PEACE-ATHABASCA DELTA

WATER MANAGEMENT WORKS EVALUATION

FINAL REPORT

PEACE-ATHABASCA DELTA IMPLEMENTATION COMMITTEE

CANADA ALBERTA SASKATCHEWAN

INDEX OF REPORTS

PEACE-ATHABASCA DELTA
WATER MANAGEMENT WORKS EVALUATION

A Report Prepared Under the
PEACE-ATHABASCA DELTA
IMPLEMENTATION AGREEMENT

Peace-Athabasca Delta Implementation Committee

CANADA ALBERTA SASKATCHEWAN

April 1987

500-04/87

PEACE-ATHABASCA DELTA IMPLEMENTATION COMMITTEE
CANADA ALBERTA SASKATCHEWAN

The Honourable Tom McMillan
Minister
Environment Canada

The Honourable Ken Kowalski
Minister
Alberta Environment

The Honourable Eric Berntson
Minister in Charge
Saskatchewan Water Corporation

Dear Sirs:

In September 1974, the Governments of Canada, Alberta and Saskatchewan entered into an agreement to construct remedial works in the Peace-Athabasca Delta with the intent of partially restoring water levels which had been adversely affected by construction of the W.A.C. Bennett Dam in British Columbia. The agreement called for the establishment of the Peace-Athabasca Delta Implementation Committee to oversee construction of the works and to subsequently monitor the effects of the restoration efforts on the delta ecosystem. The Committee was directed to report on results achieved to the Ministers representing the parties to the agreement.

We are pleased to present the Final Report of the Peace-Athabasca Delta Implementation Committee entitled "Peace-Athabasca Delta Water Management Works Evaluation". The report provides an assessment of the remedial works undertaken on the Peace-Athabasca Delta under the auspices of the Peace-Athabasca Delta Implementation Committee. It also presents the results of ancillary studies conducted by the committee on the growth of Creed Creek, a possible structure on the Quatre Fourches, fish passage at the weirs and modifications to the boat tramway.

The committee concluded that the existing control structures are operating satisfactorily and that no additional structures are warranted at the present time. Long-term hydrological and biological monitoring programs are recommended. The committee recognizes that government activities in the delta should continue to be coordinated. Therefore, it recommends that the present agreement be terminated and the responsibility for coordinating and reporting on the implementation of the recommendations of this committee be transferred to the Mackenzie River Basin Committee.

J.H. Simpson, Chairman
Alberta Environment

T.R. Heggie
Environment Canada

R. G. Weatherill
Alberta Forestry, Lands & Wildlife

G.H. Morton
Environment Canada

D.L. MacLeod
Saskatchewan Water Corporation

A.R. Murray
Saskatchewan Parks & Renewable Resources

EXECUTIVE SUMMARY

The Peace-Athabasca Delta Implementation Committee (PADIC) is an intergovernmental committee representing the governments of Canada, Alberta and Saskatchewan. It was established in 1974 to coordinate programs related to restoring low water levels that had occurred on the delta following construction of the W.A.C. Bennett Dam on the Peace River and filling of the Williston Reservoir in 1968-71.

Under the auspices of PADIC, two rockfill weirs were constructed on the Rivière des Rochers and Revillon Coupé to delay the rate of outflow and raise water levels throughout the delta. PADIC evaluated the performance of the weirs from a hydrological and biological perspective. The committee also studied the growth of the natural diversion of water from the Athabasca River into the delta lakes through the Creed Creek breakthrough and the implications of this diversion on a possible control structure on the outlet of Mamawi Lake. In addition, PADIC became involved in remedial measures for the Rivière des Rochers site by upgrading the boat tramway and evaluating the need for a fishway.

PADIC reached the following conclusions:

Hydrological Assessment

a. The weirs will continue to perform as predicted and counteract many of the hydrological changes in the delta brought about by regulation of the Peace River by Bennett Dam.

b. The weirs have nearly restored the natural summer peak water levels of the delta, but the amplitude of water levels is less than under the natural regime.

c. Recharge of the perched basins by overland flooding from the major delta lakes is similar to natural conditions; however, the weirs do not influence the perched basins flooded by the Peace River.

Biological Assessment

a. The naturally depressed water levels of the past decade have caused productive wetland habitat of the delta to decrease, particularly in the perched basins.

b. The water levels resulting from the weirs have mitigated many of the long-term biological impacts caused by Bennett Dam and created a situation substantially closer to natural conditions than would have existed if they had not been built.

c. The perched basin habitat at higher elevations on the delta has been altered by less frequent flooding, and some perched basins along the Peace River have been lost.

d. In some years the weirs may block segments of the goldeye population migrating from the Peace River into the delta lakes.

Ancillary Studies

a. The capacity of Creed Creek, a natural breakthrough from the Embarras River to Mamawi Creek, is growing. Breakthroughs such as Creed Creek are part of the natural evolution of the delta.

b. If Creed Creek continues to grow at its present rate, the ecological balance of Claire and Mamawi lakes will be affected.

c. A gated control structure at the outlet of Mamawi Lake on the Chenal des Quatre Fourches would aggravate the effects that the Creed Creek breakthrough is having on lakes Claire and Mamawi.

d. While it is possible to construct a fishway at the Rivière des Rochers weir site, a fishway should not be built until the effect of the weirs on the goldeye population of the delta lakes has been determined.

Monitoring Programs

a. The hydrometric network necessary to support the hydrodynamic model must be maintained, if the model is to be used in the future.

b. A broad, integrated, biological monitoring program is required to document long term habitat changes over a representative range of water level conditions.

c. A broader assessment of the age structure of the fish population of the delta, particularly goldeye, is required to determine whether the weirs have affected spawning success.

PADIC makes the following recommendations:

1. The network of hydrometric stations necessary to supply data to the hydrodynamic computer model of the Peace-Athabasca Delta should be operated.
2. A long-term biological monitoring program which focusses on vegetation responses to water levels should be implemented.
3. A sampling program to document the age structure of the delta goldeye population should be undertaken.
4. The growth of Creed Creek should be monitored.
5. The Peace-Athabasca Delta Implementation Agreement should be terminated and responsibility for coordinating and reporting on the implementation of recommendations be transferred to the Mackenzie River Basin Committee.

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I. INTRODUCTION

PURPOSE OF THE REPORT

The Peace-Athabasca Delta Implementation Committee (PADIC) was established in 1974 to coordinate programs related to restoring low water levels on the delta that had occurred following construction of the W.A.C. Bennett Dam (Bennett Dam) on the Peace River. PADIC is an intergovernmental committee representing the governments of Canada, Alberta and Saskatchewan.

This is the final report of PADIC. It is based on supporting documents prepared for the committee, which are available in limited quantities as appendices to this report. "Appendix A – Hydrological Assessment" was prepared by the Hydrological Subcommittee, and "Appendix B – Biological Assessment" was prepared by the Biological Subcommittee. In addition, PADIC commissioned several specific studies which are provided in "Appendix C – Ancillary Studies". These include: an "Assessment of the Growth of the Creed Creek Diversion", "Evaluation of Test Fishways on the Rivière des Rochers in the Peace-Athabasca Delta" and "A Technical Feasibility Study of the Quatre Fourches Control Structure in the Peace-Athabasca Delta".

This report is organized in nine sections. The remainder of Section I provides a description of the delta and outlines the terms of the Peace-Athabasca Delta Implementation Agreement. In the second section, remedial works constructed under the auspices of the agreement are described. The hydrologic and biologic monitoring programs conducted on the delta since 1974 are outlined in the third section. The hydrologic and biologic evaluations of the performance of the remedial works are presented in Sections IV and V. Ancillary studies conducted by PADIC are described in Section VI. The conclusions and recommendations of PADIC are presented in Sections VII and VIII. A copy of the Peace-Athabasca Delta Implementation Agreement is included in Section IX.

THE PEACE-ATHABASCA DELTA

The Peace-Athabasca Delta, an invaluable regional, national and international resource, is a complex wetland area created by the Peace and Athabasca rivers at the west end of Lake Athabasca (Figure 1). It is the largest freshwater delta in the world, and it supports a wide diversity of plant and animal life. It also provides traditional hunting, fishing and trapping grounds for local native and Metis people.

Approximately 80% of the Peace-Athabasca Delta lies in Wood Buffalo National Park, which was established in 1922 and designated as a World Heritage Site in 1985. It is the second largest national park in the world, and has the world's largest herd of free-roaming bison. National Parks' policy dictates that the park, including the delta, shall be maintained in its natural state. Only limited management, which is oriented towards the perpetuation of natural conditions, is permitted. The other 20% of the delta includes the Chipewyan Indian Reserve and Alberta Crown land. Both of these areas are managed to produce sustainable resource yields.

Four major drainage systems provide water to the delta: the Athabasca River, Lake Athabasca, Peace River and Birch River. Together, these catchments drain much of northern Alberta, northwestern Saskatchewan, and northeastern British Columbia. The water levels of the delta result from the magnitude and timing of water levels and flows in these four drainage systems. The Peace River is particularly important because it flows along the northern edge of the delta and acts as a natural hydraulic dam regulating the rate at which water flows northward, away from the delta.

The delta drainage network is illustrated schematically in Figure 2. The predominant directions of streamflow, as well as channels that experience flow reversals during major floods, are illustrated. The location of perched drainage basins flooded by the

Peace River, Athabasca River and the weirs are also shown.

The predominant direction of streamflow in the delta is northward, towards the Peace River; however, flow reversals can occur. During spring or summer flooding, the elevation of the Peace River may exceed that of Lake Athabasca, resulting in reversed flows on the Rivière des Rochers, Revillon Coupé and Chenal des Quatre Fourches. This occurred more frequently before construction of Bennett Dam. Similarly, strong easterly winds can cause flow reversals from Lake Athabasca into the Chenal des Quatre Fourches and the delta lakes.

The drainage network of the delta is made up of open drainage and perched basins. The open drainage network is an interconnected system of lakes and streams. The extent of the open drainage network is directly related to the water levels of the delta. The perched basins which are located between the open water drainages, are recharged by flooding. Perched basins at lower elevations are flooded more frequently than perched basins at higher elevations. Because the topography of the delta is relatively flat, a minor change in water levels can cause either extensive flooding or drought, particularly in the perched basins.

The delta is one of the most important waterfowl staging and nesting areas in North America. Four major flyways cross the delta, and it provides important staging and nesting habitat for whistling swans and many species of ducks and geese. The shallow water, high fertility and relatively long growing season of the Peace-Athabasca Delta combine to provide the abundance of food and habitat that these birds require. This is particularly significant during drought years on the prairies when a large proportion of the duck population is forced northward.

The delta serves as a spawning, nursery and summer feeding area for economically important fish such as goldeye, walleye, pike and whitefish. Some species, particularly goldeye, migrate from the Peace and Slave Rivers to spawn in the delta and return to overwinter in these rivers.

Trapping of furbearers, particularly muskrat, has been a traditional source of income for the native and Metis people of the delta. Subsistence hunting and fishing on the Chipewyan Reserve and in Wood Buffalo National Park are also important parts of the regional economy.

PEACE-ATHABASCA DELTA IMPLEMENTATION AGREEMENT

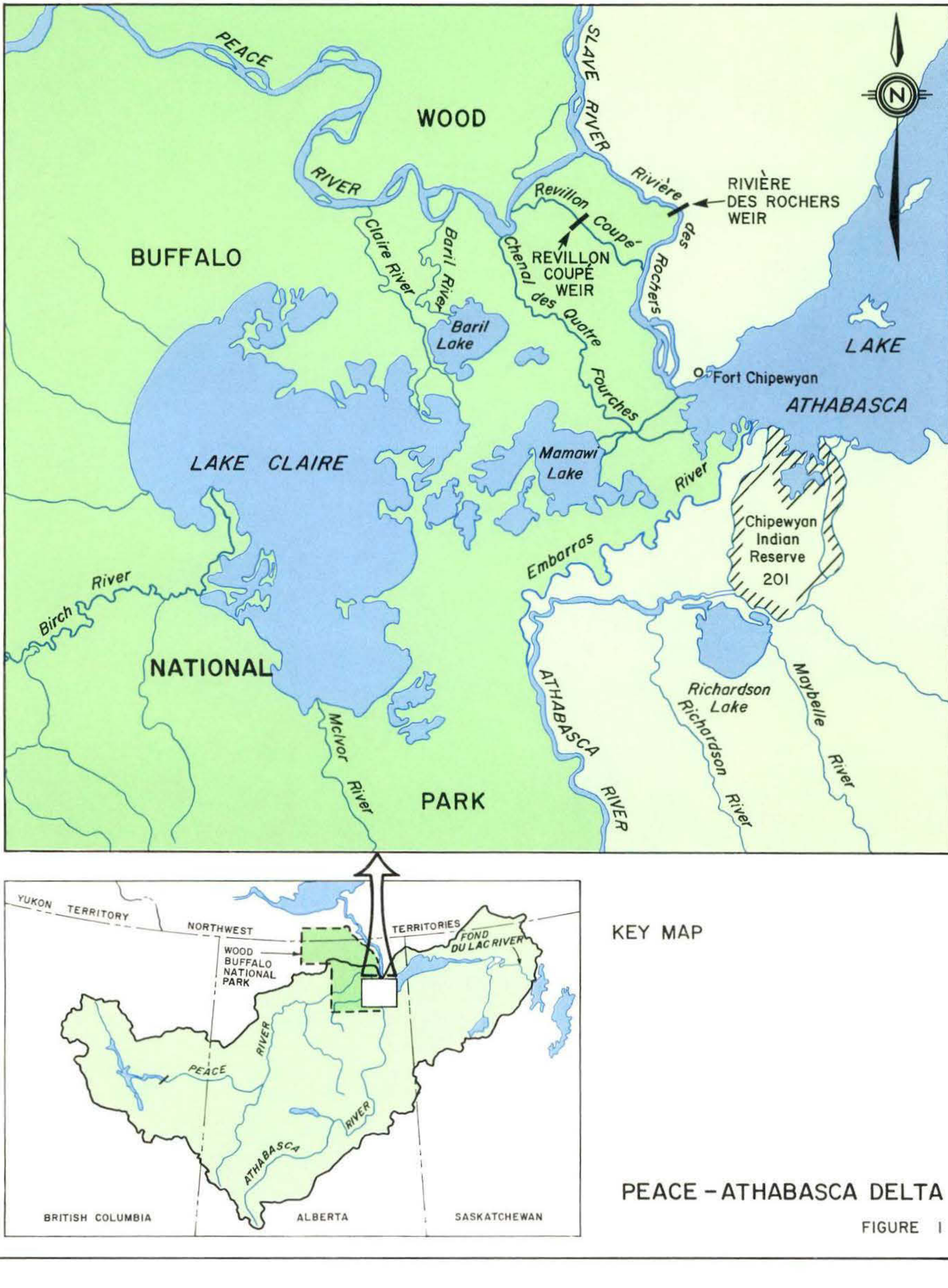
Historical Perspective

In the mid-1960s, the British Columbia government constructed Bennett Dam on the Peace River, creating the Williston Reservoir. Between 1968 and 1971, when the reservoir was being filled, low downstream water levels threatened to permanently disrupt the ecological balance of the Peace-Athabasca Delta.

The governments of Canada, Alberta and Saskatchewan established the Peace-Athabasca Delta Project (PADP) Group in 1971 to determine immediate means for raising the water levels of Lake Athabasca and the delta lakes. In the fall of 1971, a temporary dam was constructed on the west arm of the Chenal des Quatre Fourches, at a cost of $200,000. This interim measure raised water levels throughout 60% of the delta.

The PADP Group also undertook an intensive research program to find a more permanent, environmentally acceptable solution. It concluded that Bennett Dam had permanently altered the flow regime of the Peace River and that this had lowered the water levels of Lake Athabasca and the delta lakes. The most severe effects occurred between 1968 and 1971, when the reservoir was being filled. The PADP Group predicted that subsequent operation of the dam would cause continued, although less severe, changes in the ecology of the delta.

