Lake Winnipeg Regulation

A Document in Support of Manitoba Hydro's Request for a Final Licence under the Manitoba *Water Power Act*

July 2014

Manitoba Hydro

360 Portage Ave (16) • Winnipeg Manitoba Canada • R3C 0G8
Telephone / N° de téléphone : 204-360-3018 • Fax / N° de télécopieur : 204-360-6136
wpenner@hydro.mb.ca

2014 07 31

Terry Sargeant, Chair
Manitoba Clean Environment Commission
305-155 Carlton Street
Winnipeg MB. R3C 3H8

Dear Mr. Sargeant:

I am pleased to share this document with you in response to the Manitoba Clean Environment Commission's request for more information about the Lake Winnipeg Regulation (LWR) project. This review forms part of the process for Manitoba Hydro's request for a Final Licence under the *Water Power Act*.

This document:

- describes the conditions that led to the provincial government's announcement of LWR in 1970;
- explains the LWR licensing process;
- describes how the LWR system works;
- describes LWR's effects on downstream communities north of Lake Winnipeg, and outlines Manitoba Hydro's efforts to address those effects;
- discusses Manitoba Hydro's dialogue with communities and stakeholder groups around Lake Winnipeg and their concerns raised about the possible impacts of LWR on the lake itself;
- highlights Manitoba Hydro's commitment to sustainable development and ongoing water monitoring; and
- considers the implications of changing the terms of the licence.

The appendices offer additional technical background in support of these themes.

I expect that Manitobans will see this document and the CEC process related to the Final Licence request as opportunities to learn more about power generation and flood reduction on Lake Winnipeg.

Respectfully,

W.V. Penner, P. Eng.
Manager
Hydraulic Operations Department

Executive Summary

Lake Winnipeg Regulation (LWR) was announced by the Government of Manitoba in 1970 and developed by Manitoba Hydro to achieve two key objectives: to reduce shoreline flooding on Lake Winnipeg; and to support hydroelectricity generation to meet the growing demand in Manitoba. The project is a complex, engineered network of channels and structures that is used to control the outflow of water from the lake and allow higher outflow during flood conditions. It allows about 50% more water to flow out of the lake than would otherwise flow out naturally.

From the outset, Manitoba Hydro has managed LWR under the terms of an Interim *Water Power Act* Licence and is now seeking a Final Licence, which would expire in 2026. The 711 to 715 foot power production range defined in the licence is within the natural range of water levels experienced on Lake Winnipeg. When the Lake Winnipeg water level exceeds 715 feet, LWR is operated to maximize the flow of water out of the lake.

While LWR has met and is continuing to meet its objectives of reducing shoreline flooding on Lake Winnipeg and helping to provide a reliable supply of electricity for Manitobans, Manitoba Hydro recognizes that the project has significant negative effects downstream (to the north) of Lake Winnipeg. These effects have been most pronounced for Aboriginal communities and resource user groups.

Manitoba Hydro has worked with First Nations, communities and others to address effects through mitigation works, programs, and compensation. Numerous agreements with First Nations and other parties are in place, and Manitoba Hydro continues to engage in dialogue with downstream communities and other stakeholders.

Manitoba Hydro also recognizes that there are concerns about LWR's possible effects on Lake Winnipeg water levels. Based on long-term study and analysis, Manitoba Hydro concludes that LWR has not increased Lake Winnipeg's average water levels. In fact, LWR has resulted in an overall reduction in water levels compared to what Manitobans would have seen without LWR (especially in years of higher inflows). Concerns have also been expressed about shoreline erosion, water quality, the commercial fishery, and the Netley-Libau Marsh. Although the science is complex, research to date suggests that LWR is not the main factor affecting these areas. Manitoba Hydro continues to fund research focused on these concerns.

With its request for a Final Licence, Manitoba Hydro seeks no changes to the terms of the current Interim Licence. Reducing the upper end of the power production range from 715 feet would provide little additional flood reduction on Lake Winnipeg, but would result in additional negative impacts on downstream communities. A reduction would also compromise the reliability of the hydroelectric system in Manitoba and contribute to a decrease in net revenue arising from costs for new and modified facilities and downstream mitigation and compensation. Additionally any contemplated change to the licence would require extensive environmental and social study.

As with all of its operations, Manitoba Hydro is committed to ongoing dialogue with LWR stakeholders and monitoring of waterways associated with hydroelectricity generation. Manitoba Hydro will continue to collaborate with organizations seeking to understand and improve the health of Lake Winnipeg.

LWR is a cornerstone of Manitoba's hydroelectricity production and is key to reducing the impacts of Lake Winnipeg shoreline flooding. As such, maintaining this dual role is important to the entire provincial economy. Through open dialogue, good science, and informed decision-making, LWR will continue to serve Manitobans far into the future.

Table of Contents

Section 1 – Background and History	6
1.1 Introduction	6
1.2 Historic Flooding	6
1.3 A Solution to Meet Manitoba's Growing Electricity Demands	11
1.4 Lake Winnipeg Regulation Decision	12
1.5 Manitoba Hydro System History	16
Section 2 – Project Licensing, Facilities, and Operations: How It All Works	19
2.1 *Water Power Act* Licence	19
2.2 Scope	21
2.3 Project Operation	27
Section 3 – LWR Downstream Area Effects and Manitoba Hydro Responses	34
3.1 Historic Context of Development	34
3.2 Physical Effects	41
3.3 Environmental Effects	46
3.4 Socio-economic Effects	53
Section 4 – Public Engagement and Public Concerns – Lake Winnipeg	64
4.1 Public Engagement	64
4.2 Lake Winnipeg Water Levels	65
4.3 Erosion	68
4.4 Water Quality – Eutrophication	71
4.5 The Commercial Fishery	72
4.6 Netley-Libau Marsh	73
Section 5 – A Commitment to Sustainability	76
5.1 Sustainability	76
5.2 Implications of Changing the Maximum Discharge Elevation of 715 Feet	77
5.3 Coordinated Aquatic Monitoring Program (CAMP)	80
Section 6 – Final Licence Request: A Concluding Note	82
Glossary – (The first instance of all glossary terms within this document are shown in bold)	83
General References	88
Appendix 1 - 11	

Lake Winnipeg Regulation

1.0 Background and History

1.1 Introduction

On September 25, 1970, the Province of Manitoba announced its plans "to proceed with the development of Lake Winnipeg for flood control and the regulation of the Nelson River for power purposes." (Refer to 1.4.1 for the Manitoba News Release).

After years of study and debate, Lake Winnipeg Regulation (LWR) was designed and implemented with two purposes in mind: (a) to reduce the number and severity of Lake Winnipeg **shoreline flooding** incidents that affected shoreline communities; and (b) to enhance and stabilize hydropower generation for a growing population. LWR consists of a series of channels and **control structures** that increase and regulate the outflow from Lake Winnipeg.

While nature itself controls the wind, precipitation, and how much water **flows** into Lake Winnipeg, controlling how much water flows out of the lake was seen as a way to protect Lake Winnipeg communities and develop a secure energy future. In 1970, engineering and public policy came together to meet two important needs of Manitobans. LWR became operational in 1976.

1.2 Historic Flooding

Lake Winnipeg sits at the heart of an enormous **watershed**, the second largest in Canada, covering 1,000,000 square kilometres. A watershed is a large area of land that collects water and then drains into a body of water. The Lake Winnipeg watershed collects water from the Rockies to the west, from the Red River basin to the south, and from slightly west of Lake Superior to the east. Lake Winnipeg is the tenth largest freshwater lake in the world.

A large amount of water drains into Lake Winnipeg. More than a dozen rivers carry water into the lake; only one, the Nelson River, carries it out. The amount of water that flows into Lake Winnipeg varies from year to year depending on rainfall and snowfall throughout the entire watershed area. Precipitation in parts of Ontario, Saskatchewan, Alberta, Minnesota, North Dakota, South Dakota, Montana, and Manitoba, has a direct impact on inflow into Lake Winnipeg. Drought in any part of the watershed also affects inflow.

There have been times in Lake Winnipeg's history where the inflows – amplified by high winds and waves – have caused a large amount of flooding.

Shoreline Flooding

"When the Icelanders settled along the west shores of Lake Winnipeg in 1876, they were told … that some years previous to their arrival, the lake had flooded so high the entire district, including the present Townsite of Riverton, had been completely inundated by the lake." (Lakes Winnipeg and Manitoba Board, 1958)

Records of Lake Winnipeg water levels exceeding an average elevation of 715 feet above sea level go back as far as 1916. The 715 feet mark has been reached in every decade since then, except for the 1930s. Table 1 shows these high water levels (**wind-eliminated**), some of which lasted for over a year. The numbers show average levels. Water levels at any given location on the lake could be higher or lower due to wind.

1950 was a year in which flooding was prominent in the media. The Red River had swelled, sending Winnipeg and other municipalities into disarray. The shoreline flooding around Lake Winnipeg's south basin damaged property, diminished the commercial fishery, and caused great disruption. The lake had peaked at 716.78 feet above sea level, as compared to the average annual elevation of 712.7 feet from 1915 to 1949.

Year	Continuous Days over 715	Average during period (feet)	Maximum during period (feet)
1916	68	715.26	715.37
1927–1928	247	**716.21**	**716.92**
1928	78	715.28	715.46
1947	83	715.27	715.49
1948	48	715.08	715.21
1950	203	715.96	**716.78**
1951	104	715.31	715.50
1953	17	715.04	715.09
1954–1955	499	715.80	**716.73**
1956	120	715.58	**716.03**
1965	145	715.33	**716.05**
1966	244	**716.39**	717.57
1967	135	715.59	715.85
1969–1970	610	715.81	716.81
1970–1971	267	715.61	**716.27**
1972	171	715.64	**716.28**
1974–1975	573	**716.44**	718.17

Table 1: Lake Winnipeg high water levels pre-LWR.

* blue highlighting is above 716 feet
* red is above 717 feet

Winnipeg Free Press

WINNIPEG, FRIDAY, JULY 14, 1950

Civic Employees Donate $32,720 To Relief Fund

Five Injured In City Accidents

3 Slugged, Robbed, In Back Lane

Mid-Summer Madness

Two Men Reported

Lake Winnipeg Lashes Out; Badly Damages Resort Areas

Tossed by strong north-northeast winds Wednesday and Thursday, Lake Winnipeg lashed its western shores with unprecedented fury doing heavy damage to frontages of both private and resort areas. At Sans Souci park, Matlock, 19 families were reported driven from their homes by resulting flood waters.

Beach residents said Friday the lake had calmed down and receded within its banks.

Vacation areas hit by high lake waters included Matlock, Ponemah, Winnipeg Beach, Netley, Sandyhook and others in the vicinity.

At Victoria Beach, on the opposite side of the lake, wind pressure raised the level of the lake considerably, causing it to back into marshes and over roadways to the greatest depth since 1918, according to H. W. Stewart of the Victoria Beach Inn.

Eyewitness Report

"The water pounded our shore heavily but aside from a slight area of bank washed away, no damage was done," Mr. Stewart told the *Free Press*.

"It's the worst storm I've seen in the 26 years I've been here," reported L. Foures, merchant at Ponemah. "The water lashed over the banks, digging out huge chunks of it, and slopping into private cottages."

Mr. Foures said he had been told the water "would rise even higher in August," and he added it "seemed to get higher every year."

At Matlock, Walter Swerski, operator of the community store, said the lake water had "gouged" banks in front of cottages to a depth of four and five feet. A few boats had been washed away, but no buildings had been seriously damaged, he said.

Mr. Swerski said he had heard two or three hunting lodges at the mouth of the Red river, had been washed off their bases, one onto a municipal road.

Police at Winnipeg Beach proper said the water had risen unusually high and had been rough, but that no appreciable damage had resulted at that point.

Sticks, stones and driftwood littered the shore at Grand Beach making it pretty uncomfortable for campers following the two-day storm Tuesday and Wednesday. Operation Clean-up is shown here being carried on along the water front to remove the debris which strong north winds and lashing rain piled there. The storm sent the water climbing to within 40 feet of the board walk and washed away the face of the cliff on the west side, as well as inundating the highway at Grand Marais.

The following are excerpts from 1950 and 1955 Winnipeg Free Press newspaper articles. Recurring themes in the media include north winds, waves, high water levels, **erosion**, and flooding.

Figure 1: Winnipeg Free Press Archive – July 14, 1950.

- "The viciousness of Lake Winnipeg lately has got all cottagers frightened, not just here but all along the shore," Mrs. Sutherland asserted. "Surely the government will do something to prevent the loss of its largest resort areas." (August 21, 1950)
- "Unless some permanent defence against the inroads of Lake Winnipeg can be established, the entire town of Gimli might have to be moved. This was the opinion expressed Monday by Mayor Barney Egilson, who revealed that Gimli residents, particularly in the south section of town, are living in constant dread of what the lake will do during the annual October blow." (September 25, 1950)
- "Manitoba's government Thursday was urged to ask Ottawa for financial aid to relieve flood conditions and high water in the interlake region…" (February 18, 1955)
- "Interlake flooding could be relieved by the opening up of an outlet at the north end of Lake Winnipeg into the Nelson River and Hudson Bay." (February 18, 1955)
- "A Liberal MLA Thursday called upon the federal government to take action to control levels of Lakes Winnipeg…" (March 25, 1955)

FINAL EDITION

Winnipeg Free Press

EDIATOR OPENS URGENT RAIL TALKS

Waves Pound Winnipeg Lake Resort

Seven-foot waves flooding several streets at Winnipeg Beach began hammering the shoreline of Lake Winnipeg about 2 a.m. Saturday, according to an eye-witness report from J. A. Brodie of Regina. Mr. Brodie phoned the information to Winnipeg Saturday morning.

At 10 a.m. waves were still rolling in on the beach four feet high.

According to Mr. Brodie, damage to property has been almost negligible although the water reached the floor level of several cottages along Maple and Birch streets early Saturday morning.

By 11 a.m. the water had receeded six inches below floor level on these streets.

There has been no apparent damage to the government pier and, although it is isolated, parts of the pier are still above water. Other privately-owned piers are completely washed out.

Beach Inundated

The public bathing house has received more damage than any other property, said Mr. Bodie. The front section of the structure facing Lake Winnipeg has been completely washed away while the beach itself is totally inundated.

Several resident of Winnipeg Beach, said Mr. Brodie, claim that they have never seen Lake Winnipeg like this in the 40 years they have been there.

Both Sides Set Plans For Strike

Govt. Has Power To Seize Rails

9,000 Seen As Brigade Objective

Morton Takes Oath Of New Cabinet Post

New U.S. Social Security Bill Now in Final Stages

Recruiting Rises Here

U.S. Clamps Down Control On Exports To Red B

Figure 2: Winnipeg Free Press Archive – August 19, 1950.

Following the floods of the 1950s, the provincial government concluded that a dramatic intervention might have to be considered and that more study would be required.

In 1966, heavier than usual inflows (including the melt following a major March blizzard) once again pushed the waters beyond the edges of the lake. For much of the summer (80 days), the level of the lake was over 717 feet above sea level.

The following are excerpts from 1966 Winnipeg Free Press newspaper articles. The recurring themes include flooding and government intervention. During the high-water-level period in 1966, Manitoba Hydro continued to study hydropower generation options that included LWR and **Churchill River Diversion** (CRD) options.

- "Since January of 1965, the Red River, the Saskatchewan and Winnipeg Rivers have been pouring thousands of cubic feet of water a second above their average flow into Lake Winnipeg. This gradual buildup of water has caused flood conditions along the lake's shoreline." (June 22, 1966)
- "Along with the unprecedented flow of water into Lake Winnipeg two other factors contribute to the present and future flood picture on the lake: the bottleneck created by the Nelson River, the lake's only outlet, and the effect of strong northerly winds blowing water through the narrows of the lake." (June 22, 1966)
- "High water on Lake Winnipeg this year – reaching a height of over 719 feet – flooded thousands of acres of farm land and damaged summer resort areas." (December 10, 1966)

Figure 3: This Gimli shoreline flooding photo was taken at the beginning of September 1966.

Between 1950 and 1975, water levels were at or above 715 feet one-third of the time. The average annual water level was 714.3 feet despite some very low-water-level periods in the early 1960s. During some of these 26 years, water levels never went below 715 feet, even in the winter when levels are expected to be lower. Water levels exceeded 715 feet in 16 of these years, and rose above 716 feet in 12 of them. The maximum Lake Winnipeg water level during this period occurred in 1974 at 718.2 feet.

Shoreline flooding on Lake Winnipeg was an ongoing issue and stakeholders asked the government to help find a solution.

1.3 A Solution to Meet Manitoba's Growing Electricity Demands

1.3.1 Design Studies

After the flooding in the early 1950s, the provincial government, in 1956, established The Lakes Winnipeg and Manitoba Board to study the issue and consider regulation of Lake Winnipeg levels for flood control and hydropower generation. In 1958, the Board released a report that said that the costs of regulating Lake Winnipeg for flood control would be "impracticable" with the costs outweighing the benefits. The report did note, however, that controlling the outflow of water from the lake could possibly help advance the development of **hydroelectric** capacity on the Nelson River, which could ultimately prove economical.

Following this report, there were several other studies that were undertaken between 1964 and 1970. Table 2 is a summary of the major engineering and economic studies from this period.

Year	Study	Prepared By	Summary
1964	Report on Nelson River Development	G.E. Crippen and Associates	Studied arrangements for regulating Lake Winnipeg. Proposed a gated control structure and a large capacity pumping plant at Warren Landing with a 709–715 feet regulation range.
1965	Nelson River Investigation Interim Report	Nelson River Programming Board	Recommended the development of the Kettle **power** site, CRD, LWR, and high-voltage transmission facilities to bring Nelson River power to southern Manitoba (Phase I Development).
1966	Analysis of Alternative Methods of Regulating Lake Winnipeg	Manitoba Hydro	Found that LWR is attractive to the development of the Nelson River. It focused on the combined gated and pumped control option.
1968	Lake Winnipeg Regulation – Outline of a Study	Professor E. Kuiper	Summarized the Lake Winnipeg interests on a regulation range, reviewed three alternatives, and provided a benefit-cost analysis. The three alternatives were an Excavation Scheme, a Pumping Scheme, and a Two-Pool Scheme.
1968	Effect of Lake Winnipeg Regulation on Flood Damages	Manitoba Department of Mines & Natural Resources	Evaluated the effects of three possible schemes and ranges of regulation of the levels of Lake Winnipeg on agricultural interests, roads, bridges, flood-fighting costs, and shoreline erosion. The three schemes studies were: Excavation Scheme, Pumping Scheme, and the Two-Pool Scheme. The average annual flood control benefits associated with these three schemes of regulation would be $133,000, $33,000, and $200,000 respectively.
1970	Report on Lake Regulation	G.E. Crippen and Associates	Physical and economic feasibility studies of the regulation of Lake Winnipeg as a multi-purpose reservoir. Reviewed flood control, effects of Lake Winnipeg water levels on resources, six regulation schemes, and costs, benefits, and scheduling.
1970	Study of Alternative Diversions (Report on System Power Studies)	Underwood, McLellan and Associates	Recommended the CRD for initial power development. Reviewed load growth projections, performed an economic analysis, and analyzed system and development sequences.
1970	Report on Expansion of Generating Capacity in Manitoba	Manitoba Hydro Task Force	Investigated generation expansion capacity alternatives, and discussed the LWR options, CRD options, system studies, and observations and conclusions. All alternatives included a control structure and improved or new outlet channels, except for the pumping alternative.

Table 2: Major Lake Winnipeg Regulation design studies, 1964–1970.

As a result of a 1966 agreement between the Province of Manitoba and the Government of Canada, Manitoba Hydro undertook to develop the hydroelectric potential of the Nelson River. The agreement included four projects: construction of the Kettle **Generating Station**; a **high-voltage direct current** (HVDC) transmission system from Kettle to Winnipeg; CRD; and LWR. It was this agreement that set the Nelson River projects into motion.

After a number of studies, Manitoba Hydro concluded that rather than building new generating facilities on the Churchill River, another option was to divert water from the Churchill River into the Burntwood and Nelson Rivers to increase the Nelson's hydropower potential. Manitoba Hydro's original plan in 1969 was to develop a "high-level" diversion, which would have raised the level at Southern Indian Lake by 35 feet. This led to intense provincial debate about development impacts in northern Manitoba. In 1970, the new government of Premier Edward Schreyer rejected the high-level plan in favour of a lower-level diversion of the Churchill River, coupled with a plan to regulate the outflow from Lake Winnipeg.

1.3.2 Growing Demand for Electricity

After World War II, the economy of Manitoba began to expand. This economic expansion, plus the fact that a new Farm Electrification program was extending electrical service throughout the province, meant that existing generating capacity would quickly become inadequate.

Manitoba Hydro completed the Farm Electrification program in 1954. By that time, Manitoba had the distinction of being western Canada's most electrified province (75% of all farms in Manitoba had electrical service).

Studies of increasing demand included:

- 1966 – Analysis of Alternative Methods of Regulating Lake Winnipeg prepared by Manitoba Hydro for the Government of Canada and the government of the Province of Manitoba. The study noted that electricity usage in Manitoba was increasing by about 7% per year.
- 1970 – Report on Expansion of Generating Capacity in Manitoba. The report showed that actual growth exceeded that trend and that it would be "necessary to plan for a significantly higher growth rate" going forward. In 1968/69, energy usage was 10.4% greater than in the previous year; in 1969/70 it was 11.9% greater than in the previous year; and in 1970/71, usage was 12.2% greater than in the previous year.

1.4 Lake Winnipeg Regulation Decision

1.4.1 Announcement

After years of study and review, the Province of Manitoba was ready to make a decision about a way to address flood concerns and increasing power demands.

On September 25, 1970, Premier Schreyer announced the government's plans to proceed with the development of Lake Winnipeg for flood control and the regulation of Nelson River flows for power purposes. The announcement noted that the combination of Lake Winnipeg development and a low-level diversion at Southern Indian Lake justified the full development of the entire Nelson River system. Further, it stated an application had been submitted for a licence under the *Water Power Act* to proceed with the construction of the channel improvements and control structure for regulation of Lake Winnipeg. "Since the lake will be controlled within natural levels, it is anticipated the licence will be issued in the near future, the premier said."

The Province of Manitoba granted Manitoba Hydro an Interim Licence for LWR on November 18, 1970, allowing the project to proceed. Shortly after the Interim Licence was granted, Manitoba Hydro revised the plan by removing the two gated control structures planned for Metchanais and Ominawin channels, replacing them with a single control structure at Jenpeg. To address this change, Manitoba Hydro received a Supplementary Interim Licence on August 8, 1972. Manitoba Hydro added a generating station to the Jenpeg location. The Jenpeg Generating Station has a separate *Water Power Act* licence. These licences are found in Appendix 1.

NEWS SERVICE

Manitoba Government
Information Services Branch
Legislative Bldg., Winnipeg
Phone 946-7175

MANITOBA

Date: September 25, 1970.

SEP 29 1970
MANITOBA

LAKE WINNIPEG CONTROL
TO PROCEED: SCHREYER

\- - -

Low-Level Diversion Seen
For Southern Indian Lake

SOUTH INDIAN LAKE, MAN. -- Premier Ed Schreyer announced plans here to to proceed with the development of Lake Winnipeg for flood control and the regulation of the Nelson River for power purposes.

At the same time, an associated decision was announced that any future diversion of water from the Churchill River at Southern Indian Lake would be at low level, not disturbing any settled community nor raising the lake level more than some ten feet above the normal range of levels.

The combination of Lake Winnipeg development and a low-level project at Southern Indian Lake will justify the full development of the entire Nelson River system --about eight million kilowatts. This massive hydro potential, he said, is as great as the combined Columbia-Peace River potential in B.C. or the Churchill Falls project in Labrador.

Furthermore, the Lake Winnipeg control would allow an increase in the Kelsey generating plant on the Nelson from the present six units, of 32,000 kilowatts each, to "ten or more units". This station is the principal source of power for Thompson and area.

Development of Lake Winnipeg will be undertaken at once, he said, so that the necessary control will be established by the fall of 1974. Work on the Churchill diversion, as required, is expected to begin in 1972, with completion in 1975 or 1976.

The water stored with a four-foot draw-down on Lake Winnipeg would be equivalent to 24 feet of storage in Southern Indian Lake. This explains why, with Lake Winnipeg developed, a high-level storage project for Southern Indian Lake is no longer important. The water required from the Churchill (without storage) can be diverted at a much lower level, he said.

If a diversion of 30,000 cfs is required from Southern Indian Lake, and if it must be by gravity, the lake level must be raised to 850 feet, compared with the normal upper level of 840 feet. "However," he said, "this level would not interfere with any settlement nor would it affect the level of Granville Lake.

-more-

The premier stated the government's decision at this time "does not mean that it will be raised to this level but it is an assurance that this level will not be exceeded."

Mr. Schreyer emphasized that no final decision had been made with respect to Churchill River diversion from Southern Indian Lake, but whatever the plans they will not in any event involve anything greater than a low-level operation.

Decision to proceed with Lake Winnipeg development at once leaves Manitoba Hydro with at least one further year before decisions regarding the diversion of water from the Churchill must be made. This time will permit further consideration of the alternative schemes. In particular, he said, it would allow time for the full investigation of developments in Saskatchewan that could affect the water supply for the Churchill, and for necessary negotiations within the framework of the recently-developed agreement on the apportionment of interprovincial waters among the three prairie provinces.

An application has been submitted to the government for a licence to proceed with the construction of the channel improvements and control structures proposed for Lake Winnipeg control. Since the lake will be controlled within natural levels, it is anticipated that the licence will be issued in the near future, the premier said. Detailed design work will involve most of the next year, and it is anticipated that contracts can be let by the fall of 1971.

Mr. Schreyer said the Hydro work on Lake Winnipeg was but one aspect of the whole matter of the fullest development and resource use of the lake. Consequently, the government has decided to appoint a board to manage the development of Lake Winnipeg. It will, he said, have wide responsibility for all aspects of the use of Lake Winnipeg and the development of its various potentialities. These will include land use and protection, resorts, beaches, recreation, fisheries and all areas of resource development.

Funds will be provided for the board from the proceeds of the water rentals paid by Manitoba Hydro to the government for the use of the water. A contribution to the cost of the control project in respect of its resource values will be made from the same source. The total cost of the Lake Winnipeg control project is estimated at $50 million.

-30-

1.4.2 Lake Winnipeg, Churchill and Nelson Rivers Study Board (LWCNRSB)

In August 1971, recognizing that LWR and the CRD were major undertakings with considerable **environmental** and social impacts, the governments of Manitoba and Canada jointly initiated the Lake Winnipeg, Churchill and Nelson Rivers Study Board (LWCNRSB).

Completed over a three-year period at a cost of $2 million, the study was "intended to determine the effects which the regulation and diversion projects are likely to have on other water and related resource uses, to indicate ways in which the projects may prove beneficial to such other uses, to recommend modifications in the design and operation of the works, and to recommend remedial measures where considered necessary to lessen undesirable effects" (LWCNRSB, 1975). The combined reports totalled over 9,000 pages plus background documents. It was considered to be one of the most comprehensive studies of its time. It included the following elements:

- Technical report
- Comprehensive appendices covering:
    - Background documents and interim reports
    - **Hydrologic**, hydraulic, and geomorphologic studies
    - **Biophysical**, forestry, and geological studies
    - Existing works and services
    - Fisheries and **limnology**
    - Wildlife studies
    - Recreation and archaeological studies
    - Social and economic studies
- Summary report

The LWCNRSB made 47 recommendations for implementation by Canada, Manitoba, and/or Manitoba Hydro. The recommendations can be generally categorized into themes of **environmental monitoring** and management, **mitigation** of predicted impacts, community capacity building, and protection of community **infrastructure**.

1.4.3 Other Boards/Studies

The Province of Manitoba reviewed LWR through studies, public meetings, and boards:

- The Province of Manitoba established the Lake Winnipeg Management Board in 1971 which was active until 1975.
- In 1972, the Manitoba Water Commission held public hearings on LWR.
- Following the 1975 LWCNRSB report, the Province led the Lake Winnipeg, Churchill and Nelson Rivers Management Board in 1976/77.
- In 1979, there was a Commission of Inquiry headed by Justice Tritschler, which was a review of Manitoba Hydro including LWR.

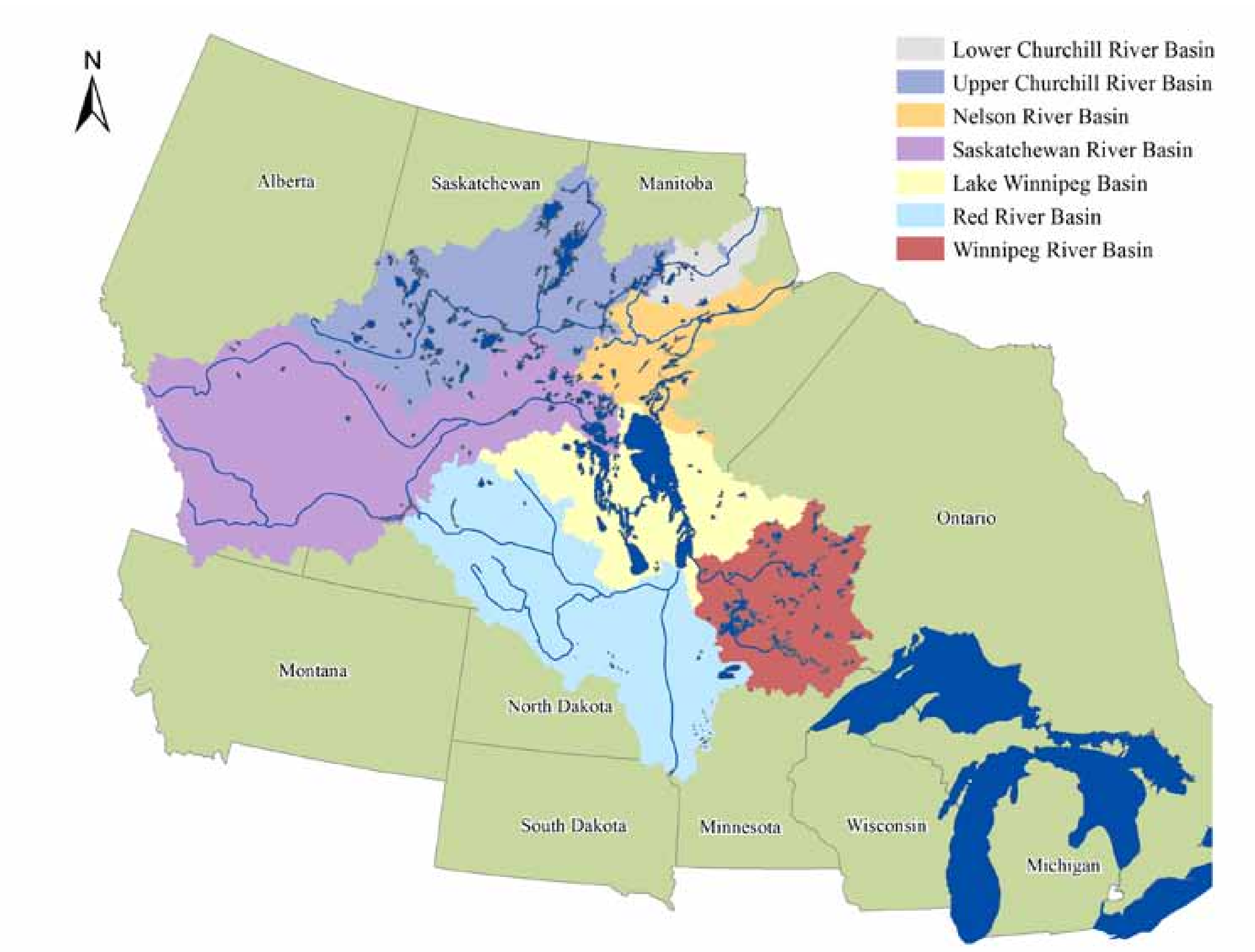
1.5 Manitoba Hydro System History

The **drainage basin** map below (Map 1) shows that water flows into Manitoba from as far west as the Rocky Mountains and from almost as far east as Lake Superior.

