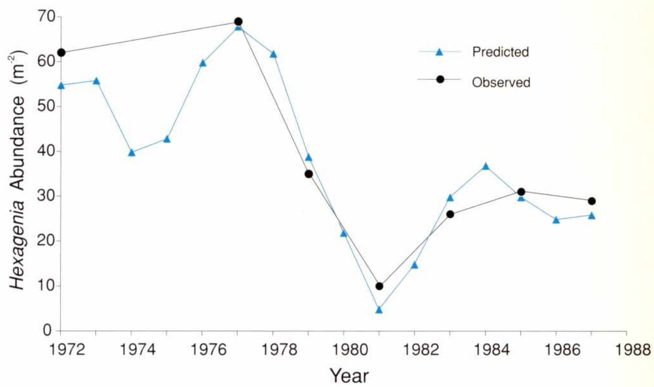
slightly following impoundment, but fell dramatically following diversion to approximately 15% of the pre-development level by 1981.

Following the 1983 survey, the reduction in burrowing mayflies standing stocks was attributed to an inability by burrowing mayflies to maintain their burrows because of severe shoreline erosion and altered substrate composition, and to a decrease in water temperatures in the northern part of the lake because of river diversion and incipient thermal stratification. Had no further surveys been done the reduction in the burrowing mayflies would have been attributed, erroneously, to the manipulations of the lake for hydroelectric development. However, the surveys were continued, and although standing stocks never returned to the pre-development level during the 10 years of post-development monitoring, populations increased substantially after 1981 and stabilized at approximately 50% of the 1972 level, despite the fact that impoundment and diversion still affected the lake. In order to interpret the long-term survey data, a doctoral study of the life history of burrowing mayfly populations in SIL was initiated in 1986. (Giberson 1991)

Weather conditions affect the abundance of burrowing mayflies in three major ways in SIL: (1) cooler water temperatures extend duration of the nymphal life cycle, which results in a higher probability of natural mortality, fewer emerging adults, and lower reproduction; (2) water temperatures affect egg hatching success, i.e. fewer eggs hatch at lower temperatures; and (3) windy or stormy weather during emergence periods results in high mortality and low mating success, again limiting recruitment. One weather variable, air temperature (expressed as atmospheric degree-days (dd) greater than 0°C during the open-water season), correlates well with the factors that affect burrowing mayfly abundance in SIL. Most areas of the lake do not thermally stratify, so bottom water temperatures are directly related to air temperatures during the open-water season. Also, during the 10-year period of weather records for SIL, windy and stormy conditions during emergence were associated with cool mean summer air temperatures, whereas calm and clear summers were usually warm. Moreover, air temperatures greater than 0°C are biologically important because they contribute to heating the water mass up to the 8°C developmental threshold for burrowing mayflies in SIL.

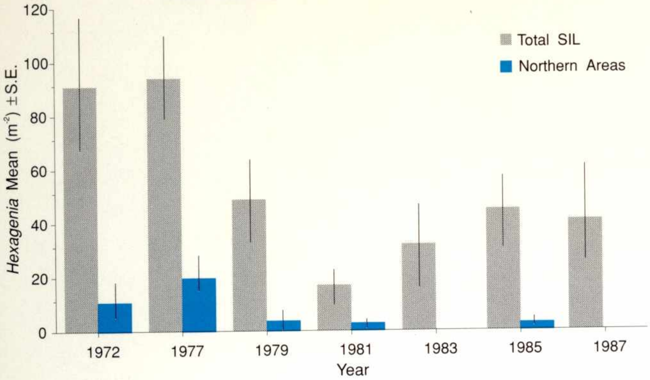
Thus, air temperatures were used in the following predictive manner; when atmospheric dd greater than 0°C (from July - July) were averaged over 3 years, (the life cycle of the burrowing mayfly in most parts of SIL) regressed against their mean abundance in SIL (no.m^{-2}), more than 95% of the variability in burrowing mayfly standing stocks during the study period could be explained. The resulting relationship was then used to predict burrowing mayfly abundance based upon air temperatures alone (Fig. 4.7). The close relationship between predicted abundances and those observed in each lake survey indicates the importance of temperature in regulating populations of burrowing mayflies in SIL.