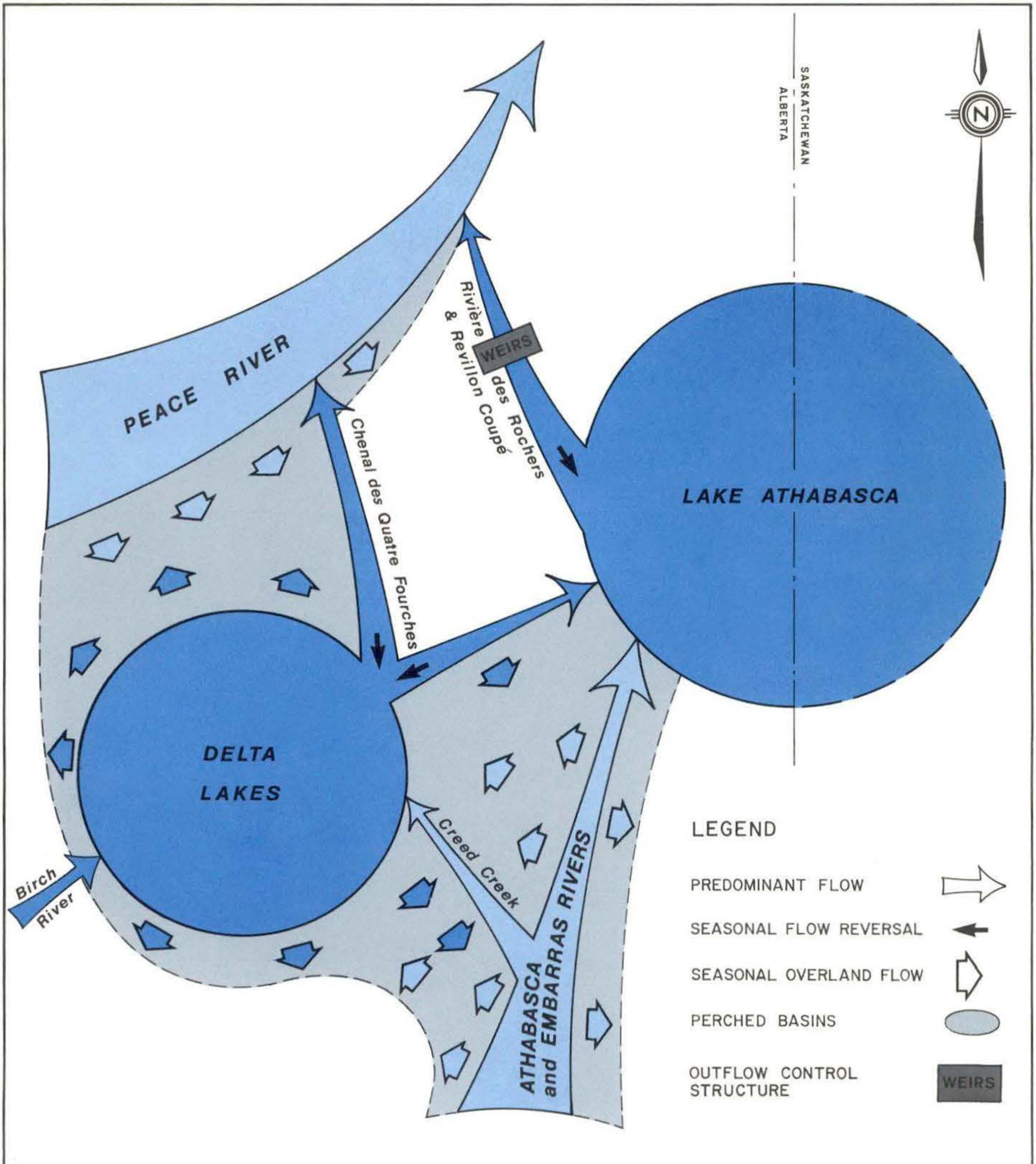
The PADP Group recommended that a fixed crest weir be constructed at the Little Rapids site on the Rivière des Rochers to restore the water levels of Lake Athabasca and the delta lakes to approximately what would have occurred under natural conditions.



KEY MAP

PEACE - ATHABASCA DELTA

FIGURE 1



SCHEMATIC DIAGRAM OF FLOW DIRECTIONS
IN THE PEACE-ATHABASCA DELTA

FIGURE 2

It also recommended that a resource monitoring program be initiated to evaluate the effectiveness of the proposed structure and that an intergovernmental committee be formed to oversee the construction and monitoring programs.

Public hearings were held in 1973 by the Alberta Environment Conservation Authority (ECA) to inform the public of the potential construction in the delta and to receive public input prior to a final decision. The hearings were held by the ECA in Fort Chipewyan and Edmonton, and jointly with the Saskatchewan government in Uranium City. The ECA recommended that the control structure be built at the Little Rapids site and that various monitoring programs be initiated.

Terms of the Agreement

On September 16, 1974, the Peace-Athabasca Delta Implementation Agreement was signed by representatives of the Governments of Canada, Alberta and Saskatchewan. These governments agreed to assign high priority to conservation of the Peace-Athabasca Delta, to establish PADIC, to remove the Quatre Fourches structure, and to jointly construct the Rivière des Rochers weir and related works.

The agreement stipulated that construction costs should not exceed $2 million, of which Canada would pay 50%, Alberta 45% and Saskatchewan 5%. Alberta would assume ownership and maintenance of the Rivière des Rochers weir once it was completed and operating to the satisfaction of PADIC. Ancillary works constructed within Wood Buffalo National Park would be owned and maintained by the Government of Canada. The agreement was to be reviewed 10 years after the effective date or earlier if requested by one of the participating governments.

In 1984, the Peace-Athabasca Delta Implementation Agreement was reviewed. In order to resolve a number of outstanding issues, it was extended until September 16, 1986.

Peace-Athabasca Delta Implementation Committee (PADIC)

The six member PADIC, representing Canada, Alberta and Saskatchewan, was established as part of the Peace-Athabasca Delta Implementation Agreement. PADIC was assigned the responsibility for administering the agreement and coordinating all programs related to restoring water levels in the delta. PADIC was also given the responsibility to monitor the environmental effects of remedial works, to make recommendations related to the preservation of environmental values in the Peace-Athabasca Delta area and to coordinate resource management programs.

In 1983, two subcommittees of PADIC were established to assess whether the remedial works had restored water levels and biological conditions in Lake Athabasca and the delta. The Hydrological Subcommittee was made up of representatives of Alberta Environment, Environment Canada and the Department of Fisheries and Oceans (Canada). It examined in detail the performance of the remedial works, given the nine year additional data base and more sophisticated modelling tools developed since the works were constructed. The Biological Subcommittee was made up of representatives of Alberta Environment, Alberta Forestry, Lands and Wildlife, Environment Canada and the Department of Fisheries and Oceans (Canada). It assessed the extent to which the remedial works had regenerated fish and wildlife habitat and populations as predicted prior to construction.

II. REMEDIAL WORKS

WORKS CONSTRUCTED BY THE PADP GROUP

Temporary Quatre Fourches Dam

In the fall of 1971, a temporary rockfill dam was built on Chenal des Quatre Fourches at the outlet of Mamawi Lake (Figure 3). The purpose of the dam was to delay runoff from the Birch River basin in order to raise the water levels of lakes Claire and Mamawi and adjacent perched basins. The Quatre Fourches structure was severely damaged during the 1974 flood, and it was removed in the fall of 1975 following completion of the permanent weir on the Rivière des Rochers.

The Quatre Fourches dam was an interim solution to the problem of low water levels. The effect of this dam, combined with the exceptional flood of 1974, resulted in the highest water levels experienced on the delta since construction of Bennett Dam. However, in its 1973 assessment, the PADP Group concluded that the Quatre Fourches dam was not suitable as a permanent structure because it would only control water levels in 60% of the delta. The Group predicted that a dam on the Chenal des Quatre Fourches would reduce the flushing action required to maintain the chemical quality of the delta lakes and form a barrier to fish spawning migration. It would neither duplicate the timing and amplitude of the natural delta water regime nor alleviate low water levels in the Chipewyan Indian Reserve and in the marshes outside of Wood Buffalo National Park.

Athabasca River Cutoff Channel

In 1972, a cutoff channel was constructed by the Government of Alberta on the Athabasca River near Embarras Portage to prevent the Athabasca River from eroding through its banks and joining with the Embarras River (Figure 3). The impending breakthrough was caused by the natural forces of erosion, not Bennett Dam. Potentially, such a situation could have led to a major part of the Athabasca River flow being diverted directly into Lake Claire or Mamawi Lake, and continuing to the Peace River, largely bypassing Lake Athabasca and the Alberta portion of the delta.

Construction of the cutoff channel was undertaken by the Government of Alberta, under an agreement with the Government of Canada. A pilot channel 6.1 m wide and 945 m long was constructed to divert flow of the Athabasca River from the eroding bank. The complete channel was developed by the river during subsequent flooding.

RIVIÈRE DES ROCHERS AND REVILLON COUPÉ WEIRS

Following the completion of the 1973 PADP Group investigations, the governments of Canada, Alberta and Saskatchewan agreed to construct a permanent weir on the Rivière des Rochers at the Little Rapids site (Figure 4). The detailed engineering design studies revealed that this weir might cause high velocities and erosion on the Revillon Coupé. Thus, a second weir was constructed on the Revillon Coupé.

The permanent rock weir, ancillary fish bypass channel, and boat tramway were completed on the Rivière des Rochers in September 1975. In March of 1976, the rock weir was completed on the Revillon Coupé.

OTHER CONTROL STRUCTURES EVALUATED BY THE PADP GROUP

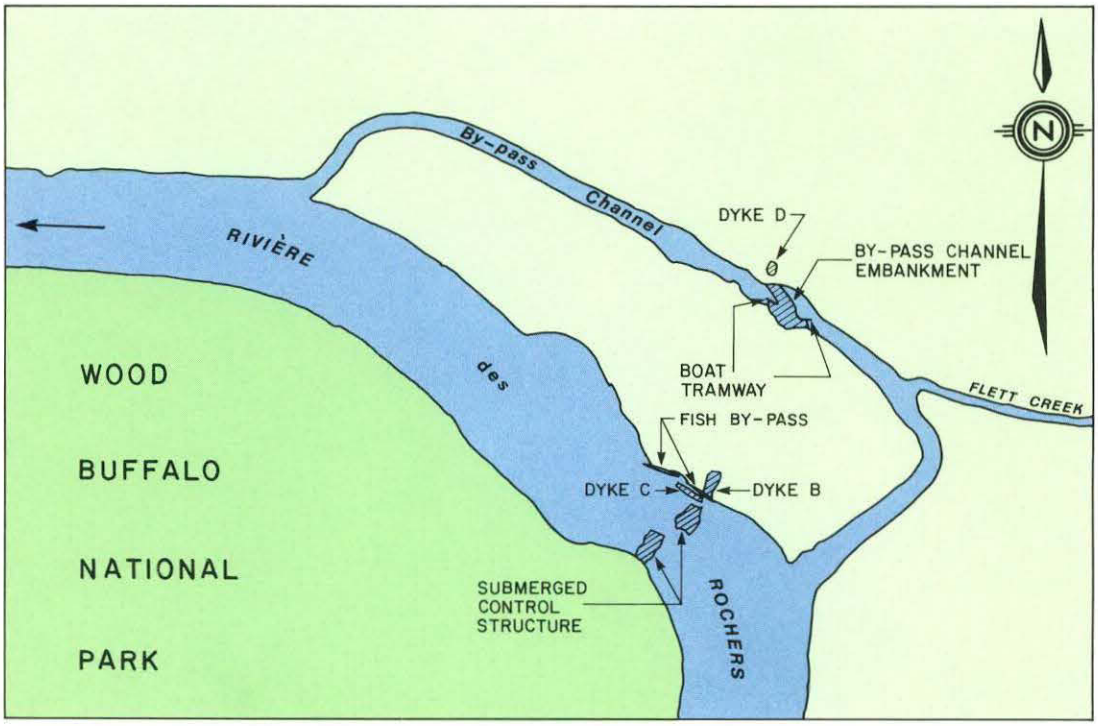
Before the decision was made to construct the Rivière des Rochers and Revillon Coupé weirs, the PADP Group carried out a preliminary investigation of a number of alternative solutions (Figure 3). Several types of permanent structures were evaluated on the basis of location, design, cost, degree of restoration, effects on wildlife and fish populations and compatibility with the National Park and other interests (Table 1). Alternative sites were proposed for the Slave River, Rivière des Rochers, Revillon Coupé and Chenal des Quatre Fourches. In addition, a number of other schemes were considered: creating a temporary blockage of the Rivière des Rochers by a man-made ice dam; assisting the natural occurrence of Slave River ice jamming and modifying Bennett Dam releases.

Table 1 – Control Structures Evaluated by the PADP Group in 1973

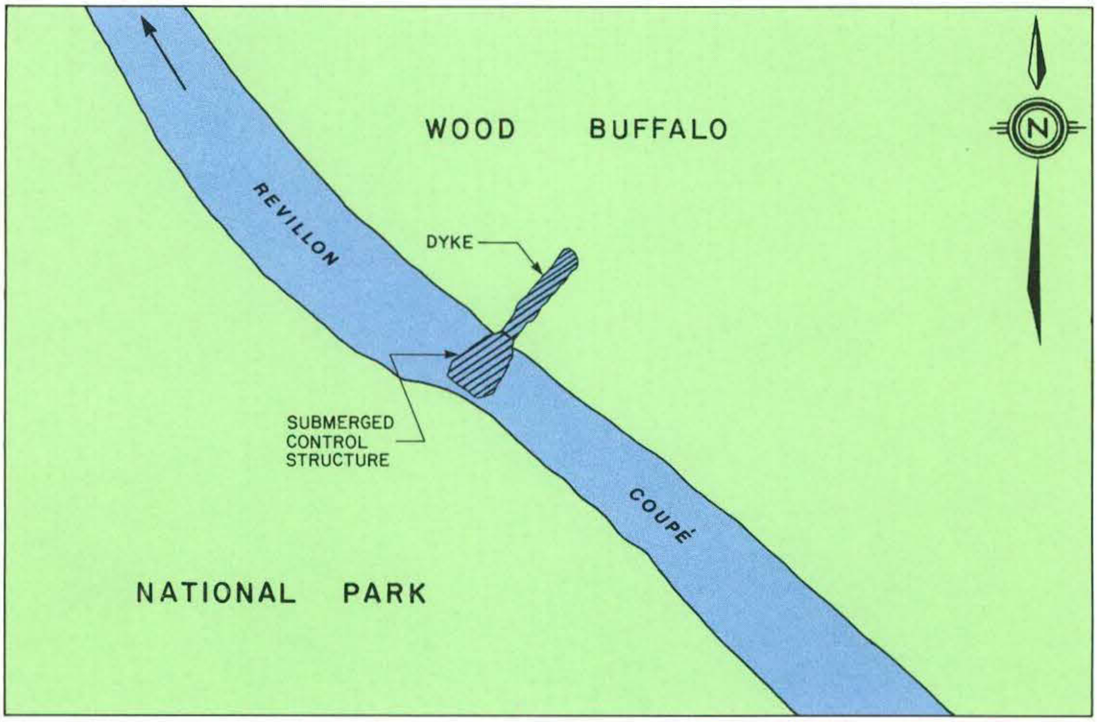
	ALTERNATE SITES			
REMEDIAL WORKS	**Slave River**	**Rivière des Rochers**	**Revillon Coupé**	**Quatre Fourches**
Gated Structure	•	•		
Weir		•		
Constriction	•	•		
Rockfill Dam			•	•
Ice Dam		•		
Ice Jam	•			

REMEDIAL WORKS INVESTIGATED AND IMPLEMENTED

FIGURE 3



RIVIÈRE des ROCHERS WEIR SITE



REVILLON COUPÉ WEIR SITE

SKETCH MAPS OF THE WEIR SITES

FIGURE 4

III. MONITORING PROGRAMS

WATER LEVELS AND STREAMFLOWS

Environment Canada and Alberta Environment operate streamflow and water level gauging networks internal and external to the Peace-Athabasca Delta (Figure 5). The internal network was established to assess the influence of Peace River flow regulation on water levels of the delta. This network consists of 23 stations, of which 14 record water level data and 9 provide miscellaneous streamflow and water level data. The external network measures major and minor inflow to Lake Athabasca and the delta at key locations. This network is comprised of 7 stations, which provide continuous streamflow and water level data. These hydrometric stations are located on the Athabasca, Birch, Fond du Lac, MacFarlane, Peace, Slave and William rivers.