Manitoba Hydro built LWR after developing the hydro resources along the Winnipeg and Saskatchewan Rivers, and prior to building the Long Spruce and Limestone Generating Stations on the Nelson River. LWR itself does not produce electricity, but enhances the availability and timing of water for electricity production by generating stations on the **lower Nelson River**. This project is the only one in Manitoba Hydro's system built for two purposes - flood reduction around Lake Winnipeg and energy production.

Pre-LWR

The present Manitoba Hydro system for providing electricity started with the development of six hydroelectric generation stations on the Winnipeg River from 1911 to the mid-1950s. This was followed by thermal stations in Brandon (1957) and Selkirk (1960), and the Grand Rapids hydroelectric station (1965). These stations all supplied electrical power to southern Manitoba. These hydroelectric projects only harnessed the power available from the Winnipeg River and Saskatchewan River Basins.



Map 1: Drainage basin map.

Hydroelectric generating stations were also built to supply power for mining in northern Manitoba. Two stations were built by Sherritt Gordon Mines on the Laurie River in 1952 and 1958. In 1961, Manitoba Hydro built the Kelsey Generating Station to supply power to the Inco mine and the community of Thompson. These generating stations did not provide power to southern Manitoba where most of the electricity demand is located. Other northern communities were supplied with electrical power using diesel-powered generators.

With the need for more energy in southern Manitoba, studies were undertaken into the feasibility of hydroelectric development north of the existing system on the Nelson River. The availability of water from other basins, particularly the upper Churchill River drainage basin was also studied. Nuclear power was another consideration from the mid-1970s to early 1980s.

High-voltage direct current (HVDC) transmission technology – a system that uses direct current for the transmission of electrical power – was key to making northern generation a feasible source of supply to meet electricity needs in southern Manitoba. Without HVDC technology, it was impractical and too expensive to transmit power over such a great distance. With southern demand growing, the Government of Canada was an important financial contributor to the two HVDC **transmission lines** in Manitoba.

The first hydroelectric generating station developed on the lower Nelson River was Kettle which first produced power in 1970. CRD and LWR were developed soon after. CRD provides additional flow capacity by diverting water from the upper Churchill River drainage basin into the Nelson River via the Rat-Burntwood Rivers. This allowed for the concentration of hydropower development on the Nelson River. LWR provides greater flow reliability during the winter and some ability to time when the water from Lake Winnipeg reaches generating stations on the lower Nelson River.

Post-LWR

The next hydroelectric generating stations were built on the lower Nelson River, starting with the first power generated at Long Spruce in 1977 and Limestone in 1990. These were followed by the Wuskwatim Generating Station on the Burntwood River in 2012. The Keeyask Generating Station on the lower Nelson River will be completed by 2022.

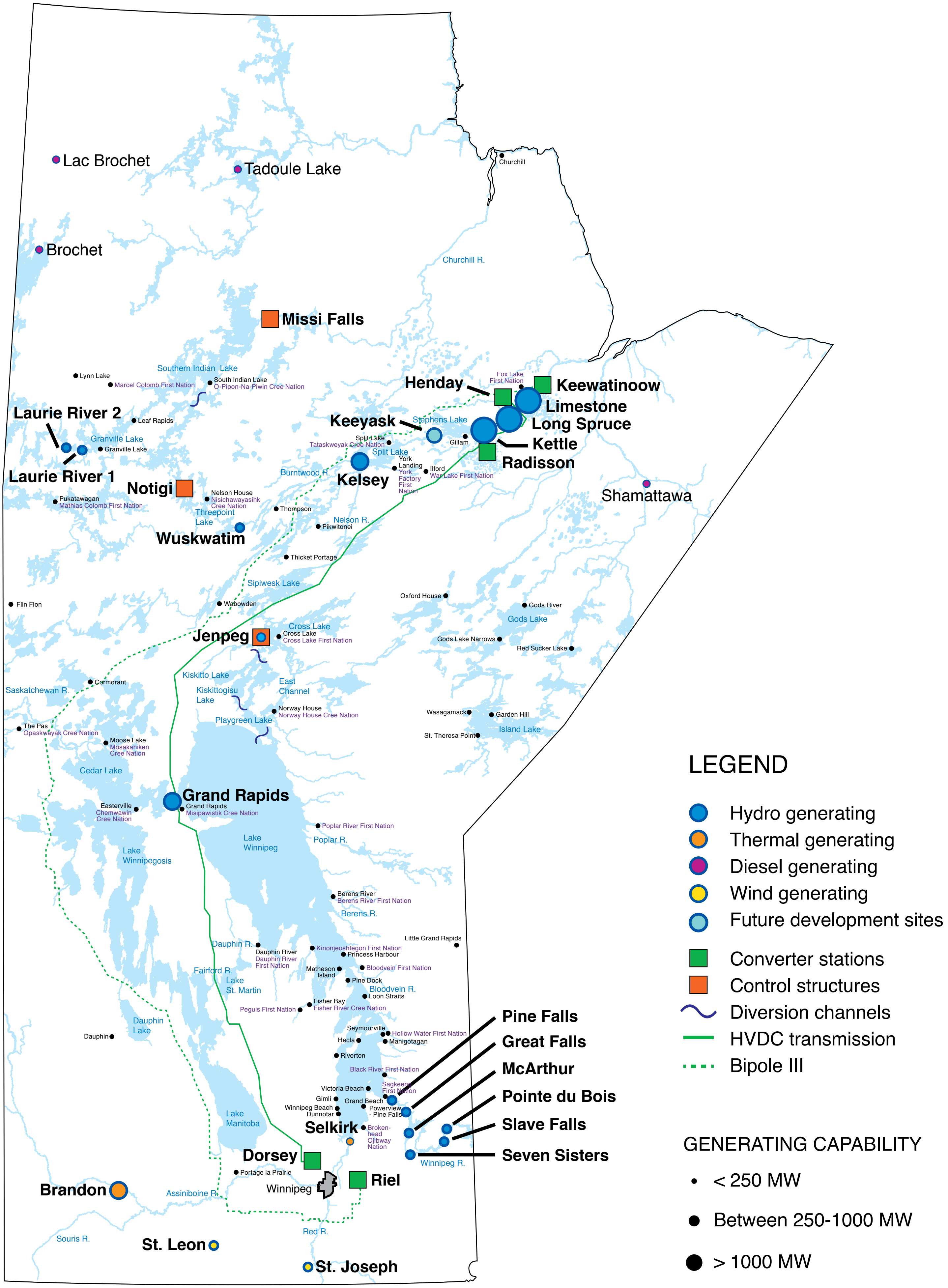
Beginning in 2005, a series of privately owned wind generators in southern Manitoba began supplying electricity to Manitoba Hydro.

Transmission

Electrical transmission interconnections linking Manitoba to Ontario, Saskatchewan, and the United States built prior to LWR set Manitoba Hydro on a path to improved reliability and economic benefits to its customers. Interconnecting with neighbouring systems greatly enhances reliability because electricity can be imported during periods of low water supplies or for emergencies. Interconnections also enable the export of electricity that is surplus to Manitoba's needs, thereby helping keep electricity rates low for Manitoba customers.

With the construction of a large transmission line to the United States in 1980, Manitoba's power exchange capability with the U.S. more than doubled. This transmission, coupled with new generation on the Nelson River, allowed Manitoba Hydro to export more electricity during the summer when U.S. demand is highest and to import more power during the winter when Manitoba's electrical demand is higher because of heating load. This effectively flattens Manitoba Hydro's annual demand profile. The ability to import more power during the winter months, lessened the need to store water for generation in the winter season.

The locations of Manitoba's generating sources and the HVDC transmission lines are shown on Map 2.



Map 2: Key components of Manitoba's generating system.

2.0 Project Licensing, Facilities, and Operations: How It All Works

LWR is an extensive engineered system of channels and structures that allows about 50% more water to flow out of the lake than would otherwise flow out naturally. This increased outflow capacity helps reduce flooding around Lake Winnipeg and helps optimize power generation along the Nelson River.

This section of the report presents a description of the licensing process and a discussion of terms of the Interim Licence. The section then describes the roles of all major physical elements of the LWR system, and how the system operates over the course of a year. The section concludes with a review of Manitoba Hydro's record of compliance with licence conditions.

2.1 *Water Power Act* Licence

In Manitoba, all projects that use water to produce power are subject to the Manitoba *Water Power Act* and its Regulations.

The Water Power Regulations entitle the licensee to a Final Licence upon implementation and compliance with the Interim Licence. Manitoba Hydro continues to operate LWR under an Interim *Water Power Act* Licence (as shown in Appendix 1) while the Province reviews the request for a Final Licence.

2.1.1 Types of Licences

A new development is initially authorized under an Interim Licence which allows a proponent to build the project and, after a period of operation, confirm that the existing licence terms are suitable. If the Minister of Conservation and Water Stewardship is satisfied that the licensee has met the terms and conditions of the Interim Licence, a Final Licence is issued. This is not a permanent licence, nor is it automatically renewed. The maximum length of term that can be granted is 50 years. When that term comes to an end, the licensee requests a Renewal Licence. If granted, this licence will also have a fixed term. The *Water Power Act* licensing process is shown in Figure 4.

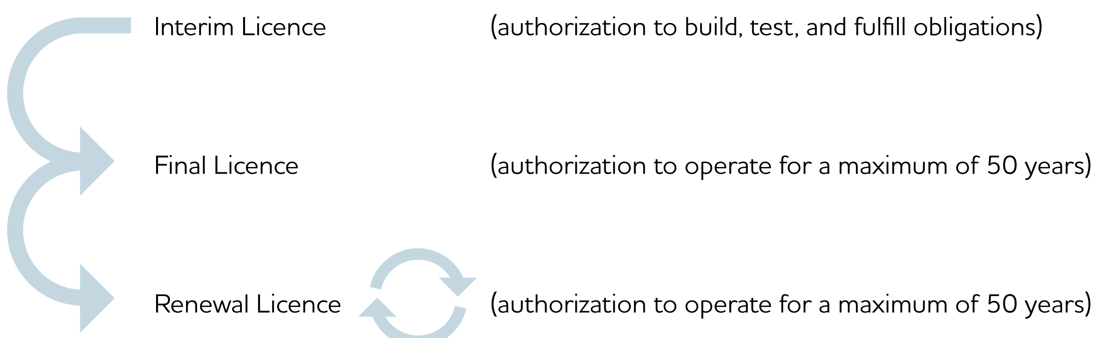


Figure 4. *Water Power Act* licensing process.

The LWR *Water Power Act* timeline, as shown in Figure 5, provides a summary of the key dates in the *Water Power Act* licence process.

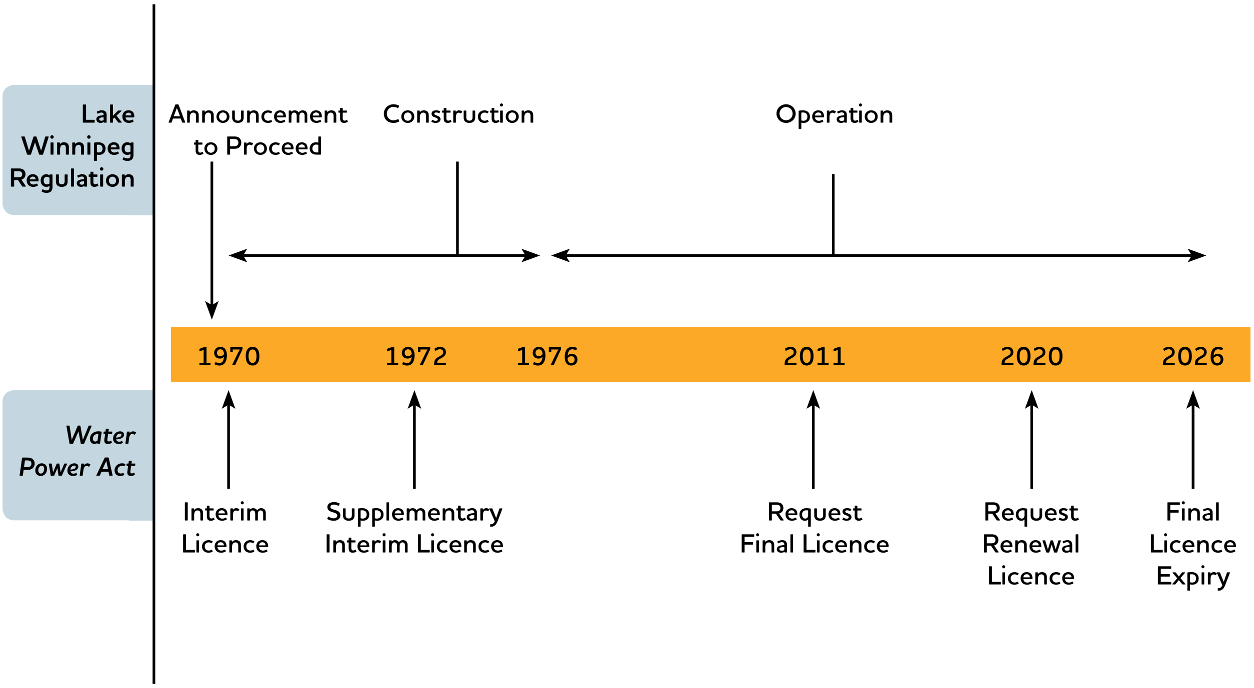


Figure 5: LWR *Water Power Act* timeline.

2.1.2 Terms

The LWR Interim *Water Power Act* Licence provides the following operating conditions, shown in summary form.

- **Operating Ranges**: Manitoba Hydro may regulate water levels to and between the following elevations in feet above sea level (with wind effect eliminated):
  - Lake Winnipeg – maximum 715.0 and minimum 711.0 (this is the range in which Manitoba Hydro regulates outflows in a manner that meets the utility's power generation needs)
  - Playgreen Lake – maximum 714.9 and minimum 707.0
  - Kiskittogisu Lake – maximum 714.8 and minimum 706.0
  - Kiskitto Lake – natural range
  - The licensee is to maximize the use of water for power production.
- **Maximum Discharge**: When the level of Lake Winnipeg exceeds 715.0 feet above sea level, maximum flow must be **discharged** at Jenpeg until the level is restored to 715.0 feet.
- **Minimum Outflow**: The combined flow from all the natural and artificial channels from Lake Winnipeg must be not less than 25,000 **cfs (cubic feet per second**, a measurement of water flow).
- **Low Level Support**: When the level of Lake Winnipeg falls below 711.0 feet above sea level, the Minister of Conservation and Water Stewardship determines how outflows should be managed.
- **Outflow Rate of Change**: The maximum rate of flow change at Jenpeg in a 24-hour period is 15,000 cfs.

2.1.3 Why A Regulation Range of 711–715 Feet?

Initially, Manitoba studied and considered a variety of Lake Winnipeg water level regulation ranges. The studies considered the interests of agriculture, recreation, power, navigation, wildlife, and the fishery. In the end, the Interim *Water Power Act* Licence issued by the Manitoba government set the range as 711–715 feet. This is within Lake Winnipeg's natural historical range of 709.3–718.2 feet, reduces flooding around Lake Winnipeg, and is adequate for Manitoba's power generation needs.

A 1972 provincial report, Program for Regulation of Lake Winnipeg, reaffirmed the 711–715 foot range of the LWR Interim Licence after citing the Crippen Report (1970), and the Manitoba Hydro Task Force Report (1970). The 711–715 foot range was adequate for Manitoba Hydro's needs, would reduce Lake Winnipeg water levels in high inflow years by about two feet, and would reduce the risk of shoreline flooding. The report anticipated that because of LWR, the annual median level of the lake would increase by a few inches, while the minimum levels would be a foot higher than they would be without LWR.

One of the key considerations in choosing a water range was the varying Lake Winnipeg outflow capability as the water level changes. The higher the water level, the more water can pass downstream, while the lower the water level, the less water can pass downstream. A range that is too low will restrict the flow capacity and compromise power generation. This is an important factor to consider in deciding whether the project is economically viable and provides the required level of reliability.

The continued full authority of Manitoba Hydro to regulate outflows in the Lake Winnipeg water level range established by the licence is essential for the reliable and economic operation of Manitoba's power system.

2.2 Scope

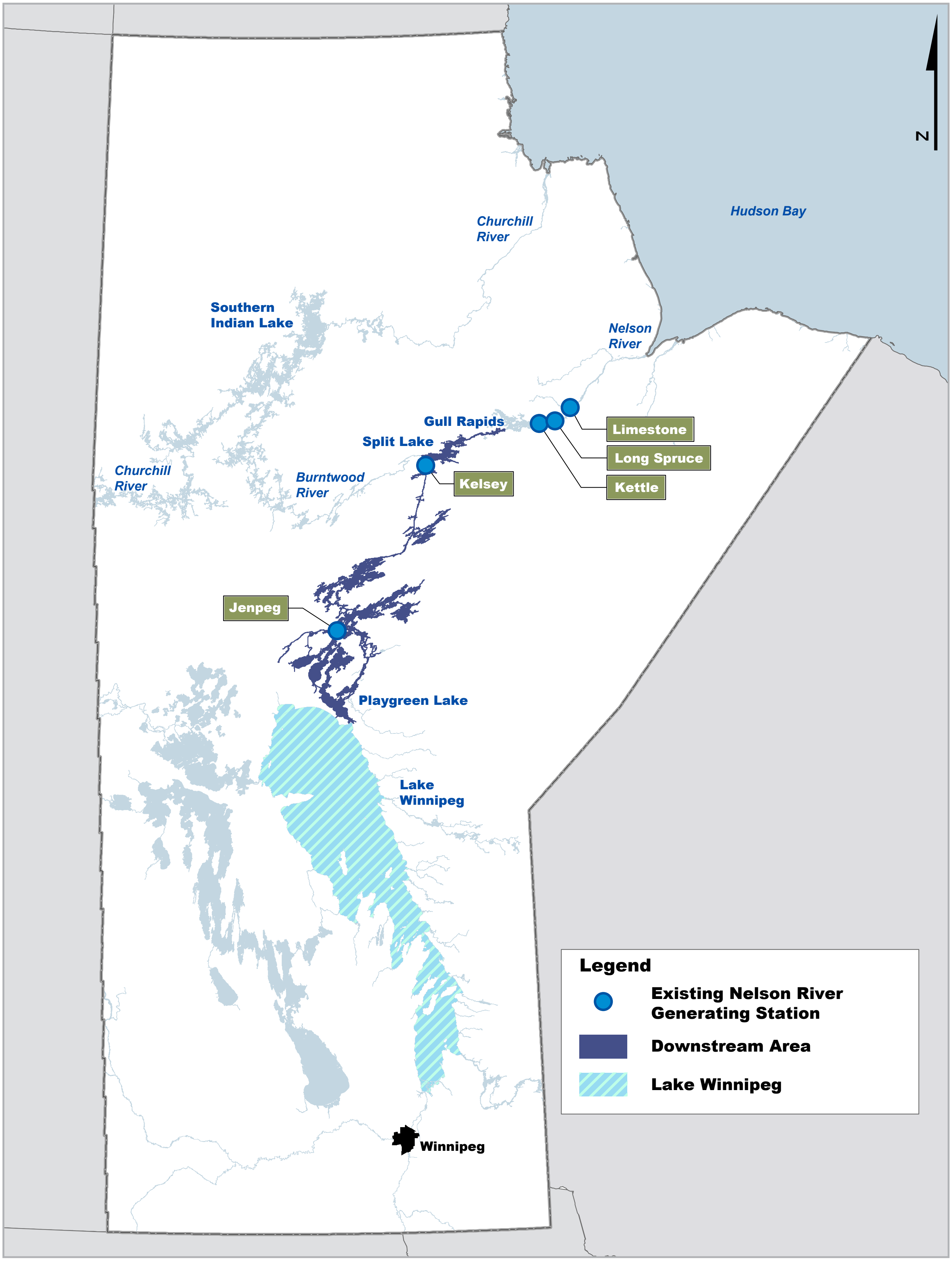
2.2.1 Regions of Interest

In determining the regions of interest for this report Manitoba Hydro considered several factors:

- The physical structures that comprise the LWR project are located between the outlet of Lake Winnipeg and Jenpeg.
- LWR influences the Nelson River **water regime** from Lake Winnipeg to Hudson Bay.
- Downstream of Gull Rapids, the operation of Kettle Generating Station is the primary influence on the water regime.
- Lake Winnipeg stakeholders continue to have a variety of concerns about LWR.

As a result, Section 3 of this report describes the effects between the outlet of Lake Winnipeg and Gull Rapids which in this document is referred to as the **Downstream Area**. Section 4 discusses public concerns specifically related to Lake Winnipeg. These areas are shown on Map 3.

Separate from this document, Manitoba Hydro is working with the Province of Manitoba to develop a Regional Cumulative Effects Assessment (RCEA) that describes the impacts of previous hydropower developments including LWR, CRD, and other projects.



Map 3: Regions of interest.

2.2.2 Physical Structures

The key structures associated with LWR are located between Lake Winnipeg and Jenpeg. Certain components are required for the proper and efficient operation of LWR, and other components are required to limit the **forebay** flooding. These structures are listed as follows with descriptions further below:

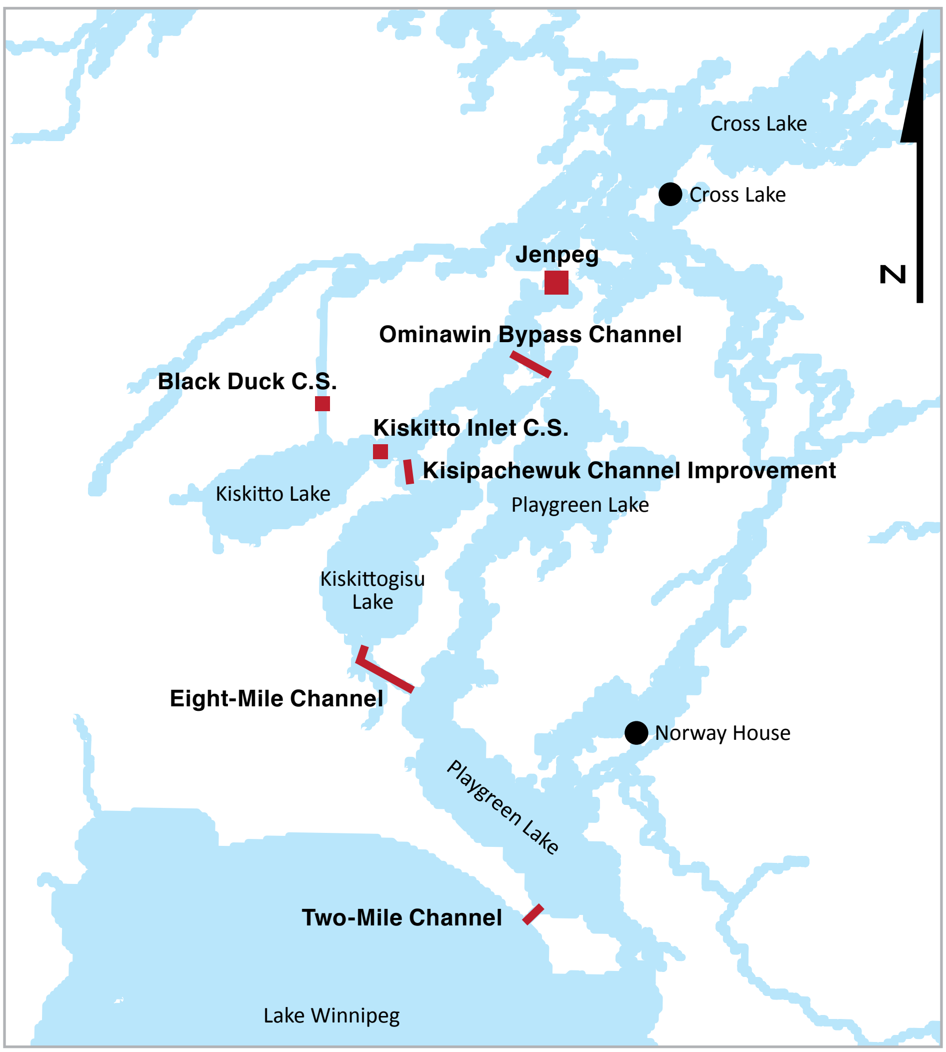
Operational components:

- Two-Mile Channel
- Eight-Mile Channel
- Ominawin Bypass Channel
- Kisipachewuk Channel Improvement
- Jenpeg

Other important components:

- Kiskitto Lake Inlet Control Structure, Main **Dam**, and **Dykes**
- Black Duck Control Structure and Diversion Channel
- Stan Creek Diversion (not shown)

The location of each of the major operational components is shown on Map 4.



Map 4: LWR major operational components

A summary of some of the key features of channels constructed to improve the flow out of Lake Winnipeg are presented in Table 3.

Component	Construction Period	Approximate Dimensions		
		Length	Width	Depth
Two-Mile Channel	1973–1976	2 miles (3.1 km)	600–700 feet (183–213 m)	30 feet (9 m)
Eight-Mile Channel	1971–1976	8 miles (12.9 km)	700–1,200 feet (213–366 m)	20 feet (6 m)
Ominawin Bypass Channel	1972–1975	2.1 miles (3.4 km)	1,400 feet (427 m)	20 feet (6 m)

Table 3: Lake Winnipeg Regulation channel summary information.

The operational components of the LWR project are the Two-Mile Channel, Eight-Mile Channel, Ominawin Bypass Channel, Kisipachewuk Channel Improvement, and Jenpeg.

Figure 6: Two-Mile Channel.

Two-Mile Channel
Two-Mile Channel connects Lake Winnipeg and Playgreen Lake as a second outlet for Lake Winnipeg. The channel is about two miles (3.2 km) long, 600–700 feet (183–213 m) wide, and about 30 feet (9 m) deep. The natural outlet is located east at Warren Landing. This outlet has a few major islands with one wider channel, and then transitions to one channel with numerous vegetated shallows, rock outcrops, and smaller islands. These features impede the flow of water during the open water season with even more significant flow constrictions in winter as ice grows.

Figure 7: Eight-Mile Channel.

Eight-Mile Channel
Eight-Mile Channel provides a direct flow of water from Playgreen Lake to Kiskittogisu Lake, which allows water to flow more directly to the Nelson River. It ranges in width from about 700 to 1,200 feet (213–366 m) and is about 20 feet (6 m) deep. Without this channel, water could only flow downstream through a relatively narrow part of Playgreen Lake and then through an even narrower portion at the north end of the lake called Whiskey Jack Narrows.

Figure 8: Ominawin Bypass Channel.

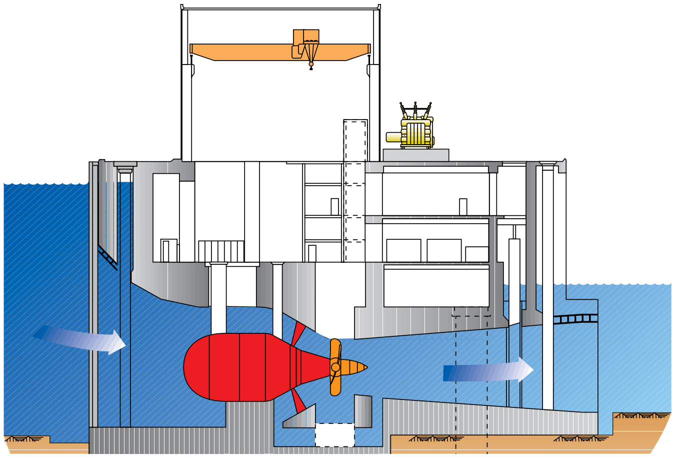
Ominawin Bypass Channel
The Ominawin Bypass Channel is located at the north end of the Kiskittogisu Lake and allows water flow to bypass the natural restrictions of the Ominawin Channel. The channel has a centre division (a rockfill groin) designed to reduce ice thickness. The Ominawin Bypass Channel is about 1,400 feet (427 m) wide, about 20 feet (6 m) deep, and about 2.1 miles (3.4 km) long.

Figure 9: Kisipachewuk Channel Improvement.

Kisipachewuk Channel Improvement
The Kisipachewuk Channel Improvement was constructed to increase water flows through this outlet channel from Kiskittogisu Lake into the Nelson River. The channel improvement is an excavation of the river bed over a length of about 260 feet (80 m) and width of 200 feet (60 m).

Figure 10: Jenpeg generates electricity and has a capacity of around 125 MW.

Jenpeg
Jenpeg is located about 62 miles (100 km) north of Lake Winnipeg, on the upper portion of the Nelson River. Jenpeg controls most of the flow of water out of Lake Winnipeg for flood protection on Lake Winnipeg and power generation along the Nelson River. Although originally envisioned to be a control structure only, a decision was made to add a generating station at Jenpeg. A separate *Water Power Act* licence was issued for the generating station. Manitoba Hydro has also requested a Final Licence for the Jenpeg Generating Station.



Jenpeg was the first generating station in North America to use bulb-type turbine generators, as shown in Figure 11. This design reduces the depth of excavation required into the underlying **bedrock**.

The main dam extends across the west channel of the Nelson River, diverting water to Jenpeg's 125 **MW powerhouse**, and a **spillway** where surplus water can flow. The main dam is approximately 1,075 feet (289 m) long with a maximum height of 84 feet (24 m) above the river's bottom.

Figure 11: Jenpeg Generating Station and Control Structure.

Other Important Components

Other important components of LWR are the Kiskitto Lake Inlet Control Structure, main dam, and dykes, the Black Duck Control Structure and Diversion Channel, and the Stan Creek Diversion Channel. A description of these is provided below.

Kiskitto Lake Inlet Control Structure, Main Dam, and Dykes.

The Kiskitto Inlet Control Structure regulates inflow to Kiskitto Lake so that Kiskitto Lake water levels can be maintained within their natural range. The **impoundment** of water from the construction of Jenpeg required prevention of the free flow of water from entering and flooding Kiskitto Lake. While a dam and dyke prevent this, some inflow is required to control the water level. The flows through the culvert are regulated using a vertical lift gate. The original gated steel culvert was replaced in 2003/04 with a concrete box culvert.

Figure 12: Kiskitto Lake Inlet Control Structure.

