REGIONAL CUMULATIVE EFFECTS ASSESSMENT

FOR HYDROELECTRIC DEVELOPMENTS ON THE CHURCHILL, BURNTWOOD AND NELSON RIVER SYSTEMS: **PHASE I REPORT**

Manitoba Hydro

PREAMBLE

The Clean Environment Commission (CEC) Bipole III Report (2013) included a list of licensing and non-licensing recommendations to be carried out by Manitoba Hydro and/or Manitoba. On behalf of the government, the Minister of Conservation and Water Stewardship committed to implementing these recommendations.

The CEC report stated that:

"…it became apparent that past hydroelectric developments in northern Manitoba have had a profound impact on communities in the area of these projects, as well as on the environment upstream and downstream."

The CEC made a similar statement in their 2004 report on the Wuskwatim Generation Project.

In response, the CEC made non-licensing Recommendation 13.2 in the Bipole III Report (2013) that stated:

"Manitoba Hydro, in cooperation with the Manitoba Government, conduct a Regional Cumulative Effects Assessment for all Manitoba Hydro projects and associated infrastructure in the Nelson River sub-watershed; and that this be undertaken prior to the licensing of any additional projects in the Nelson River sub-watershed after the Bipole III project."

To address this non-licensing recommendation, a Terms of Reference (Appendix 1A) has been jointly agreed to between Manitoba and Manitoba Hydro that has increased the scope of the Regional Cumulative Effects Assessment (RCEA) to include the Nelson, Burntwood, and Churchill River systems — an area referred to in this report as the "Region of Interest" (see Map 1-1).

Manitoba Hydro has a lengthy history in this region and a vast amount of work has been completed to understand and address the effects of past hydroelectric developments. The final RCEA report will be based on a review and synthesis of these past and ongoing studies and monitoring programs, and will include both scientific information and Aboriginal Traditional Knowledge to the extent that each is available.

The Terms of Reference describe a two phase approach to the assessment:

- **Phase I:** This initial report provides the proposed scope of the study including the time span covered (temporal scope), the geographic area covered (spatial scope), and the methods to be employed for the assessment; a description of the history of hydroelectric development; and an initial summary of available information that will be used to determine the cumulative environmental effects of northern hydroelectric development within the Region of Interest. These information sources are extensive and will be further expanded upon as the analysis proceeds in Phase II.

- **Phase II:** The Phase II report will use the best assessment methodology available to quantify (where possible) or qualitatively describe the cumulative effects of hydroelectric development on the people, the water, and the land in the Region of Interest. The assessment will describe, to the extent possible, the overall health of the ecosystem. The Phase II report will conclude with a description of ongoing and future monitoring initiatives that will provide information to the public on the Region of Interest.

At the start of Phase II, Manitoba and Manitoba Hydro will describe the process for public engagement with Aboriginal and other communities in the Region of Interest, as well as other interested parties.

This document is the Phase I report. It was prepared within a reasonably short time frame and, given the volume of information available and reviewed for the Region of Interest, may contain some errors or omissions. It has been developed as an interim product to provide an early indication of the approach and documentation being employed to undertake the RCEA. The final Phase II report will present a more complete discussion of the history of hydroelectric development in the Region of Interest and associated environmental changes.

MASTER TABLE OF CONTENTS

Manitoba Hydro

REGIONAL CUMULATIVE EFFECTS ASSESSMENT

MASTER TABLE OF CONTENTS

MASTER TABLE OF CONTENTS

PART I: INTRODUCTION AND APPROACH

Manitoba Hydro

REGIONAL CUMULATIVE EFFECTS ASSESSMENT

PART I

INTRODUCTION AND APPROACH

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

ACRONYMS, ABBREVIATIONS AND UNITS

Acronym/Abbreviation	Term/Unit
ATK	Aboriginal Traditional Knowledge
CAMP	Coordinated Aquatic Monitoring Program
CEC	Clean Environment Commission
CRD	Churchill River Diversion
CWS	Conservation and Water Stewardship
EA	Environmental assessment
FEMP	Federal Ecological Monitoring Program
GS	Generating Station
HVdc	High Voltage Direct Current
ISD	In-service date
kV	kilovolt
LWR	Lake Winnipeg Regulation
MEMP	Manitoba Ecological Monitoring Program
MH	Manitoba Hydro
MW	megawatt
NFA	Northern Flood Agreement
RCEA	Regional Cumulative Effects Assessment
RMA	Resource Management Area
RSC	Regional Study Component
TBD	To be determined
SSEA	Site Selection and Environmental Assessment