The recorded flows of the major rivers contributing to the Peace-Athabasca Delta were compared to determine how the water yields from the contributory basins relate to water levels on the delta. Continuous records are available for the three major contributory rivers for the period 1960-1985: Athabasca River below Fort McMurray, Fond du Lac River at outlet of Black Lake, and Peace River at Peace Point.

Table 2 – Average Annual Flows of the Major Contributory Basins 1960-67, 1963-67 and 1972-85

STREAM	PERIOD	AVERAGE ANNUAL FLOW (m^3/s)	
Athabasca River	1960-67	684	
	1972-85	684	
Difference		0	(0%)
Fond du Lac River	1963-67	331	
	1972-85	296	
Difference		35	(-10.6%)
Peace River	1960-67	2,270	
	1972-85	2,080	
Difference		190	(-8.4%)
Total	1960-67	3,285	
	1972-85	3,060	
Difference		225	(-6.8%)

Average annual flows of the three major contributory basins were compared using 1960-67 data to represent pre-Bennett Dam condition and 1972-85 data to represent post-Bennett Dam conditions (Table 2). The average yield of all three basins has been slightly lower in the more recent period.

In the short-term, however, average annual flows of the major contributory basins to the Peace-Athabasca Delta have been significantly below the long-term average (Table 3). This has contributed to low water levels on the Peace-Athabasca Delta in the 1980s.

Table 3 – Average Annual Flows of the Major Contributory Basins 1960-79, 1963-79 and 1980-85

STREAM	PERIOD	AVERAGE ANNUAL FLOW (m^3/s)	
Athabasca River	1960-79	698	
	1980-85	601	
Difference		97	(-13.9%)
Fond du Lac River	1963-79	310	
	1980-85	277	
Difference		33	(-10.6%)
Peace River	1960-79*	2,260	
	1980-85	1,850	
Difference		410	(-18.1%)
Total	1960-79	3,268	
	1980-85	2,728	
Difference		540	(-16.5%)

* Not including Williston Reservoir filling during 1968-1971.

The Peace River acts as a hydraulic dam during the spring flood, retarding the flow from Lake Athabasca and maintaining high water levels in the Peace-Athabasca Delta. An examination of peak flows on the Peace River at Peace Point before and after construction of Bennett Dam shows that although average annual discharge for these two periods is within 8%, the peak flows have decreased significantly (-34%) since completion of the dam.

Water levels recorded before and after construction of the weirs do not provide a valid measurement of the effectiveness of the weirs because contributory flows to the delta have been low in recent years. Therefore, a hydrodynamic model was developed by Alberta Environment and Environment Canada for PADIC, to simulate the water levels for the period 1960-85. The model allowed the water levels resulting from Bennett Dam and the weirs to be compared to natural levels for a common time period. The model and results are described in Section IV.

VEGETATION

Vegetation changes in the Peace-Athabasca Delta were monitored annually between 1974 and 1978 along a series of transects established by the Canadian Wildlife Service in 1968. The monitoring programs were conducted for PADIC by the University of Calgary under contract to Parks Canada. They provide a basis for describing short-term vegetation responses to water level changes over the 1968-1978 monitoring period. The status of vegetation communities on the delta provides an important indicator of water level changes and their effects on wildlife communities.

WATERFOWL

Between 1971 and 1974, a program of waterfowl population monitoring was conducted by Ducks Unlimited (Canada) with funding from the Canadian Wildlife Service. In 1975 and 1976, the studies were undertaken for PADIC by the Canadian Wildlife Service and funded by Parks Canada. These census studies provide a basis for understanding how waterfowl populations related to water levels during that six-year period.

MAMMALS

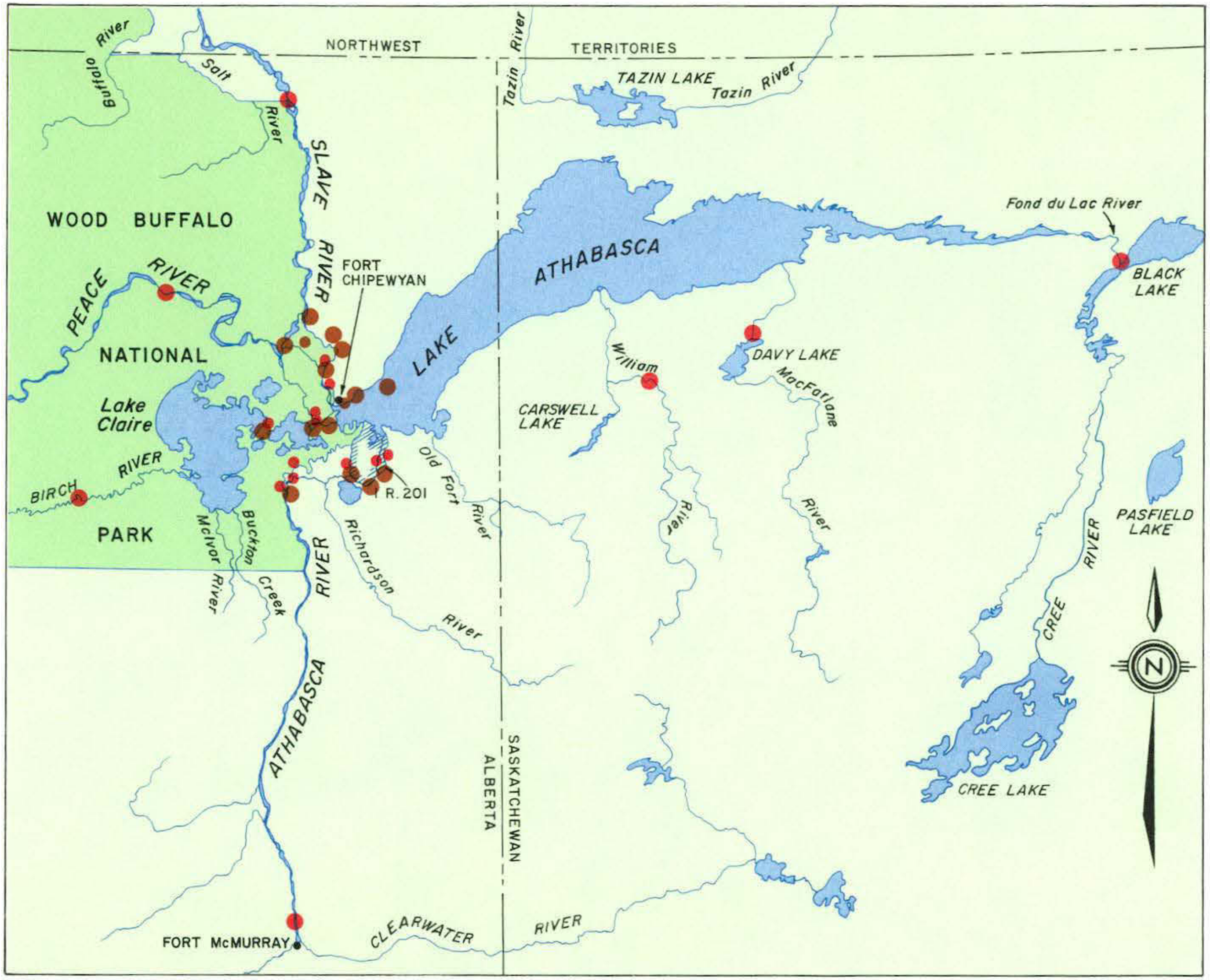
The Peace-Athabasca Delta provides habitat for a variety of mammals. The monitoring program conducted for PADIC focused on muskrats because they are economically important to local trappers and sensitive to water level changes. Other furbearers were not monitored, as their populations are related to water levels to a lesser degree. Field studies of muskrats in the Peace-Athabasca Delta were conducted for PADIC by the Canadian Wildlife Service between 1973 and 1975 and by Canadian Wildlife Service and Parks Canada between 1976 and 1978. These studies compared estimates of muskrat populations for 31 lakes and perched basins.

Bison and moose were evaluated in the 1973 PADP Group investigations, and no adverse impacts were predicted to occur from water level changes. Factors other than water levels (i.e. hunting pressure and disease) were felt to be more important determinants of population numbers. Parks Canada monitors ungulate populations and habitat conditions, particularly for bison within Wood Buffalo National Park.

FISH

Fisheries field investigations in the Peace-Athabasca Delta have focussed primarily upon goldeye and walleye. Both of these species have important spawning and rearing areas within the delta and both species are utilized by the local domestic and sport fishery. There is a significant commercial fishery for walleye on Lake Athabasca. Goldeye were fished commercially in the delta between 1948 and 1966.

The fisheries field programs conducted in the delta have been largely problem-oriented. In 1976 and 1977, fish movements in the vicinities of the Rivière des Rochers and Revillon Coupé weirs were studied and it was concluded that the weirs impeded goldeye movements during parts of the spawning



LEGEND

	RECORDING	NON-RECORDING
STREAMFLOW GAUGE	●	•
WATER LEVEL GAUGE	●	•

WATER LEVEL AND STREAMFLOW GAUGING NETWORK

FIGURE 5

migration. Therefore, in 1980, field studies were conducted to prepare fishway designs to aid fish passage at the weirs.

In 1977 and 1978 field programs confirmed that, for its size, Richardson Lake is probably the single most important water body for the production of walleye in the Peace-Athabasca Delta. However, in most years, more walleye are produced by other delta lakes, particularly the Lake Claire-Mamawi system. The study did not document any effects on the walleye population caused by water levels.

IV. HYDROLOGICAL ASSESSMENT

EVALUATION BY THE PADP GROUP

As part of the 1973 evaluation of alternative remedial measures to restore water levels in the Peace-Athabasca Delta, a mathematical model was developed by the PADP Group to simulate the fluctuation of Lake Athabasca water levels. The model provided comparative water level hydrographs for the time period 1960-71 for natural conditions, for conditions with Bennett Dam and for conditions with alternative remedial control structures. Summer peak water levels and average water levels during the critical summer growing period (May 15-August 15) were two of the key parameters used to evaluate the alternative remedial measures. It should be noted that the average summer level for the 1960-71 modelling period used to establish the natural condition in the model was 0.2 m higher than the long-term average summer level.

The 1973 modelling results indicated that Bennett Dam regulation resulted in peak water levels 0.6 m lower than the natural regime and average summer levels 0.3 m lower. The amplitude of summer lake levels was reduced from 0.5 m to 0.2 m. The modelling results predicted that the Rivière des Rochers and Revillon Coupé weirs would restore mean summer peak water levels to within 0.1 m of the natural mean peak, but would also raise the average summer growing season water levels above the mean natural level by about 0.1 m. The amplitude of the average summer lake levels would remain at about 0.2 m, the same as under the Bennett Dam regime.

When it was developed, this model represented the best simulation model of the complex hydraulics of the delta. However, the model had several inherent weaknesses, the most important of these was that it treated Lake Athabasca and the delta lakes as a single water body. The delta lakes and their surrounding basins often exhibit water level fluctuations that are independent of Lake Athabasca. Therefore, as part of the PADIC evaluation, a more sophisticated hydrodynamic model was developed to assess the performance of the weirs.

PURPOSE OF THIS EVALUATION

In June 1983, the Hydrological Subcommittee was formed by PADIC to assess whether the Rivière des Rochers and Revillon Coupé weirs had been successful in restoring water levels of the Peace-Athabasca Delta and Lake Athabasca. The evaluation by this subcommittee considered in detail the hydraulic performance of the weirs, taking into account the greater amount of hydrometric data available and the more sophisticated models that had been developed in the 10 years since the previous analysis. The One-Dimensional Hydrodynamic Model was used for evaluation.

ONE-DIMENSIONAL HYDRODYNAMIC MODEL

Description

The theoretical basis for the hydrodynamic model was developed at the Massachusetts Institute of Technology, and has been verified in numerous practical applications in the United States. The model has also been adapted successfully to the St. Lawrence and Fraser Rivers by Environment Canada. The hydrodynamic model was well-suited to its application to the Peace-Athabasca Delta, because it allowed the simulation of water levels and flows in a network of interconnected lakes and river channels, with and without control structures.

Application

The hydrodynamic model was used to conduct comparative simulations of three water regime scenarios for the common time period 1960-84. The three scenarios were: the natural regime, the regulated Bennett Dam regime, and the regulated Bennett Dam regime with the weirs in place. The major input data to the hydrodynamic model were recorded water levels and flows for the Athabasca, Birch, Peace and Slave rivers. In addition, data from other hydrometric stations in the delta were used to calibrate and verify the model.

The study area and model network are shown in Figure 6. The network consisted of 22 nodes connected by reaches to simulate the flow pattern of the delta. The north boundary of the model was defined by the reaches of the Peace and Slave Rivers that extend from Peace Point (node 11) to Fitzgerald (node 22). The south boundary was defined by the reaches extending from Birch River (node 3) to Lake Athabasca at Crackingstone Point (node 1). The north and south boundaries were connected by a network of channels. The flows of these channels were determined by the relative differences in water levels between the north and south boundaries.

The simulated water levels in the delta network were dependent on the inflow data and the routing of the flows through the delta lakes system. Flows and water levels were computed at each node, and at intermediate points, in two-hour time steps for each of the three scenarios.

When the hydrodynamic model was first applied to the Peace-Athabasca Delta in 1978, it was limited to calibration for open water flow conditions. The scope of the modelling was also limited by the available data base describing the topography of the delta. Between 1978 and 1985, the following improvements were made to increase the accuracy of the simulations:

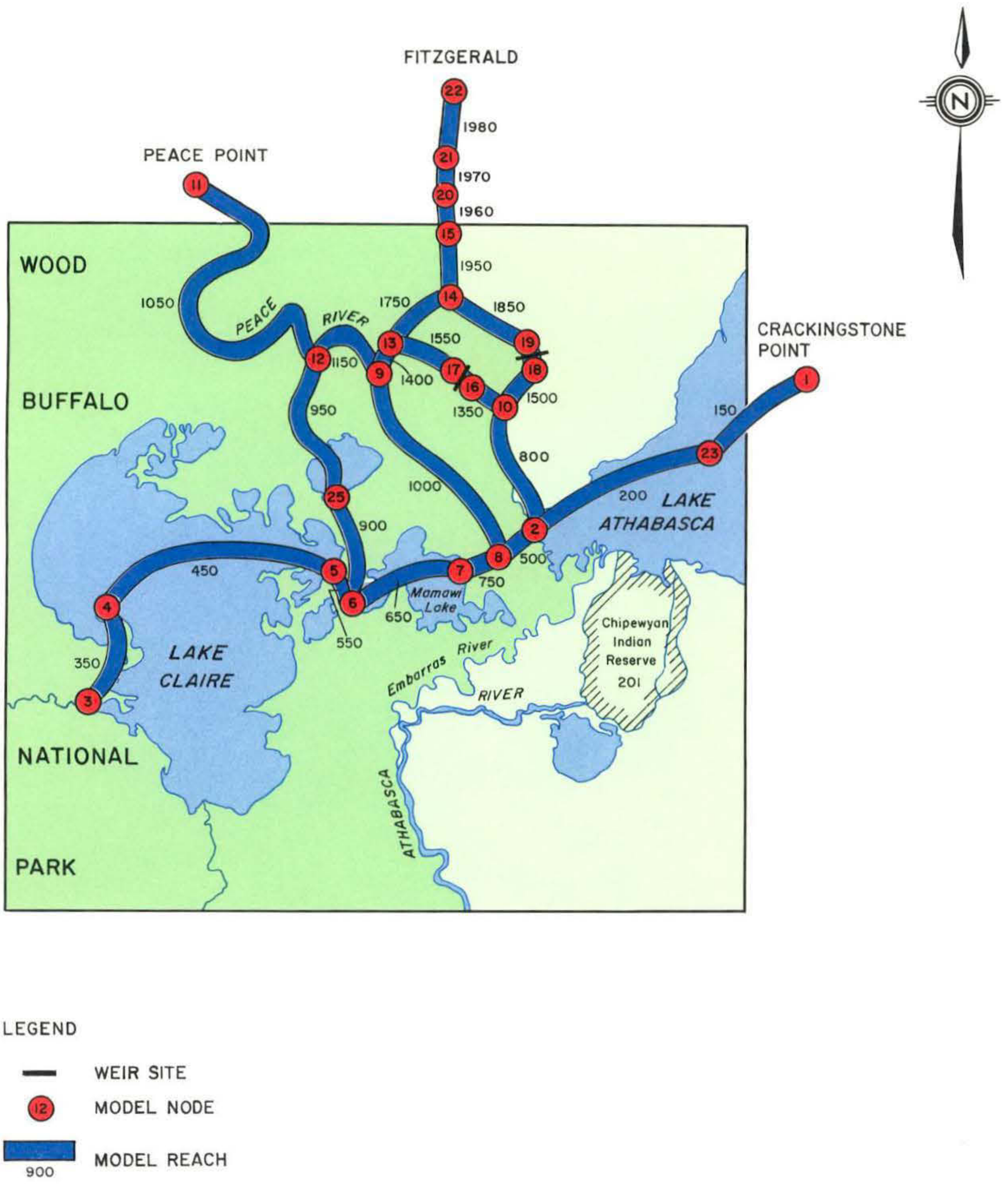
- New cross sections were surveyed along the Peace River to improve water level calibrations between Peace Point and Rivière des Rochers and to establish the hydraulic influence of Peace River levels on Lake Athabasca outflow and the Baril Lake bypass channel flows.
- Two reaches were added to the model configuration to simulate overflow during extreme events between the delta lakes, Baril Lake and the mouth of the Baril River on the Peace River.
- The Slave River reach was added to the model configuration to allow recorded data from the Fitzgerald gauging station to be used to describe the control at the downstream boundary of the model.
- Channel cross sections were updated in the Lake Claire, Prairie River, Mamawi Lake and Mamawi Lake outflow channel reaches.
- Ice cover was applied to all reaches during the winter period, and evaporation losses were computed for the large water bodies during the summer period.