Figure 4.7 Relationship between Observed Abundances of Burrowing Mayflies and Predicted Abundances, Based on Air Temperatures, Southern Indian Lake

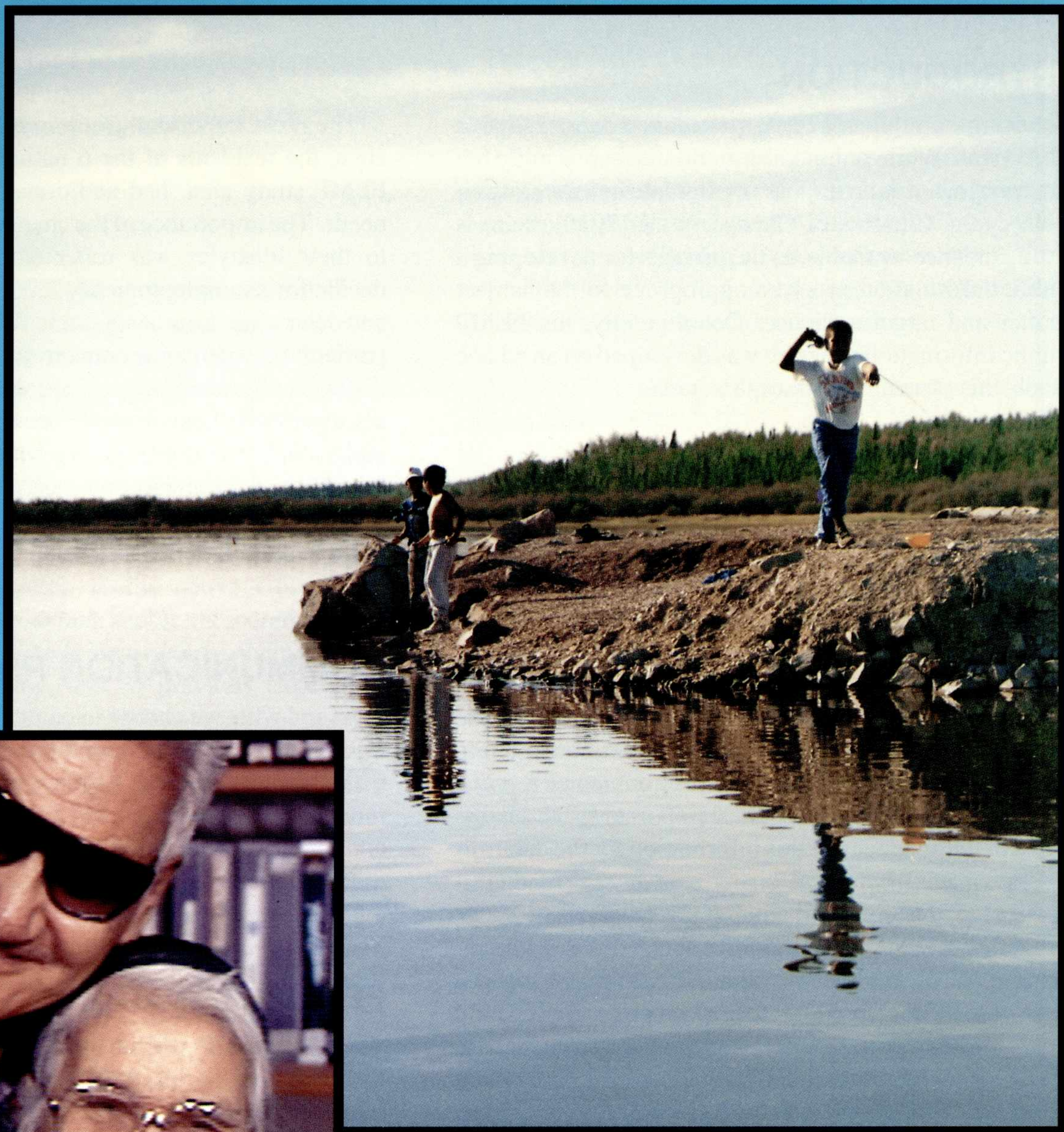


Effects of lake manipulation, however, were not entirely blameless in changing standing stocks in burrowing mayflies in SIL. After impoundment and diversion, water temperatures decreased in the large northern areas of the lake because warm Churchill River water was diverted away from these regions. This resulted in delayed ice break-up in the spring, reduction in length of the heating season, and lowered maximum water temperatures relative to regions upstream of the diversion. Burrowing mayflies were never abundant in these regions (because of the deep, cool nature of these regions even before diversion), so changes in standing stocks in these regions had little effect on total lake response. However, the period of below-average temperatures combined with cooling due to water diversion produced a different pattern of abundance for these regions than for the rest of the lake (Fig. 4.8). Although burrowing mayflies appear to be recovering in most regions of SIL, they have disappeared from all but the warmest, most sheltered northern areas of the lake.

Figure 4.8 *Comparison of Hexagenia Abundance in Northern Area of Southern Indian Lake to Total Lake, 1972 - 1987*



This study of the burrowing mayflies in SIL clearly illustrates the challenge in environmental monitoring to discriminate between natural variability and anthropogenic effects. Moreover, the nature of the problem is critical when dealing with populations at or near their limits of distribution, because such populations can be extremely sensitive to environmental change. Survey data alone, while usually inadequate for establishing cause and effect, are valuable for indicating areas that need attention in the course of a monitoring program. The results of post-development monitoring at SIL indicated a need to examine factors other than those related to hydroelectric development in order to explain patterns of abundance of burrowing mayflies. It was a combination of survey and experimental approaches which helped distinguish between the effects of lake manipulation and natural variability on the burrowing mayflies in SIL.



CHAPTER 5

FEMP REPORTING

INTRODUCTION

Advising the public of FEMP's results was one of FEMP's objectives. While public information is increasingly being recognized as an important principle in federal water policy (e.g. Currents of Change, Water 2020), there is little guidance available on the process for developing a public information program appropriate to the subject matter and target audience. Consequently, the FEMP public information program was developed on an ad hoc basis; this chapter discusses this process.