1.0 INTRODUCTION AND APPROACH

1.1 INTRODUCTION AND BACKGROUND

The Clean Environment Commission's (CEC) Bipole III Report on Hearing (2013) included a list of licensing and non-licensing recommendations to be carried out by Manitoba Hydro (MH) and/or Manitoba. On behalf of government, the Minister of Conservation and Water Stewardship (CWS) committed to implementing these recommendations.

This document is intended to address CEC non-licensing Recommendation 13.2 from that report, which states:

"Manitoba Hydro, in cooperation with the Manitoba Government, conduct a Regional Cumulative Effects Assessment for all Manitoba Hydro projects and associated infrastructure in the Nelson River sub-watershed; and that this be undertaken prior to the licensing of any additional projects in the Nelson River sub-watershed after the Bipole III project."

The CEC report describes the rationale for this recommendation. In short, during the Bipole III hearings, some communities expressed concerns regarding the effects that they have experienced, and continue to experience, as a result of existing MH projects. The CEC noted that:

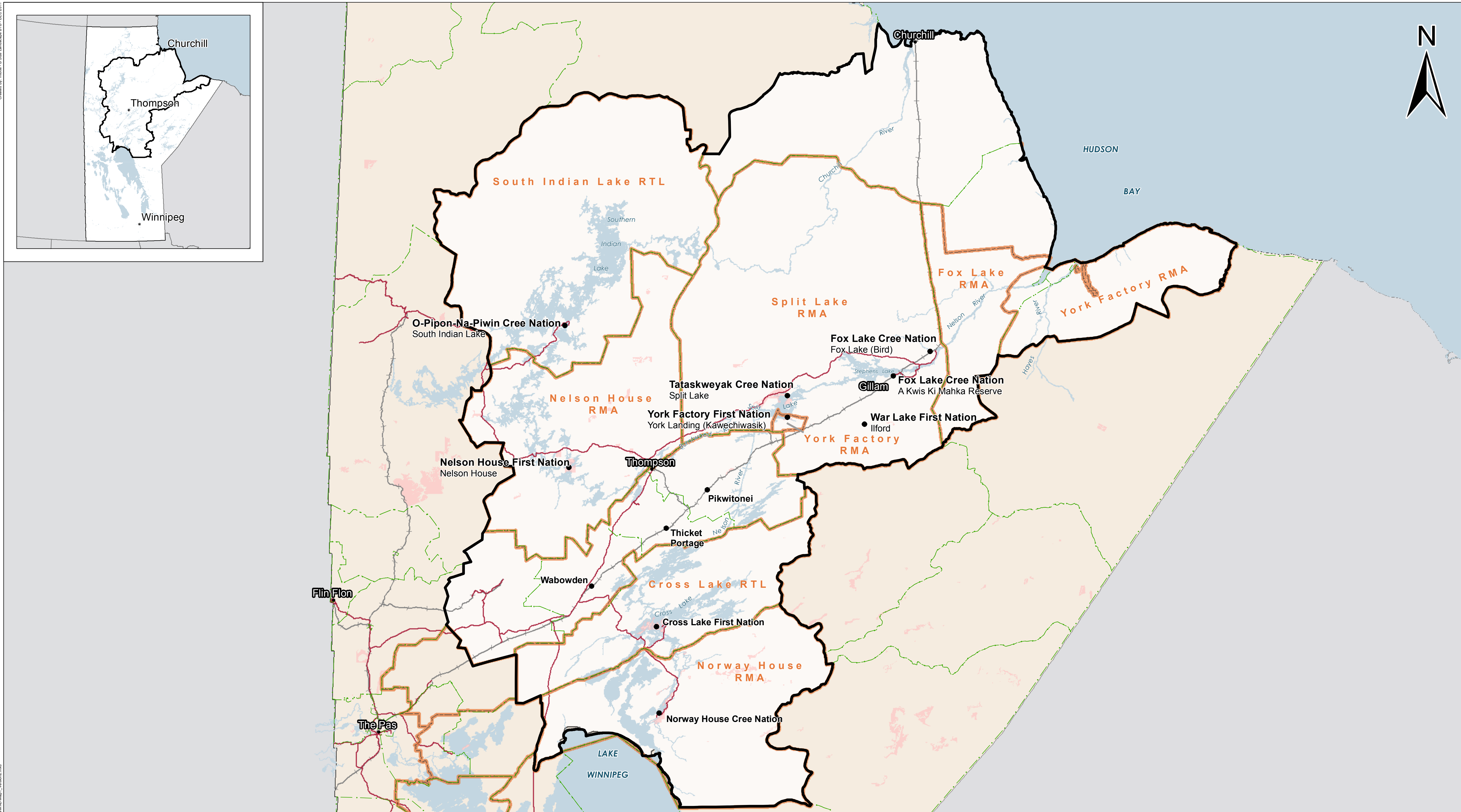
"…it became apparent that past hydroelectric developments in northern Manitoba have had a profound impact on communities in the area of these projects, as well as on the environment upstream and downstream."