Results

The results of the comparative water level simulations for lakes Athabasca, Claire and Mamawi for the natural regime, the Bennett Dam regime without weirs, and the Bennett Dam regime with weirs are provided in Figure 7. The hydrographs indicate that Bennett Dam regulation without the weirs results in significantly lower summer peak levels than would occur under the natural regime, but low levels experienced in the late winter are approximately the same. The hydrographs show that although the weirs have closely restored the summer peak levels in the delta, winter levels have been increased, thereby producing a lower amplitude between the summer peaks and the winter lows in comparison to the natural regime. This effect was predicted by the PADP Group in 1973.

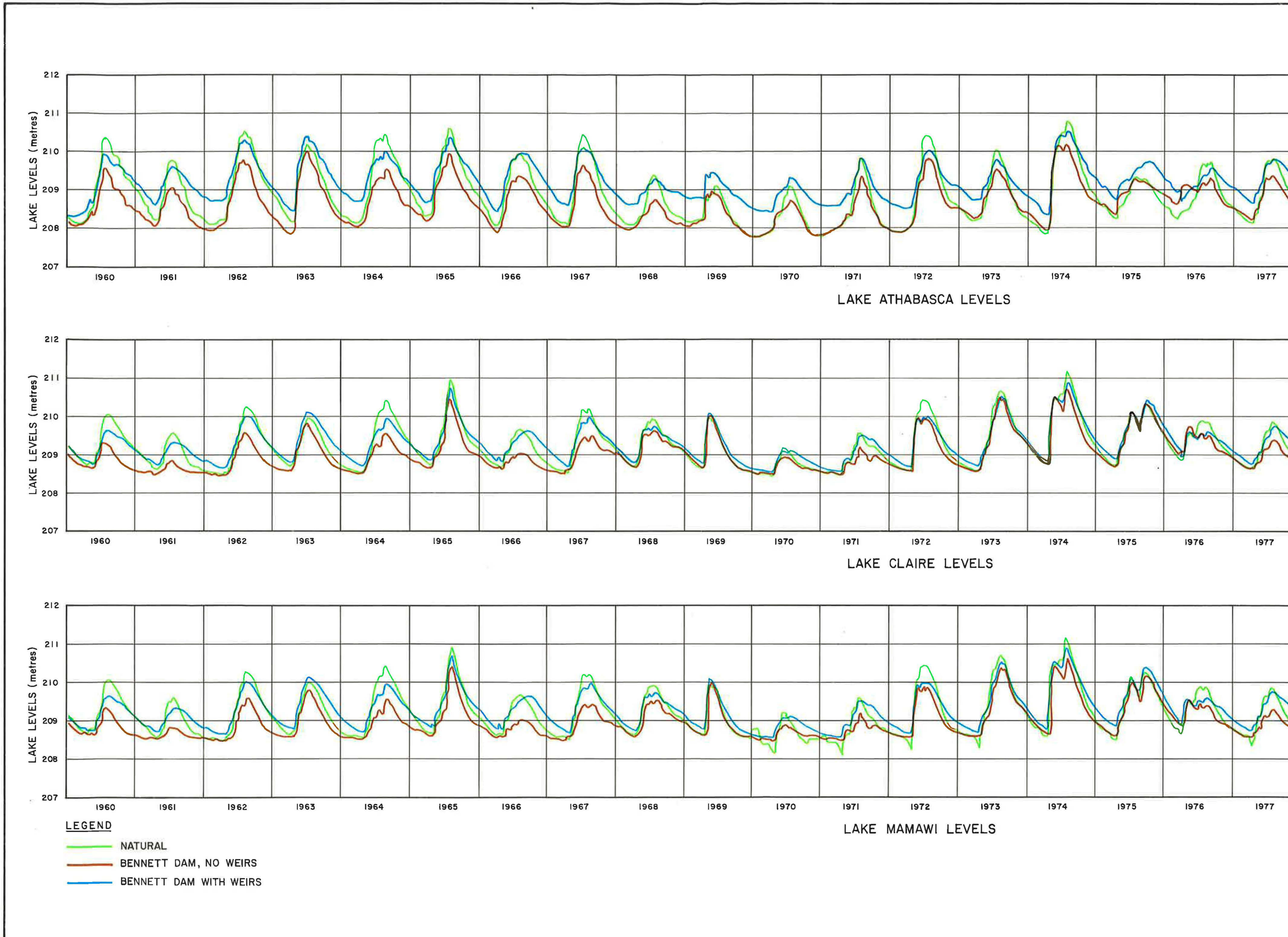
Average summer Lake Athabasca peak levels, simulated with weirs in place, match the simulated natural levels within 0.1 m; while minimum and mean annual water levels are higher than natural by about 0.6 m and 0.4 m, respectively. The mean amplitude of annual levels with the weirs is reduced by about 0.6 m from natural conditions.

Lake Athabasca's average levels during the summer growing season (15 May to 15 August) with the weirs in place are about 0.1 m above the natural average (Figure 8). Peak summer levels are

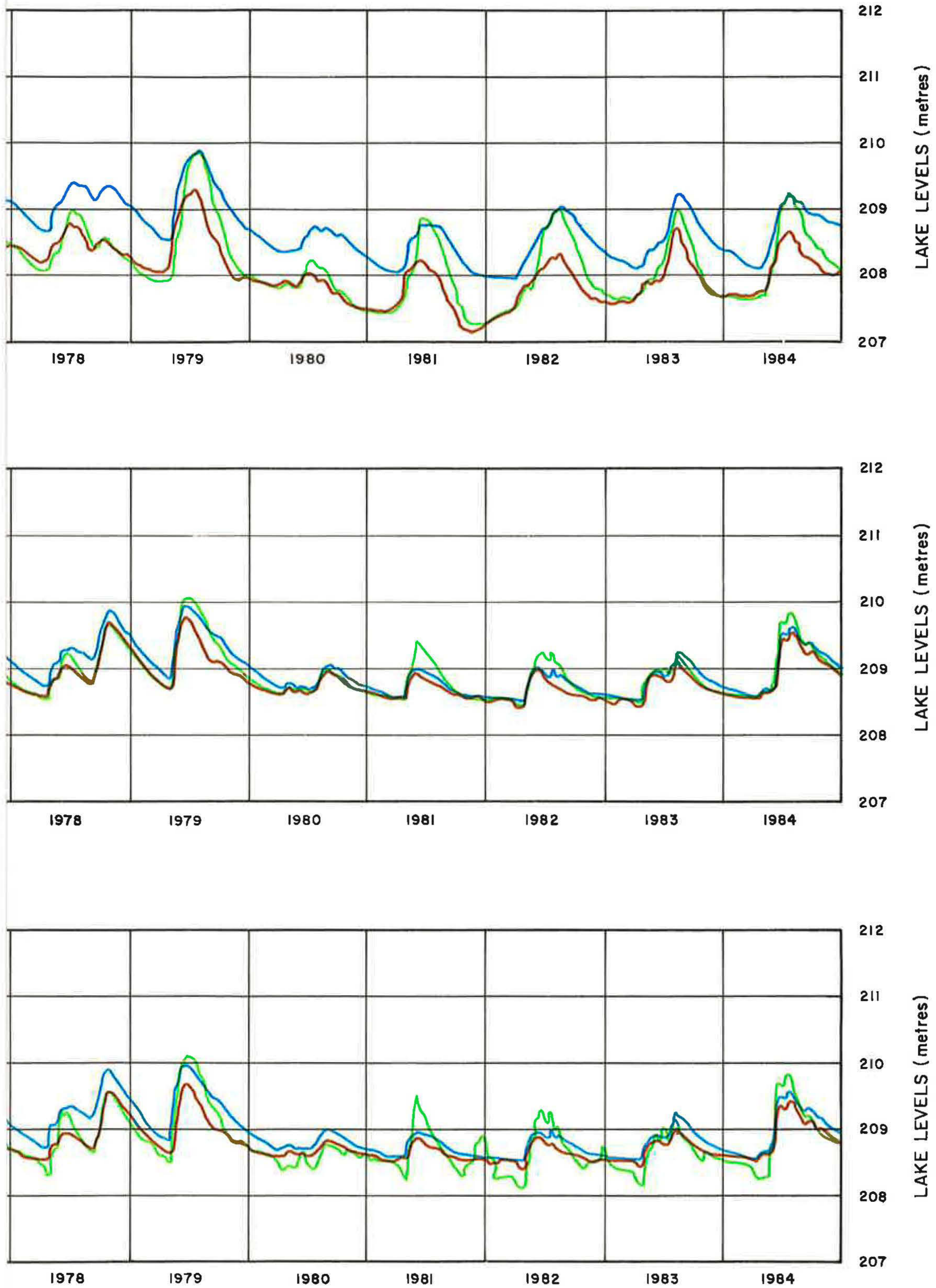


ONE DIMENSIONAL HYDRODYNAMIC MODEL NODES AND REACHES

FIGURE 6

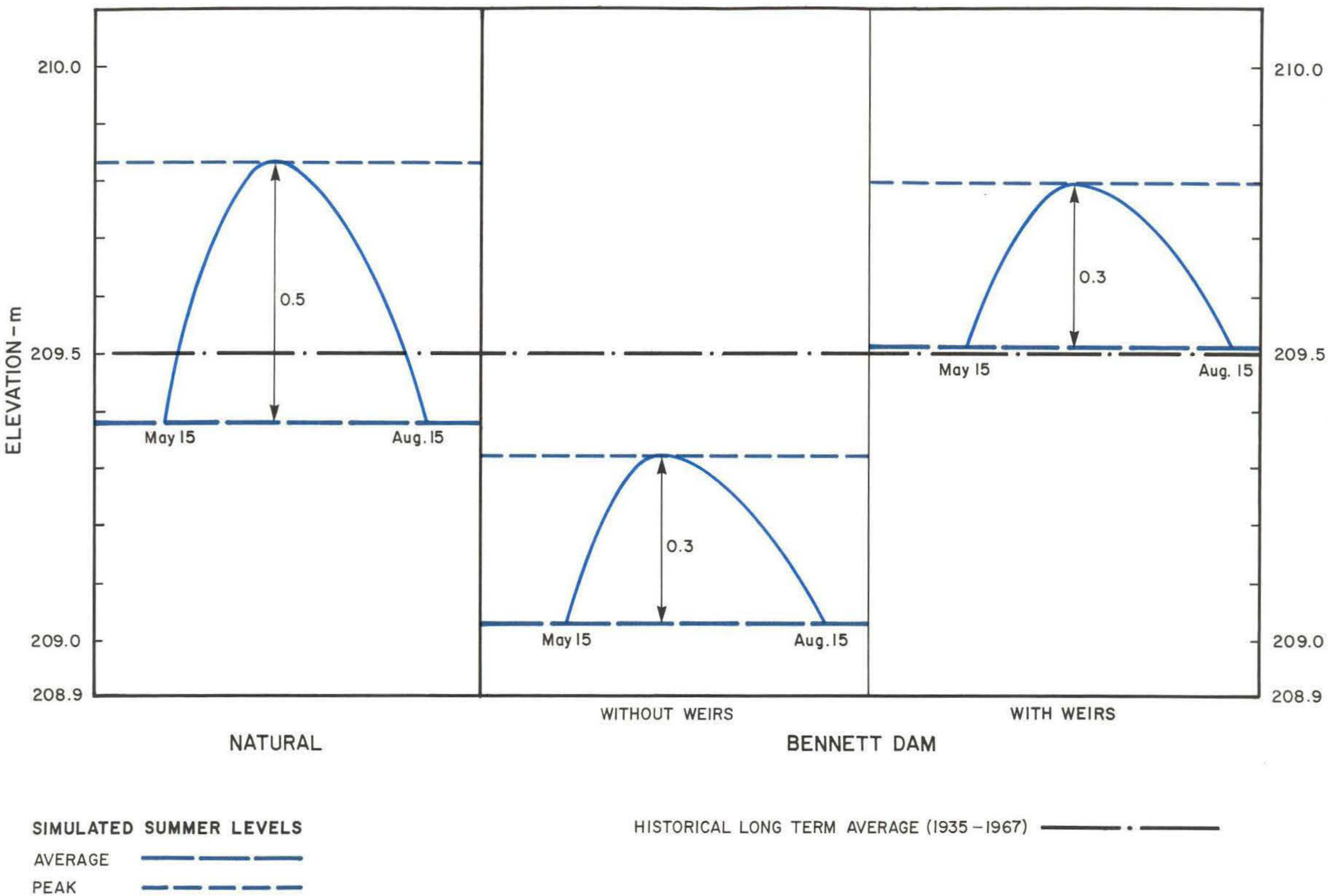


LAKE LEVELS (metres)
212
211
210
209
208
207
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
LAKE ATHABASCA LEVELS
LAKE CLAIRE LEVELS
LAKE MAMAWI LEVELS
LEGEND
NATURAL
BENNETT DAM, NO WEIRS
BENNETT DAM WITH WEIRS