FEMP MESSAGE

As noted previously, the intent of FEMP was to partially address federal responsibilities under the NFA, by developing a scientific understanding of the environmental changes in the FEMP study area since the Lake Winnipeg, Churchill, Nelson (LWCN) Rivers Hydroelectric Project. The pursuit of this goal necessitated: 1) the scientific documentation of current conditions; 2) the review of all relevant data and environmental reports, especially historical; and 3) most importantly, an assessment of the adequacy of this information for the determination of environmental changes over time and ultimately of the environmental impacts of the LWCN project. Consequently, it was recognized that while reporting FEMP conclusions should be the major component of the FEMP public information program, it would also be necessary to report on the process by which these conclusions were obtained. This process included the documentation of when, and why, there were occasions where insufficient information precluded the drawing of scientifically supportable conclusions.

FEMP AUDIENCE

Determining the target audience, and in particular the information needs of this audience, was the other critical component of the FEMP public information program. The FEMP target audience was a diverse group, consisting of the native communities in the FEMP study area, lawyers, consultants, politicians, civil servants, scientists, and others with a general interest in environmental studies in northern Manitoba. A characteristic shared by most of this target audience was their lack of a scientific background in most, and often in any, of the scientific disciplines employed in FEMP. Thus, FEMP results had to be reported in a non-technical manner.

The most important group in the FEMP target audience, the residents of the 6 native communities in the FEMP study area, had additional, unique information needs. The importance of the changes in the environment to their lifestyles was reflected in their information needs; for example, mercury levels in the FEMP rivers and lakes, the source of their drinking water, was a particularly worrisome concern for many residents. The distinct cultural identity of these communities further distinguished them from the rest of the FEMP target audience. For example, elders, who are highly respected members of these communities, frequently only speak Cree; hence, part of the FEMP public information program had to be in this language.

COMMUNICATION PRODUCTS

How and what we choose to communicate is a reflection of our value system. The multiple value systems of the FEMP target audience, a reflection of their diverse cultural identities, necessitated the use of more than one communication technique. Two different types of communication products were produced: FEMP reports and a FEMP videotape.