The Kiskitto Main Dam is about 2,000 feet (600 m) in length, with a maximum height of 49 feet (15 m) from its base. There are also 16 separate dykes with a total length of 8.75 miles (14 km). These dykes protect Kiskitto Lake and the surrounding area from the higher water levels of the Nelson River's west channel.

The Black Duck Control Structure and Diversion Channel

The Black Duck Control Structure, as shown in Figure 13, regulates the amount of water diverted from Kiskitto Lake into the Minago River via Black Duck Creek. The control structure is made of concrete with wooden stoplogs used to regulate flow. The purpose of the structure along with the Kiskitto Lake Inlet Control Structure is to regulate the water level of Kiskitto Lake within its natural range.

Figure 13: Black Duck Control Structure.

The Kiskitto-Minago Drainage Channel, sometimes called the Black Duck Diversion channel, diverts water from Kiskitto Lake to the Black Duck Control Structure. The channel is about 10 feet (3 m) wide at its base. Its length is about 2 miles (3.3 km) between Kiskitto Lake and the control structure, and about 0.9 miles (1.5 km) from there to Black Duck Creek.

The Stan Creek Diversion Channel

The Stan Creek Diversion routes local natural drainage into Kiskitto Lake that was blocked from flowing into the Nelson River by the construction of dykes. The channel is approximately 10 feet (3 m) wide at its base, is on average 9 feet (2.7 m) deep, and is about 5,000 feet (1,500 m) in length.

2.3 Project Operation

2.3.1 System Operations

Operating a power system involves developing a plan, or series of planned operating decisions, to ensure that supply (electrical generation) and demand (electrical load) will be in balance over the entire operating horizon – whether that's the next hour or many months into the future. If economics were the only priority, then an optimal plan would simply achieve this supply and demand balance while maximizing net revenues. However, the actual challenge is more complex because additional priorities must be considered, and these priorities often compete with each other.

Figure 14 illustrates the balance concept in power system operations planning.

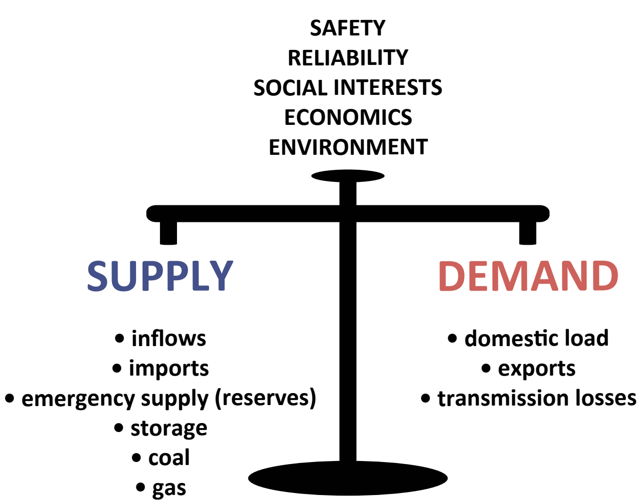


Figure 14: The operations planning balance.

Figure 15 illustrates the basic elements of the Manitoba Hydro system and helps explain the **parameters** of operations planning and the processes and complexities faced by operations planners.

1. Precipitation
2. Runoff and regulated inflows
3. Upstream stakeholders and environment
4. Reservoir operating limits
5. Reservoir level
6. Hydroelectric generation and powerhouse flow
7. Spill flow
8. Station outflow (combined powerhouse and spill flow)
9. Downstream stakeholders and environment
10. Hydroelectricity provided to grid (one direction)
11. Electricity delivered to load (one direction)
12. Domestic load obligation
13. Export or import over interconnecting transmission
14. Wholesale electricity market (generation and load)

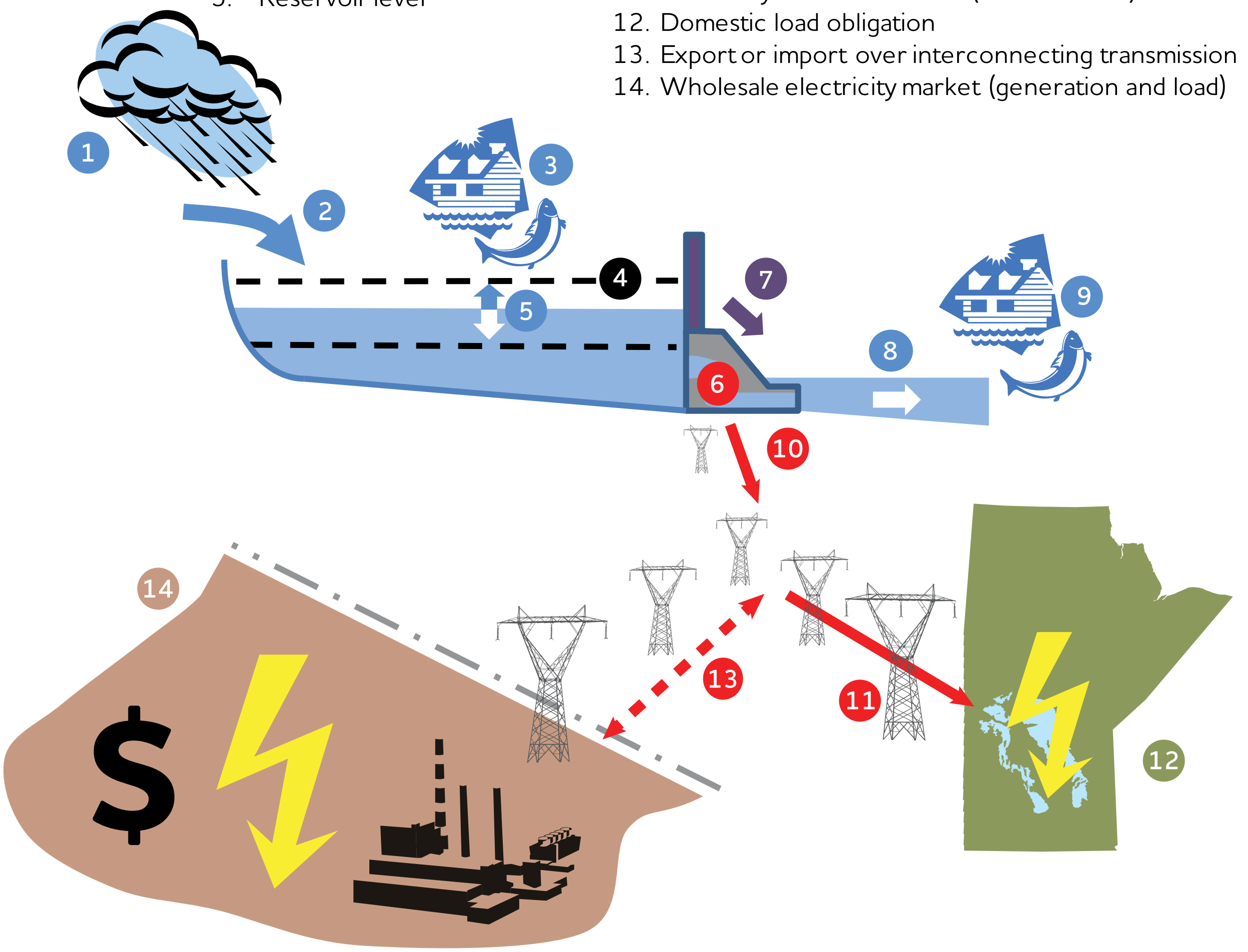


Figure 15: Basic elements of a simplified integrated hydroelectric system.

With the vast amount of information that needs to be considered in operations planning, manual calculations are insufficient to capture all of the possible trade-offs. To assist decision-making, Manitoba Hydro uses a suite of computer **models** referred to as a Decision Support System. This system has models for forecasting important information including inflows, ice conditions, market prices, and load. Other forecasts, including plant maintenance schedules, are also provided as inputs. A flow simulator is used to examine in detail the response of the lakes and rivers to planned operating changes, possible inflows, and ice conditions. Figure 16 illustrates the planning cycle. The operations planning process is continually updated and generally repeated weekly.

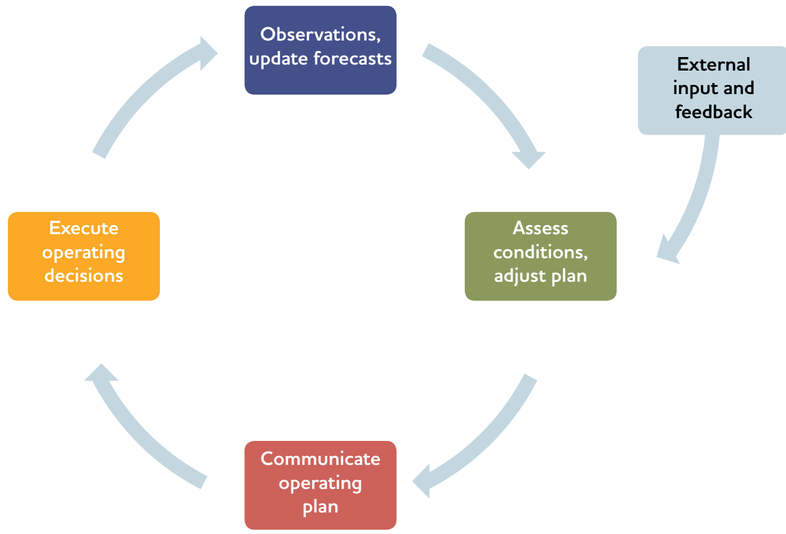


Figure 16: Energy operations planning cycle.

While day-to-day decisions are generally economic in nature, they are made within the framework of the LWR Interim Licence and with consideration of stakeholders and the environment. As shown in Figure 16, external input and feedback are part of the energy operations planning process. Community concerns and stakeholder interests are relayed to Manitoba Hydro staff. Discussions consider trapping, hunting, fishing, travel activities, cultural pursuits, and other matters in areas affected by the operating plan. Through this communication, Manitoba Hydro works to reduce the impacts of its operations.

Examples of how Manitoba Hydro has modified LWR operations to address community and stakeholder concerns include:

- changing the flow at Jenpeg during the freeze-up period at a slower rate than allowed by the LWR Interim Licence and limiting the peak outflow from Jenpeg after the lakes downstream are frozen; this limits the potential to cause slush ice which can impede travel;
- changing the flow at Jenpeg during the open water season at a slower rate than allowed to limit the change in water levels on downstream lakes and river **reaches**, thereby reduces the impact on waterway users; and
- increasing LWR outflow, even to the point of causing spill, earlier than required by licence to reduce the likelihood and duration of exceeding 715 feet on Lake Winnipeg.

Reservoir storage is one of the most important components of hydroelectricity production, and serves a number of roles over a range of time horizons. The two key roles are:

- managing variability of inflow over the full spectrum of conditions, from drought to floods; and
- timing flow releases so electricity generation matches electricity demand.

Not surprisingly, the usefulness of a reservoir for hydroelectric operations depends on its storage capability between its upper and lower operating limits. Commonly referred to as the reservoir's "active storage," this is usually defined by physical or regulatory restrictions. However, to understand the usefulness of a reservoir for hydroelectric operations, the active storage must be looked at in relation to:

- the average inflow to the reservoir;
- the generation capability downstream of the reservoir; and
- the flexibility and certainty of controlling outflow from the reservoir.

2.3.2 LWR Operations

Manitoba Hydro's system has a number of waterbodies that serve as reservoirs. On an annual average, Lake Winnipeg contributes about 40% of the storage across the Manitoba Hydro system, as shown in Figure 17. Despite the large geographic diversity of the Churchill-Nelson River drainage basin, inflows into Lake Winnipeg vary tremendously from year to year. With the narrow storage range defined by the licence, Manitoba Hydro has only a limited ability to manage these large variations in inflows. Except for periods of very low inflows, outflows must match inflows within a one year or shorter time frame. Compared to other major hydro utilities in Canada, Manitoba Hydro has relatively limited reservoir storage capability. For example, BC Hydro and Hydro Quebec have multi-year storage reservoirs.

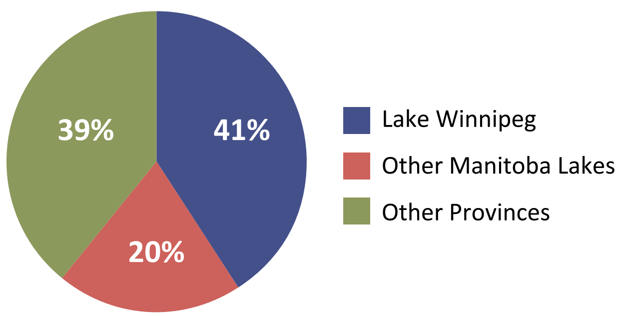


Figure 17: Total average annual energy in reservoir contribution from 1977 to 2014.

Lake Winnipeg is not useful for short-term operations because it takes several weeks for water released from the lake to reach Manitoba Hydro's major generating stations on the lower Nelson River. For example, if Manitoba Hydro were to experience a sudden period of exceptionally high electrical demand, such as a heat wave in summer, changes to Lake Winnipeg outflows wouldn't help because it would take too long for the water to reach Manitoba Hydro's major generation stations on the lower Nelson River. Instead, Lake Winnipeg releases are planned based on current storage levels, near term water supply trends, and seasonal load patterns.

Maximum Discharge

The operation of LWR maximizes discharge when Lake Winnipeg water levels are above 715 feet (217.93 m). In general, maximum discharge is accomplished by lowering the Jenpeg forebay to a minimum water level. To avoid physical damage at Jenpeg, the lowest water level to which the forebay can be drawn down is 702 feet (213.97 m) in summer. Even during periods of maximum discharge, forebay variations occur due to local and upstream conditions. Wind set-up at the north end of Lake Winnipeg increases lake outflow and can cause the forebay level to increase temporarily. This can wrongly give the appearance that maximum discharge is not occurring.

Lake Winnipeg discharge is also maximized during most winters when ice in the outlet of Lake Winnipeg reduces outflow capacity. The thickening of ice upstream of Jenpeg as winter progresses gradually reduces outflow. The degree of the reductions differs from year to year depending on the duration and severity of the winter. To achieve maximum outflow under ice conditions the forebay is drawn to 703 feet (214.27 m).

At some point after the Nelson River freeze-up, Lake Winnipeg outflow will be limited by the ice constrictions, rather than by the Jenpeg forebay elevation. When this occurs, maximum discharge can be achieved with forebay levels greater than the minimum. The *Water Power Act* licence recognizes that maximum discharge varies according to the circumstances prevailing at the time.

Freeze-up Program

During freeze-up, flow is temporarily reduced – typically for a week or two – to permit the formation of a smooth ice cover that improves the Nelson River West Channel flow capacity. This ultimately increases the total Lake Winnipeg outflow capability over the winter. After this ice cover is formed, maximum discharge operations can be resumed if required. Operations during the freeze-up period attempt to reduce the impact on local **resource users**. **Monitoring** of ice conditions upstream and downstream occurs on a daily basis during the program.

Typical LWR Operations

LWR operating decisions are made considering water supply conditions and other factors at the time. The following is a broad description of typical LWR operations over the course of a year. It is not meant to be a comprehensive guideline applicable to all possible conditions.

Winter

Following the freeze-up program, flows are usually increased to supply Nelson River generation during the winter when Manitoba load is highest. Flows are typically increased to the maximum possible – which is mainly dependent on the level of Lake Winnipeg and the ice constrictions upstream of Jenpeg. In all but one of the years since 1977, flows have been maximized during winter. Winter differences in outflow are the result of varying Lake Winnipeg water levels and differences in ice constrictions.

Spring

As spring approaches, LWR operations are planned based on current Lake Winnipeg levels, storage levels elsewhere in the system, snowpack, and inflow forecasts. Generally, the objective for spring operation of LWR is to allow some refill of the lake with spring runoff while avoiding overloading the lower Nelson River with Lake Winnipeg outflows at a time when demand is lower. However, under above average or higher water supply conditions (*e.g.*, above average Lake Winnipeg levels and high expected snowmelt runoff), maximum discharge operations may continue through the spring into the summer to avoid Lake Winnipeg levels rising close to or above 715 feet. In low water supply years, lake outflows will be reduced to conserve spring runoff to supply lower Nelson River generation at a later time.

Summer

LWR outflows during the summer are largely dependent on inflows at the time which can vary greatly from year to year and can change relatively quickly. Inflows can transition from normal to flood inflows after only a few widespread, major rain events. LWR provides increased discharge capability to manage floods and this capacity can be used in response to an increase in inflows. There is a much wider range of outflows in summer, from the minimum outflow required by licence up to maximum discharge to manage flood inflows. In comparison, the range of outflows during the winter months is smaller since outflows are almost always maximized.

Fall

Inflows to Lake Winnipeg typically decline through August and into the fall. Evaporative losses from Lake Winnipeg are highest in late summer and early fall which decreases the net inflow to the lake. Fall floods are not as common as spring and summer floods but they do occur. LWR outflows are generally less in the early fall than the summer because inflows are lower on average and because electrical demand is less in the early fall versus summer. Lake Winnipeg levels typically decline through the fall, however when water supply conditions are low (*i.e.*, system storage and inflows are low), outflows will be reduced to conserve water for use in supplying winter demand and to protect against the possibility of drought. In late fall, between mid-November and early December, LWR outflow is usually reduced for the freeze-up program described above.

Best Management Practices

Manitoba Hydro's objective is to plan for the secure and economic operation of Manitoba Hydro's system of reservoirs and generating stations while considering the effects on stakeholders and the environment. To meet this objective, Manitoba Hydro's operations are planned based on numerous operations planning activities or processes. These activities are referred to as Best Management Practices (BMPs) because they have proven to give consistent and reliable results, given the unique characteristics of Manitoba Hydro's system, frequently surpassing legislative requirements. Manitoba Hydro's BMPs have continued to evolve over the years, adapting to new technologies and to an increased awareness and understanding of social, environmental, and economic concerns of stakeholders affected by hydroelectric operations. Each BMP helps Manitoba Hydro achieve its annual operation planning objective. The BMPs are:

- Ongoing dialogue with downstream communities informs operating decisions.
- Manitoba Hydro accommodates flow reduction requests to ensure the safety of participants during search and rescue efforts and other emergencies.
- Forecasts are updated each week using the most current information as it becomes available.
- Operational forecasts are compared to actual inflows, market, and load each week and over the course of the year to assess forecast accuracy.
- Manitoba Hydro aims to maintain minimum energy reserves for use during extreme drought. On an emergency basis, energy reserves can be used to avoid possible load interruptions to the power supply when no alternative resources are available.
- In all its operations planning decisions, Manitoba Hydro complies with its *Water Power Act* Licences. Manitoba Hydro has a formal reporting program, providing flow and level data to the provincial regulator on a regular basis and self-reporting any deviations from licence conditions.
- Manitoba Hydro uses a computer-based Decision Support System to help identify economic and strategic opportunities, ensuring water resources are used as efficiently as possible, while still considering other priorities.

2.3.3 Licence Compliance

Manitoba Hydro complies with water level and flow conditions based on the LWR Interim and Supplementary Interim *Water Power Act* Licences issued November 18, 1970, and August 8, 1972, respectively. For charts showing Manitoba Hydro's record of compliance with the licence terms see Appendix 2.

Playgreen Lake and Kiskittogisu Lake

Licence Term 6 dictates that Manitoba Hydro may regulate the water levels on Playgreen Lake between 707.0 and 714.9 feet, and on Kiskittogisu Lake between 706.0 and 714.8 feet. Water levels on Playgreen and Kiskittogisu Lakes have been within the mandated ranges 99.9 % of the time. Most instances when water levels have been outside the range were the result of wind set-up on Lake Winnipeg. Wind set-up is a condition where wind depresses water on one side of a lake, and elevates it on the other. The water surface is tilted, with one side being higher than the other, but the average elevation is unchanged. Water levels on Playgreen Lake are directly influenced by water levels on Lake Winnipeg.

Maximum Discharge

Licence Term 7 dictates that Manitoba Hydro must operate the control structure at Jenpeg to maximize discharge when the water level on Lake Winnipeg exceeds 715 feet. Manitoba Hydro has operated to maximum discharge 100 % of the time when Lake Winnipeg has exceeded 715 feet.

Minimum Outflow

Licence Term 8 dictates that Manitoba Hydro must operate the control structure at Jenpeg so that the combined outflow of water from Lake Winnipeg through Jenpeg and the Nelson River East Channel is not less than 25,000 cubic feet per second (cfs). Manitoba Hydro has operated so that the combined outflow has not been less than 25,000 cfs 99.9 % of the time. All instances where Lake Winnipeg total outflow has not been in compliance with this licence term were the result of wind effects reducing flow out of Lake Winnipeg through the East Channel of the Nelson River.

Outflow Rate of Change

Licence Term 12 dictates that Manitoba Hydro must operate the control structure at Jenpeg to keep the rate of change in discharge below 15,000 cfs per day. The rate of change discharge has been below the licence condition 94.8 % of the time. The primary reasons for exceeding this licence condition include unexpected powerhouse unit or transmission line outages, operator error during flow or generation adjustments, wind effects, ice jamming issues, and emergency situations.

Although there will likely continue to be some instances when discharge rate of change will exceed 15,000 cfs per day, Manitoba Hydro has made efforts to reduce the frequency. The percentage of time this licence condition is exceeded has been reduced over the years. From 1976 to 1999, this licence condition was exceeded about 7 to 8 % of the time, and from 2000 to 2012, this has been reduced to less than 2 % of the time. Included in this is an authorized deviation that occurred in 2010 to install an **ice boom**. The improvement in performance related to this condition is partly attributable to a compliance monitoring program that was implemented in 2005 and to increased operator experience.

Kiskitto Lake

Licence Term 12A dictates that Manitoba Hydro must regulate water levels on Kiskitto Lake within the natural range. Water levels on Kiskitto Lake have been within the natural range 100 % of the time.

Reporting

Manitoba Hydro implemented a reporting program in 2005 that monitors near real time compliance with all of Manitoba Hydro *Water Power Act* licences on a weekly basis. The program is intended to demonstrate that Manitoba Hydro is following its licences. Any deviation from a licence condition is reported to Manitoba Conservation and Water Stewardship, typically within one week of the event. Manitoba Hydro also provides Manitoba Conservation and Water Stewardship with an Annual Water Levels and Flows Report that is made available to internal and external stakeholders. The report contains information on data collection, verification, and reporting related to *Water Power Act* licences, as well as a summary of deviations from licence compliance during the calendar year. Annual Water Level and Flows Reports from 2008 to 2013 are posted on the Manitoba government website http://www.gov.mb.ca/waterstewardship/licensing/water_power_licensing.html.

Licence Term 11 of the Interim Licence requires Manitoba Hydro to provide a 90-day forecast of water levels and flows for the LWR project each month to the Minister of Conservation and Water Stewardship. These forecasts include daily inflows to Lake Winnipeg, flows for the Nelson River (East and West Channel), and levels for Lake Winnipeg, Playgreen and Kiskittogisu Lakes. In addition to providing this to the minister, Manitoba Hydro reports the forecast on its website.

3.0 LWR Downstream Area Effects and Manitoba Hydro Responses

3.1 Historic Context of Development

Aboriginal peoples have a strong cultural and spiritual connection to the land and water. Manitoba Hydro has large investments in areas where Aboriginal peoples live and harvest resources, practise their culture and traditional way of life, and exercise their legal and constitutional rights. The development of the Manitoba Hydro system including LWR has affected the environment upon which Aboriginal peoples and communities in northern Manitoba rely. While northern communities have benefited from access to a reliable, low-cost, and convenient energy source, many have also experienced substantial negative effects on their traditional way of life and, as communities have indicated, a sense of powerlessness and marginalization in decision-making processes affecting their lives.

LWR was evaluated, debated, and constructed during a time when the social, political, and legal environment was quite different from today. Decisions about LWR occurred in an era when there was much less understanding of the effects of developments on people and the environment, and when there were fewer environmental regulations and legislation. Notably, approval of LWR predated the *Constitution Act* (1982), the *Environment Act* (Manitoba) [1987], the *Canadian Environmental Assessment Act* (1992), and the *Sustainable Development Ac*t (Manitoba) [1997]. Development occurred at a time when economic and other interests (*i.e.*, flood reduction on Lake Winnipeg) of predominantly southern society took precedence over the interests of potentially affected northern populations.

As a result, Canada's, Manitoba's, and Manitoba Hydro's approach to development during this time period was very different than today. While in line with practices of the day and consistent with government requirements, past projects involved much less engagement and consultation than what would be considered appropriate today, and considerably less upfront planning with respect to reducing environmental impacts. Measures to avoid or reduce negative effects were not always identified in advance of project construction nor were they included in capital cost estimates.

During the 1970s and 1980s, public environmental awareness and media attention about the environment began to increase dramatically. Scientific research confirmed that people and the environment were being affected by industrial development in more ways than previously thought. Globally, there was increased pressure on governments and corporations to protect the environment. Respect for Aboriginal peoples and appreciation of their experiences with the development process were also growing. Affected communities were asserting their rights and seeking restitution for the adverse effects they experienced as a result of development. The *Constitution Act*, which was passed in 1982, provided constitutional protection of Aboriginal and treaty rights for Aboriginal peoples in Canada.

As society's understanding and appreciation advanced, Manitoba Hydro became increasingly involved in environmental initiatives and in efforts to understand and address Aboriginal grievances and claims about past projects. Manitoba Hydro has established a range of measures to correct damage that resulted from its activities, to reduce the number of new effects, and to compensate those people and communities who have been affected. Today, Manitoba Hydro is working towards long-term relationships with Aboriginal peoples founded on trust and shared interests. This includes the implementation of policies, programs, and activities aimed at increasing Aboriginal participation in employment; providing business and partnership opportunities in new developments; maintaining regular contact with communities; and managing community-specific issues, including supporting and promoting the safety of people using affected waterways, and others.

Manitoba Hydro acknowledges that some of the changes brought about by LWR are irreversible and that, as would be expected, some members of various communities may not feel that measures taken to address or compensate for effects are sufficient to address losses that were experienced.

3.1.1 Communities in the Downstream Area

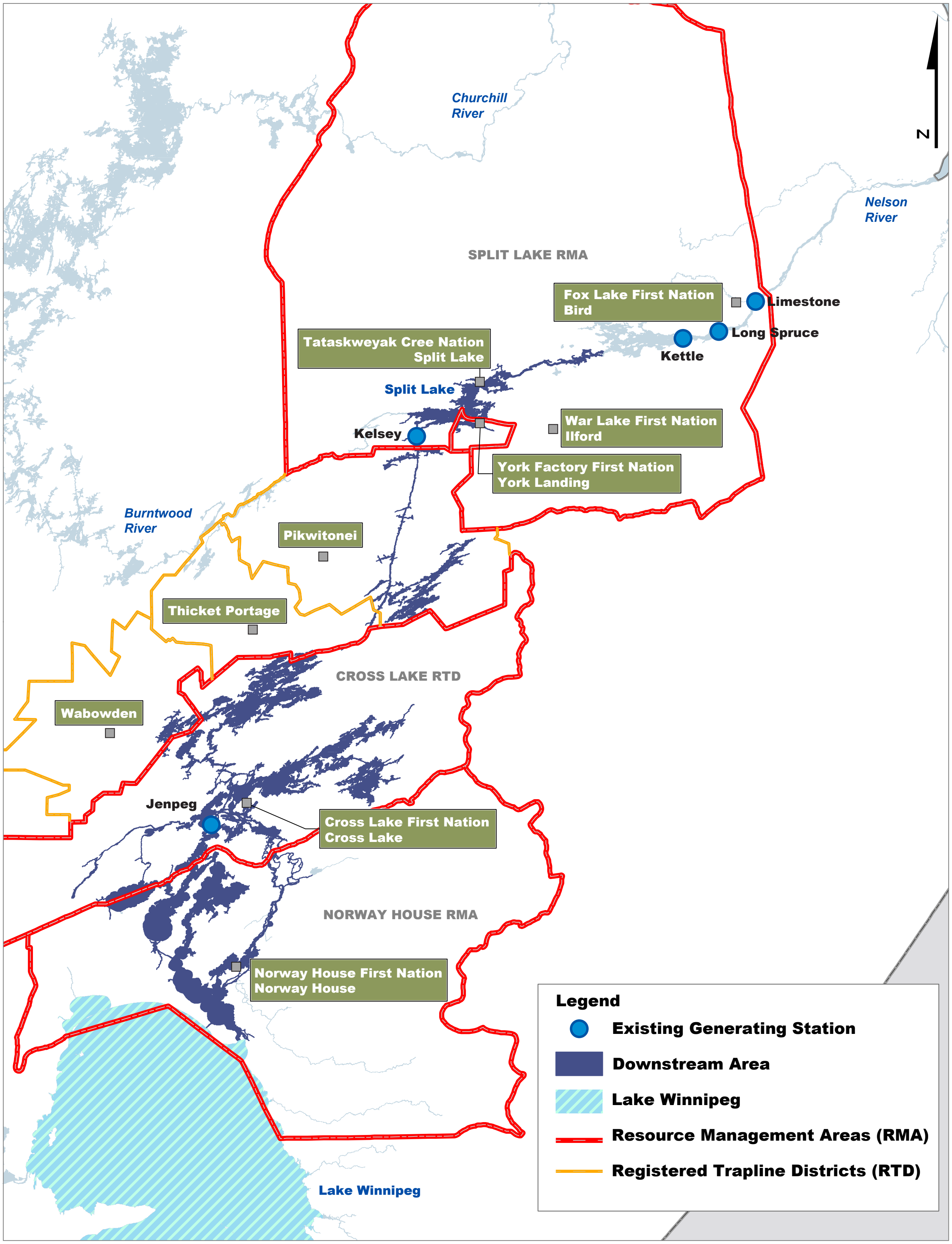
Map 5 highlights the location of communities located in the Downstream Area as well as their **Resource Management Areas** (RMAs) and **Registered Trapline Districts** (RTDs). Communities in northern Manitoba fall into three distinct types: First Nations; Northern Affairs Communities (NACs); and industrial towns and cities. The vast majority of the population in the region live in these three types of communities, with only a very small portion living in remote areas.

As the map shows, there are a total of six First Nations and six NACs downstream of Lake Winnipeg that have been identified as being affected by LWR. The impacts experienced by each of these communities vary in nature and extent. These communities are listed in Table 4.

There are Métis people who live in communities in the Downstream Area. Adverse effects experienced by Métis residing in the LWR Downstream Area have been addressed through mitigation programs and works and the various community and resource user group settlement agreements discussed in the pages that follow.

First Nations	Northern Affairs Communities
Norway House Cree Nation (NHCN)	Norway House
Cross Lake First Nation (CLFN)	Cross Lake
York Factory First Nation (YFFN)	Wabowden
Tataskweyak Cree Nation (TCN)	Pikwitonei
War Lake First Nation (WLFN)	Ilford
Fox Lake Cree Nation (FLCN)	Thicket Portage

Table 4: Communities in the Downstream Area.



Map 5: Communities in the LWR Downstream Area.

3.1.2 The History of Settlement Agreements

The following sections summarize the various collective settlement processes in which Manitoba Hydro has participated as part of its efforts to resolve historic grievances. Information is provided that is relevant to LWR, including the **Northern Flood Agreement** (NFA), Comprehensive Implementation Agreements (CIAs), ongoing NFA implementation at Cross Lake First Nation (CLFN), and other settlement agreements. In addition to these collective settlement arrangements, Manitoba Hydro has entered into individual settlements for personal property loss and damage.