COMPARATIVE WATER LEVEL SIMULATIONS
FOR LAKES ATHABASCA, CLAIRE AND MAMAWI

FIGURE 7



SIMULATED AVERAGE SUMMER LEVELS AND PEAKS OF LAKE ATHABASCA

FIGURE 8

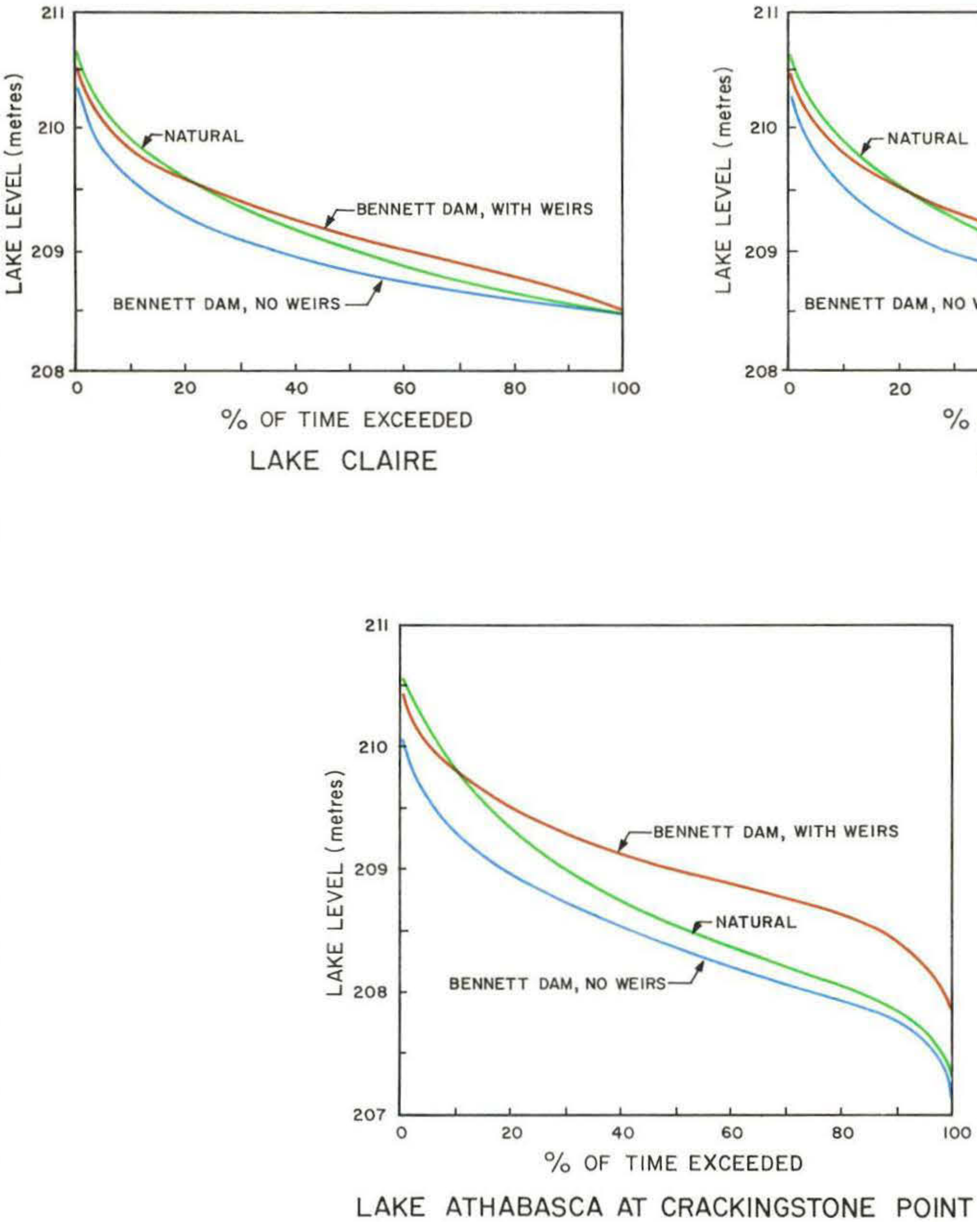
less than 0.1 m below the natural average. The mean amplitude of summer levels is reduced from 0.5 m to 0.3 m for both the Bennett Dam and the Bennett Dam with weirs regimes. When compared to the long-term summer average Lake Athabasca level, the simulated natural levels are slightly lower and the simulated levels with the weirs are slightly higher.

The summer peak levels simulated for Lake Claire, with weirs in place, are about 0.2 m lower than the simulated natural levels. Both the minimum and mean water levels are higher than natural by about 0.1 m. Average summer peak levels on Mamawi Lake, with weirs in place, are about 0.1 m lower than natural, while minimum and mean water levels are both higher than natural by about 0.1 m. The mean amplitude of annual levels on lakes Claire and Mamawi has been reduced by about 0.3 m.

Curves illustrating the duration of daily water levels for lakes Athabasca, Claire and Mamawi are provided in Figure 9. The curves show the percentage of time that specific levels are equalled or exceeded, based on the simulated data. The duration curves, like the hydrographs, illustrate that the amplitude of annual water levels has been significantly reduced by the weirs.

The duration curves for lakes Claire and Mamawi indicate that the peak levels above elevation 209.6 m are not being attained as regularly as with the natural regime. This suggests that the perched basins are being replenished less frequently with the present regime. During the percentage of time that elevation 209.6 m is exceeded (less than 20%), peak levels are restored to within 0.2 m of the natural regime. If the weirs had not been constructed, elevation 209.6 m would be achieved approximately 18% less frequently. However, below 209.6 m most of the perched basins that are recharged by overland flooding from the delta lakes should have their supplies replenished more frequently than under the natural condition.

The duration curves also show that the peak Lake Athabasca levels are virtually restored; that is, under the existing regime, lake levels above elevation 209.9 m are exceeded only 1-2% less frequently than under the natural regime. During this percentage of time (less than 10%), peak levels are restored to within 0.1 m.



WATER LEVEL DURATION CURVES
FOR LAKES ATHABASCA, CLAIRE AND MAMAWI

FIGURE 9

V. BIOLOGICAL ASSESSMENT

EVALUATION BY THE PADP GROUP

In 1973, the PADP Group examined the long-term biological implications of the low water levels caused by the Bennett Dam and assessed conditions resulting from alternative remedial control structures. Their conclusions were based on biological field monitoring programs, as well as a computer model that simulated wildlife habitat in relation to water levels of lakes Athabasca, Claire and Mamawi.

The PADP Group predicted that there would be long-term biological changes in the delta if water levels were not restored. Less frequent summer flooding would result in a reduction of productive wetland vegetation at the edge of open water areas and in the perched basins. They predicted that this would result in a decline in waterfowl production, muskrat population and fish habitat. The PADP Group anticipated that the water levels resulting from the Rivière des Rochers weir would reverse these general trends, although they would not return the delta to natural conditions.

PURPOSE OF THIS EVALUATION

In June 1983, the Biological Subcommittee was formed by PADIC to assess the performance of the Rivière des Rochers and Revillon Coupé weirs from a biological perspective. Its evaluation was based on the results of the biological monitoring programs described in Section III, as well as computer modelling of wildlife habitat and statistical analyses. Trends in biological communities observed in recent field reconnaissance surveys were also taken into consideration.

QUANTITATIVE ASSESSMENT

Simulation of Wildlife Habitat

The wildlife simulation model developed for the PADP Group in 1972 was used to simulate long-term changes in the wildlife habitat of the Peace-Athabasca Delta for three scenarios: the natural condition, Bennett Dam without weirs, and Bennett Dam plus the weirs. The wildlife model translated the effects of the water level fluctuations simulated by the hydrodynamic model for the period 1960-84 into wildlife habitat, wildlife populations and wildlife carrying capacities using a set of assumptions and rules of changes. The vegetation successional rules of change for declining water levels and increasing water levels formed the basis for computing wildlife habitat (Figure 10). Lake levels computed for lakes Athabasca, Claire and Mamawi by the hydrodynamic model provided the water level input to the wildlife simulation model.

Statistical Analyses

Two statistical analyses were performed using the data collected in the biological monitoring programs to answer specific questions about the impacts of the weirs on the biological communities of the delta. A statistical comparison of waterfowl populations and Lake Athabasca water levels was prepared by Canadian Wildlife Service to determine whether there was any relationship between population trends and water level fluctuations. A frequency analysis of water level differences above and below the Rivière des Rochers weir (hydraulic head) was performed because field studies had suggested that when the hydraulic head was above a critical value, fish movement was blocked. This analysis was conducted to ascertain how frequently fish passage would be impaired during the goldeye spring migration period.

VEGETATION

Vegetation communities on the Peace-Athabasca Delta change in response to water level fluctuations. Typical vegetation responses to prolonged above-average and below-average water levels are illustrated in Figure 11. With above-average water levels, all of the perched basins would be flooded and there would be an abundance of productive wetland vegetation types including submergents, emergents, immature fen and sedge meadows. With below-average water levels, there would be colonization by more permanent terrestrial vegetation, such as grass meadows and shrubs, particularly in the perched basins. The most dynamic communities and those most susceptible to water level fluctuations are the early successional communities located adjacent to the water's edge. These include the immature fen and sedge meadow communities.

As water levels dropped between 1975 and 1978, field studies showed that the general succession trend at the margin of open water areas was from immature fen to sedge meadow. These vegetation communities stabilized as the difference between summer maximum and winter minimum water levels decreased. This trend probably continued into the 1980's as water levels have continued to be relatively low.

Field observations have indicated that the perched basins along the Peace River and at higher elevations in the delta do not appear to have been recharged since the major flood of 1974. Thus, as the perched basins have become drier, the early successional communities are being replaced by more permanent species, such as willow and poplar.

The assessment of runoff from the river basins that contribute water to the Peace-Athabasca Delta showed that water yields have been relatively low in recent years (Section III). If water yields from the contributory basins increase, vegetation communities throughout those parts of the delta affected by the weirs can be expected to approach natural conditions. Perched basins along the Peace River will flood only rarely, and vegetation succession in these perched basins will probably accelerate towards willow shrub communities. The width of productive habitat around the margins of open water areas can be expected to decrease somewhat, as the weirs have decreased the annual amplitude of water level fluctuations.

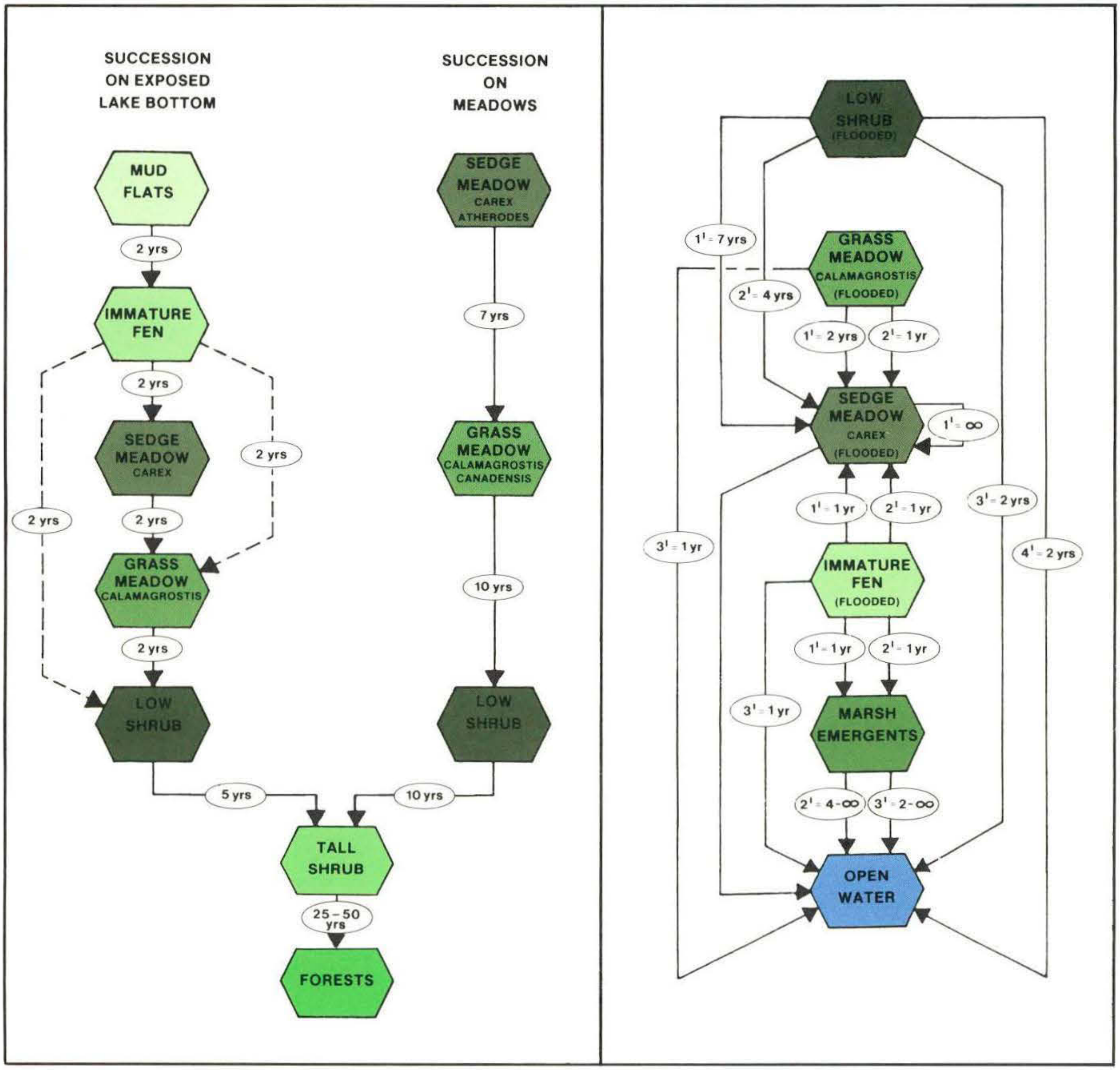
The wildlife simulation model predicted similar trends. In the long term, the model indicates that the productive vegetation communities of the delta would decrease by about 10% from the natural condition both with Bennett Dam only and with the weirs. However, the causes of the decrease would be different. The extreme low water levels that would have resulted from Bennett Dam without the weirs would have caused an increase in the extent of upland shrubs and forest vegetation and a significant decrease in the area of open water. The higher water levels caused by the weirs will result in a slight increase in the areas of both shrub and forest communities and open water, at the expense of the more productive communities.

WATERFOWL

Waterfowl production on the Peace-Athabasca Delta is best when extensive summer flooding does not occur and late summer water levels decline rapidly. Since summer water levels have remained relatively constant in open water areas after completion of the weirs, conditions have probably been favourable for production. However, the extensive loss of perched basin shoreline, particularly along the Peace River and at higher elevations, may have reduced overall waterfowl production in the delta.

The statistical analyses of waterfowl populations based on 1960-80 data showed no significant differences among waterfowl populations for the pre-dam, post-dam and post-weir periods. Thus, it appears that the fluctuations in the waterfowl populations within the first four years following installation of the weirs were within the range experienced before weir construction.

The wildlife simulation model predicted that long-term waterfowl production under the hydrological regime created by the weirs should approximate natural conditions. This prediction does not take into account influences on waterfowl numbers external to the delta. It also predicted that available habitat for fall staging would decrease from the natural condition, because the weirs have caused fall water levels to decline more slowly.