The CEC made a similar statement in their 2004 report on the Wuskwatim Generation Project.

Manitoba and MH have developed an agreed to Terms of Reference (see Appendix 2A) that outlines a joint approach for MH and the province to undertake a Regional Cumulative Effects Assessment (RCEA) of hydroelectric developments in a manner that addresses CEC Recommendation 13.2. Through this Terms of Reference, the scope of the RCEA has been expanded to include the Churchill, Burntwood, and Nelson River systems, an area referred to as the "Region of Interest" and shown in Map 1-1.

The Terms of Reference provide for a two-phase approach to undertaking the RCEA, and outline the scope of the RCEA, the approach to the study, end products, a process for collaboration between CWS and MH, and a project schedule. The Terms of Reference also note that opportunities for public engagement with Aboriginal and other communities in the Region of Interest, as well as other interested parties, will be determined and implemented as part of the second phase of the RCEA.

This report meets the requirements of the Terms of Reference for the first phase of the project.



DATA SOURCE:
Manitoba Hydro; Government of Manitoba; Government of Canada

CREATED BY:
Manitoba Hydro - Hydro Power Planning - GIS & Special Studies

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	16-MAY-14	
0 30 60 Kilometres / 0 25 50 Miles	VERSION NO: 1.0	QA/QC: RB/MT

Legend

- RCEA Region of Interest
- Resource Management Area (RMA)
- Registered Trapline (RTL)
- Highways
- Rail
- Aboriginal Lands

RCEA Region of Interest

Map 1-1

1.2 RCEA: OVERVIEW

The RCEA will assess (quantitatively and/or qualitatively) environmental change over time as a result of previous hydroelectric developments in the Region of Interest. It will include a discussion of effects, mitigation and remedial works that have been put in place to reduce effects, compensation provided for effects that could not be mitigated, community issues and concerns, and the current state of the environment (where possible).

The proposed Region of Interest is greater than that identified in the CEC report and is shown in Map 1-1 above; the primary facilities to be included in the study are identified in Figure 1-1 and shown in Map 1-2 (main generation facilities) and Map 1-3 (main transmission facilities).

The final Phase II RCEA report will be retrospective in nature and will:

- Identify, describe, and acknowledge the cumulative effects of past Hydro developments in the Region of Interest;
- Describe the current state of the environment in areas affected by Manitoba Hydro's developments within the Region of Interest; and
- Describe a process for continued monitoring of and reporting on the state of the environment into the future.

The RCEA report will be based on a review and synthesis of past and ongoing studies and monitoring programs, and will include both scientific information and Aboriginal Traditional Knowledge to the extent that each is available.

In accordance with the Terms of Reference, the RCEA will be undertaken based on a two-phase approach. This document represents the Phase I report. The Phase II report will be completed in late fall, 2015.