Northern Flood Agreement

As planning for the LWR and CRD projects proceeded in the early 1970s, the potential impacts on northern Aboriginal communities came to the forefront. At the same time, the Lake Winnipeg, Churchill and Nelson Rivers Study Board was commissioned by Canada and Manitoba to undertake consultation on and an environmental review of the two projects, including potential impacts on northern Aboriginal communities. The Study Board Report was published in April 1975.

As construction got underway, five affected First Nations formed the Northern Flood Committee (NFC) to undertake joint discussions with Manitoba Hydro and the federal and provincial governments about the projects. The five First Nations represented by the NFC were the Cross Lake First Nation (Pimicikamak); Nelson House First Nation (Nisichawayasihk Cree Nation); Norway House Cree Nation; Split Lake First Nation (Tataskweyak Cree Nation); and York Factory First Nation.

Cross Lake First Nation (CLFN) takes the position that its rights under the NFA are properly the rights of Pimicikamak and the proper representative is the traditional government of Pimicikamak Okimawin. Canada and Manitoba view the CLFN as the signatory to the agreement. The NFC, funded by the federal government, negotiated the NFA in 1977. The signatories to the agreement included Canada, the Province of Manitoba, Manitoba Hydro, and the NFC as representative of the First Nations noted above.

The NFA was intended to be a comprehensive framework agreement among the governments of Canada and Manitoba, Manitoba Hydro, and the NFC (on behalf of the five NFA First Nations). The agreement established principles, processes, and obligations among the parties. It was designed to address effects on First Nation lands, pursuits, activities, and lifestyles arising from the construction and operation of CRD, LWR, and all existing and planned generating stations on the Nelson and Burntwood Rivers.

The NFA established a process by which **easements** (rights to use someone else's land) could be granted to Manitoba Hydro over Reserve Land to facilitate the construction and ongoing operation of hydroelectric developments. As part of the easement process, First Nations would be entitled to select replacement land on the basis of four replacement acres for every acre of land taken up by the easement. Hold areas were established for each First Nation, which prevented land within the area from being developed or otherwise granted for a five-year period. Other NFA articles provided for the establishment of committees, priority for First Nation members in the allocation of resources, programming to provide for and encourage ongoing traditional land use, trapping and fishing programs, and cultural preservation. The NFA also provided for a range of measures to mitigate negative effects to the extent possible and to compensate those affected. These measures were intended to address water regime management, erosion, travel safety, cemeteries, and other cultural and heritage issues. The NFA introduced the concept of resource areas and community planning processes. The resource areas included the registered traplines, which were next to each First Nation, and the rivers and lakes traditionally used.

Despite the significant amount of work carried out by the Lake Winnipeg, Churchill and Nelson Rivers Study Board, not all of the effects of LWR and CRD were known at the time the NFA was negotiated and signed. This uncertainty resulted in the creation of an arbitration process to resolve unsettled claims. The NFA notes that the costs of these processes would be borne by Canada and Manitoba governments and Manitoba Hydro. The NFA also requires Manitoba Hydro to prove that it did not cause any alleged effects or damage.

Implementation of the NFA proved challenging. As written, the NFA left much room for interpretation by all parties. This resulted in disagreement on the spirit and intent of various clauses. The implementation process was costly and, with the exception of resolving most issues of quantifiable losses, resulted in few issues being resolved. It also led to mistrust and adversarial working relationships. In the wake of an initial limitation period, the NFA resulted in the filing of a large number of claims in the early 1980s.

The NFA claims process resulted in a significant number of retroactive and interim compensation arrangements and/or settlement agreements, as well as related programming. These agreements and arrangements addressed claims from the communities related to commercial and domestic trapping, commercial and domestic fishing, personal property loss and damage, recreational impacts, cultural impacts, and impacts on navigation and transportation.

Comprehensive Implementation Agreements

In 1986, the NFC recommended that CIAs or settlements be developed with each First Nation, thereby resolving all outstanding claims under the NFA. The NFC proposed Global Negotiations. The Global Negotiations resulted in the Proposed Basis of Settlement, which did not proceed. At that point, Split Lake (now TCN) suggested that it was prepared to proceed alone with a comprehensive agreement to resolve the NFA consistent with the approach in the Proposed Basis of Settlement. This led to the 1992 Split Lake First Nation Settlement Agreement. Subsequently, negotiations resulted in the signing of agreements with three of the other four NFA communities: YFFN in 1995; NCN in 1996; and NHCN in 1997 (the agreement with NHCN is known as a Master Implementation Agreement [MIA]).

While each CIA/MIA is unique, they each include common elements relating back to the NFA. The agreements resolved each community's outstanding NFA claims as a whole rather than on a claim-by-claim basis. The CIAs also put decision-making and resources into the hands of the First Nations who assumed responsibility for managing compensation monies and program implementation within their communities. The agreements all include compensation (including funding and processes for economic development), trust indentures for the protection of funds, land exchanges (of significantly greater magnitude than under the NFA), the establishment of RMAs, consultation processes for any proposed future developments, and environmental monitoring.

Ongoing Implementation of the NFA at Cross Lake

From 1994 to 1997, Canada, Manitoba, and Manitoba Hydro negotiated with CLFN to reach a CIA. In 1997, CLFN indicated that it did not wish to enter into a CIA and decided instead to proceed with implementation of the specific terms of the NFA. Manitoba Hydro continues to work with CLFN, Manitoba, and Canada to implement the NFA.

Obligations to the CLFN outlined in the NFA have been addressed through various cash settlements, the construction of remediation or mitigation works at Cross Lake, and ongoing programming. Examples of these initiatives and programs include:

- shoreline maintenance;
- dock installation;
- maintenance of dog sled trails;
- an Elders fuel wood program;
- emergency response and safety patrols;
- safe water and ice travel programs;
- a safe portage initiative;
- personal property damage claims;
- archaeology assistance;
- resource harvesting agreements;
- a gardening and alternative foods program;
- a school hot lunch program;
- the establishment of a community information centre; and
- various recreational initiatives such as an indoor skating arena.

In addition, under the NFA, CLFN and its members can make claims to be compensated for adverse effects if they are not otherwise resolved.

Other Settlement Agreements

Around the same time Manitoba Hydro was negotiating the CIAs with the NFA communities, efforts were also underway to resolve grievances over project impacts with other communities. Agreements were negotiated between Manitoba Hydro and the Province of Manitoba with the Fox Lake Cree Nation (FLCN) [2004] and War Lake First Nation (WLFN) [2005], as well as the NACs of Cross Lake (1990 and 2010) and Wabowden (1992). Manitoba Hydro is continuing to work with the Mayor and Councils from Thicket Portage and Pikwitonei to resolve outstanding grievances. As well, an Agreement-in-Principle (AIP) was signed with the Norway House NAC in 2003 that sets out principles and understandings to guide the ongoing settlement negotiations.

Manitoba Hydro has also entered into agreements with various resource user groups, and individual resource users. As noted above, a number of these were completed in the context of NFA claims. In addition, Manitoba Hydro has entered into subsequent agreements with the CIA communities and the CLFN on other issues. This would include providing for pre-determined compensation clauses, which govern the amount of compensation paid when water levels or flows go outside established water regime parameters.

3.1.3 Pathways of Effects

Development of LWR has resulted in positive and negative outcomes for the people, land, and water downstream of Lake Winnipeg. These outcomes, or effects, have varied depending on location and stage of project life.

A direct change to one aspect of the environment (physical, biophysical, and socio-economic) can often result in indirect changes or effects to other aspects of the environment. For example, changes to the water regime (including, for example, changes to water depth, seasonality, and velocity) can affect fish **habitat** and fish populations in a lake. This, in turn, can affect the viability of a local commercial or domestic fishery. Changes to the water regime can also increase the amount of **debris** in a waterway causing a navigation hazard for local resource users. In this way, development creates pathways of effect across environments.

Changes to the physical environment are generally the primary source of pathways of effect to the biophysical and socio-economic environments. This includes changes to water regime, ice conditions, shoreline erosion, physical changes to the **landscape** (including the waterway), and **sedimentation**. These physical changes lead to subsequent changes in the biophysical environment that can ultimately affect people's relationship (*e.g.*, use, enjoyment) with local lands and waters. Changes in the socio-economic environment can also be driven by other aspects of development such as employment or population migration.

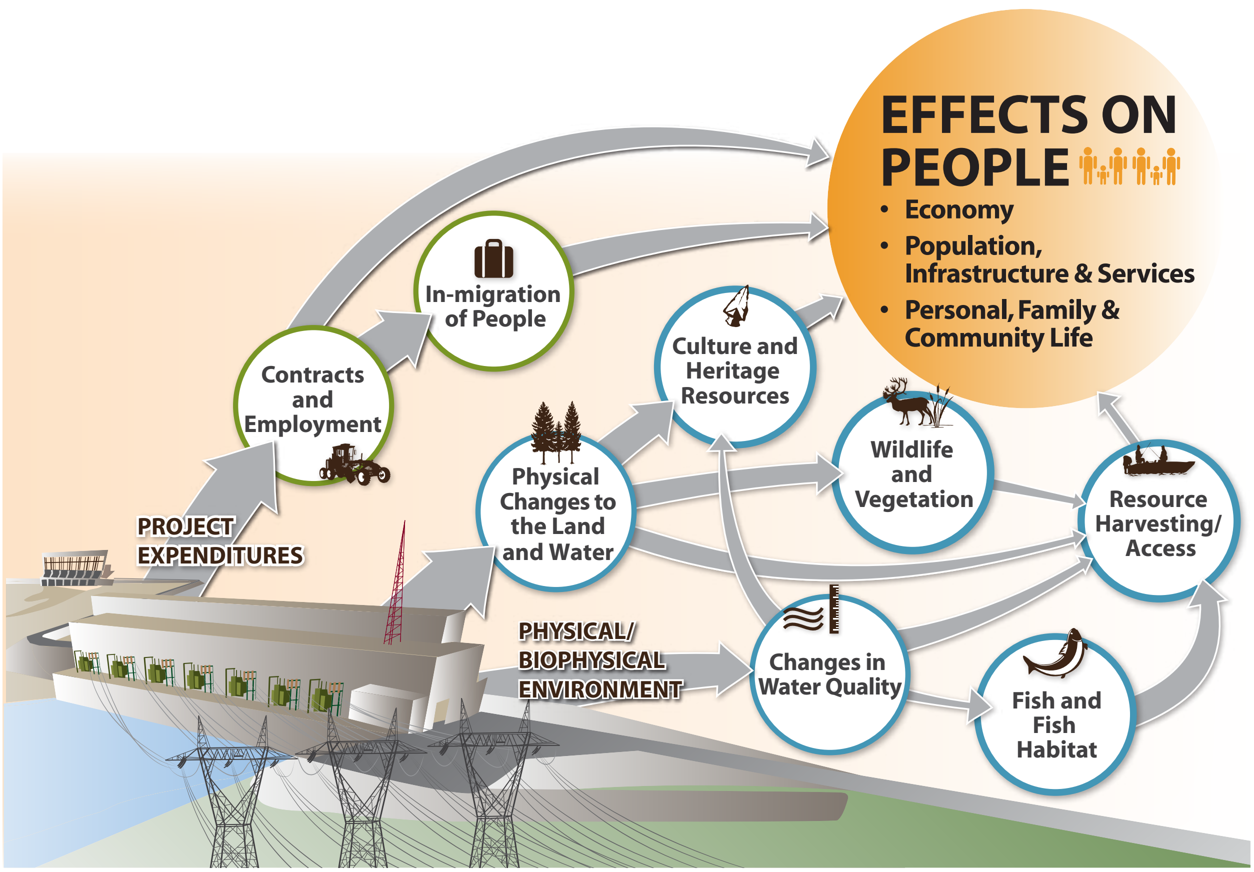


Figure 18: Pathways of effects associated with hydroelectric development.

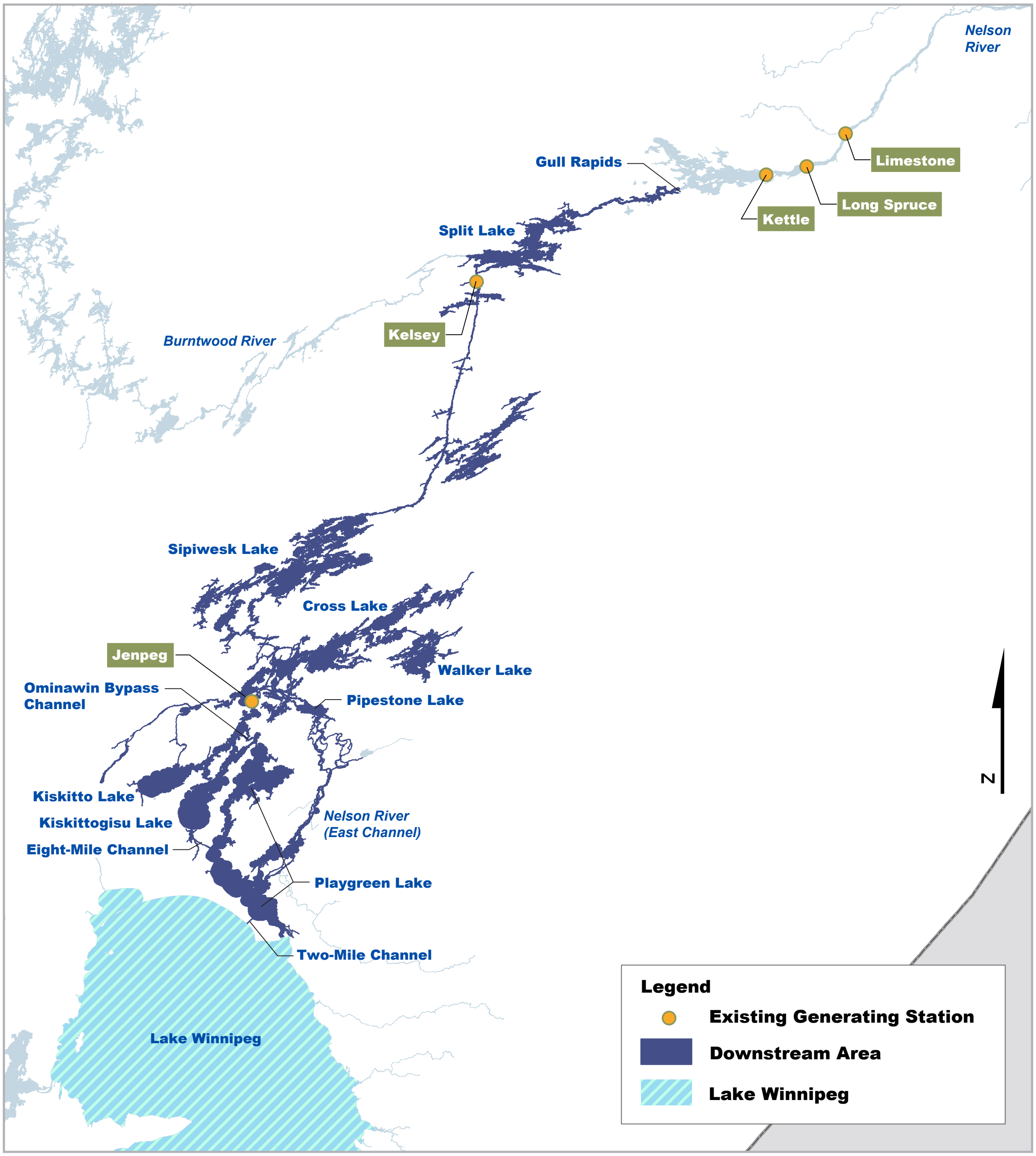
The following sections discuss the types of effects experienced in the downstream physical, biophysical, and socio-economic environments as a result of LWR.

3.2 Physical Effects

3.2.1 Water Regime

The water regime is driven by the amount of precipitation in a river system's drainage basin or watershed. Some of the factors that can affect the water regime include upstream water regulation, water withdrawals, evaporation, and groundwater flow. LWR's diversion channels and Jenpeg also affect the water regime.

The effect of LWR on the water regime in the Downstream Area (as shown on Map 6) is described in this section. For more details see Appendix 3.



Map 6: Downstream Area.

LWR also has the potential to affect the **ice regimes**, including increased water level fluctuations that can potentially contribute to the formation of slush ice. Although operating decisions are made in a manner that attempt to reduce the potential to create slush ice, other factors such as heavy snowfall can also contribute to slush ice conditions.

Playgreen and Kiskittogisu Lakes

Water levels on Playgreen and Kiskittogisu Lakes are influenced by upstream water levels on Lake Winnipeg as well as downstream Jenpeg operations. To better assess and communicate the effects of LWR, Manitoba Hydro undertook a study for the period 1977–2013 that compares Lake Winnipeg water levels and flows with and without regulation under the same hydraulic and climatic conditions. The results from this study can be further used to develop a comparison of Playgreen Lake water levels with and without LWR. The detailed study called An Assessment of Regulation Effects on Lake Winnipeg is located in Appendix 4.

LWR has reduced the range of water levels on Playgreen Lake. Water levels haven't been as high since regulation and they haven't been as low. Study results estimate that the average Playgreen Lake water level is between 0.1 feet lower and 0.5 feet higher with LWR than it would have been without LWR.

Water levels on Kiskittogisu Lake are within the historic range; however LWR has increased the minimum water levels and the mean water levels by about 1 to 2 feet.

Kiskitto Lake

Kiskitto Lake is isolated from LWR operations by the Kiskitto Dam and a series of dykes. The lake is regulated within its natural range by operation of separate inlet and outlet control structures.

Jenpeg Forebay

The Jenpeg forebay area includes the Nelson River West Channel from Kisipachewuk Channel to Jenpeg, including the Ominawin Bypass Channel. The forebay is the area directly influenced by impoundment (the holding of water to a certain level), where hourly water level variations are mainly attributed to Jenpeg operations. LWR increased the average water level in the Jenpeg forebay area and increased the range of water levels from 7 feet (from 681 to 688 feet) to 12 feet (from 702 to 714 feet), as shown in Figure 19. In high-flow periods and during the winter, LWR is operated to maximize discharge at Jenpeg resulting in lower forebay water levels. To store water in Lake Winnipeg in low-flow periods, LWR is operated to reduce discharge at Jenpeg resulting in higher forebay water levels.

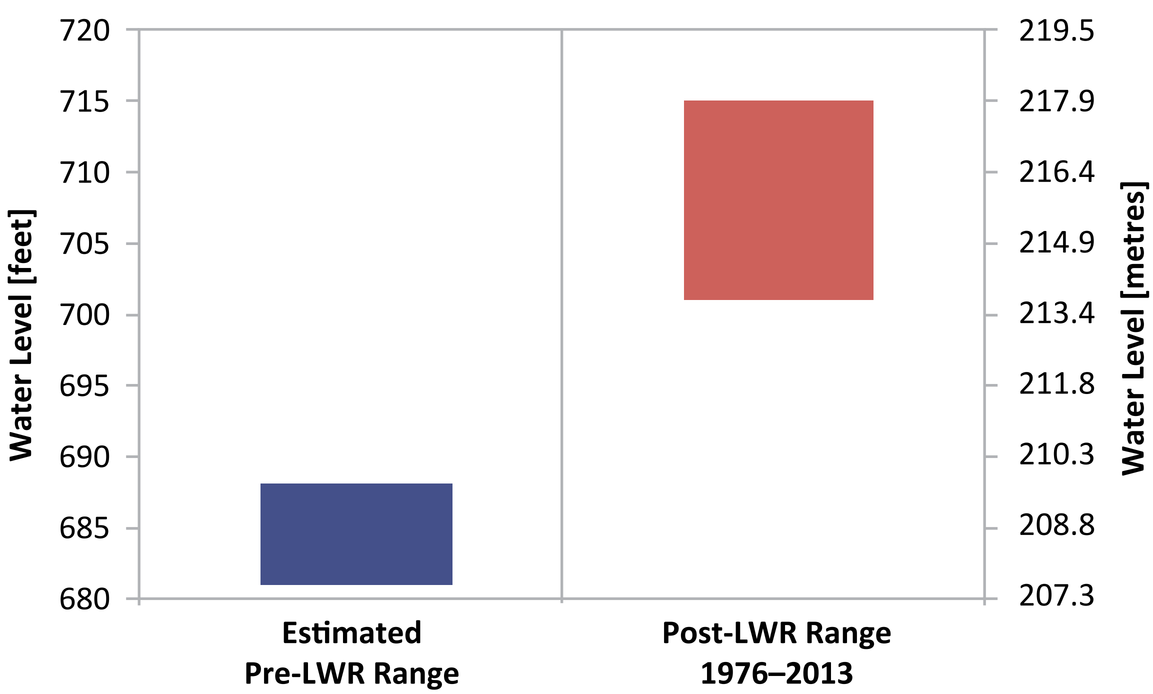


Figure 19: Jenpeg forebay water level range.

Nelson River East Channel

The East Channel of the Nelson River is not regulated as part of the LWR project and carries about 15% of the total Lake Winnipeg outflow. It is estimated that the average flow through the East Channel is similar to what is would have been without LWR because the average water level on Little Playgreen Lake is within 0.5 feet of what it would be without LWR. However, the timing and variability of flows has been affected. For example, in higher-flow years when Lake Winnipeg and Playgreen Lake water levels are lowered by maximizing discharge at Jenpeg, less water flows down the East Channel. Conversely, in lower-flow years when Lake Winnipeg and Playgreen Lake are held higher by decreasing discharge at Jenpeg, more water flows down the East Channel.

Cross Lake and Surrounding Area (Pipestone and Walker Lakes)

LWR affects the seasonal patterns and variability of water levels on Cross Lake and increases flooding in some high-flow years. In low-flow years, LWR reduces the flow out of Lake Winnipeg into Cross Lake in the summer and increases it in the winter. This is a reversal of the natural seasonal pattern. In high-flow years, the seasonal pattern remains generally the same except that the maximum flow out of Lake Winnipeg and into Cross Lake is increased at times. Below average flows in the post-LWR period (1976–1991) resulted in a seasonal reversal of water levels (Figure 20), which led to the installation of the Cross Lake **weir** in 1991.

Pipestone Lake is affected in a similar manner to Cross Lake, while Walker Lake is affected when Cross Lake water levels exceed 681 feet.

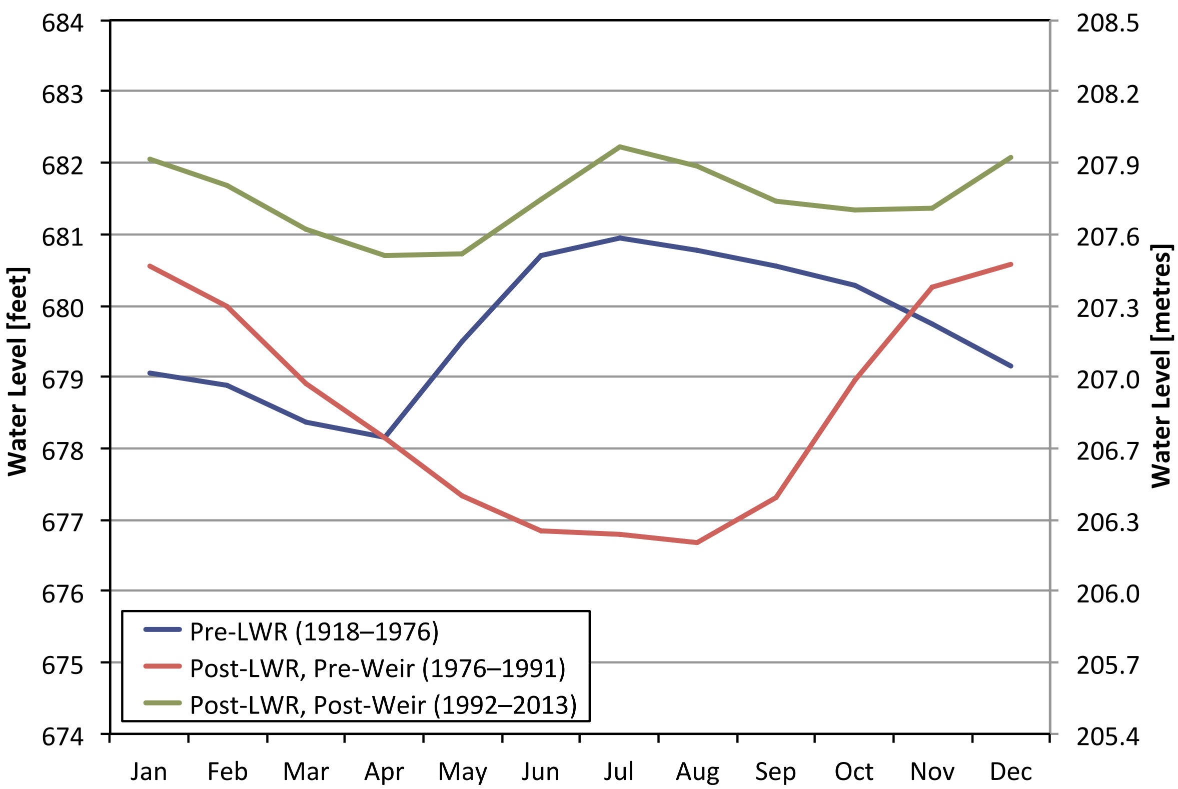


Figure 20: Monthly average Cross Lake water levels.

Cross Lake Weir

The Cross Lake weir was developed to lessen the effects of LWR by increasing the average water level and reducing the range of water levels on Cross Lake. Construction of the weir was completed in 1991 and modified the lake's main outlet channels by filling in a portion of the centre channel and excavating a portion of the East Channel (Figure 21).

Since installation of the weir, the average water level on the lake has increased while the range in water levels has decreased. Higher flows during this time period has caused the seasonality of water levels to more closely resemble natural conditions (Figure 20). A seasonal flow reversal still occurs in low to average flow years, while in high-flow years the seasonal flow pattern remains similar to the natural condition. The Cross Lake weir also allows greater discharge at high lake levels than was possible under natural conditions.

Following the completion of the weir in 1991, a co-operative study between CLFN and Manitoba Hydro was implemented to monitor the response of the fish population to the weir. The study was later expanded to include Pipestone Lake (at the request of CLFN). The monitoring program has established a fish population database for Cross and Pipestone Lakes since 1992 and 1993 respectively. The weir post-project monitoring program was concluded in 2008, but Cross Lake (west basin) continues to be monitored. The fish population is currently dominated by Northern Pike, White Sucker, and Walleye (CAMP, 2014). Although Lake Whitefish populations continue to be extremely low, Cross Lake is now supporting both commercial and domestic fisheries.

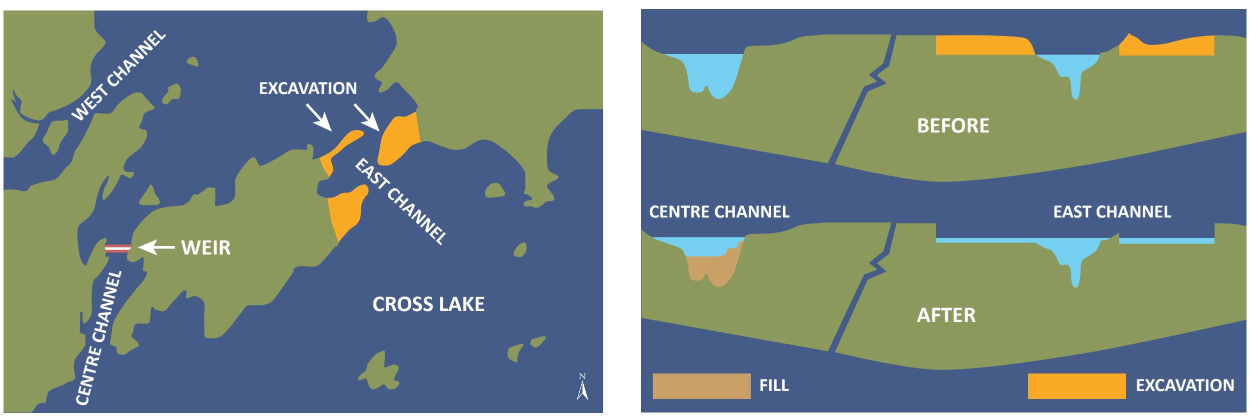


Figure 21: Cross Lake Weir and channel excavation.

Sipiwesk Lake to Kelsey Generating Station

The Kelsey Generating Station affects the water level on the Nelson River upstream, up to and including Sipiwesk Lake. The water level effects at the generation station are immediate and diminish as you go upstream to Sipiwesk Lake. Hourly variations generally influence water levels between Sipiwesk Lake and the Kelsey Generating Station while changes to the daily average can affect Sipiwesk Lake. Similar to the effects on Cross Lake, LWR has affected the seasonal flow pattern into Sipiwesk Lake and increased flooding in high-flow years.

Split Lake to Gull Rapids

The operations of CRD and LWR have affected water levels on Split Lake and downstream on the Nelson River to Gull Rapids, as shown in Figure 22. CRD has increased average flows, while both CRD and LWR have affected the seasonal flow pattern. Winter flows and levels are generally higher because of CRD and LWR. Specifically on Split Lake, the average water level is 1.2 feet higher now than before CRD/LWR. Also, the seasonal pattern of water levels has reversed with CRD/LWR.

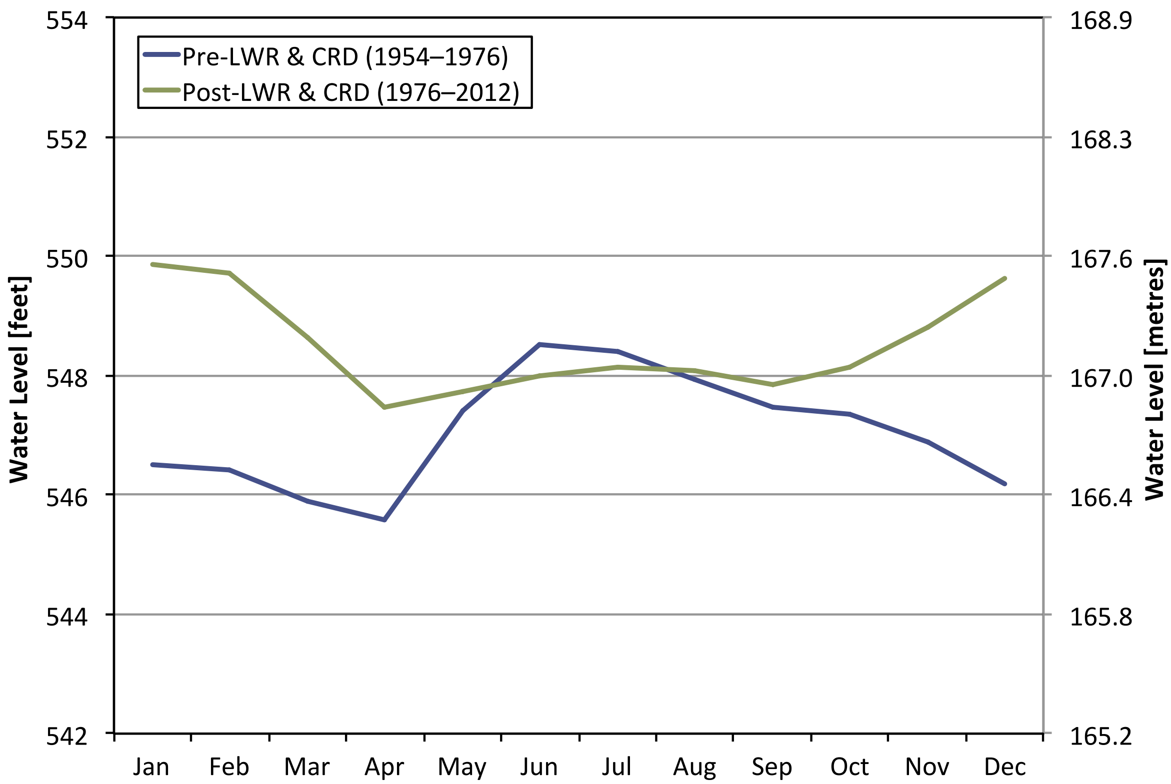


Figure 22: Monthly average Split Lake water level.