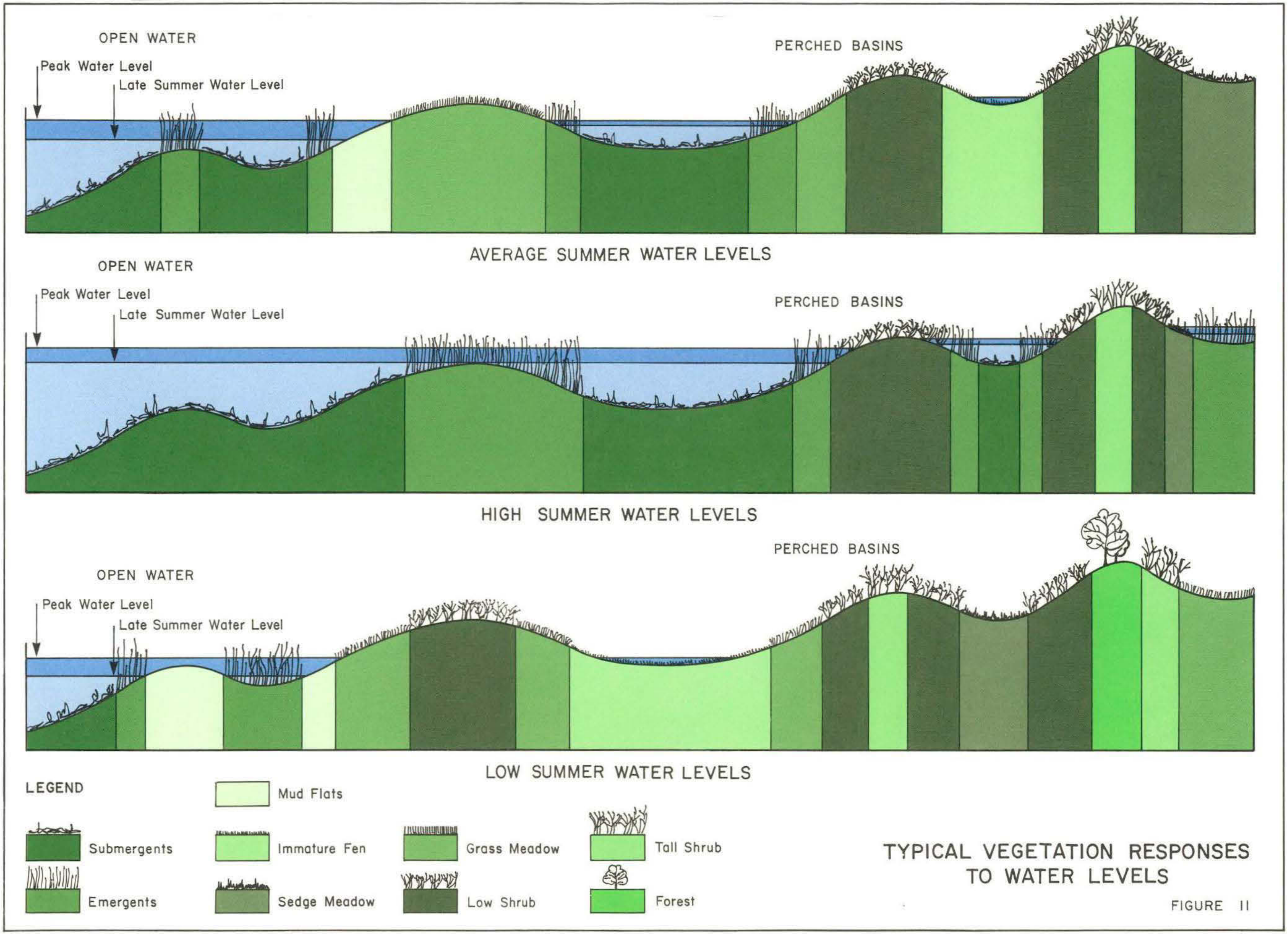


Conditions of declining water levels.

Conditions of prolonged flooding.

SUCCESSION TRENDS USED BY THE WILDLIFE SIMULATION MODEL

FIGURE 10



TYPICAL VEGETATION RESPONSES TO WATER LEVELS

FIGURE 11

MUSKRATS

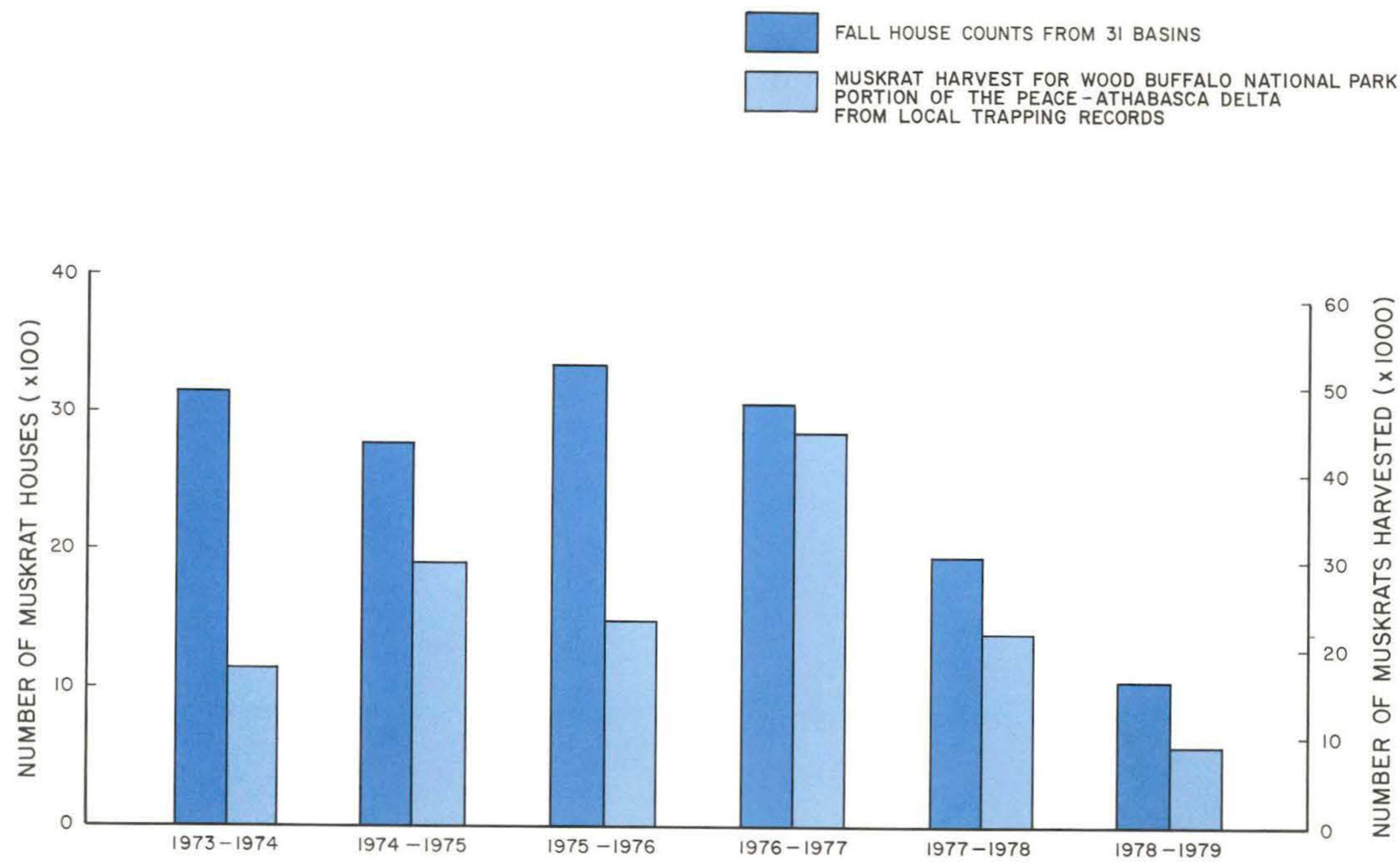
Trapper success rates and population estimates showed that the Peace-Athabasca Delta muskrat populations peaked in response to the high 1974 water levels. Muskrat numbers appear to have declined since 1975, as water levels dropped (Figure 12).

When historical muskrat populations were compared with Lake Athabasca water level data, it was clear that water levels high enough to flood at least 50% of the perched basins of the delta always preceded peak muskrat numbers. It was also evident that in equally as many occasions similar water levels did not correspond with a detectable increase in the muskrat population. In many cases, the numbers actually declined despite seemingly better habitat conditions. Other factors, such as trapping, predation and disease can reduce population numbers. Thus, if overall water levels on the Peace-Athabasca Delta increase, the basic habitat necessary for the muskrat population to recover will exist throughout much of the delta. Less frequent flooding of perched basins not influenced by the weirs, particularly along the Peace River, will result in a long-term decline in muskrat population in these areas.

FISH

Fisheries studies in the Peace-Athabasca Delta between 1971 and 1980 showed that the majority of the goldeye that overwinter in the Peace and Slave rivers, migrate during spring to spawn in the delta lakes. These goldeye enter the delta through the Rivière des Rochers, Revillon Coupé and Chenal des Quatre Fourches. Fisheries studies in the delta after completion of the weirs focussed on the effects of the weirs on goldeye migrations. During field studies in 1976, 1977 and 1980, high numbers of fish accumulated downstream of the weirs and appeared to concentrate there during periods of high hydraulic head. These studies indicated that the Rivière des Rochers weir and, to a lesser extent the Revillon Coupé weir, may have impeded movements of goldeye during part of the spring migration period.

A major concern for all fish species of the delta is the effect that more stable summer water levels may have on shoreline vegetation and invertebrates, the major food sources for young fish. Higher winter water levels are likely to have enhanced the suitability of delta channels for overwintering.



FALL MUSKRAT HOUSE NUMBERS AND MUSKRAT HARVEST, 1973-1979

FIGURE 12

VI. ANCILLARY STUDIES

CREED CREEK BREAKTHROUGH ASSESSMENT

Purpose

Following the 1982 spring runoff, the Creed Creek breakthrough began developing in an ancient oxbow between the Embarras River and Mamawi Creek (Figure 13) (This channel is called Cree Creek by local people.). Although lateral shifting of stream channels in the Peace-Athabasca Delta is common and part of the natural evolution of the delta, a major channel joining the Embarras River and Mamawi Creek would change the water level of the delta lakes by providing a direct link from the Athabasca River to lakes Claire and Mamawi. This would cause long-term changes in the water levels and the ecology of the delta and could affect the performance of the Rivière des Rochers and Revillon Coupé weirs.

A field survey program to monitor the natural growth of Creed Creek was initiated by Alberta Environment in 1982. Six cross sections were established on Creed Creek, and surveyed in 1983 and 1985. Stream discharge measurements were taken from 1982 through 1985 on Creed Creek and on the Embarras River upstream of the Creed Creek breakthrough.

Monitoring Results

Between 1983 and 1985, the following changes in the hydraulic properties of Creed Creek occurred: the average cross section top width increased by 36%; the average channel depth increased by 12%; and the average channel area increased by 49%. The average channel slope decreased from 0.22% in 1983 to 0.12% in 1985.

A comparison of the relative discharges of Creed Creek and the Embarras River, between 1982 and 1985, showed that Creed Creek appears to be diverting an increasing proportion of flow from the Embarras River. The general trend is shown in Figure 14. Further monitoring, to include a greater range of discharges, is needed to verify this trend.

Based on the results of monitoring to date, it appears that Creed Creek could potentially divert all of the flow of the Embarras River. The Embarras River currently diverts 10% of the flow of the Athabasca River at the confluence, and there is no evidence to suggest that the relative flows of these two rivers will change. Further field surveys are ongoing to confirm these estimates.

QUATRE FOURCHES STRUCTURE FEASIBILITY ANALYSIS

Purpose

In response to concerns expressed by the Fort Chipewyan Hunters and Trappers Association in 1984 about the drying up of the perched basins surrounding lakes Claire and Mamawi, PADIC requested PFRA to examine the technical feasibility of constructing a gated control structure on the Quatre Fourches outlet channel of Mamawi Lake at Dog Camp (Figure 15). The purpose of the structure would be to raise water levels in lakes Claire and Mamawi to their natural hydrological regimes, thus recharging the perched basins and improving fur production. The study, which was undertaken by PFRA, included a review of all background information pertaining to the previous Quatre Fourches dam, a feasibility level design and cost estimate, and an evaluation of the impacts of the structure on the water levels of the delta lakes.

Conceptual Design

The control structure would consist of a gated control section in the center of the Quatre Fourches Channel, with rockfill dams extending to each bank. Gates with a motorized hoisting system would be required to perform the frequent adjustments necessary to simulate natural water level conditions upstream of the dam. Due to the flat relief of the Dog Camp site and the extensive flooding observed in the past, the rockfill dam would have to be designed to withstand overtopping by floodwaters, thus effectively serving as an overflow weir during extreme flood events.

Results of the Hydrodynamic Model Simulations

The hydrodynamic model was used to assess the effects of the control structure on the water levels of the delta. Several modifications were made to the model which resulted in it varying from that used to assess the performance of the weirs (Section IV). An artificial perched basin was added to the nodal network to simulate water loss from the system which occurs when the perched basins fill with water. Flow into Mamawi Creek through the Creed Creek diversion was added. A subroutine was added to include the effects of the Quatre Fourches control structure.

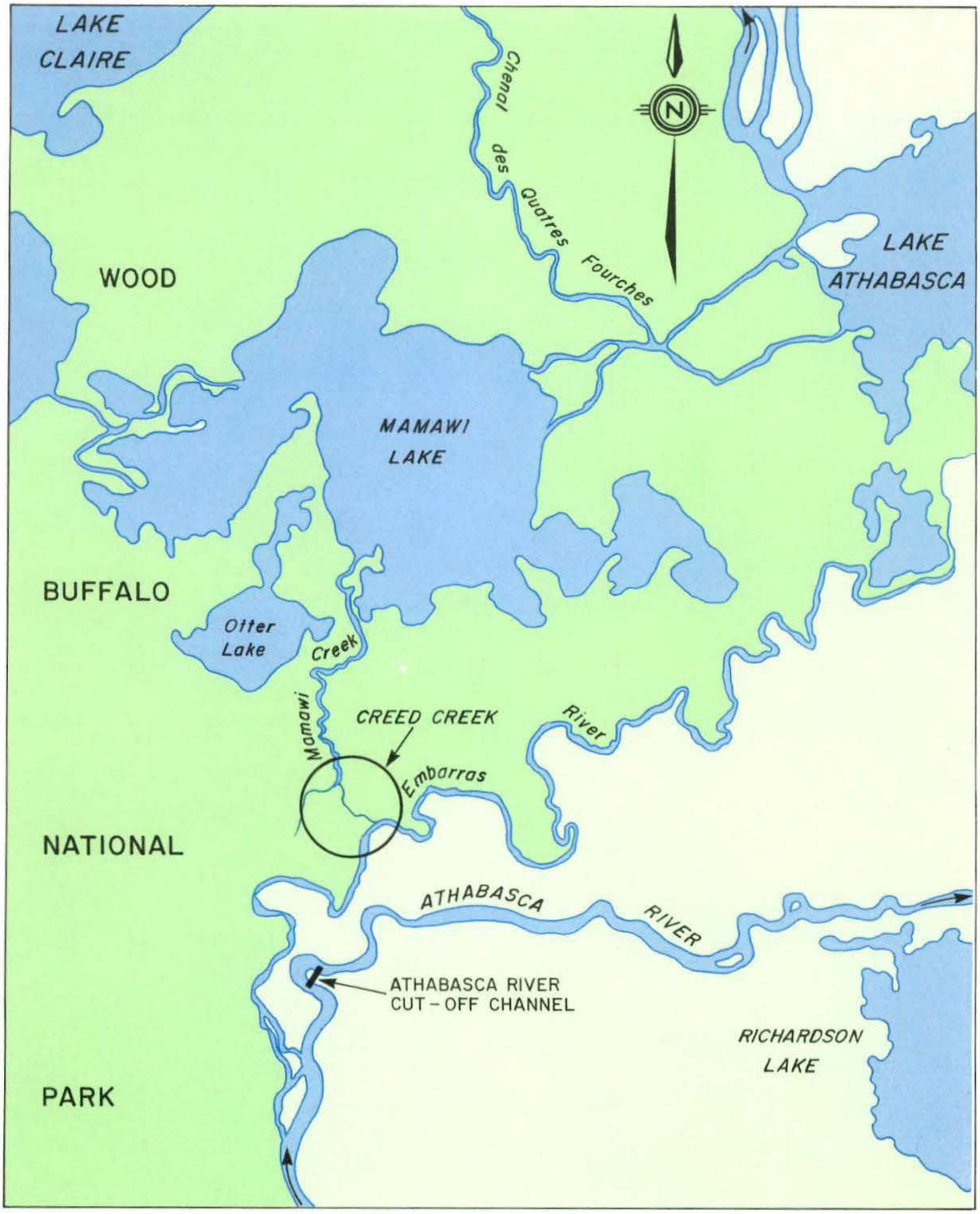
The simulation period covered the years from 1970-81 in order to evaluate the results under both high and low water levels in the delta. In all model runs, it was assumed that Bennett Dam and the existing control weirs on Rivière des Rochers and Revillon Coupé would remain in place.