FEMP Reports

The first FEMP public information product was the FEMP Report Series, which was initiated in 1987. The intent of this series was to disseminate the interim results of FEMP, as quickly as possible, primarily to the other members of the 4-party Program Advisory Board (PAB). More than 20 reports were produced in this series. The number of copies printed of each report varied from approximately 50 copies, for the more esoteric subjects, to approximately 250 copies, for the annual reports. A formal opportunity for PAB members to comment on the content of these reports, and indeed on all aspects of FEMP, was provided at the annual FEMP workshops.

The major FEMP public information product was the FEMP Final Report, consisting of this report and the accompanying technical appendices. This report is intended to address the information needs of the non-technical reader (by employing, for example the extensive use of graphics, a technical glossary, etc.), while the accompanying appendices provide full documentation on individual FEMP projects to meet the needs of the more technical reader. The FEMP Final Report provides a complete record of FEMP, which it is hoped, will enable the reader to obtain a full understanding of the FEMP results.

FEMP Videotape

While copies of all FEMP reports were made available to the native communities in the FEMP study area and to the Northern Flood Committee, it was recognized that this information had to be supplemented if the specific environmental concerns of the communities' residents were to be addressed, and in their own language. A videotape format was selected for the following reasons: 1) the oral form of Cree is more widely understood than the written form, (undoubtedly, the result of the traditional importance of oral story-telling in the native culture); 2) videotaped interviews would enable the communities' residents to relate, in their own words, their specific environmental concerns; and 3) previous experience with Cree language videotapes, on mercury, suggested that the videotape format was a successful method for communicating environmental information to native communities.

A Cree language videotape had been produced, on mercury in the mid 1980s, for Nelson House and South Indian Lake, as part of the public information program of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion (CMMA). A retrospective analysis of the CMMA's public information program (McKerness 1989a) concluded that the active involvement of the native communities was critical in the planning and implementation of the public information activities for them. A similar conclusion was reached during the production of the Cree language videotape, in the late 1980s, for the James Bay mercury program in Quebec.

In order to assess the level of community interest in a FEMP videotape, a pilot project was conducted in one of the 6 communities, selected at random. The Chief and Council of the Cross Lake Band were contacted, the concept explained to them, and their permission requested to film in their community. Permission was granted and Mrs R. Monias, the Cross Lake Key Communicator, was named as the designated contact person for the pilot project, which was begun in March 1990.

The pilot project was invaluable in: 1) identifying the environmental concerns in Cross Lake; 2) providing a sample tape of community interviews for previewing in the other 5 communities, when permission to film in their communities was being sought; 3) estimating the logistical requirements of filming in all 6 communities (e.g. cost, time); and 4) establishing an excellent working relationship with Mrs R. Monias, and through her, with the Key Communicators in the other communities.

The Key Communicators are community residents employed by the bands to advise their community about all NFA activities. The Key Communicators worked closely with the FEMP videotape crew on all aspects of the filming in their community, including: 1) scheduling the visits; 2) selecting community residents for the videotaped interviews; 3) arranging guides and boats for exterior shots; and 4) in general, providing logistical support (e.g. translation services). The greatest benefit, however, that resulted from working with the Key Communicators was that their involvement helped foster a climate of trust. (The community contact in South Indian Lake, a non-NFA community, was the mayor, who was equally helpful in the FEMP filming.)

The FEMP videotape did not have a pre-prepared script; instead, the many hours of community interviews were carefully viewed to identify the major environmental concerns, based primarily on the number of times a concern was raised. Then, those FEMP results that were relevant to the identified concerns were selected for incorporation into the FEMP videotape. The interviews, usually accompanied by visuals to illustrate the speaker's comments, were interwoven with graphics and brief narratives on the relevant FEMP results to produce the FEMP videotape.

Copies of the English and Cree versions of the FEMP videotape were sent to all 6 communities. In addition, each community received an unedited VHS copy of all the tape shot in their community - the exterior shots, as well as the interviews. The broadcast-quality master tapes have been placed in government archives in Winnipeg to preserve this unique material for possible future users.

SUMMARY

Reporting on the results of the FEMP was a multi-step process that began with the critical step of identifying the information needs of the target audience. This process is outlined in Fig. 5.1.

Figure 5.1 FEMP Reporting Process