3.2.2 Shoreline Erosion

While shoreline erosion is a natural process that can occur in all waterways, LWR has accelerated erosion and debris generation/accumulation in several ways including through flooding in the Jenpeg forebay, increased water levels on Cross Lake, and at times increased flows in the Nelson River. Shoreline erosion can make accessing the shoreline difficult, and can result in the loss or addition of natural beach areas as well as islands, reefs, and other natural navigational markers.

Downstream Area communities have voiced concerns about shoreline erosion. NHCN and Norway House Community Council have indicated that the addition of Two-Mile Channel caused additional debris in Playgreen Lake which causes navigational hazards for fishers on the lake.

The CLFN has experienced increased erosion and debris in areas used by its members as a result of LWR. The Jenpeg forebay is located in the Cross Lake Registered Trapline District (RTD) and is used by members of the First Nation for resource harvesting. Portions of the forebay are also utilized by Norway House members.

Although Thicket Portage, Wabowden, and Pikwitonei are not located on a waterway impacted by hydroelectric development, some traplines within their RTDs have been affected by debris and other navigational hazards (*i.e.*, shallow areas, island erosion, and flooded reefs).

On Split Lake and through to Gull Rapids, the combined effects of LWR and CRD include impacts on erosion, debris, and navigation affecting TCN, YFFN, WLFN, and FLCN.

Manitoba Hydro understands LWR's effect on shoreline erosion, navigation hazards, and debris as follows:

- Two-Mile Channel provides a second flow path for debris from the north shore of Lake Winnipeg to enter Playgreen Lake.
- Erosion has been ongoing in Two-Mile and Eight-Mile Channels and is regularly monitored by Manitoba Hydro as part of a program that was established in 1978.
- LWR does not significantly contribute to shoreline erosion on Playgreen and Little Playgreen Lakes because the average water level is similar to what it would have been without LWR. LWR has also reduced the range of water levels on these lakes. Previous studies support this conclusion (MacLaren Plansearch Inc., 1985; J.D. Mollard and Associates Ltd., 1994).
- LWR has resulted in increased rates of shoreline erosion and increased debris in the Jenpeg forebay. LWR caused about 25 square miles of flooding, which is confined to the Jenpeg forebay area.
- The Cross Lake shoreline is mostly bedrock during most water levels. However, during extreme high-flow events, significant erosion can occur on susceptible shorelines, as it did during the 2011 flood. LWR may increase shoreline erosion by increasing the timing and magnitude of high-flow events. The increase in average water level as a result of the Cross Lake weir may have also increased erosion rates in areas susceptible to erosion.
- Downstream from Cross Lake, LWR along with other projects contribute to shoreline erosion and debris.

For more information on Downstream Area shoreline erosion see Appendix 5. Manitoba Hydro's efforts to address navigational hazards and debris is discussed in Section 3.4.4.

3.3 Environmental Effects

Manitoba Hydro has heard and acknowledged the concerns that have been expressed about the impact LWR has had on **water quality**, fish populations, mercury levels, and wildlife downstream of (north of) Lake Winnipeg. In this section, these concerns are reviewed and the most recent knowledge is provided.

Manitoba Hydro and Manitoba have developed a systematic, system-wide aquatic monitoring program that monitors key physical, chemical, and biological parameters associated with waterways affected by Manitoba Hydro's hydraulic generation system, including LWR, CRD, the Winnipeg River, and the Saskatchewan River. The Coordinated Aquatic Monitoring Program (CAMP) creates a basis to better understand the **environmental effects** of hydroelectric development. For additional CAMP information refer to Section 5.3.

For a more detailed environmental analysis, readers are encouraged to review Appendix 6.

3.3.1 Water Quality

Changes in water quality have been a major concern of most communities located in the area affected by LWR. The primary concerns expressed include: increased **turbidity** (cloudiness of water caused by small particles) and a corresponding decrease in water clarity; increased algae in the water; increased mercury in the water; and decreased oxygen in the winter which in some areas (such as Cross Lake prior to the construction of the weir) has killed fish. Overall, there is a general feeling among the community that water quality has deteriorated and that the poorer water quality has affected aquatic life.

The LWCNRSB report made a number of predictions related to water quality resulting from LWR (see Appendix 6 for more details). Potential pathways of effects to water quality are primarily related to changes to flow rates and patterns due to construction of various channels and regulation of water levels. Potential effects of these physical changes on water quality include increased turbidity due to increased shoreline erosion; decreased turbidity due to increased sedimentation in reservoirs; increased nutrients and metals from erosion, transport and flooding, and decreased **pH** and dissolved oxygen due to decomposition of flooded **organic** materials; decreased dissolved oxygen due to increased water residence times and/or changed ice regime; and changed water temperature due to changed water levels, flows, residence times, and velocities.

Studies of water quality have been conducted prior to and following LWR. Most water quality parameters were within Manitoba water quality objectives and guidelines for the protection of aquatic life prior to and following LWR. This means that most parameters were at **concentrations** over the long term necessary to support a healthy aquatic **ecosystem** (including plants, invertebrates, and fish).

However, some changes in water quality were noted in some waterbodies after LWR. Changes in Cross and Sipiwesk Lakes were assessed by Playle and Williamson (1986) and Williamson and Ralley (1993) and the conclusions of these studies were largely in agreement. For Cross Lake, these assessments concluded no changes to a number of parameters including **total suspended solids** (TSS), hardness, **conductivity**, pH, alkalinity, calcium, magnesium, sulphate, and coliform bacteria, increases in total inorganic and organic carbon, and chloride and decreases in colour and nitrogen. Other changes are less clear as the findings and trends in the scientific literature are inconsistent or contradictory. Overall, Williamson, and Ralley (1993) wrote that changes in water quality following LWR were of "small magnitude and should not have significantly affected water uses."

For Sipiwesk Lake, these assessments concluded no changes to a number of parameters including phosphorus, hardness, pH, alkalinity, calcium, magnesium, sulphate, decreases in colour and nitrogen, and increases in some major ions (chloride, sodium, and potassium), carbon (inorganic and organic forms), and fecal coliform bacteria. Williamson and Ralley (1993) concluded that water quality changes in Sipiwesk Lake after LWR "probably had little effect on vegetation and aquatic organisms since all statistically significant changes were below the Manitoba Surface Water Quality Objectives."

Despite the existence of a comprehensive database, the effects of LWR on water quality downstream of Kelsey Generating Station are difficult, if not impossible, to separate from the effects of the CRD. While it is clear that water quality effects did occur including decreased conductivity (the extent to which water can pass an electrical current), the effects are much more closely related to the effects of CRD than LWR and cannot be separated.

In recent years, water quality has been monitored regularly by the Province of Manitoba and Manitoba Hydro under CAMP. Seven sites in the LWR area were sampled over the period of 2008 through 2010, including both on-system and **off-system** waterbodies. Consistent with earlier studies, the results showed that most water quality parameters were within Manitoba Water Quality Standards, Objectives and Guidelines (MWQSOGs) for the protection of aquatic life (PAL); including important parameters such as pH, ammonia, nitrate/nitrite, and most metals. There were a few parameters that exceeded the MWQSOGs for both on-system and off-system waterbodies. Total phosphorus concentrations on average exceeded the Manitoba narrative guideline for nutrients (0.025 mg/L for lakes, reservoirs, and ponds) in Playgreen, Little Playgreen, Cross, Walker, and Split Lakes (Figure 23). Dissolved oxygen was also below the most stringent PAL guideline at depth in an on-system lake (Cross Lake) and two off-system lakes (Walker and Setting Lakes) in some winters. Exceedances of Manitoba guidelines for aluminum and iron were observed in a number of waterbodies in the Downstream Area, including off-system lakes. Several other metals occasionally (*i.e.*, one sample at one site) marginally exceeded the PAL objectives or guidelines including mercury and silver.

While past studies indicate there were changes in some water quality parameters resulting from LWR, water quality monitoring conducted from 2008–2010 indicates that most water quality parameters are currently within MWQSOGs for the protection of aquatic life. In many cases where the objectives and guidelines were exceeded, the parameters were also exceeded in off-system waterbodies indicating these exceedances or conditions may result from factors other than LWR. Further, at least some parameters that are currently above guidelines for PAL were above these guidelines at some sites prior to LWR (*e.g.*, total phosphorus in Cross and Sipiwesk Lakes [Williamson and Ralley, 1993]).

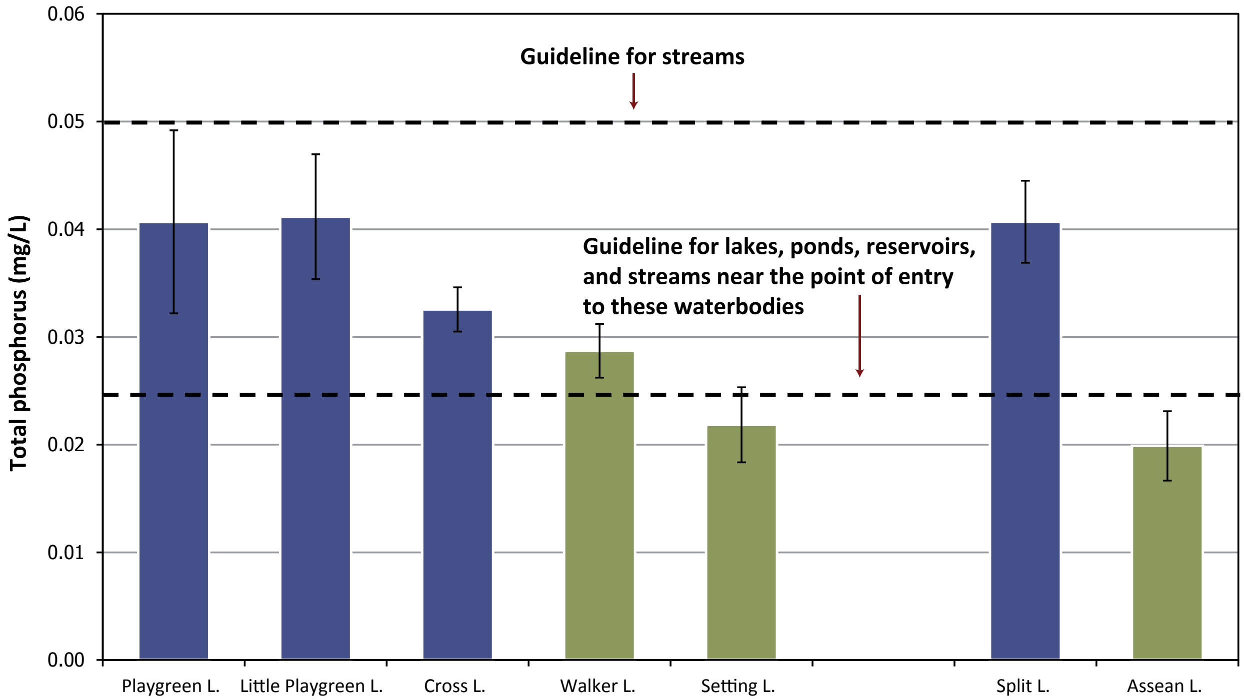


Figure 23: Mean ± Standard Error (SE) total phosphorus in waterbodies sampled as part of CAMP, 2008–2010 (modified from CAMP, 2014). Dashed lines indicate the Manitoba narrative guideline for TP. Off-system waterbodies are indicated in green.

As stated earlier, many studies of water quality have been conducted prior to and following LWR. Results of these studies found that most water quality parameters were within Manitoba water quality objectives and guidelines for the protection of aquatic life prior to and following LWR. Water quality continues to be monitored under CAMP.

3.3.2 Fish Populations

Communities have expressed a number of concerns regarding the effects of LWR on fish populations. These include: decreased fish populations; changes in the relative abundance of key fish **species** such as Lake Whitefish; increased mercury levels in fish; and a decline in the taste and texture of the fish.

The types of effects vary between waterbodies depending on the types of physical changes that occurred (*e.g.*, whether average water levels increased or decreased after LWR). To some degree, this depends on whether the waterbody is upstream or downstream of Jenpeg and whether it was affected by other developments such as the Kelsey GS and/or CRD.

Upstream of Jenpeg, the physical changes in the water regime changed fish habitat ranging from minimal, due to a small increase in water levels at Playgreen Lake, to much more substantial increases in water level and a change from a river to a reservoir environment in the Jenpeg forebay.

The construction of channels to facilitate flow (Two-Mile and Eight-Mile) has also resulted in localized increased suspended **sediments** which would contribute to increased turbidity and sediment deposition that would affect fish habitat. Other LWR effects would include the loss of aquatic habitat due to the physical presence of dams and control structures which create blockages preventing upstream fish movement.

Even though physical changes from LWR have occurred in the area upstream of Jenpeg, studies do not indicate that large, negative impacts have occurred to fish populations in most areas. Moreover, commercial fishing harvests continue to be high in Playgreen Lake and CAMP data show that Playgreen Lake fish populations are relatively healthy with high fish catches compared to many other waterbodies in the area (including waterbodies not affected by Manitoba Hydro). Therefore, while the LWR water regime has had effects on fish habitat, most fish populations in the area upstream of Jenpeg area continue to support both commercial and domestic fisheries.

The primary effects of LWR downstream of Jenpeg (**upper Nelson River**) include: decreased water levels and flows in some areas; seasonal reversal of flow pattern (*e.g.*, increased winter flows and decreased summer flows); and loss of aquatic habitat due to the physical presence of dams that have created blockages preventing upstream fish movement.

In Cross Lake, fish populations (particularly Whitefish and Tullibee) declined substantially after LWR. This was particularly important as Whitefish was the preferred food fish of the Elders. These declines were primarily attributed to reduced **spawning** success due to the timing of periodic dewatering of spawning areas, the drying out of Whitefish eggs in the winter associated with the Jenpeg freeze-up program (see Section 2.3.2 LWR Operations), and fish kills when water levels were particularly low.

The construction of the Cross Lake weir, in 1991, has substantially reduced the water level effects. Although Whitefish populations continue to be low, the overall fish **community** has stabilized. The relatively recent presence of Rainbow Smelt, which are also competitors with small Whitefish, could contribute to reduced recovery of Whitefish populations. After a commercial fishery closure between 1982 and 1995, the lake now supports both domestic and commercial fisheries. Although commercial catches on Cross Lake for Lake Whitefish are substantially lower, Walleye harvests are similar to pre-LWR levels and Northern Pike catches have increased.

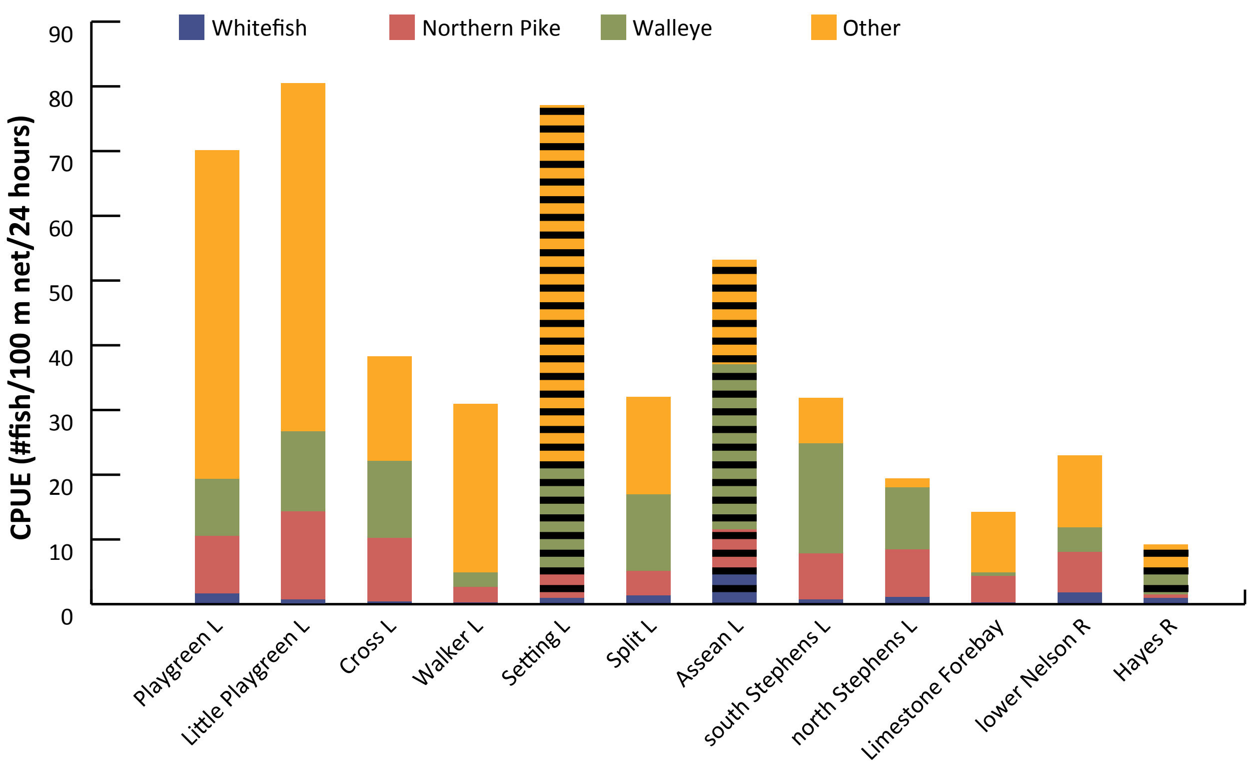


Figure 24: Mean catch-per-unit-effort (CPUE) for the total catch and select fish species in standard gang index gill nets in waterbodies sampled as part of CAMP, 2008–2010 (off-system waterbodies are indicated with lined bars as opposed to solid colours).

Overall it is difficult to separate the effects of LWR from other factors that are also affecting fish populations in the area including: the introduction of Rainbow Smelt which has significantly altered fish communities in some areas; the effects of other projects such as the Kelsey Generating Station and CRD; and climate change among others. However, current conditions on a number waterbodies between Playgreen Lake and Gull Rapids will continue to be monitored as part of CAMP to determine the overall health of the waterbody and what changes, if any, are occurring.

Information on the domestic and commercial fisheries is discussed in Section 3.4.3.

3.3.3 Mercury

In the mid-1970s, it was discovered that flooding caused by hydroelectric development increased mercury levels in the nearby aquatic environment. Information on elevated mercury levels in fish from impounded water in the Churchill River and Nelson River systems was first published in 1979. Since that time, a large amount of research has been conducted to study the processes that led to elevated mercury concentrations in water and organisms living in reservoirs and in the rivers downstream.

Mercury levels were high in fish in the early 1970s prior to LWR, and a number of commercial fisheries, including Lake Winnipeg itself, were closed. These elevated concentrations were attributed primarily to chemical production facilities in Saskatchewan and Ontario which used large amounts of mercury in their process to make chlorine and sodium hydroxide.

Most lakes affected by LWR were not flooded and scientific studies have shown that there were no large increases in the mercury content in fish from lakes (such as Cross Lake).

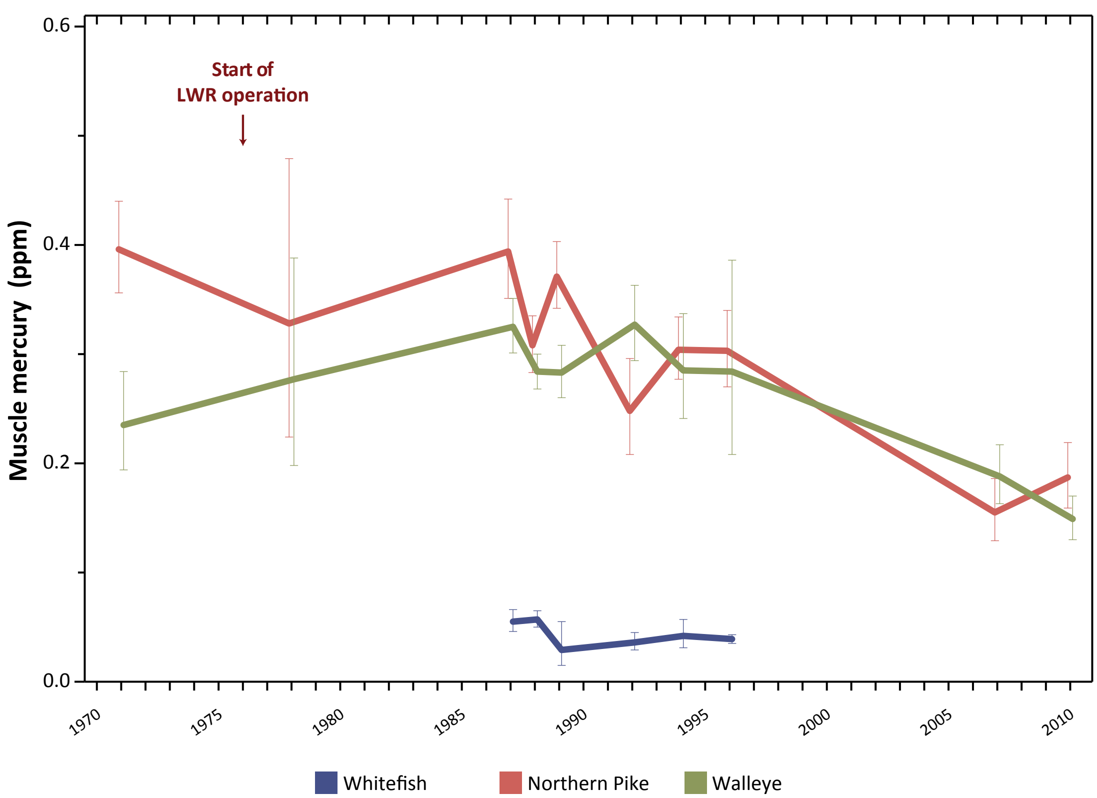


Figure 25: Mean length-standardized muscle mercury concentrations from Cross Lake 1971–2010.

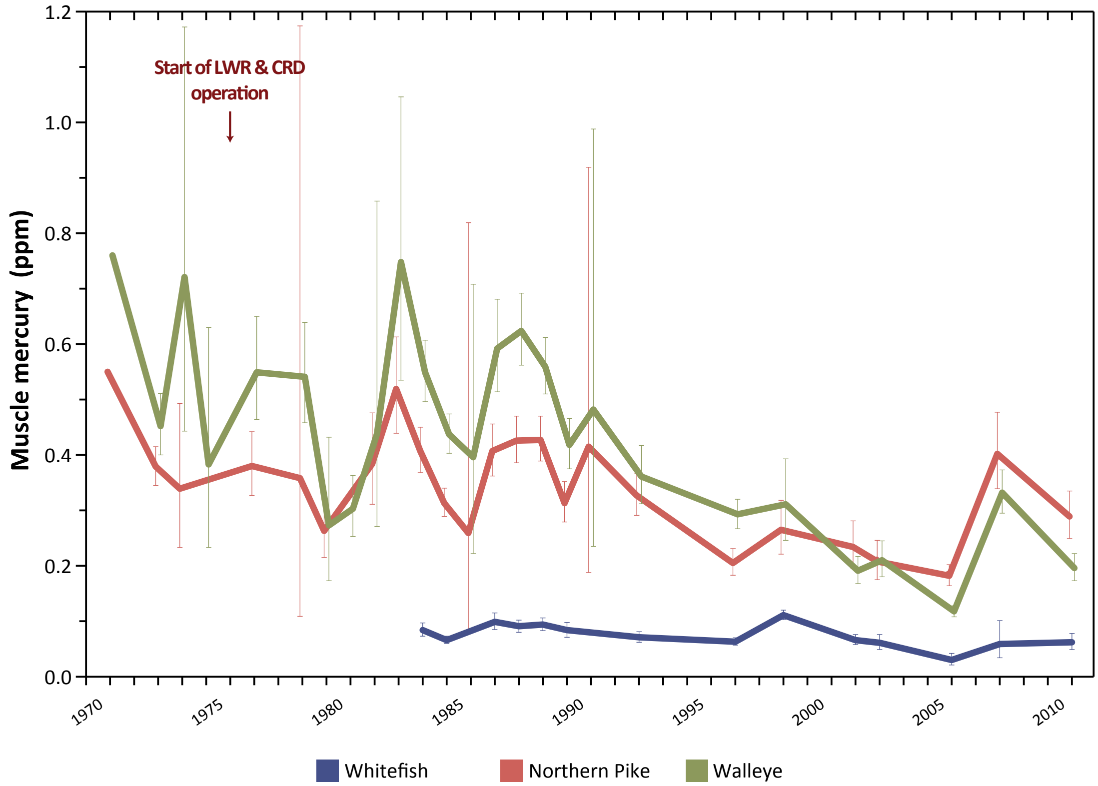


Figure 26: Mean length-standardized muscle mercury concentrations from Split Lake 1971–2010.

Fish mercury concentrations have been monitored extensively since the link between reservoir flooding and increased mercury levels was made. These will continue to be monitored under Manitoba Hydro and Manitoba's CAMP in a number of waterbodies affected by LWR. It has been found that mercury levels in the Downstream Area have declined to pre-LWR or near pre-LWR levels. Figures 25 and 26 show the mercury concentrations from Cross Lake and Split Lake.

Health concerns with mercury are discussed in Section 3.4.5.

3.3.4 Wildlife

Communities along LWR that rely on wildlife resources have expressed concerns that there has been a reduction in waterfowl, aquatic **furbearers** (like beavers and muskrat), and moose populations since regulation.

As with fish populations, the effects of LWR on wildlife populations vary according to the species of wildlife and the specific physical changes that occurred. Since most of the changes were on or near the water, those species most closely associated with riparian habitat (near the shoreline) would be most affected by the change in water regime. **Upland** species that don't utilize shoreline habitats would be less affected.

More specifically, upstream of Jenpeg some wildlife would likely have been affected by direct loss of **terrestrial habitat** due to flooding and the physical presence of hydro structures. However, it is difficult to assign an amount of impact in this area due to a lack of pre-and post-LWR population data and in most cases, commercial harvesting data (particularly for trapping) do not accurately reflect animal abundance. Other factors, such as fur prices, have a large effect on the amount of harvesting activity that takes place.

Waterfowl data suggest LWR may have affected the distribution of some diving duck species, but the link to LWR is unclear. Natural variability in North American waterfowl populations over the last several decades along with broader regional habitat alterations and flyway pattern changes, makes quantifying local impacts very difficult. For example, wet conditions on the Canadian Prairies are believed to have contributed to record high duck counts in 2012 and this sort of external factor could be contributing to local abundances.

Factors such as increased access and harvest pressure along with land use management activities have contributed to the impacts on moose populations and changes to the ecosystem on which they depend. This confounds quantification of the impact of LWR's physical changes.

Downstream of Jenpeg, fluctuating water levels likely affect aquatic furbearers like muskrat and beaver in the winter, and moose through loss of shoreline access and a reduction in available food. Changes to shoreline habitat may also have affected the distribution or use of an area by nesting waterfowl.

The post-LWR seasonal reversal of water levels in the Cross Lake area negatively affected shoreline habitat for waterfowl, aquatic furbearers, and moose. Increased water level fluctuations in the late fall and winter also reduced muskrat and beaver populations and, to a lesser extent, mink and otter populations. Moose were affected by the loss of aquatic vegetation along the shoreline in the spring and increased harvesting pressure caused by increased road access along with habitat **fragmentation** due to various development activities.

Construction of the Cross Lake weir improved conditions on Cross Lake for wildlife by reducing the water level range and increasing minimum levels in the spring and summer. However, as with in the area upstream of Jenpeg, quantifying the amount of change due to LWR and the benefits of the weir are difficult given the large natural variability in wildlife populations (especially waterfowl), the impacts from increased access and harvest pressure on animal populations, and the changes to terrestrial ecosystems associated with land management practices and other forms of development.

The effects of LWR on wildlife in the Sipiwesk to Gull Rapids area is difficult to determine due to the effects of other facilities such as Kelsey GS and CRD as well as other factors such as harvesting pressure and climate change.

3.4 Socio-economic Effects

Development of LWR has resulted in positive and negative effects on individuals and communities. While Manitobans in general gained from access to reliable and low-cost power as well as economic development opportunities (training, employment, and business opportunities), people downstream of Lake Winnipeg have experienced negative effects arising from environmental changes, an increased rate of modernization, and inadequate participation in decision making.

To understand the effects of LWR on the socio-economic environment, a number of factors that play a part in the well-being of people, families, and communities are considered. Changes in the physical environment can directly affect the health and well-being of people. For example, changes in water levels and flows can affect the safety of water and ice conditions for travel. Physical changes can also affect heritage resources. Changes to the habitat for plants, animals, and fish can affect the land and resources that are used by people for sustenance, as well as to support their overall way of life. While not the focus of this document, project construction activities and related expenditures can affect local populations through short-term employment, business opportunities, and the in-migration of workers. Some of these effects can continue beyond construction.

This section describes Manitoba Hydro's understanding of and response to effects in the Downstream Area on:

- culture, way of life, and heritage resources;
- the way the landscape looks;
- resource use;
- reserve land;
- navigation, transportation, and public safety;
- health issues and concerns;
- personal property loss and damage;
- employment, training, and business opportunities.

The socio-economic environment in the Downstream Area has also been affected by non-hydroelectric development activities including commercial and domestic resource use, industrial development (*i.e.*, mining and forestry), and the development of infrastructure such as roads, railways, and airstrips. As well, government policies and programs (*i.e.*, the residential school system, the welfare system, and Registered Trapline System) have had significant impact on the communities, families, and individuals living in the area. Looking back, it is not always possible to separate the impacts of these other developments, events, and policies from the impacts of LWR.

3.4.1 Culture, Way of Life, and Heritage Resources

Development of waterways can result in the physical loss or destruction of cultural resources, the loss of culturally important places (such as buildings or places of cultural, spiritual, or religious meaning), and general changes to the landscape (physical and aesthetic). Such loss and change can affect attachments to the land that have been forged over generations, and one's ability to exercise customs, practices and traditions. Because of their inherent link to place, cultural practices and pursuits are not always replaceable or transferable to other locations and, as such, related effects cannot always be mitigated.