The comparative water level simulations were conducted in two distinct phases. The first phase examined the response of the water levels of lakes Claire and Mamawi to both the width and operation of the gated portion of the control structure. A crude operating policy for the gates was used to prevent outflow from Mamawi Lake for varying periods during the spring and summer months. The second phase of simulations assessed the response of the water levels to gated control widths greater than those modelled in the first phase and the sensitivity of water levels to flows through the Creed Creek diversion. The majority of the simulations were for structures with fully open gates, since the intent was to establish the minimum gated width capable of matching the minimum and receding water levels of the existing conditions.

During the first phase, simulations were conducted to establish a structure capable of producing the natural peak water levels on lakes Claire and Mamawi without significantly affecting the existing minimum water levels, which are already higher than under natural conditions. Based on these simulations, it was found that a structure with a gated width of 40 m was capable of achieving the desired peak water levels, but often resulted in time lags in the receding water levels compared to natural or existing conditions. This delay would decrease the available waterfowl staging and bison grazing habitats, and reduce overwinter survival of muskrats. Therefore, the criteria of acceptability were revised to ensure that the structure would be capable of achieving natural peak water levels while producing minimum and receding water levels which coincided with the existing conditions. A control structure with a gated width of 60 m appeared to satisfy these revised criteria, but the crude operating policy of the simulation made it difficult to fully assess the suitability of the structure. It was evident that the desired maximum water levels could be readily achieved through judicious operation of the gates.

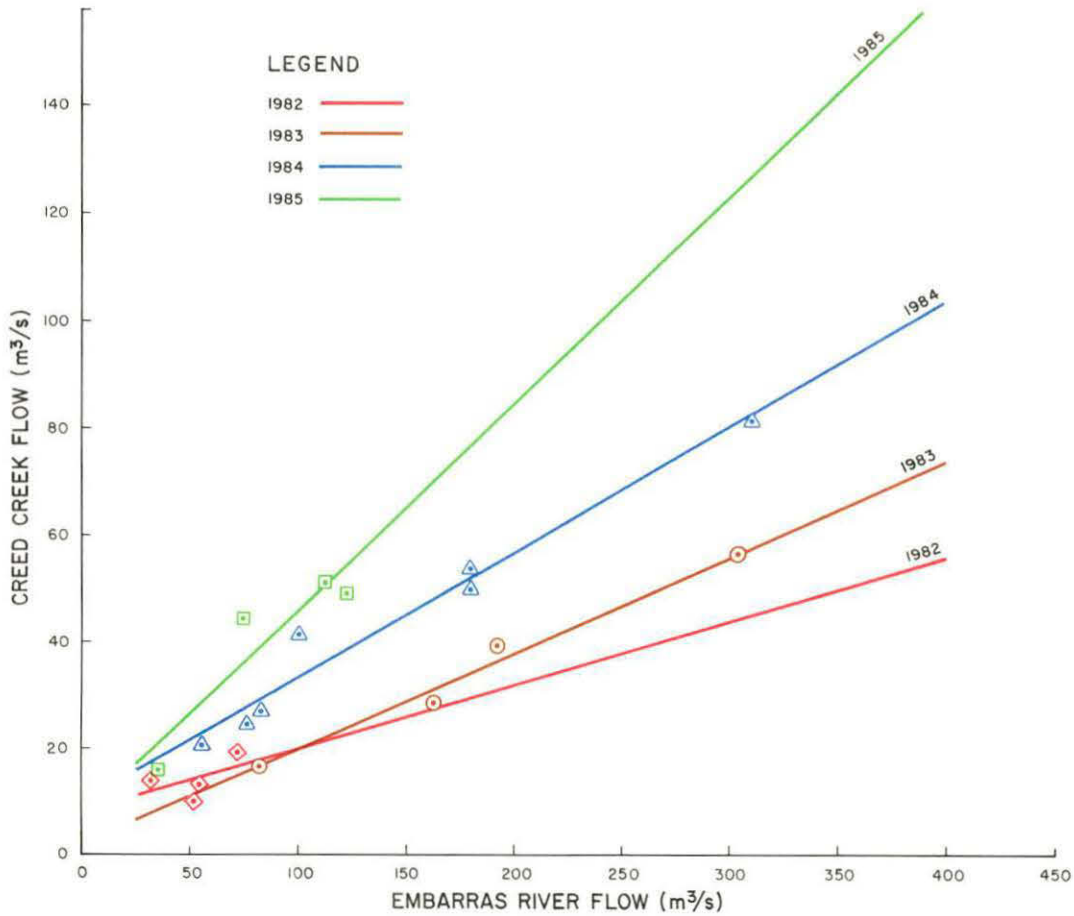
For the first phase simulations, Creed Creek flows were calculated using the regression relationship between the Athabasca River and Creed Creek in 1982, 1983 and 1984. This relationship assumed that the Creed Creek channel was stable whereas in reality the capacity doubled between 1982 and 1984. An analysis of the inflows to Mamawi Lake indicated that the Creed Creek flows comprised a significant proportion of the total inflow to the delta lakes.

The second phase of simulation examined the sensitivity of water levels of lakes Claire and Mamawi to Creed Creek flows. To do this a constant percentage of the flow of the Athabasca River was input to Mamawi Lake. A variety of diversion rates were



CREED CREEK

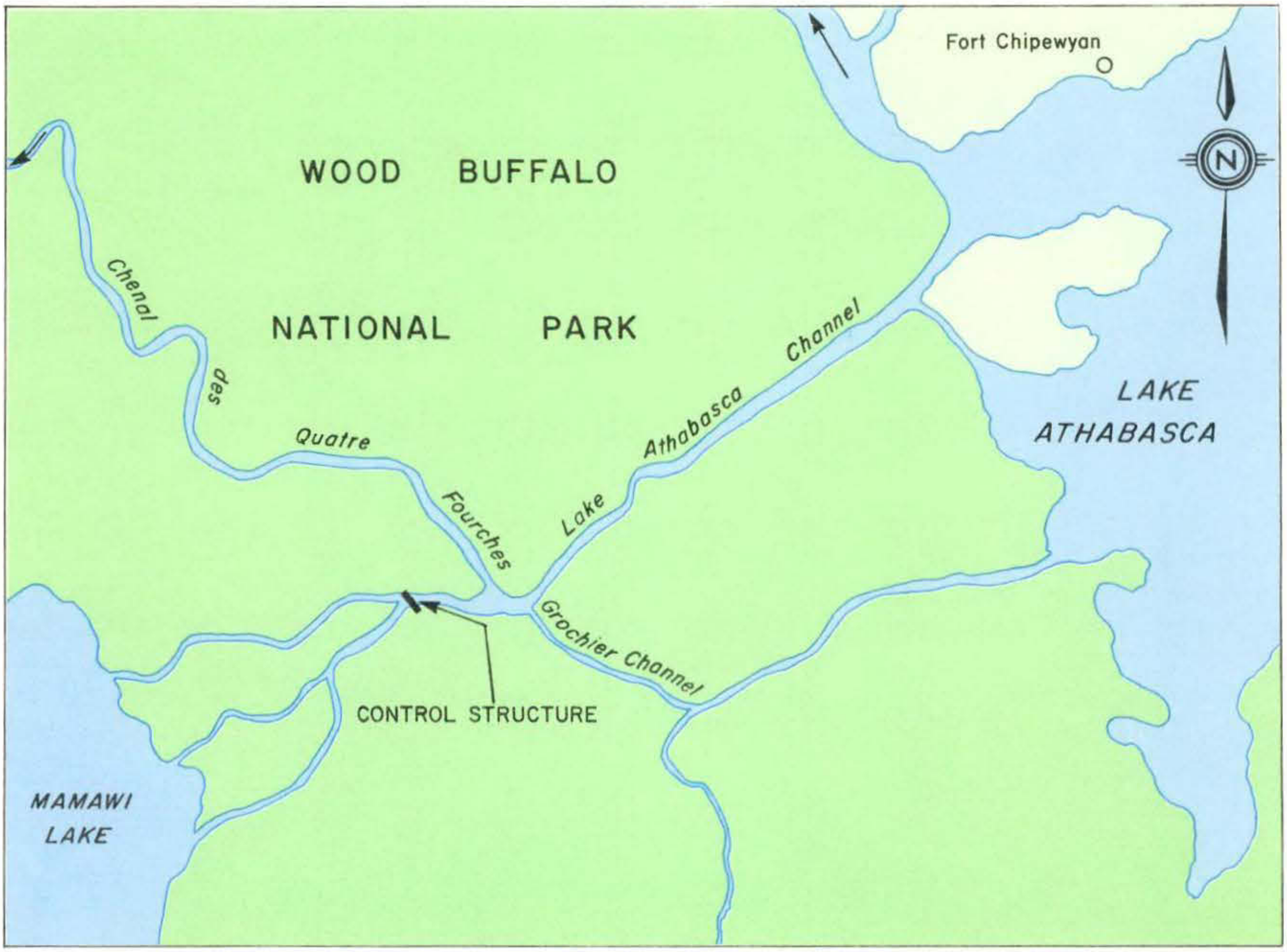
FIGURE 13



NOTE: THESE ARE MEASURED DISCHARGES.

CREED CREEK FLOW COMPARED TO EMBARRAS RIVER FLOW

FIGURE 14



QUATRE FOURCHES CONTROL STRUCTURE SITE

FIGURE 15

modelled. These ranged from 4.5% (the present rate) to 25%; however, subsequent analysis determined the maximum potential rate to be 10% (i.e. all the flow of the Embarras River). The model showed that the overall effect of Creed Creek is to raise and sustain the water levels in lakes Claire and Mamawi, as well as the surrounding perched basins. This increase in overall water levels appears to be proportional to the amount of flow diverted.

If the capacity of Creed Creek continues to increase as it presently appears to be doing, the comparative water level simulation showed that a control structure on the Quatre Fourches Channel would not restore the hydrologic regime of the Delta Lakes to natural conditions as the outlet channel of Mamawi Lake appears to have insufficient capacity to release the additional water (Figure 16). Any control structure which further delays the outflow would only increase the difference between the existing and natural hydrologic regime.

At low Creed Creek diversion flows, similar to those experienced in the period 1982-84, a structure on the Quatre Fourches would provide some desirable increase in the water levels of the delta lakes; however, as the capacity of the Creek Creed diversion expands and flows through the diversion increase, the benefits of the control structure on the Quatre Fourches would decrease until, at some point, the structure would become a restriction to the recession of the high water levels in lakes Claire and Mamawi.

If Creed Creek stabilizes at a discharge capacity approximating that observed in the period 1982-1984, the results of the model runs indicate that a gated control on the Quatre Fourches would help the water levels of the delta lakes to more closely correspond to natural conditions. A control structure with 60 m of gated width appears to be capable of restoring the natural peak water levels without significantly increasing the minimum water levels or delaying the receding water levels beyond those of the existing conditions.

The effectiveness of any gated control structure built on the Quatre Fourches outlet channel of Mamawi Lake would be determined by operation of the gates. If the structure is built in the future, a model will have to be developed to predict water levels so that the control structure can be operated to achieve desired target levels.

Cost Estimate

The estimated capital cost for a control structure with a total gated width of 60 m is $7,000,000. This includes the control structure with remote controlled gate hoists, a cofferdam for construction of the gated section, the rockfill portion of the dam, and facilities for boat and fish passage. The annual operation and maintenance cost is estimated to be approximately $70,000.

EVALUATION OF EXPERIMENTAL FISHWAYS

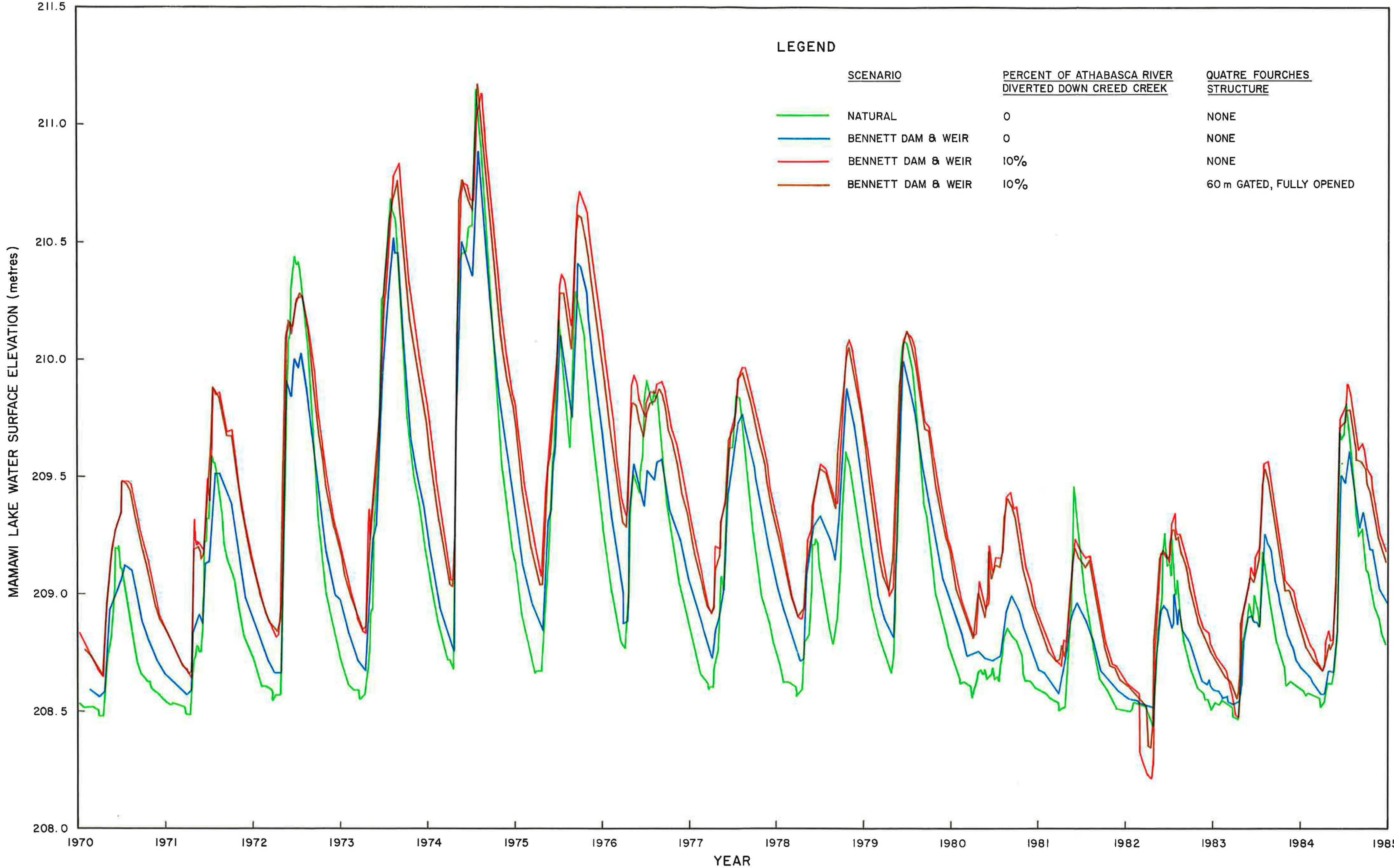
Purpose

Fish passage problems during the spring migration of goldeye were identified at the Rivière des Rochers and Revillon Coupé weir sites in 1976 and 1977 (Section V). In 1980, a study was conducted to design fishways at the two sites. The use of fishways by goldeye had not been studied previously, therefore two different types of fishways, vertical slot and Denil, were constructed and tested in 1984 to determine whether goldeye would ascend them.

Field Trial Results

Tests on the two experimental fishways were conducted between May 6 and June 14, 1984 through a cooperative effort by Alberta Environment and the Department of Fisheries and Oceans. Monitoring included air and water temperatures, dissolved oxygen, turbidity, pH, water levels, fish capture data and fishway hydraulics. Adverse conditions precluded many field measurements and limited the program results.