In the Downstream Area, water regime changes and related flooding and exacerbated shoreline erosion have negatively affected culture, ways of life, and heritage and archeological resources for people living along and using affected waterways. This has resulted in the reduction of traditional, cultural, social, and recreational opportunities, and related infrastructure that relied on unregulated waterways and shorelines, including losses of traditional spiritual sites, burial grounds (and exposure of human remains), meeting places, beaches, and seasonal family campgrounds.

Addressing Effects on Culture, Way of Life, and Heritage Resources

Settlement Agreements
Various settlement agreements contain specific provisions addressing impacts on culture, way of life, and heritage resources. This includes related impacts on resource use and recreation. Specific related claims were submitted through the NFA arbitration process, and settled either through settlement agreements or through the negotiated CIAs.

Archaeological Programming
Since the development of LWR, Manitoba Hydro has been conducting or participating in a variety of archaeological programs to address impacts from past development and to prepare for future developments. Agreements are also in place committing additional resources for the future. As well, communities have negotiated agreements directly with government regarding heritage resources of importance to them. The identification and protection of potentially at-risk heritage resources and found human remains are a requirement of provincial legislation and Article 7 of the NFA. Manitoba Hydro has worked closely with Aboriginal communities and the provincial Historic Resources Branch (HRB), which enforces the *Heritage Resources Act* (1986). In addition to the *Heritage Resources Act*, Manitoba Hydro's projects adhere to the provincial Policy Concerning the Reporting, Exhumation and Reburial of Found Human Remains (1987).

Archaeological activities being funded by Manitoba Hydro in relation to LWR include:

- Archaeological mitigation efforts for the Hunting River Burial Site (Nelson River) in collaboration with the Province, Pikwitonei Community Council, and CLFN;
- The Sipiwesk Lake Archaeological Program, which is funded by Manitoba Hydro through the Cross Lake Action Plan and delivered by the HRB. Sipiwesk Lake comprises a large area, has upwards of 3,200 km of shoreline, and is virtually unknown archaeologically. The program is a cooperative venture that also includes the participation of the Manitoba Museum and the Manitoba Department of Aboriginal and Northern Affairs. The objective of this program is to identify the locations of archaeological sites on Sipiwesk Lake and to provide a preliminary assessment of the cultural resources on a site-by-site basis to be integrated into a plan for the management of the area's heritage resources;
- A System-Wide Archaeological Project (SWAP) being conducted by HRB for areas not covered by the above programs. This 10-year $950,000 agreement was signed in 2006. The purpose of this program is to assist Manitoba Hydro in managing the impact on heritage resources within specific areas of Manitoba affected by past hydroelectric development, but not already managed under other established Manitoba Hydro supported archaeological programs. The SWAP encompasses the Winnipeg River in the southeast, the Laurie River in the northwest, portions of the Nelson River in the northeast, and the Saskatchewan River-Cedar Lake area in central-western Manitoba;
- Shoreline protection initiatives for a number of at-risk sites along developed waterways, such as cemeteries, burial sites, and other culturally important sites; and
- Work undertaken in partnership with the Community at the Chipiy Naya site and cemetery around the Anglican Church on TCN Reserve Land to protect human remains threatened by erosion.

3.4.2 The Way the Landscape Looks

LWR has resulted in physical and visual changes to the landscape, including the water and waterways. The presence of new physical infrastructure can influence the visual landscape, particularly in sensitive settings. The way the landscape looks (aesthetics) does, to a certain extent, differ according to a person's values and perspectives. An individual's response to visual changes on the landscape and the magnitude of the concern related to a particular viewscape is a function of the types of views involved, the distance, perspective, and duration of view. The way the landscape looks will depend on:

- the physical relationship of the viewer (*e.g.*, living in the area, driving through, sightseeing); and
- the contrast between the project and the surrounding environment.

Manitoba Hydro has heard concerns from communities affected by LWR regarding changes to the way the land and water look. This has included, for example, concerns that the water is no longer clear (or is "muddy"), that sandy beaches and islands have been lost, and that physical infrastructure in the water caused disruption. Visual impacts are strongly related to impacts on culture, spirituality, and way-of-life.

3.4.3 Resource Use

Development of waterways can affect resource use in a number of ways. Examples include enhancement or reduction of access to resources, loss of harvesting and gathering areas through flooding and reduced wildlife or plant populations.

LWR resulted in negative effects on domestic and commercial resource harvesting including fishing, hunting, trapping, gathering of medicinal and other plants/berries, and fuel wood. Effects on resource harvesting have resulted in negative effects on the connection of communities to the land, patterns of traditional food consumption and food security, and the ability of communities to practise their customs and traditions and transmit traditional teachings to younger generations.

Effects on resource use are among the most commonly raised concerns by communities and resource user groups. This is reflected in the negotiation of a large number of related settlement agreements (both through the NFA arbitration process and other settlements with other communities and resource user groups). It is also reflected in the significant number of studies that have been completed on resource use. For further information on fish population refer to Section 3.3.2 and Appendix 6.

The sections below broadly describe effects on domestic and commercial fisheries, trapping, and hunting.

Domestic and Commercial Fisheries
Impacts on fish populations are among the most studied effects of northern hydroelectric development, from both an environmental and a socio-economic perspective. The volume of study on this topic, as well as the extent of community concerns that have been voiced, reflects the importance of fish to local communities. Domestic and commercial fishing are vital to the people of northern Manitoba. Commercial harvesting data and fish population research have been extensively analyzed in response to claims launched against Manitoba Hydro – which have generally been resolved.

As noted in Section 3.3.2, fish communities in areas affected by the LWR have responded differently depending on the effects on the water regime. As a result, related project effects on associated domestic and commercial fisheries have varied as well.

In addition to concerns about the fisheries, communities affected by LWR have expressed concerns regarding the taste, texture, and quality of fish caught for domestic consumption. Manitoba Hydro has worked with communities to understand these concerns and has engaged outside assistance (Fisheries and Oceans Canada

[DFO] in one study and University of Manitoba in three studies) to test the fish in several communities. The study conducted by DFO at Norway House included taste tests (a simple pass or fail) by their fish quality lab as well as tests for various contaminants. All fish passed all tests. In the studies conducted by the University of Manitoba, panelists from all three communities (Bird, Split Lake, and York Landing) showed some preference for fish from lakes that have not been previously affected by hydroelectric development. However, the difference in mean palatability scores to on-system waterbodies was not statistically significant. It was noted that the results of the palatability study, particularly at York Landing, do not reflect the views of most community members on the taste of fish species used in the study. In particular, there was a concern that no fish were tested that were captured when water temperatures were warmer and taste differences would be more noticeable.

Addressing Effects on Fisheries (Domestic and Commercial)

Settlement Agreements

Manitoba Hydro has entered into several settlement agreements that specifically address effects on commercial and domestic fishing activities. Implementation of the NFA resulted in a significant number of retroactive and interim compensation arrangements and/or settlement agreements addressing fishery impacts. For NCN, YFFN, TCN, and NHCN, these agreements, as well as any related outstanding claims, were fully and finally resolved through the negotiation of CIAs. The CIAs include provisions regarding resource use impacts, including impacts on fishery activities. At Cross Lake, ongoing implementation of the NFA includes implementation of a summer and winter domestic fishing program that pays domestic fishers to fish on Cross Lake and some off-system lakes and to bring the fish back into the community where it is made available for members. As part of a settlement of a specific claim under the NFA, the Province and Manitoba Hydro provided funds for the delivery of programming to encourage and support commercial fishing at Cross Lake.

Settlement agreements with other groups related to the fisheries have been negotiated as well. This includes, for example, agreements with the Sipiwesk Lake Commercial Fishermen's Association and the Ilford Community Council.

Lake Sturgeon Stewardship and Enhancement Program

Manitoba Hydro has implemented the Lake Sturgeon Stewardship and Enhancement Program as a commitment to maintain and enhance Lake Sturgeon populations in areas affected by Manitoba Hydro's operations, now and in the future. Program activities include:

- determining the status of Lake Sturgeon populations throughout areas affected by Manitoba Hydro's operations and identifying factors that may be limiting populations;
- funding and conducting research relating to hydroelectric facilities and Lake Sturgeon in Manitoba;
- reducing the effects of new and existing facilities on Lake Sturgeon populations;
- participating in the management and recovery of existing stocks by promoting education and community participation through sturgeon management boards;
- educating the public and raising awareness; and
- rearing and stocking of Lake Sturgeon.

Nelson River Sturgeon Board

The Nelson River Sturgeon Board was established in 1993 for an initial 10-year term to fulfill a sturgeon-related claim under the NFA. Community representatives from the Board reside at Norway House, Cross Lake, Split Lake, York Landing, Wabowden, Thicket Portage, and Pikwitonei. Now that the original term is complete, the program relies on funding from Manitoba Hydro and the Province of Manitoba that is not based on claims. The work of the Board covers the reach of the Nelson River between Cross Lake and the Kelsey Generating Station.

The mandate of the Board is to: (a) to provide for the subsistence and cultural needs of the communities as it relates to Lake Sturgeon; and (b) to provide for the preservation of declining Lake Sturgeon stock. As part of a five-year review of the initiative, education programming in both schools and the communities related to cultural and traditional ties to sturgeon will be expanded. Through education, the goal is to curtail harvesting by increasing awareness about the Nelson River Lake Sturgeon population.

Kischi Sipi Namao (Formerly Lower Nelson River Sturgeon Stewardship Committee (2013–present)

Kischi Sipi Namao comprises interested stakeholders committed to implementing measures to protect and enhance sturgeon populations in the lower Nelson River from the Kelsey Generating Station to Hudson Bay, as well as the Hayes, Gods, and Echoing Rivers and **tributaries** along the Nelson River that are important to these fish. The Kischi Sipi Namao was established in May 2013 under the lower Nelson River Sturgeon Stewardship Agreement. It includes representation from the Lower Nelson First Nations of FLCN, YFFN, TCN, WLFN and the Shamattawa First Nation, along with Manitoba Hydro and the Keeyask Hydro Limited Partnership. Manitoba Conservation and Water Stewardship also participates as a non-voting member. Committee activities will consider the Lake Sturgeon Management Strategy for Manitoba developed by Manitoba Conservation and Water Stewardship. Funding for the Kischi Sipi Namao is provided by Manitoba Hydro and is guaranteed for a 20 year term, after which funding may be renegotiated.

Hunting, Trapping, and Gathering

The effects of waterway development on activities such as hunting, trapping, and gathering of medicinal plants/berries are caused by changes to habitat and disruption/loss of plant species of importance, and changes to the number and location of species. Project operations also can increase access which can result in loss of resources through pressure on the resource by non-community members. Effects can also occur as a result of navigational challenges created for hunters, trappers, and gatherers (*e.g.*, fluctuating water levels in summer time, debris and other navigational hazards along affected waterways, and poor ice conditions in winter). These pathways have reduced opportunities and increased costs and time for trappers and hunters to undertake this traditional pursuit in the Downstream Area.

Addressing Effects on Hunting, Trapping, and Gathering

Manitoba Hydro has entered into several settlement agreements that specifically address impacts on commercial and domestic hunting and trapping activities, and impacts on community traplines. In some cases these agreements stem from claims under the NFA, and include related programming and support measures.

In addition, the NFA and CIAs deal with impacts on wildlife in several ways. Article 10 of the NFA indicates that Manitoba will have regard to minimizing the destruction of wildlife caused by controlling water levels and flows on project-influenced waterways to the extent that is practical. Article 15 of the NFA gave priority over wildlife harvesting to the NFA First Nations within areas most commonly used by them for those purposes, or alternate areas, and includes provisions to support the continued opportunity to hunt, fish, and trap. As well, Resource Management Boards (RMBs) were established under the CIAs to consider broader resource management issues specific to each First Nation's resource area and to develop resource management plans.

Schedule D of the NFA established the Registered Trapline Program to provide for, over a certain time period, the relocation of traplines where necessary and compensation for the loss of fur production resulting from development, and to encourage the efficient use of existing fur resources. The program also provided for, where appropriate, improvements to portages and the establishment of additional access routes should the remaining or new trapline area substantially increase the travelling distance required. A Committee was established to administer the program and included representatives from Manitoba Hydro, a Conservation Officer, the President of the Local Fur Council, and a representative from Manitoba Aboriginal and Northern Affairs.

As part of a settlement of a specific claim under the NFA the Province and Manitoba Hydro continue to fund, manage, and deliver programming to encourage and support trapping in the Cross Lake RTD (to September 30, 2025). Programming has included the following components:

- Aquatic Fur and Incremental Effort Subsidy;
- Grubstake Loan;
- Registered Trapline Improvement Funding;
- Trapline Rehabilitation and Habitat Enhancement;
- Youth/Elders Trapping Training; and
- Annual Review and Consultation.

Settlement agreements with other groups related to trapping have been negotiated as well. This includes, for example, agreements with the Pikwitonei Trappers Association and trappers from Thicket Portage and Wabowden.

3.4.3 Loss of Reserve Land

Inundation of Reserve Land due to flooding, and the potential future loss of land due to erosion, have been addressed through the granting of an easement over land below a “severance” line in accordance with provisions set out in the NFA, CIAs, and other settlement agreements. Reserves were generally established with the title right to the water’s edge. Severance line in the NFA/CIA context is defined as the boundary of the easement area granted to Manitoba Hydro by Canada for inundation and storage of water. The easement area is based on engineering criteria of a 100-year water level, wind and wave events, and shoreline composition which determines the likelihood and extent of erosion.

Under the NFA, any Reserve Land taken was to be compensated by replacement land at a ratio of 4:1. Under the CIAs, the ratio of replacement land to taken land was substantially higher. As well, if any of the compensation land was subject to easement, that acreage did not count against the total.

Addressing Effects on Reserve Land
Manitoba Hydro monitors shoreline erosion and installs shoreline protection along affected Reserve Lands, cemeteries, and identified burial sites. Other remedial works undertaken have included, for example, replacement recreation opportunities, causeways, and beach restoration.

3.4.4 Navigation, Transportation, and Public Safety

Changes to water levels and flows caused by LWR have had a direct effect on navigation, transportation, and public safety in the Downstream Area. Changes to water levels and flows resulted in shoreline erosion (which makes accessing the shoreline difficult in certain locations), debris generation/accumulation, and navigation dangers (*e.g.*, floating debris, like driftwood). While these natural processes occur in all waterways, hydroelectric development can increase the rate at which they occur. Woody debris resulting from hydroelectric development and water regime changes has inhibited access to shorelines and bays and has created navigational hazards in the water. In some locations, debris has clogged or inhibited access to portages required by community members, fishers, and trappers following traditional or current lifestyles. Additionally, debris has impeded access and use of traditional gathering areas, beaches, or other shorelines having special value to local communities.

Changes in natural rates of water flow and water levels in LWR-affected waterways have altered the quality and timing of ice cover, which can adversely affect winter travel for resource harvesting and recreation. Shorter periods of ice cover, along with slush ice and ice jams have caused hazards for travellers and for wildlife in some areas. Winter travel for trapping, subsistence and commercial fishing, hunting, and general recreation is important to northern communities as a traditional and current lifestyle.

Addressing Impacts on Navigation, Transportation, and Public Safety

Maintaining public safety is very important to Manitoba Hydro. As a result, significant effort has been made to establish related mitigation measures to ensure the ongoing and safe use of affected waterways and areas.

Settlement Agreements

Various settlement agreements contain specific provisions addressing water regime, predetermined compensation, and, in some cases, transportation safety measures and environmental monitoring.

Waterways Management Program

Manitoba Hydro's Waterways Management Program (WMP) supports and promotes the safety of people travelling on waterways affected by Manitoba Hydro's operations. The program includes boat patrols, debris management, and safe ice travel. The program extends beyond the communities in the Downstream Area.

In the early stages of the WMP, there were a number of community requests for access to safe harbours as a refuge during severe storm events. Marking of these sites and clearing of debris to allow unencumbered access provides boaters with a safe alternative. Removal of debris provides safe unhindered access to facilitate travel within traditional resource use areas.

Boat Patrols

The purpose of the boat patrol program is to reduce floating debris hazards to make waterways safer for users. The patrols work during the open water season until just prior to freeze-up, usually from June to October. Boat patrols map and record daily routes, mark deadheads and reefs, identify debris work areas, place hazard markers identifying safe travel routes for resource users, and gather floating debris, deadheads, and old nets relocating them to safe areas.

Each boat patrol consists of two workers. Boat patrol workers are seasonal Manitoba Hydro or contract employees hired from northern Aboriginal communities. In 2012, a total of 19 patrols were deployed under the program (extending beyond the communities affected by LWR). Thirty-five seasonal Manitoba Hydro employees and five contract employees were hired in 2012. In addition to regular patrols and debris removal, boat patrol crews provide assistance to waterway users in emergency situations.

Debris Management

Following construction of LWR, Manitoba Hydro undertook a number of initiatives designed to respond to the individual concerns and needs of affected communities regarding debris management and clearing.

In 1998, Manitoba Hydro formalized debris clearing efforts into a single Debris Management Program (DMP). The program establishes priorities for debris clearing activities and includes a range of activities to enhance safety on impacted waterways. The guidelines for the program were developed through discussions with the province and affected Aboriginal communities.

The DMP includes identifying debris work locations, and collecting and burning debris. The program only deals with debris accumulated on shore. Floating debris is collected by the boat patrol crews. All debris collected is piled above the high-water mark to prevent it from going back into the water. Debris piles accumulated throughout the summer are usually burned late in the season, typically after the first snowfall, to minimize the risk of forest fire. The burning piles are monitored and water pumps are on stand-by. Burning permits are obtained from Manitoba Conservation and Water Stewardship.

Safe Ice Travel

Manitoba Hydro works with northern communities to develop and maintain a Safe Ice Travel Program. Safe ice trails are installed by seasonal contract workers, typically experienced resource users hired from northern Aboriginal communities. Trails are then monitored by local Manitoba Hydro employees who map the trails, test for ice thickness, clear obstructions, and routinely monitor and patrol the trails. The program's ice trails provide a safe alternative to travelling on unchecked routes. Safe cabins that can be used in emergency situations have been built into the trail network. The trails may vary slightly from year to year because of water levels, weather, and the quality of ice. Safe ice trails are generally monitored twice a week.

Water Level Forecast Notice Program

Manitoba Hydro's Water Level Forecast Notice Program informs people living next to waterways affected by Manitoba Hydro's operations of projected water level and flow conditions. Public safety is always the main consideration in any notification decision. The program began in the late 1970s as a result of NFA obligations to provide water level forecast notices to the five NFA First Nations. Since then, and through various negotiated settlement agreements with communities, the process has grown to include an increasing number of forecast notice sites, recipients, and copy requests. Notices are issued in both Cree and English. The frequency of notifications is increased in the event of rapidly changing conditions. These forecasts have been publicly available on the Manitoba Hydro website since the late 1990s.

3.4.5 Health Issues and Concerns

Hydroelectric development can result in both positive and negative effects on human health. Positive effects can result from an improved standard of living generated by project training, employment, and business opportunities. Health can also improve as a result of improved regional infrastructure resulting from direct and indirect government investments. Negative health effects can flow from biophysical pathways such as potential increased mercury exposure, potential changes in water quality, changes to patterns of traditional food consumption, food security, and stress and anxiety brought about by social change. The following sections summarize health effects documented in relation to LWR.

Water Quality and Potable Water

Changes to water quality can have a direct impact on the people and communities that rely on the affected waterway for drinking water, transportation, recreation, and a variety of other uses. Details on water quality were discussed earlier in Section 3.3.1.

Concerns regarding potable water raised by the NFA communities are acknowledged by the Government of Canada as its responsibility. Article 6 of the NFA reinforced the federal government's responsibility and states that "Canada accepts responsibility to ensure the continuous availability of a potable water supply on each of the Reserves. The quality of the water shall meet the health and safety standards set by Canada to protect the public health."

Addressing Impacts on Water Quality and Potable Water

At the time the NFA was signed, it was expected that changes in water quality resulting from hydroelectric development could increase water treatment costs (*e.g.*, to address increased total suspended solids levels). To address this, Article 6 of the NFA set out that "Canada shall be reimbursed by Hydro to the extent of 50% of its reasonable expenditures incurred in providing potable water to any Reserve to the extent that such expenditures are attributable to adverse effects of the Project, or to the risk of such adverse effects." In other words, Manitoba Hydro would reimburse 50% of the incremental costs associated with providing potable water if additional expenditures were incurred because of hydroelectric impacts. Disputes between Canada and Manitoba Hydro about what this meant and the costs eligible for reimbursement were resolved. Manitoba Hydro has met, and continues to meet, its reimbursement obligations to Canada.

Ongoing concerns raised by the NFA communities regarding potable water are appropriately deferred to the federal government.

Mercury

Changes in mercury can negatively impact the commercial and domestic fisheries in affected communities, as well as the suitability of fish for consumption (due to the risk to human health). LWR effects on mercury were discussed earlier in Section 3.3.3.

As there was no Cree word for "mercury," some of the information provided by government sources to the affected communities shortly after LWR, used the word "poison," which increased concerns regarding mercury in all areas regardless of whether mercury levels had increased or not. Concerns regarding elevated mercury levels in fish can be a source of stress and anxiety for local residents. If not addressed, such concerns could result in residents seeking to avoid foods they believe to be contaminated with mercury. While it has been found that current fish mercury concentrations are generally similar to pre-LWR levels it remains an issue of concern in many communities.

Addressing Community Concerns Regarding Mercury

Mitigation options for mercury are limited and have focused on consumption recommendations. Guidelines regarding safe consumption levels were developed in the 1980s through the Federal Ecological Monitoring Program (FEMP) and shared with affected communities.

FEMP was launched in 1986 by DFO as a joint five-year program of research and monitoring in northern Manitoba. FEMP was the result of Claim 18 (1981) under the NFA. Claim 18, which was filed by the five NFA First Nations and the NFC, alleged that the Government of Canada, the Province of Manitoba, and Manitoba Hydro had not met the responsibility of the NFA “to implement a long-term coordinated ecological monitoring and research program that would allow evaluation of impacts on the communities.” One of the programs focused on mercury. FEMP was initiated to look at the effects of Manitoba Hydro projects including LWR, CRD, and hydroelectric projects along the Nelson River.

The 1992 FEMP Final Report reported on mercury testing in First Nations across Canada done by Health Canada between 1976 and 1990 as part of a national program to test First Nations. LWR communities in northern Manitoba that were included in the program were Split Lake and York Landing, Norway House, and Cross Lake. Health Canada tested First Nations until 1999. Following that, testing was conducted at the request of a community.

Summary level FEMP results indicate that all of the communities had levels in the normal range. Split Lake, York Landing, and Cross Lake showed that of the members tested, 98 % had values in the normal range which is 0–19 parts per billion (ppb). In Norway House, 97 % had values in the normal range. The Health Canada Final Report did note a limitation with respect to the data in terms of trends including that individuals couldn’t be followed from year to year in published records and changes in the number of community members tested annually. The percentage of members tested in communities ranged from 15 to 33 %. Another limitation to the data noted is that the annual reporting of test results obscured any seasonal patterns that may have occurred.

3.4.6 Personal Property Loss and Damage

LWR-induced changes to the water regime have resulted in personal property loss and damage, and personal injury to individuals. Property damage includes, but is not limited to, damages to snowmobiles, outboard motors, nets and traps, boats, and other personal items.

Addressing Personal Property Loss and Damage

Under the NFA, members of the five participating First Nations were eligible to make claims for losses associated with LWR. Under the agreement, Manitoba Hydro has to establish that it did not cause nor contribute to a negative effect where any claim is made either by the First Nation or by an individual because of an actual or perceived negative effect. The intent of the NFA was that no affected party would be left in a worse position than they would have been in the absence of the negative effect. While CLFN is the only remaining community covered under the NFA, these principles have been carried over into the CIAs, as well as other settlement agreements with communities and resource user groups. Unlike the NFA, however, responsibility for managing the claims process was transferred to the community level and funds were provided to do so. Addressing individual claims of personal property loss and damage includes compensation and/or repair or replacement of damaged equipment and property.

In addition to the claims process, the Water Level Forecast Notice Program and the WMP are also in place to reduce personal property loss and damage, and contribute to personal safety.

3.4.7 Employment, Training, and Business Opportunities

Development of LWR has presented both short- and long-term employment and business opportunities. This includes operational employment, operational business opportunities, seasonal employment under the WMP, shorter-term employment and business opportunities associated with construction of projects and various mitigation measures (*e.g.*, the Cross Lake weir), and employment associated with the implementation of settlement agreements.

Enhancing Employment, Training, and Business Opportunities

Manitoba Hydro has a range of programs and policies designed to encourage and enhance Aboriginal representation in Manitoba Hydro's projects and operational work force, and to promote the participation of northern Aboriginal businesses in construction and operations activities.

4.0 Public Engagement and Public Concerns—Lake Winnipeg

As any Lake Winnipeg cottager, year-round resident, fisher, or boating enthusiast will tell you, Manitoba's largest lake is impressive and majestic. It is perhaps the most remarkable natural feature of the province. Its waters are home to a large commercial and recreational fishery; its shores a home for Aboriginal communities and thousands of other year-round residents, and a haven for cottagers and tourists. The lake also serves as a transportation system and holds cultural significance for many Manitobans.

Through many interactions with communities, individuals, environmental and cottage associations, Manitoba Hydro has learned about stakeholder concerns with Lake Winnipeg and LWR. They include water levels, shoreline erosion, water quality, the commercial fishery, and the Netley-Libau Marsh. This section describes Manitoba Hydro's public engagement efforts, the concerns of lake stakeholders learned through these efforts, reviews the extent of LWR's influence on the lake, and shares the most recent knowledge on these concerns.

4.1 Public Engagement

Manitoba Hydro has undertaken a wide range of public participation initiatives to learn about the interests and concerns of stakeholders downstream and around Lake Winnipeg as well as among the general public. These activities also provide an opportunity to increase the public's understanding of LWR and its influence on the lake and downstream waterways.

In recent years, engagement with First Nations, communities, and cottage and environmental associations on Lake Winnipeg has increased. This is for two reasons: first, there is a broad-based desire to strengthen communication with all stakeholders along waterways used by Manitoba Hydro's system; and second, there is increased interest in LWR operations, heightened by the LWR Final Licence request. In 2013 Manitoba Hydro's Lake Winnipeg Engagement Program was initiated to provide all First Nations and communities around the lake with the opportunity for ongoing dialogue with Manitoba Hydro on Lake Winnipeg and LWR. To date all communities around Lake Winnipeg have been contacted and provided an opportunity for on-going dialogue. In some cases this has resulted in further communications with their broader community, and to partnering on lake-based community initiatives (as described below).

Manitoba Hydro engages with the public at many levels – through direct contact such as the Lake Winnipeg Engagement Program, and indirectly through participation and financial support of Lake Winnipeg stakeholder initiatives involving scientific research, water policy and management, and education. Key examples of the latter include the following:

- Lake Winnipeg Research Consortium to help support the operation of the research vessel Namao, the advancement of research, and the sharing of information about Lake Winnipeg.
- The Water Innovation Centre of the International Institute of Sustainable Development to demonstrate innovative water management solutions with a focus on the Lake Winnipeg basin.
- The new Lake Winnipeg: Shared Solutions exhibit at The Manitoba Museum raises awareness of the excess-nutrient issues plaguing the lake and how to address them.
- Lake Friendly Stewards Alliance and Accord, is a multi-stakeholder initiative spearheaded by Minister Gord MacIntosh and Dunnottar Mayor Rick Gamble, to improve water quality by reducing nutrient loading across the Lake Winnipeg basin through the engagement of all stakeholders.
- Become An Aquavist public education program of Lake Friendly to educate, engage and empower the general public to take action to protect Lake Winnipeg.
- First Nations Alliance for Lake Winnipeg initiative for First Nations residing around Lake Winnipeg to share environmental stewardship perspectives and identify common goals for the lake.
- The Survey of the Physical Environment on Lake Winnipeg, and the Lake Winnipeg Shore Processes and Ice Scour Research projects, which are a joint effort of the Geological Survey of Canada, Manitoba Geological Services Branch and the University of Manitoba.

- Manitoba Great Lakes Coastal Wetlands research and development project conducted by Ducks Unlimited and the University of Manitoba to develop a base of scientific information on the factors affecting the coastal wetland of Lake Winnipeg.
- Bioenergy Production in Manitoba Using Biomass Cattail, a research project by the University of Manitoba.
- Shoreline Erosion Technical Committee of the Province of Manitoba.

LWR public engagement involves a variety of media and activities. Manitoba Hydro's website has information on its hydroelectric infrastructure and hydro system waterways. Since 2010, Manitoba Hydro has provided an interactive page dedicated to answering the public's LWR questions. In 2012, Manitoba Hydro produced a video documentary called "Lake Winnipeg Regulation, A Closer Look" to provide information on the history, role, and effects of regulation. During high-water events such as 2011 and 2014, public media announcements provided additional information to the public on water levels and flows throughout hydro system waterways. Manitoba Hydro staff dedicated to providing information to the public on LWR and other system waterways participated in conferences, tradeshows, and community open houses, and hold workshops, presentations, meetings, and tours of LWR facilities.

4.2 Lake Winnipeg Water Levels

Many people believe that LWR has raised water levels on Lake Winnipeg particularly during the fall, while others believe LWR results in water levels being held at a constant level.

LWR provides Manitoba Hydro with the ability to regulate outflow from Lake Winnipeg, which in turn influences the water level of the lake. This results in a reduction of shoreline flooding that, along with the need for increased power generation, drove the development of LWR in the first place. The degree to which the level is affected depends on inflow, precipitation, evaporation, and outflow. Of these, Manitoba Hydro activities only affect outflow from Lake Winnipeg.

The record of Lake Winnipeg water levels indicates that the average water level before LWR was 713.4 feet. The average post-LWR level is 713.6 feet (Figure 28). The record also shows that LWR has reduced the range of water levels observed on Lake Winnipeg by reducing peak flood levels and increasing the lowest water levels. However, the lake still follows a typical seasonal pattern of rising in the summer and falling through the winter as shown in Figure 29.

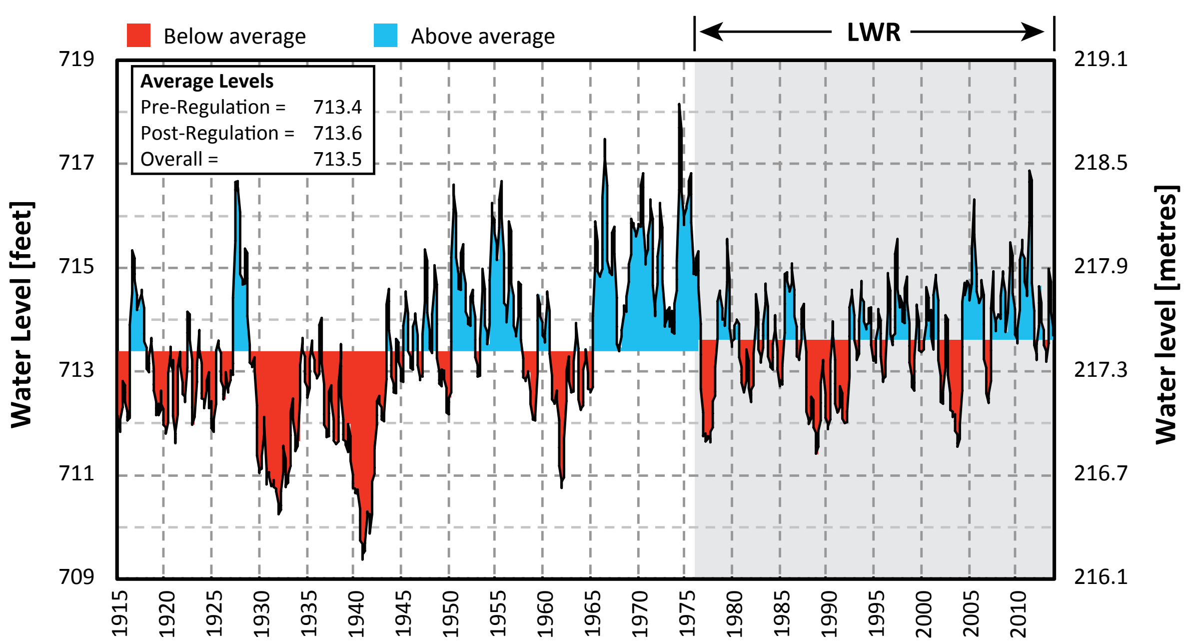


Figure 28: Observed monthly average Lake Winnipeg wind-eliminated water level (1915–2013).

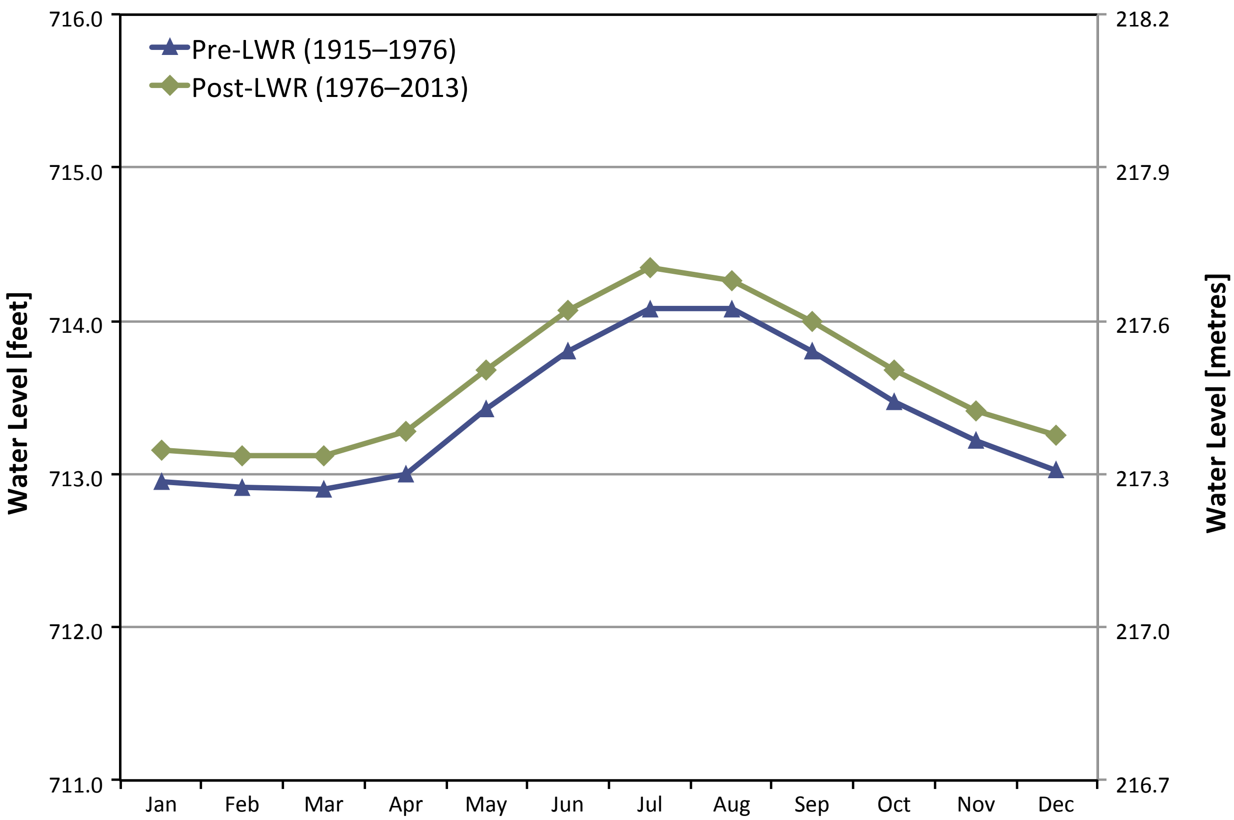


Figure 29: Pre- and post-LWR monthly average Lake Winnipeg water levels.

Over the past couple of decades average inflows into Lake Winnipeg have increased, especially from the Red River watershed. Given the change in the hydrologic conditions, simply comparing pre- and post-regulation data is not very useful as it does not account for the effect of this wetter trend on water levels. To understand the effect of regulation on Lake Winnipeg water levels, LWR must be isolated from other changes in the water regime including natural climate variability, upstream regulation, water consumption, and changes in land use. Manitoba Hydro initiated a study to estimate Lake Winnipeg water levels with the effects of LWR removed from 1977 to 2013. This study found that the operation of LWR has resulted in an overall reduction in water levels in comparison to what would have occurred without the project in place, especially during flood years. Average annual discharge out of Lake Winnipeg remains the same as it would have been with LWR in place. However, seasonal effects of LWR are apparent, with increased average outflows in winter months and corresponding decreases in average summer outflows compared to naturalized conditions. Complete details of this study are found in Appendix 4.

Based on a comparison of Lake Winnipeg observed water levels and simulated water levels without regulation, the study found that:

- regulation has lowered peak water levels;
- regulation has not increased the average water level;
- with regulation, water levels in the fall are lower during wet years and higher during dry years;
- with regulation, water levels continue to follow a typical seasonal pattern; and
- water residence times are similar to natural conditions.

LWR has resulted in average water levels between 0.1 and 0.9 feet lower than they would have been with unregulated conditions (Figure 30). LWR reduced the highest monthly average water levels by 1.7 to 2.5 feet and increased the lowest monthly average water levels by 0.6 to 1.5 feet. In most years, the seasonal water level pattern with LWR is the same as it would have been without LWR.

During the fall months (September/October), LWR has resulted in lower fall water levels in all of the more recent wet years since 1995. During many of the drier or lower-water-level years, particularly between 1976 and 1995, LWR resulted in higher fall water levels. It is estimated that LWR has reduced fall water levels by up to 1.6 to 3.6 feet in wetter years and increased water levels by up to 0.9 to 1.6 feet in drier years.

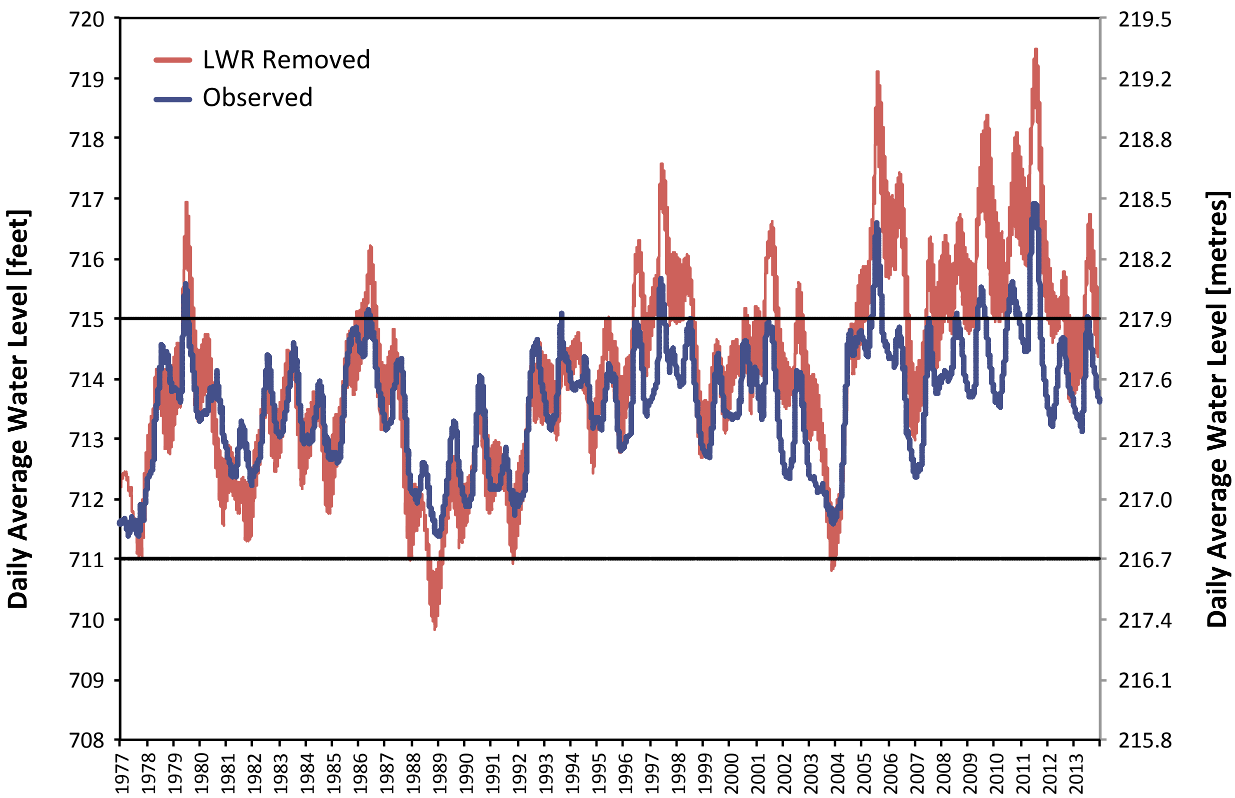


Figure 30: Lake Winnipeg water levels observed and simulated without regulation.

Water flowing into Lake Winnipeg does not stay long compared to other large lakes. Water flowing into Lake Winnipeg flows out in typically less than five years. By comparison, the “residence time” for Lake Superior is nearly 200 years. With LWR, the average water residence time of Lake Winnipeg remains similar to what it would have been under natural outlet conditions.

As part of Manitoba Hydro’s Corporate Climate Change Strategy to adapt and plan for a changing climate, Manitoba Hydro has studied Lake Winnipeg watershed’s historic and future climate conditions. These studies indicate that the Global Climate Models are projecting an increase in the mean temperature and precipitation conditions for the Lake Winnipeg watershed into the 21st century. These models also generally project that the average annual runoff in the Lake Winnipeg watershed may increase. When studying future climate change impacts it is important to recognize the uncertainties that surround the climate models used in the studies. They are not designed to capture the full range of variability that may be found into the future and instead provide a picture of what the future may look like based on a variety of assumptions on how the climate system will respond to a range of greenhouse gas scenarios. For more details on Manitoba Hydro’s Climate Change Strategy see Appendix 7.

4.3 Erosion

The shoreline around Lake Winnipeg is eroding in many areas. Many people feel that shoreline erosion around Lake Winnipeg is worse because of LWR.

Shoreline erosion around Lake Winnipeg is a major, long-standing issue. Newspaper archives show reports of significant flooding and erosion of Lake Winnipeg shorelines during high-water events before regulation as outlined in Section 1.2.

In 1958, the Lakes Winnipeg and Manitoba Board (LWMB) report emphasized the magnitude of the shoreline erosion problem on Lake Winnipeg.

> "...Above-normal lake levels combined with wind setup and wave action, may also cause erosion of the shoreline, a problem that concerns the owners of beach resorts and cottages on Lake Winnipeg between Riverton and Matlock.... During the time that this area has been used for recreational purposes, and probably long before that, a gradual erosion of the shoreline has taken place. Over most of the total distance, the recession of the shoreline has not exceeded 10 to 12 feet since the beginning of this century. However, there are other places, more exposed to wave action, or composed of less erosion-resistant soils, where the recession has been greater than 50 feet. Needless to say, the unfortunate private owners who happen to be situated in such places are greatly concerned about the erosion problem."

In 1974, as part of the LWCNRSB work, shoreline erosion rates around Lake Winnipeg were investigated. This involved creating two sets of maps using aerial photos and land subdivision surveys. One set of maps plotted the location of the shoreline at several different points in time starting in 1876, while the other set used these shoreline positions to determine erosion/accretion rates at various locations. The shoreline in the south basin of Lake Winnipeg was found to be eroding at typical rates of between 1 and 2 feet/year, with extremes of 0 to 25 feet/year (Penner and Swedlo, 1974). However, it is not uncommon for a single storm to cause more erosion than has been observed for the preceding several years. Figure 31 is graphical representation of Figure 10 from the Penner and Swedlo report (1974) showing about 700 feet of erosion between 1876 and 1971 at a location 5 km north of Gimli. Further erosion at this location was reported at approximately 108 feet between 1971 and 1994 (Baird and Stantec, 2000).

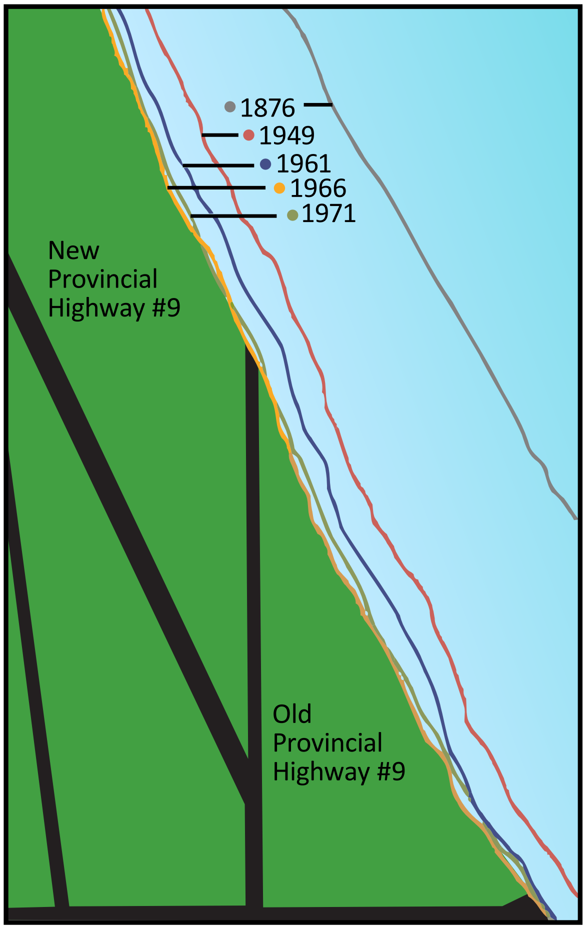


Figure 31: Shoreline erosion profile north of Gimli prior to LWR.

Lake shoreline erosion is a natural process that results from the presence of wave and water movement along the shoreline, causing soil from the shore to be detached, washed away, or moved to another shoreline. This build-up of material in another location is called accretion. Material eroded from beaches can be reached/redeposited by wave action, but erosion of a bank is irreversible without human intervention.

Many factors influence erosion, including soil type, **topography**, the presence of vegetation, and soil moisture content. However, wind and wave energy are the primary driving forces of shoreline erosion.

Wind set-up occurs when sustained winds push water up against the downwind shoreline. Consequently, a wind set-down is produced at the upwind end of the lake. Wind set-up and set-down, as shown in Figure 32, result in localized changes to the water levels even though the average water level of the lake remains unchanged. In the case of Lake Winnipeg, sustained north winds generate wind set-up in the south basin. To highlight the potential impacts resulting from severe wind events, consider the event commonly referred to as the "weather bomb" that occurred in October 2010. As shown in Figure 33, the water levels recorded by Water Survey of Canada at Gimli and Victoria Beach were 5 feet above the wind-eliminated levels due to the wind set-up resulting from sustained north winds. Concurrently, Montreal Point in the north basin experienced a wind set-down of nearly 3 feet. Events like these have the potential to cause significant flooding and shoreline erosion.

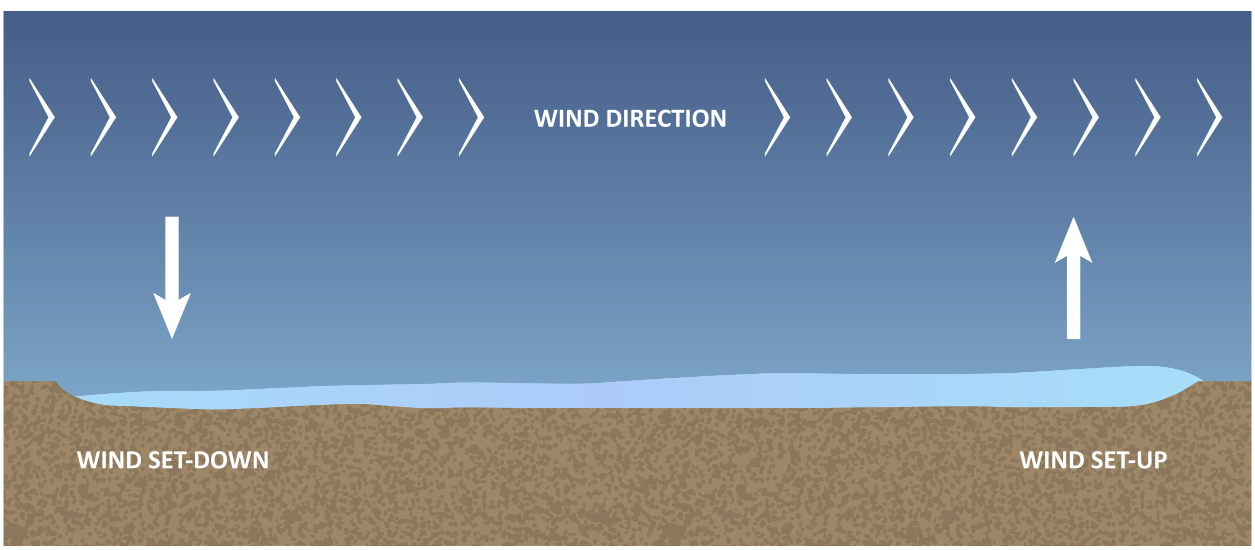


Figure 32: Wind set-down and wind set-up.

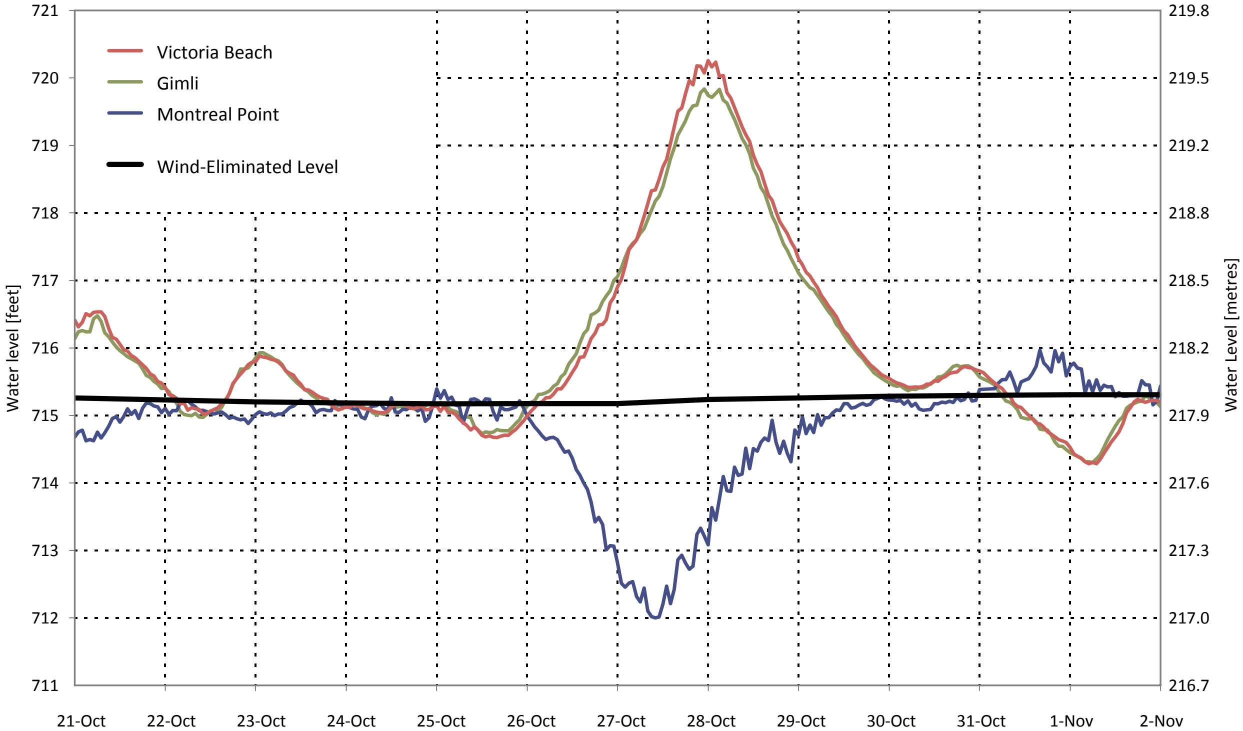


Figure 33: Lake Winnipeg water level during October/November 2010.

In response to ongoing concerns voiced by Lake Winnipeg stakeholders, the province of Manitoba established the Lake Winnipeg Shoreline Erosion Advisory Group (LWSEAG) in 1998 to review specific issues related to erosion of Lake Winnipeg's shorelines. The Province of Manitoba also initiated the Shoreline Erosion Technical Committee (SETC).

LWSEAG membership consisted of officials from municipalities along the lake's south basin, First Nations, the Manitoba Métis Federation, Lake Winnipeg property owners, and professional engineers with expertise in hydrology and erosion. The LWSEAG identified public concerns, confirmed how Manitoba Hydro measures lake levels, and assessed the magnitude of erosion over 40 years. The LWSEAG also researched shoreline erosion processes and identified the shoreline types that are prone to erosion.

> "The principal finding is that in most instances, erosion, flooding and dynamic beach changes at the shoreline are the result of naturally occurring processes. Man-made alterations to the natural lake systems may affect the extent of the erosion, flooding and dynamic beach changes, but typically to a much lesser degree than the natural processes." (LWSEAG, 2000)

The LWSEAG also reported, based on information from the Geological Survey of Canada, that southward movement of the Lake Winnipeg ridge around the south end of Lake Winnipeg is due to **glacial rebound**. This is a phenomenon where the Earth's surface in a defined area lifts slowly as it recovers from the weight of the glacial sheets of ice that once rested upon it. The rebound was found to be greater at the north end of the lake, resulting in a tilting action that has shifted the position of the southern ridge by more than 16 miles, (187 km), over the past 4,000 years.

Based on the conclusions of shoreline erosion experts, Lake Winnipeg shoreline erosion is driven by natural processes. As discussed in the previous section, Manitoba Hydro studies show that regulation has reduced water levels from where they would have been without LWR. Based on this information, it is Manitoba Hydro's understanding LWR has not increased Lake Winnipeg shoreline erosion rates.

4.4 Water Quality—Eutrophication

Lake Winnipeg received international attention in 2013, having been named the "Threatened Lake of the Year" by the Global Nature Fund. The lake suffers from an increased loading of nutrients (primarily from the Red River inflows), resulting in increased frequency and severity of algal blooms, increased phytoplankton biomass, and a general shift in the dominant group of phytoplankton (cyanobacteria or "bluegreen algae"). If this condition continues to worsen, there are concerns that the many uses and benefits that are derived from the lake will decline. Due to this concern, researchers are actively studying the sources of the nutrients and potential ways to solve the problem.

The speculation that LWR contributes to eutrophication in Lake Winnipeg is based on the notion that the lake acts as a reservoir – a storehouse for water used for power generation as needed. As a reservoir, some people speculate, the lake holds excess nitrogen and phosphorus longer than would be held in an unregulated environment, thereby causing the nutrients to remain in the lake. However, there is uncertainty regarding current and historical rates of nutrient retention and internal cycling in Lake Winnipeg, and ultimately, regarding how retention may have changed, if at all, after regulation.

Lake Winnipeg is not a typical reservoir. Dr. Al Kristofferson, Managing Director of the Lake Winnipeg Research Consortium stated:

> "So, the assumption is... we've created a reservoir as far as Lake Winnipeg is concerned, we've slowed down the velocity of the water, all of this particulate phosphate that's coming into the lake is going to settle (on) the bottom, and it's going to build-up over time and it's going to create a problem. Well, we don't know that, and in a sense, we have to accept the fact that Lake Winnipeg isn't a typical reservoir. ...A really good example of a typical reservoir is the Hoover Dam on the Colorado River. When that was built, the Colorado River was a raging sediment-laden river, flowing into the Gulf of California. So when they built the Hoover Dam in the early '30s, they slowed the velocity down and they created a reservoir, Lake Mead. So when all of these suspended particles came in, they would indeed settle to the bottom. That's really not the case in Lake Winnipeg. As a matter of fact, in high-water years, it isn't a reservoir at all." (Manitoba Hydro, Lake Winnipeg Regulation, A Closer Look Video, 2012)

Two recent publications have shown that the increased external loading of phosphorus to the lake is primarily related to the Red River. One of these publications (Bunting et al., 2011) attributes these increases to increased loading of phosphorus to the land within the Red River drainage basin. The other report (McCullough et al., 2012) attributes the increase primarily to increased flows (and flooding) in the Red River. Although the conclusions of these studies differ in terms of the ultimate cause, both concluded that increases in nutrients in Lake Winnipeg in recent decades are primarily due to the increased supply from the Red River. Additionally, the sharp increases in nutrients in Lake Winnipeg in recent years have coincided with a wetter regional hydrological cycle that has seen more water flowing into the lake.

It is Manitoba Hydro's understanding that the common view of lake researchers is that LWR's impact on eutrophication of the lake (if any) is likely negligible or small and is greatly overwhelmed by other pressures on the lake. However, Manitoba Hydro recognizes that more research is required to confirm this. To that end Manitoba Hydro provides funds to studies conducted to better understand and address the water quality challenges of Lake Winnipeg. Manitoba Hydro is a significant supporter of scientific research, policy development, and public education on Lake Winnipeg.

A more comprehensive review of water quality issues on Lake Winnipeg is provided in Appendix 8.

4.5 The Commercial Fishery

While the commercial harvest in recent years (particularly Walleye) is the highest it has been in the past 50 years, there continue to be concerns that LWR is causing the changes that the Lake Winnipeg fishery is experiencing.

Lake Winnipeg has been fished commercially since at least 1872. Some species have declined over time and Lake Sturgeon were virtually eliminated from the lake following a very large commercial fishery that operated between the late 1800s and the early 1900s. Commercial catches for Lake Whitefish peaked in the 1920s after which they declined until the early 1970s. High levels of mercury, attributed primarily to chemical production facilities and pulp mills, resulted in the closure of the commercial fishery on Lake Winnipeg in the early 1970s. When the commercial fishery re-opened, Walleye was the main quota species harvested.

The Lake Winnipeg commercial fishery has fluctuated widely over the past 100 years. In response to declining commercial Whitefish harvests, Manitoba Hydro commissioned a study in the early 1990s to determine the potential effect of LWR on the fishery. The study, which was conducted by two senior independent experts (Lawler and Doan, 1992), concluded that:

> "Based on a review of Lake Winnipeg Whitefish production and a consideration of biological factors that might account for a decrease in Whitefish numbers attributed to Lake Winnipeg regulation, there is no reasonable basis to conclude that Lake Winnipeg regulation has had any measurable impact on the Whitefish fishery."

More recently, a biological review of the Lake Winnipeg commercial fishery commissioned by the Minister of Water Stewardship (Ayles et al., 2011) concluded that:

> "...the fisheries of Lake Winnipeg are generally in a healthy state."

The Lake Winnipeg commercial fishery has been managed under an evolving quota system by Manitoba Conservation and Water Stewardship since 1972. The total quota as of 2009 is 6.52 million kilograms. While the commercial harvest in recent years (particularly Walleye) is the highest it has been in the past 50 years, there continue to be concerns regarding management practices and other changes that the Lake Winnipeg fishery is experiencing that are caused by eutrophication, invasive species, and climate change.

Given that LWR is not driving the change in water quality, and since market factors, climate change, and invasive species are thought to all be more significant risks to the fishery than LWR, evidence suggests that LWR is not impacting the sustainability of the commercial fishery.

A more comprehensive review of Lake Winnipeg commercial fishery issues is provided in Appendix 8.

4.6 Netley-Libau Marsh

Many people are concerned that LWR is the driving force behind the profound changes in the Netley-Libau Marsh.

Netley-Libau Marsh is a large (100 square miles, 258 square kilometres), coastal wetland situated at the mouth of the Red River on the south end of Lake Winnipeg, as shown on Map 7. The marsh is a complex collection of shallow basins and inter-connecting channels, bisected by the Red River, which flows through the marsh before entering Lake Winnipeg. As a wetland, it provides important habitat for many species of fish, birds, mammals, and amphibians, and facilitates the uptake of materials transported in terrestrial runoff (*e.g.*, eroded soil, other particulate matter, pesticides, metals, and fertilizers), and sewage effluent (from urban centres).

Map 7: The Netley-Libau Marsh.

Mapping of the marsh, conducted intermittently since 1922, indicates a loss of vegetation; a loss of island and upland habitats; and a large reduction in the number of basins in the marsh as waterbodies have merged due to the loss of vegetation and levees (Grosshans et al., 2004).

Reduction in marsh vegetation is typically attributed to extended periods of high water during the summer that causes plants to senesce (deteriorate/die-back).

Manitoba Hydro understands that the health of the Netley-Libau Marsh has significantly declined over the past 80 years. Although the effects of LWR on the marsh are not fully understood, it is clear that the health of the marsh was declining prior to the existence of LWR. It is also clear that there are many factors affecting its health including Red River flows, The Netley Cut, glacial rebound, the introduction of invasive species, and Lake Winnipeg water levels.

A more comprehensive review of Netley-Libau Marsh is provided in Appendix 8. Manitoba Hydro continues to support research to help address marsh degradation issues and concerns.

The Red River and the Netley Cut

The Red River has a major hydrological influence on the marsh. Historically this was due to flooding under high-flow events and, since around 1913, it has been due to the excavation of the "Netley Cut" as shown in Map 7 (Cicek et al., 2006). The "cut" was intended to facilitate boat navigation into this basin and allow water entering the basin during Lake Winnipeg wind set-up events to exit more quickly, thereby reducing the length of time that the basin would hold water over hayland (Grosshans et al., 2004). Over time, this cut has eroded and now conveys a substantial portion of the Red River's flow into the west half of the marsh.

The diversion of flow through the cut inundates that half of the wetland in a high-flow event. This reduces the potential for a dewatered, moist mudflat to emerge and it is that state that is needed for emerging vegetation seed germination – critical to the ongoing regeneration of a wetland (van der Valk and Davis, 1978).