No large movement of fish was observed through either fishway. A meaningful assessment of fishway performance was not possible because very low numbers of fish (56) were captured. It was suspected that the fish could escape from the fish traps of both



COMPARATIVE WATER LEVEL SIMULATIONS FOR MAMAWI LAKE

FIGURE 16

fishways and that the numbers of fish using the fishways were actually somewhat higher, although the extreme turbidity of the water made it impossible to see the fish. The major goldeye migration occurred near the end of the monitoring period when the hydraulic head across the Rivière des Rochers weir was low enough for fish to cross the weir directly. Based on the results of the field trial, it was apparent that the fishways performed hydraulically as designed, and that some fish were able to ascend both fishways.

RIVIÈRE DES ROCHERS BOAT TRAMWAY MODIFICATIONS

Purpose

When the Rivière des Rochers weir was constructed, it was recognized that it would block movement of boats through the river channel. Therefore, a tramway, which consisted of light rails, a hand operated winch and boat dolly, was built to haul boats up to 7.3 m long and 3.6 tonnes around the weir site. The tramway rails rise on a 22 m ramp with a 4:1 slope, continue along a 10 m curved horizontal crest and drop on a 22 m ramp with a 4:1 slope.

Potential tramway users, including local residents and government employees, began complaining about the tramway system soon after it was constructed because it was slow and difficult to operate. On behalf of PADIC, Alberta Environment investigated the tramway in 1983, by examining the size and nature of boats, frequency of use, and existing conditions of the tramway. It was concluded that although the original objectives of the tramway system were still valid, the basic design was not satisfactory and potential users warranted a better facility.

Modifications

As a result, PFRA designed modifications which included installing a thermoelectric powered winch to operate the existing dolly on the existing track, constructing an elevated operating platform and adding pulleys to allow the winch to be used on the flat section of the tramway. Construction was completed in 1986.

VII. SUMMARY AND CONCLUSIONS

HYDROLOGICAL ASSESSMENT

Following filling of Williston Reservoir on the Peace River in 1968-71, water levels declined markedly on the Peace-Athabasca Delta. Weirs were built on the Rivière des Rochers and Revillon Coupé in 1976 to raise water levels closer to natural conditions. When the decision was made to construct the weirs, it was recognized that although they would increase water levels of the delta, the weirs would not duplicate the range and timing of water level fluctuations experienced before construction of the dam. To assess the hydrological performance of the weirs, simulated water levels were compared for three scenarios: natural conditions, Bennett Dam without weirs, and Bennett Dam plus the weirs. The simulations were based on a common time period, 1960-84. Based on the simulations it was concluded that:

a. The weirs will continue to perform as predicted and counteract many of the hydrological changes in the delta brought about by regulation of the Peace River by Bennett Dam. Without the weirs, water levels would be considerably lower.

b. The weirs have nearly restored the natural summer peak water levels of the delta, but average summer and minimum winter levels have been raised. Thus, the amplitude of seasonal and annual water level fluctuations is less than under the natural regime.

c. Recharge of the perched basins by overland flooding from the major delta lakes is similar to natural conditions. However, the weirs do not influence the recharge of the perched basins by flooding from the Peace River.

BIOLOGICAL ASSESSMENT

The biological community of the Peace-Athabasca Delta was affected adversely by low water levels after construction of Bennett Dam. Although the weirs were constructed to mitigate long-term impacts, it was recognized that they would not return the delta to its natural condition. The effects of the weirs on the biological communities were evaluated by analyzing the results of field surveys, monitoring programs, and simulation modelling. The assessment showed that:

a. The depressed water levels of the past decade have caused a decrease in the productive wetland habitat of the delta, particularly in the perched basins. Without the weirs, the extent of productive habitat would have decreased even more. Declining wildlife populations should partially recover when water levels return to average conditions.

b. The water levels resulting from the weirs have mitigated many of the long-term biological impacts caused by Bennett Dam and created a situation substantially closer to natural conditions than would have existed if they had not been built. However, the weirs will not restore the biological communities to natural conditions.

c. The reduced frequency of flooding of the perched basins at higher elevations will result in altered habitats in these wetland areas. The loss of perched basins along the Peace River will result in permanent loss of some wetland habitats.

d. In some years, the weirs may block segments of the goldeye population migrating from the Peace River into the delta lakes. The effect that this may have on the goldeye population of the delta has not been documented.

ANCILLARY STUDIES

PADIC conducted several ancillary studies. The growth of Creed Creek and its implications on a proposed control structure on the west arm of the

Chenal des Quatre Fourches were assessed; and the feasibility of a Rivière des Rochers fishway was examined by analyzing water levels across the weirs during the spawning migration period of goldeye and by testing experimental fishways. These investigations led to the following conclusions:

a. The capacity of Creed Creek, a natural breakthrough from the Embarras River to Mamawi Creek, is growing. Potentially, Creed Creek could capture 100% of the Embarras River flow. This would result in 10% of the Athabasca River flow being diverted directly into lakes Claire and Mamawi. Breakthroughs such as Creed Creek are part of the natural evolution of the delta.

b. If Creed Creek continues to grow at its present rate, the increased flow into lakes Claire and Mamawi will cause summer and winter water levels to exceed both the existing and natural conditions. Also, the time taken for peak water levels to recede in the late summer and fall will increase. This could have implications on the ecological balance of the delta lakes.

c. A gated control structure at the outlet of Mamawi Lake on the Chenal des Quatre Fourches would aggravate the effects that the Creed Creek breakthrough is having on lakes Claire and Mamawi. Because the structure would restrict the capacity of the Quatre Fourches channel, it would cause the levels of the delta lakes to be higher than both the natural and existing situation.

d. It is possible to construct a functional fishway at the Rivière des Rochers weir site. It should not be built until the effect of the weirs on the goldeye population of the delta lakes has been determined.

MONITORING PROGRAMS

Hydrological and biological monitoring programs were conducted under the auspices of PADIC. Some of these programs were developed for PADIC, others were continuations of previous programs. The adequacy of the monitoring programs was assessed by PADIC with the following results:

a. The hydrometric network necessary to support the hydrodynamic model must be maintained, if the model is to be used in the future.

b. A broad, integrated, biological monitoring program is required to document long term habitat changes over a representative range of water level conditions. Future biological monitoring programs should focus initially on vegetation responses to fluctuating water levels as vegetation provides a good biological indicator.

c. A broader assessment of the age structure of the fish population of the delta, particularly goldeye, is required to determine whether the weirs have affected spawning success.

VIII. RECOMMENDATIONS

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

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

2. **A long-term biological monitoring program which focusses on vegetation responses to water levels should be implemented.**

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

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

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

4. **The growth of Creed Creek should be monitored.**

   The diversion of water from the Athabasca River drainage basin by Creed Creek to lakes Claire and Mamawi could have serious effects on the hydrology and ecology of the delta. The size of the Creed Creek breakthrough and the rate of growth are needed for the hydrodynamic model, for biological studies and for consideration of remedial measures.

5. **The Peace-Athabasca Delta Implementation Agreement should be terminated and responsibility for coordinating and reporting on the implementation of recommendations be transferred to the Mackenzie River Basin Committee.**

   PADIC has completed its assessment of the remedial works constructed on the delta, as set out in the Peace-Athabasca Delta Implementation Agreement. Further work in the delta will be of a long-term nature; therefore, it should be coordinated by an intergovernmental body with broad interests and responsibilities. It would be appropriate to assign this co-ordination function to the Mackenzie River Basin Committee.

IX. PEACE-ATHABASCA DELTA IMPLEMENTATION AGREEMENT

THIS AGREEMENT made in triplicate this 16th day of September 1974
BETWEEN:

THE GOVERNMENT OF CANADA (hereinafter called "Canada") represented herein by the Minister of Indian and Northern Affairs

OF THE FIRST PART

-and-

THE GOVERNMENT OF THE PROVINCE OF ALBERTA (hereinafter called "Alberta") represented by the Minister of the Environment and the Minister of Federal and Intergovernmental Affairs

OF THE SECOND PART

-and-

THE GOVERNMENT OF THE PROVINCE OF SASKATCHEWAN (hereinafter called "Saskatchewan") represented herein by the Minister of the Environment

OF THE THIRD PART

WHEREAS the parties hereto jointly undertook a study to examine and prepare a report on the causes and consequences of low water levels in the Peace-Athabasca Delta and Lake Athabasca:

AND WHEREAS the said report has recommended the undertaking of remedial works to restore as nearly as possible water levels in the Delta and thereby re-establish associated ecological conditions;

AND WHEREAS the parties hereto recognize the importance of the restoration of the wildlife of the unique Peace-Athabasca Delta for the benefit of Canadians and the well-being of local residents:

AND WHEREAS the parties hereto recognize the importance of the preservation of ecological conditions in the Delta area of provincial and national importance and for the nesting and migration of waterfowl of international importance;

AND WHEREAS the parties hereto recognize the importance of maintaining water levels in Lake Athabasca and its outflow channels for navigation, fisheries and recreation and the general well-being of adjacent communities;

AND WHEREAS His Excellency the Governor General in Council by Order-in-Council 1974-1/1539 dated July 16, 1974 has authorized the Minister of the Environment and the Minister of Indian Affairs and Northern Development to execute the agreement on behalf of Canada;

AND WHEREAS His Honour the Lieutenant Governor in Council for Alberta by Order-in-Council 1418/74 dated August 13, 1974 has approved that the Minister of the Environment enter into this agreement on behalf of Alberta and the Minister of Federal and Intergovernmental Affairs has approved this agreement;

AND WHEREAS His Honour the Lieutenant Governor in Council for Saskatchewan by Order-in-Council 1325/74 dated August 20, 1974 has authorized the Minister of Environment to execute this agreement on behalf of Saskatchewan;

NOW THEREFORE the parties covenant and agree as follows:

ARTICLE I

In accordance with the recommendations of the Peace-Athabasca Study Report, the parties hereto:

(a) assign a high priority to the conservation of the Peace-Athabasca Delta.

(b) hereby establish the Peace-Athabasca Delta Implementation Committee (hereinafter called "the Implementation Committee") to provide liaison between the parties in achieving the objectives herein set out;

(c) agree to undertake jointly remedial works with regard to water levels as recommended in the report, including a weir at the Little Rapids site on the Rivière des Rochers and such ancillary works as may be required;

(d) agree to undertake jointly the removal of the temporary rockfilled dam on the west arm of the Quatre Fourches after the control structure at the Little Rapids site has effectively restored water levels.

ARTICLE II

DEFINITIONS

In this agreement

(a) "the Implementation Committee" means "the Peace-Athabasca Delta Implementation Committee" composed of two members appointed by each of the parties hereto in accordance with Article I (b) above and having terms of reference as set out in Article III;

(b) "the Little Rapids Site on the Rivière des Rochers" means the site of a weir at N.W. 19 and S.W. 30, Twp. 114, Rg. 7, W. 4 in the Province of Alberta";

(c) "works" means "a weir on the Rivière des Rochers and such ancillary measures or structures as are deemed necessary by the Implementation Committee to effect restoration of the water levels including the removal of the Quatre Fourches structure";

(d) "Peace-Athabasca Study Report" means the report published in 1972 by the Peace-Athabasca Delta Project Group which was jointly administered and financed by the parties hereto.

ARTICLE III

The Implementation Committee will:

(a) administer this Agreement;

(b) provide liaison and coordination of all programs of the parties hereto related to the restoration of water levels and related matters in the Peace-Athabasca Delta area;

(c) recommend and coordinate activities aimed at monitoring the effects of the restoration measures on water levels, habitat, wildlife and related matters;

(d) recommend to the parties hereto on matters related to the preservation of environmental values in the Delta area;

(e) provide liaison and coordination for intensive management programs where appropriate having specific objectives such as the increase of local production of muskrat, waterfowl and fish;

(f) undertake any other assignments referred to the Implementation Committee by the Ministers representing the parties hereto;

(g) report annually to the Ministers representing the parties hereto on January 1st or more often if deemed desirable.

ARTICLE IV

The cost of construction of the works shall not exceed two million dollars, unless agreed to by the parties hereto, and subject to the provision of funds by Parliament and the Governments of Alberta and Saskatchewan.

ARTICLE V

Canada will pay the cost of construction of the works in the first instance and recover from Alberta and Saskatchewan their shares of the cost, as set out in Articles VI, VII and VIII below. Subject to the cost-sharing provisions of this agreement and the approval of the Implementation Committee, Canada may include costs for construction of works incurred after July 1, 1974.

ARTICLE VI

Canada hereby agrees to pay 50% of the cost of construction of the works. The aggregate sum to which Canada shall be liable shall not exceed $1,000,000.

ARTICLE VII

Saskatchewan agrees to pay $50,000 or 5% of the cost of construction of the works, whichever is the lesser.

ARTICLE VIII

Alberta hereby agrees to pay the balance of the cost of construction of the works not provided for in Articles VI and VII herein. The aggregate sum to which Alberta shall be liable shall not exceed $950,000.

ARTICLE IX

Canada may submit progress claims to Alberta and Saskatchewan during the construction period and will submit a final claim within three months after the completion of the weir.

ARTICLE X

Alberta and Saskatchewan may make payment on the progress claims received from time to time in accordance with Article IX. Alberta and Saskatchewan shall each make full payment of their respective shares of the cost of construction of the works within six months of the date of completion of construction of the works or within three months of receipt of the final claim from Canada, whichever is the later.

ARTICLE XI

Canada shall keep complete records of all expenditures made pursuant to this agreement and shall support such expenditures with proper documentation. Canada, upon request, shall make these records and documents available to auditors appointed by the other parties hereto. Detailed financial and administrative arrangements not established in this agreement shall be established by the Implementation Committee.

ARTICLE XII

(a) Canada shall make available to Alberta by way of an agreement such lands as are agreed to by the parties hereto to be necessary to make possible the construction and maintenance of that portion of the weir located on the west bank of the Rivière des Rochers.

(b) Subject to Clause (c), Alberta shall assume ownership of the completed weir and shall also assume full responsibility for the maintenance of the completed weir.

(c) Maintenance of the completed weir shall not constitute nor involve substantial modifications.

(d) If the Implementation Committee is of the opinion that substantial modifications to the weir are necessary, it shall so report and recommend to the parties to this agreement. The parties to this agreement shall then jointly consider appropriate arrangements for implementing the said recommendations.

ARTICLE XIII

Ancillary works constructed pursuant to this agreement and located wholly within Wood Buffalo National Park shall be maintained by Canada.

ARTICLE XIV

Each of the parties hereto, for the purpose of managing water resources within the limits of its jurisdiction, agrees to the restoration of water levels and modified flows resulting from the construction of the works or activities relating thereto.

ARTICLE XV

The parties hereby agree that it is desirable to complete the construction of the works no later than March 31, 1976 but time shall not be the essence of this agreement.

ARTICLE XVI

This agreement shall be reviewed ten years after the date on which it becomes effective or at an earlier date upon the request of one of the parties hereto. Upon such review, the agreement may be terminated or continue in effect or be amended by agreement of the parties hereto.

ARTICLE XVII

No Member of Parliament of Canada or Members of the Legislative Assemblies of Alberta and Saskatchewan shall hold, enjoy or be admitted to any share or part of any contract, agreement, commission or benefit arising out of this agreement.

ARTICLE XVIII

This agreement shall come into effect and be binding on the parties on the date that it is signed by the party who is the third party to sign it.

IN WITNESS WHEREOF the Honourable Jeanne Sauvé, Minister of the Environment, and the Honourable J. Judd Buchanan, Minister of Indian and Northern Affairs, have hereunto set their hands on behalf of Canada, and the Honourable W.J. Yurko, Minister of the Environment, and the Honourable D.R. Getty, Minister of Federal and Intergovernmental Affairs for Alberta, and the Honourable N.E. Byers, Minister of the Environment for Saskatchewan.

In the Presence of	Signed on behalf of Canada	Date
		SEP 16 1974
		Sept 13, 1974

In the Presence of	Signed on behalf of Alberta	Date
		Aug. 14, 1974

In the Presence of	Signed on behalf of Saskatchewan	Date
		August 21, 1974

This agreement is hereby approved and ratified as a binding intergovernmental agreement of the Government of Alberta as evidenced by the signature of the Minister of Federal and Intergovernmental Affairs.

In the Presence of

Minister of Federal and Intergovernmental Affairs