In 1999, dredging (which allowed relatively unrestricted flow from the Red River into Lake Winnipeg) was discontinued. This resulted in sediments in-filling the mouth causing a backwater effect that exacerbates the marsh's flooding (Grosshans et al., 2004).

The Province also implemented an annual, late-winter ice-cutting program on the Red River between the Netley Cut and the Selkirk Bridge in 2006. The intent of this program is to reduce the effects of ice jams by opening a centerline channel through the river ice to improve ice flow towards Lake Winnipeg, thereby reducing backwater effects that threaten populated centres upstream. The impact of ice-cutting on water inundation issues associated with Netley-Libau Marsh is currently unknown. Since ice-cutting has at times not continued downstream past the Netley Cut, this would have presumably facilitated flow through the cut and into the basins on the west side of the marsh. This would likely have contributed to erosion and vegetation flooding.

Glacial Rebound

Among the oldest of factors influencing Lake Winnipeg is post-glacial isostatic rebound. On a time-scale of centuries, its effect on Lake Winnipeg is an upward tilting of the lake bottom at its north end with a corresponding increase in water depth at the lake's south end. With the relatively wide, naturally-occurring gaps in the beach ridge between Lake Winnipeg and Netley-Libau Marsh, post-glacial rebound is a potential contributor to increased levels of inundation in the marsh.

Common Carp

The introduction of Common Carp to Netley-Libau Marsh, in the 1940s also contributes to the current state of the marsh. Carp **foraging** behaviour uproots submersed vegetation, which increases turbidity and impedes plant growth. The loss of vegetation intensifies the soil erosion along shorelines, leading to further loss of vegetation, and the marsh's islands.

Lake Winnipeg Water Levels

Wetlands typically cycle through periods of low and high water levels that affect the wetland's soil/water interface, and nutrient, biotic, and vegetation communities. Following extended (*i.e.*, one to several years) periods of normal or high water levels, a wetland's vegetation community will begin to senesce (deteriorate/die-back), creating open-water areas that were previously vegetated. An extended period of low water levels is then required to re-establish the lost vegetation. This is known as the regenerative phase, which is also considered to be the most diverse and productive phase in the wetland's hydrologic cycle. The dewatered, moist mud-flat state resulting from a low-water period is necessary for the germination of deep marsh vegetation seeds that would otherwise lie dormant in the wetland's seed bank. Thus, a normal hydrologic cycle is vital to wetland health.

It has been suggested that the regulation of Lake Winnipeg may have contributed, at least in part, to a reduction in deep marsh vegetation by disrupting the wetland's hydrologic cycle. However, the overall influence of regulation on the marsh is not fully understood. For example, in high-flow years LWR has kept water levels on Lake Winnipeg lower. Reducing the extent (depth and duration) of vegetation inundation in the marsh may reduce the extent of flood-induced vegetation die-back.

In addition to high water levels caused by large inflows, water levels can also increase due to high winds on Lake Winnipeg (Cicek et al., 2006). Strong, persistent winds from the north can cause a 3.7 feet (1.13 metre) increase in water level at the south end and can last up to 39 hours (Baird and Stantec, 2000). The October 2010 storm resulted in a total wind effect of about 5 feet (1.52 m).

5.0 A Commitment to Sustainability

LWR is a key component of hydroelectric power generation in Manitoba today and for the future. Manitoba's future as a renewable energy leader depends on a healthy environment, a strong infrastructure, comprehensive monitoring and an overarching commitment to sustainable development.

Consistent with the concept of sustainable development, Manitoba Hydro:

- actively monitors the health and condition of the waterways associated with its hydropower operations;
- undertakes extensive public engagement activities; and
- strengthens Manitoba's economy, provides employment opportunities, and reduces the vulnerability of communities once threatened by shoreline flooding around Lake Winnipeg.

Changing the upper limit for maximum discharge on Lake Winnipeg from 715 feet would be inconsistent with the concept of sustainable development.

5.1 Sustainability

Manitoba has been endowed with a remarkable landscape and system of lakes and rivers that allow Manitoba Hydro to generate reliable power to meet Manitoba's energy needs for the long-term. LWR is one of the cornerstones of this complex system. In addition, LWR has provided significant flood reduction benefits around Lake Winnipeg.

The development and operation of LWR for both hydroelectric and flood reduction purposes has had effects on downstream northern communities. Manitoba Hydro is committed to ongoing monitoring and dialogue in an effort to understand the effects, and to continue to respond accordingly.

Manitoba Hydro's vision is "to be recognized as a leading utility with respect to safety, reliability, rates, customer satisfaction, and environmental leadership." To this end, Manitoba Hydro is committed to the integration of sustainable development practices into its business. Manitoba Hydro's corporate sustainable development policy, adopted in 1993, is consistent with the principles and guidelines developed by the Manitoba Round Table on the Environment and Economy. See Appendix 9 for Manitoba and Manitoba Hydro's Sustainable Development Principles.

The concept of sustainable development is based upon an understanding of the connections among the environment, society and the economy. It involves the recognition that actions in one area may have impacts on another. Manitoba Hydro endeavours to meet the energy needs of Manitobans today without compromising the ability of future generations to meet their needs.

Environmental Sustainability
Manitoba Hydro acknowledges LWR's environmental impacts downstream of Lake Winnipeg. Through agreements and ongoing programming, Manitoba Hydro has specific mitigation, remedial, and compensation activities in place for water regime management and affected shorelines. An example, mentioned previously in this report, is the Cross Lake weir which substantially reduced water level effects on Cross Lake and improved conditions for both fish and wildlife.

Most water quality parameters in the waterways affected by LWR continue to meet Manitoba water quality objectives and guidelines for the protection of aquatic life and most of the lakes continue to support domestic and commercial fisheries. Manitoba Hydro continues to work on increasing our understanding of the current ongoing environmental concerns and is keenly focused on data collection through CAMP to provide further knowledge and insights.

Social Sustainability
Manitoba Hydro recognizes the challenge in meeting the different needs of the communities associated with the LWR project. Historically, some stakeholders along Lake Winnipeg have requested increased outflows to keep the water levels lower for recreation and property protection. In contrast, lower water levels on Lake Winnipeg would increase flooding for people along the Nelson River.

Manitoba Hydro continues to address issues with First Nations, communities, and resource user groups in the Downstream Area. This involves working with communities and resource user groups to put in place measures that address adverse effects. Manitoba Hydro continues to mitigate, remediate, and compensate for LWR effects in areas such as navigation, heritage resources, and infrastructure.

Manitoba Hydro also supports a number of Lake Winnipeg stakeholder initiatives to develop a better understanding of the health of the lake.

Economic Sustainability
LWR contributes to the economic sustainability of Manitoba in a number of ways. It provides a reliable flow of water to Manitoba Hydro's generating stations along the Nelson River. This supplies a source of dependable clean renewable energy, enabling Manitoba Hydro to meet its obligations to Manitobans and export customers. In essence, LWR provides a secure foundation for Manitoba's Clean Energy Strategy and contributes in a major way to satisfying our obligations under *The Manitoba Hydro Act*.

LWR provides for ongoing employment and business opportunities through implementation of the NFA and CIAs as well as operational contracts.

By reducing shoreline flooding around the populated south basin of Lake Winnipeg, LWR reduces the vulnerability of lakeside communities and their economies. LWR allows Manitobans to enjoy reliable renewable power at rates that are among the lowest in North America.

5.2 Implications of Changing the Maximum Discharge Elevation of 715 feet

There has been much public debate about the licence condition which specifies the 711–715 foot range under which LWR operates. Many stakeholders around Lake Winnipeg suggest that the upper limit be reduced to 714 feet to provide further flood reduction benefits. The current LWR operating range is beneficial for both flood reduction on Lake Winnipeg and power production on the Nelson River. Reducing the range would increase impacts to downstream communities and result in decrease net revenue, while providing minimal additional flood reduction benefits to Lake Winnipeg stakeholders.

The LWR *Water Power Act* Licence requires Manitoba Hydro to maximize outflows for when Lake Winnipeg is above 715 feet. This licence allows regulation for power below that level. On that basis, Manitoba Hydro has developed the size and number of generating stations along the Nelson River. While additional storage above 715 feet would be beneficial to hydro development, operations above that level are reserved to provide flood reduction benefits for Lake Winnipeg.

To assess the implications of changing the 711–715 foot range, Manitoba Hydro simulated the water levels and flows that would have occurred since LWR became operational under two different upper limits, 714 feet and 716 feet. Details of this study are found in Appendix 10. Other analysis was conducted to assess the economic impact that these changes would have. These studies indicate that operating under these changed limits would result in significant costs to Manitoba Hydro in addition to physical, environmental, social, and economic implications for the Downstream Area.

Physical Implications
Reducing the upper end of the LWR operating range to 714 feet from 715 feet has been suggested as a way to benefit Lake Winnipeg lakeside residents and cottagers. The study indicates the average and peak flood water level on Lake Winnipeg would be reduced by a few inches. Wind would not change, meaning the driving force behind erosion on Lake Winnipeg would remain. On the other hand, as shown in Figure 34, the frequency of flooding downstream from Lake Winnipeg would increase significantly if the upper end of the range dropped to 714 feet as Manitoba Hydro would have to go to maximum discharge 2.5 times more often, from 9 times with an operating range of 711 feet to 715 feet to 24 times with an operating range of 711 feet to 714 feet. This would increase impacts to downstream communities by increasing water level variations and the frequency of flood peaks. Going to maximum discharge more often also means that water levels would typically be lower going into the winter, leading to reduced winter discharge and energy production.

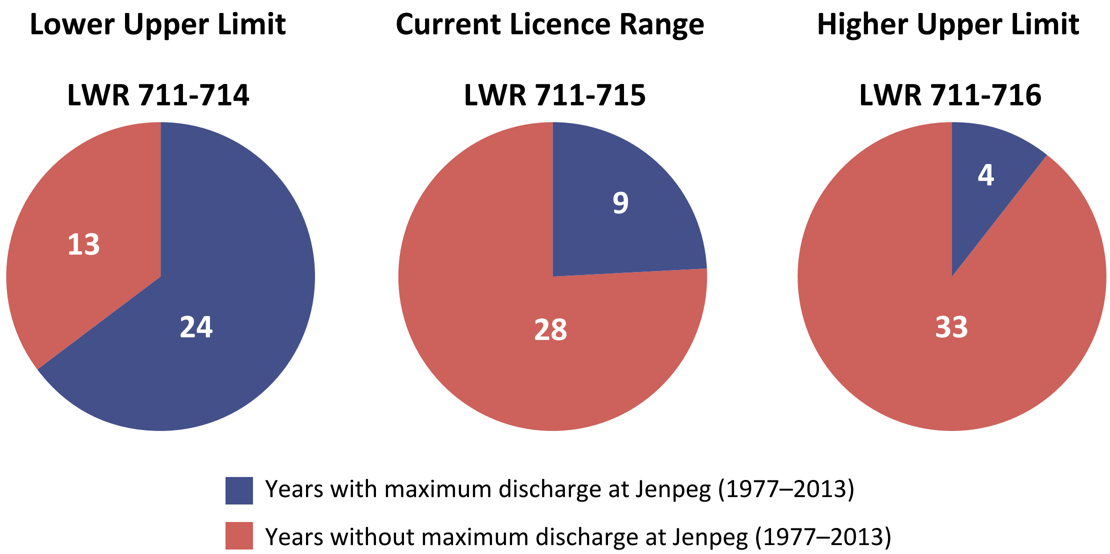


Figure 34: Years with and without maximum discharge at Jenpeg under different operating ranges during open water.

Increasing the upper end of the LWR operating range to 716 feet from 715 feet would provide additional storage for hydroelectric generation. The model indicates the average and peak flood water level on Lake Winnipeg would be increased by a few inches. The increased storage capability would reduce the number of occasions Manitoba Hydro would have to go to maximum discharge to less than half as often, as shown in Figure 34.

Environmental Impacts
LWR has affected the environment in the Downstream Area in a variety of ways including impacts to fish, wildlife populations, and shoreline erosion. The physical changes related to decreasing the upper end of the LWR operating range to 714 feet would lead to further environmental impacts. The increased frequency of flood peaks would likely cause additional shoreline erosion, while greater water level variation would potentially increase impacts on fish and wildlife in the Downstream Area.

Increasing the upper end of the LWR operating range to 716 feet would cause minimal change to environmental impacts in the Downstream Area because water levels and flows would be similar to current conditions.

Changing the upper end of the LWR operating range to either 714 or 716 feet would likely have minimal environmental effect on Lake Winnipeg because the average and peak water levels only change by a few inches.

Any contemplated change to operating limits would require extensive study of environmental impacts.

Social Impacts

The physical changes related to decreasing the upper end of the LWR operating range to 714 feet would lead to further social impacts in the Downstream Area. Increasing the frequency of flood peaks would likely cause additional erosion and debris which would affect navigation and resource use and potentially lead to further cultural losses. These changes could require re-negotiating numerous settlement agreements.

Increasing the upper end of the LWR operating range to 716 feet would cause minimal change to social impacts in the Downstream Area because water levels and flows would be similar to current conditions.

Changing the upper end of the LWR operating range to either 714 or 716 would likely have minimal effect on Lake Winnipeg stakeholders because the average and peak water levels only change by a few inches.

Any contemplated change to operating limits would require extensive study of social impacts.

Economic Implications

From a long-term planning perspective, reducing the upper end of the LWR operating range by 1 foot would result in a net present value loss in the order of $440 million (2014 dollars). Refer to Appendix 11 for economic details.

Reducing the upper end of the LWR operating range to 714 feet from 715 feet would result in decreased net revenue for multiple reasons:

- less storage capacity resulting in the need for new facilities to provide the required energy during droughts;
- reduced winter discharge resulting in the need for new generating stations to meet winter load requirements;
- reduced operating flexibility resulting in reduction in revenue from the sale of surplus energy;
- potential modification to existing generating stations to accommodate changed flow regime; and
- negotiations, new agreements, and potential mitigation efforts to address new downstream impacts.

Each of the items listed above would result in large capital, operating, and opportunity costs to Manitoba Hydro.

Increasing the upper end of the LWR operating range to 716 feet from 715 feet would result in a net present value benefit in the order of $360 million (2014 dollars). This is because Manitoba Hydro would be able to keep more water in storage for release at optimal times for generation. Also, Manitoba Hydro would have to go to maximum discharge less often and the frequency of discharging excess water over spillways at downstream generating stations would be decreased.

These estimates represent an average of the resource planning simulations for all historic flow cases (1912 to 2010). These estimates do not consider the costs of negotiations, new agreements, and potential mitigation for new downstream impacts.

5.3 Coordinated Aquatic Monitoring Program (CAMP)

As part of its commitment to sustainable development Manitoba Hydro actively monitors its system. CAMP is a systematic, system-wide aquatic monitoring program that monitors key physical, chemical, and biological parameters associated with waterways affected by Manitoba Hydro's hydraulic generation system, including the CRD, LWR, the Winnipeg River, and the Saskatchewan River. To ensure appropriate coverage of Manitoba Hydro's hydraulic system, CAMP was divided into eight monitoring regions (Map 8), each of which contains a number of on- and off-system waterbodies that are sampled annually or on a three-year rotation. These waterbodies will continue to be monitored under CAMP into the future in order to further our understanding of LWR impacts on the aquatic ecosystem.

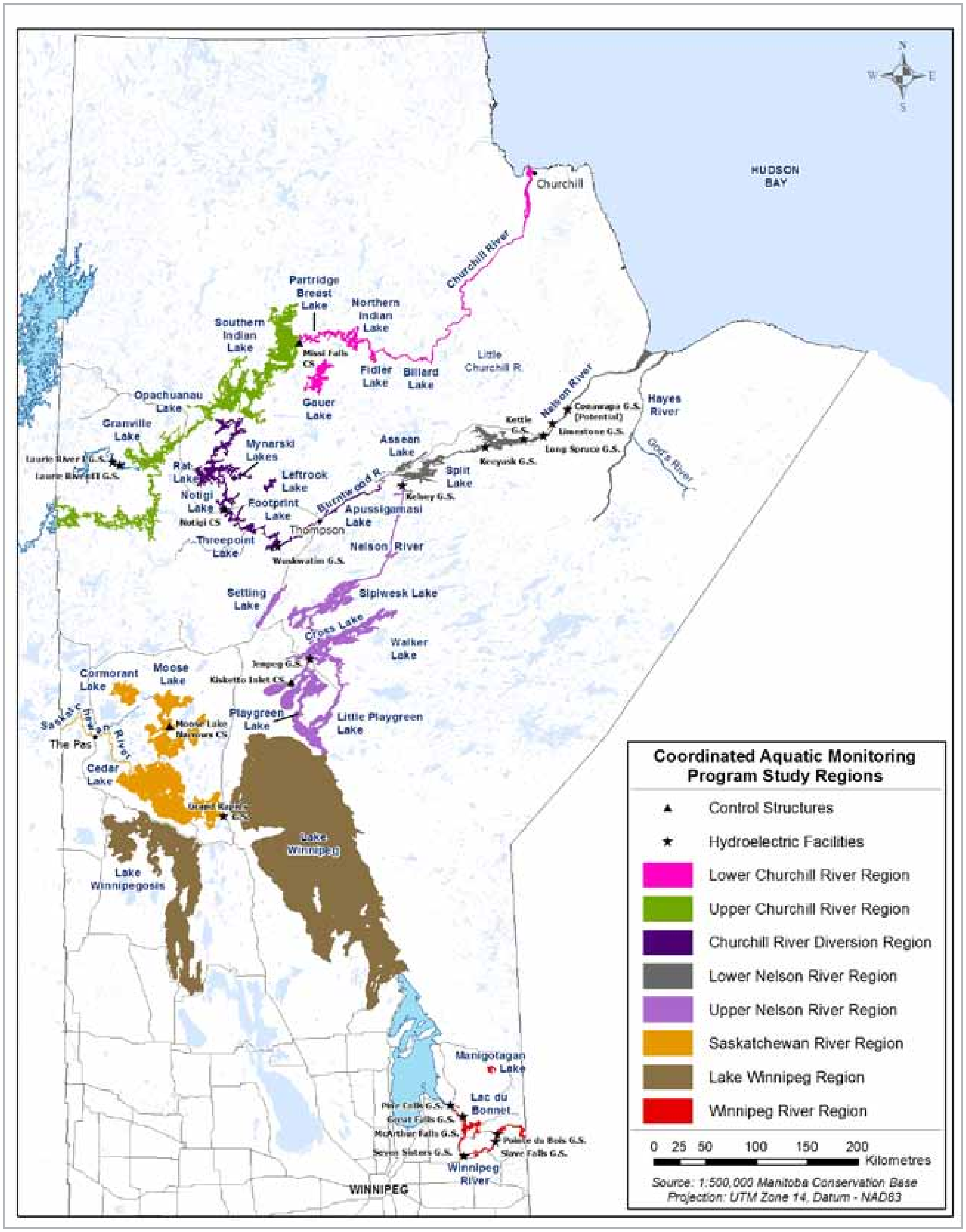
CAMP was developed under a partnership between Manitoba and Manitoba Hydro in response to the environmental review process for the Wuskwatim Generating Station. The Memorandum of Understanding (MOU) between the partners summarizes and defines the need for coordinating aquatic monitoring to address the growing expectation from environmental regulators, local communities, and the general public for a program that created a better understanding of the environmental effects of hydroelectric development. "MOU Objectives" were established to help guide the development of the CAMP:

- assisting in evaluating whether and to what extent the water regime in the areas of the system is or will be affected by the addition of new hydroelectric facilities;
- assisting in identifying adverse impacts and positive impacts resulting from effects on the water regime; and
- assisting in considering measures that may be undertaken to address any identified adverse effects.

A working group comprising Manitoba and Manitoba Hydro representatives is responsible for overseeing the development and implementation of CAMP and to ensure it meets the MOU Objectives. This MOU Working Group has worked collaboratively to develop the current set of program objectives that target more specific goals and measurable terms to assist in the program's implementation. These are referred to as the "CAMP Objectives" and include:

- coordinate standardized monitoring of aquatic ecosystem health by Manitoba and Manitoba Hydro via important physical, chemical, and biological parameters from selected waterbodies within (on-system) and outside (off-system) of Manitoba Hydro's hydraulic system;
- provide regular reporting on scientifically relevant indicators of aquatic ecosystem health;
- provide the public and stakeholders with timely and accurate information on the state of waterbodies in Manitoba Hydro's system and seek feedback on the program;
- annually review the program to ensure scientific rigour and evaluate the applicability of new aquatic monitoring technologies, methodologies, and protocols; and
- coordinate with researchers and regulators to identify research priorities to address needs or information gaps detected by the program.

The CAMP website is http://campmb.com/.



Map 8: CAMP monitoring regions.

6.0 Final Licence Request: A Concluding Note

LWR was designed to fulfill two purposes: flood reduction around Lake Winnipeg and power generation for all Manitobans. Operating under the terms of the Interim Licence, LWR successfully fulfills these purposes.

The excavated channels at the north end of Lake Winnipeg allow about 50% more water to flow out of the lake. Because of this the frequent shoreline flooding events around Lake Winnipeg in the 1950s and 1960s have been drastically reduced and Manitobans benefit from the province's safe and reliable hydroelectric system. And while there have been negative impacts downstream of Lake Winnipeg, Manitoba Hydro has worked with First Nations, communities and others to address effects through mitigation works, programs and compensation.

Manitoba Hydro seeks no changes to the terms of the licence. Changing the upper end of the power production range from 715 to 714 feet would have negative impacts on people and the environment downstream of Lake Winnipeg, reduce electrical system reliability, decrease net revenue, and not provide additional flood reduction on Lake Winnipeg.

Manitoba Hydro is committed to ongoing dialogue with stakeholders, monitoring of the waterways associated with its operations and continued collaboration with organizations studying Lake Winnipeg. Healthy waters and healthy communities are among the keys to Manitoba Hydro's future success, and critical to the well-being of all Manitobans.

Manitoba Hydro welcomes your questions and comments on Lake Winnipeg Regulation and all aspects of our operations. See http://www.hydro.mb.ca/corporate/news_media/ask_hydro/index.shtml.

Glossary

Bedrock: A general term for any solid rock, not exhibiting soil-like properties, that underlies soil or other surficial materials.

Biophysical: A branch of science concerned with the application of physical principles and methods to biological problems

Bipole: In the HVDC transmission context, a transmission system consisting of a transmission line and converter facilities, and comprising both a positively and a negatively energized pole.

Catch-per-unit-effort (CPUE): The number or weight of fish caught in a given time period with a specific equipment.

Churchill River Diversion (CRD): The diversion of water from the Churchill River to the Nelson River via the Rat River and the impoundment of water in Southern Indian Lake.

Community: In ecology, a community is an ecological unit composed of a group of organisms or a population of different species occupying a particular area, usually interacting with each other and their environment.

Concentration: The density or amount of a material suspended or dissolved in a fluid (aqueous) or amount of material in a solid (*e.g.*, sediments, tissue).

Conductivity: A measure of the ability of a solution to conduct electrical flow.

Control structure: A type of structure designed to control the outflow from a waterbody (*e.g.*, Kiskitto Control Structure).

Cubic feet per second (cfs): A flow rate that quantifies the number of cubic feet of water flowing in one second.

Dam: A barrier built to hold back water.

Debris: Any material, including floating or submerged items (*e.g.*, driftwood, plants), suspended sediment or bed load, moved by flowing water.

Discharge: Another word for flow rate often measured in cubic metres per second or cubic feet per second.

Downstream Area: The area where the effects of LWR as described in this document occur. It is limited to the area adjacent to the Nelson River between the outlet of Lake Winnipeg and Gull Rapids.

Drainage basin: A large area of land that collects water and then drains into a body of water (used synonymously with watershed).

Dyke: An earth embankment constructed to contain the water in the reservoir and limit the extent of flooding.

Easement: A right to cross or otherwise use someone else's land for a specified purpose.

Ecosystem: A dynamic complex of plant, animal, and micro-organism communities and their non-living components of the environment interacting as a functional unit.

Environment: The components of the Earth, including (a) land, water, and air, including all layers of the atmosphere, (b) all organic and inorganic matter and living organisms, and (c) the interacting natural systems that include components referred to in (a) and (b).

Environmental effect: In respect of a project, any change that the project may cause in the environment, including any change it may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species, as those terms are defined in subsection 2(1) of the *Species at Risk Act*.

Environmental monitoring: Periodic or continuous surveillance or testing, according to a predetermined schedule, of one or more environmental components. Monitoring is usually conducted to determine the level of compliance with stated requirements, or to observe the status and trends of a particular environmental component over time.

Erosion: A process by which the Earth's surface is worn away by the actions of water and wind.

Flooding: The rising of a body of water so that it overflows its natural or artificial boundaries and covers adjoining land that is not usually underwater.

Flow: Motion characteristic of fluids (liquids or gases); any uninterrupted stream or discharge.

Forage(ing): To locate, capture, and eat food.

Forebay: Impoundment area immediately upstream from a dam or hydroelectric plant intake structure that forms the downstream portion of the reservoir.

Fragmentation: Refers to the extent to which an area is broken up into smaller areas by human features. Eventually, remaining areas may be too small to provide usable or effective habitat for a species.

Furbearer: Refers to those mammal species that are trapped (*e.g.*, marten, fox, etc.) for the useful or economic value of their fur.

Generating station: A structure that produces electricity. Its motive force can be provided in a variety of ways, including burning of coal or natural gas, or by using water (hydro) power. Hydroelectric generating stations normally include a complex of powerhouse, spillway, dam(s), and transition structures; electrical energy is generated by using the flow of water to drive turbines.

Glacial rebound: The rise of land masses that were depressed by the huge weight of ice sheets during the last glacial period.

Habitat: The place where a plant or animal lives; often related to a function such as breeding, spawning, feeding, etc.

High-voltage direct current (HVDC) transmission system: A high-voltage electric power transmission system that uses direct current. Direct Current flows constantly in only one direction.

Hydroelectric: Electricity produced by converting the energy of falling water into electrical energy.

Hydrology/Hydrologic: The branch of science concerned with the properties of the Earth's water, and especially its movement in relation to land.

Ice boom: A floating structure, anchored at opposite shorelines and/or the river bottom, designed to help form and hold an ice cover in place.

Ice regime: A description of ice on a water body (*i.e.*, lake or river) with respect to formation, movement, scouring, melting, daily fluctuations, seasonal variations, etc.

Impoundment: The containment of a body of water by a dam, dyke, powerhouse, spillway, or other artificial barrier.

Infrastructure: The basic physical and organizational structures and facilities needed for the operation of a society.

Landscape: The ecological landscape as consisting of a mosaic of natural communities; associations of plants and animals and their related processes and interactions.

Limnology: The scientific study of bodies of freshwater (as lakes).

Megawatt (MW): The unit of electrical power equivalent to 1,000,000 watts.

Mitigation: A means of reducing adverse effects. Under the *Canadian Environmental Assessment Act*, and in relation to a project, mitigation is the elimination, reduction or control of the adverse environmental effects of a project, and includes restitution for any damage to the environment caused by such effects through replacement, restoration, compensation, or any other means.

Model: A description or analogy used to help visualize something that cannot be directly observed. Model types range from a simple set of linkage statements or a conceptual diagram to complex mathematical and/or computer model.

Monitoring: Measurement or collection of data.

Nelson River (lower): The stretch of the Nelson River that extends from Split Lake to Hudson Bay.

Nelson River (upper): The stretch of the Nelson River that extends from Playgreen Lake to the entrance of Split Lake.

Northern Flood Agreement (NFA): An agreement signed in 1977 by Manitoba Hydro, the governments of Canada and Manitoba, and the Northern Flood Committee on behalf of five affected First Nations regarding the effects of the construction and operation of CRD, LWR and all existing and planned generating stations on the Nelson and Burntwood Rivers.

Off-system waterbodies: Lakes and areas of rivers where water levels and flows are either entirely or largely unaffected by Manitoba Hydro's hydraulic system.

Organic: The compounds formed by living organisms.

Outflow: The water flowing out of a waterbody (lake, reservoir, etc.).

Parameter: Characteristics or factor; aspect; element; a variable given a specific value.

pH: Method of expressing acidity or basicity of a solution. pH is the logarithm of the reciprocal of the hydrogen ion concentration, with a pH of 7.0 indicating neutral conditions. pH values of less than seven are acidic.

Population: A group of interbreeding organisms of the same species that occupy a particular area or space.

Power: The instantaneous amount of electrical energy generated at a hydroelectric generating station, usually expressed in megawatts.

Powerhouse: Structure that houses turbines, generators, and associated control equipment, including the intake, scroll case, and draft tube.

Reach: A section, portion or length of stream or river.

Registered Trap Line (RTL): An area of land allocated by Manitoba Conservation where a person is granted the exclusive opportunity to harvest (trap) furbearing animals. These traplines are within a RTD.

Registered Trap Line District (RTD): An area designated as a registered trapline district by the regulations set out under *The Wildlife Act*.

Resource Management Area (RMA): An area to be jointly managed by a Resource Management Board established by agreement between Manitoba and a First Nation or a local Aboriginal community.

Reservoir: A body of water impounded by a dam and in which water can be stored for later use. The reservoir includes the forebay.

Resource use: Subsistence and economic activities that make use of the resources derived from the natural environment.

Sediment(s): Material, usually soil or organic, which is deposited in the bottom of a waterbody.

Sedimentation: A combination of processes, including erosion, entrainment, transportation, deposition, and the compaction of sediment.

Shoreline: The narrow strip of land in immediate contact with a lake.

Spawning: The act of reproducing in fish.

Spillway: A concrete structure that is used to pass excess flow so that the dam, dykes, and the powerhouse are protected from overtopping and failure when inflows exceed the discharge capacity of the powerhouse.

Species: A group of organisms that can interbreed to produce fertile offspring.

Terrestrial habitat: The land areas where plants and animals live. The terrestrial habitat section classifies and maps habitat based on plants, standing and fallen dead trees, soils, ground ice, groundwater, surface water, topography, and disturbance (*e.g.*, fire) conditions.

Terrestrial: Belonging to, or inhabiting the land or ground.

Topography: General configuration of a land surface, including its relief and the position of its natural and manmade features.

Total suspended solids (TSS): Solids present in water that can be removed by filtration consisting of suspended sediments, phytoplankton, and zooplankton.

Transmission line: A linear arrangement of towers and conductors which carries electricity from generating stations and transmission stations to load centres like communities and industries to meet electrical needs.

Tributary(ies): A river or stream flowing into a lake or a larger river or stream.

Turbidity (Tu): The cloudiness in water due to suspended particles. This is generally correlated to the total suspended solids (TSS).

Upland: A land ecosystem where water saturation at or near the soil surface is not sufficiently prolonged to promote the development of wetland soils and vegetation.

Water quality: Measures of substances in the water such as nitrogen, phosphorus, oxygen, and carbon.

Water regime: A description of a waterbody (*i.e.*, lake or river) with respect to water levels, flow rate, velocity, daily fluctuations, seasonal variations, etc.

Watershed: A large area of land that collects water and then drains into a body of water. (used synonymously with drainage basin)

Weir: A low dam built across a river to raise the level of water upstream or regulate its flow.

Wind-eliminated water level: A calculated water level to remove the effect of wind on a waterbody.

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