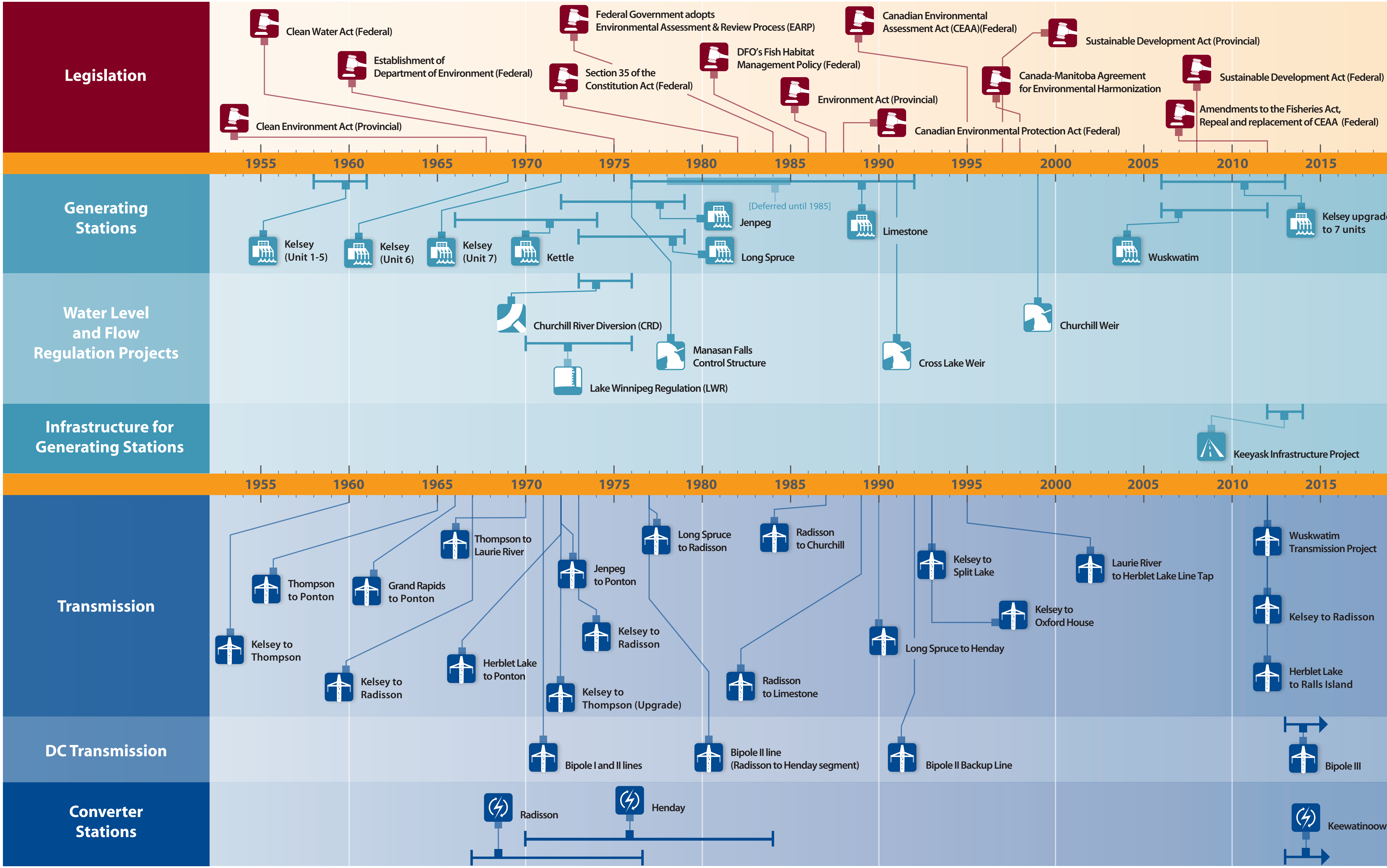
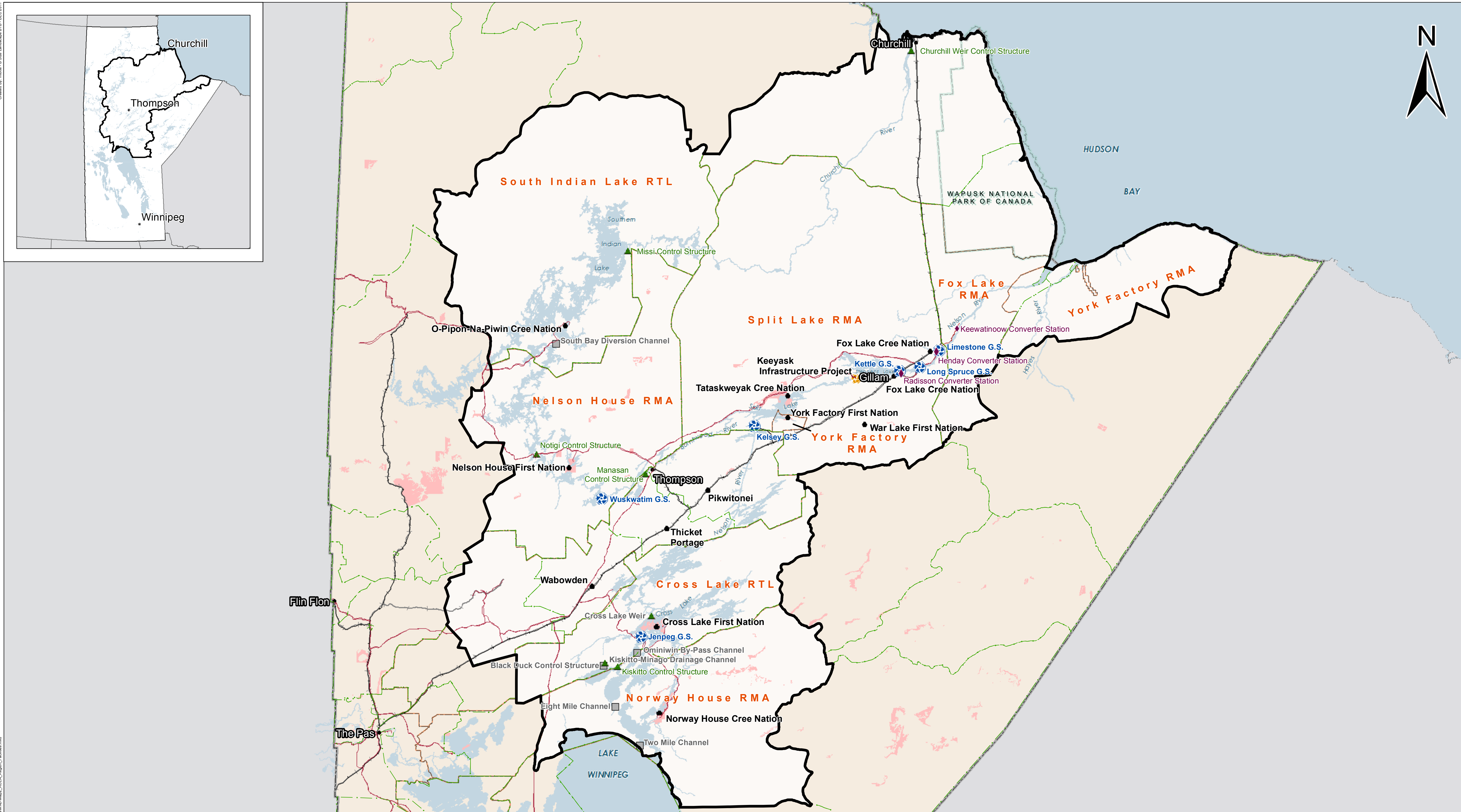


Figure 1-1: Hydroelectric Development in the RCEA Region of Interest and Key Environmental Legislation Over Time

Note: See Table 1-1 for more details



Manitoba Hydro

DATA SOURCE:
Manitoba Hydro; Government of Manitoba; Government of Canada

CREATED BY:
Manitoba Hydro - Hydro Power Planning - GIS & Special Studies

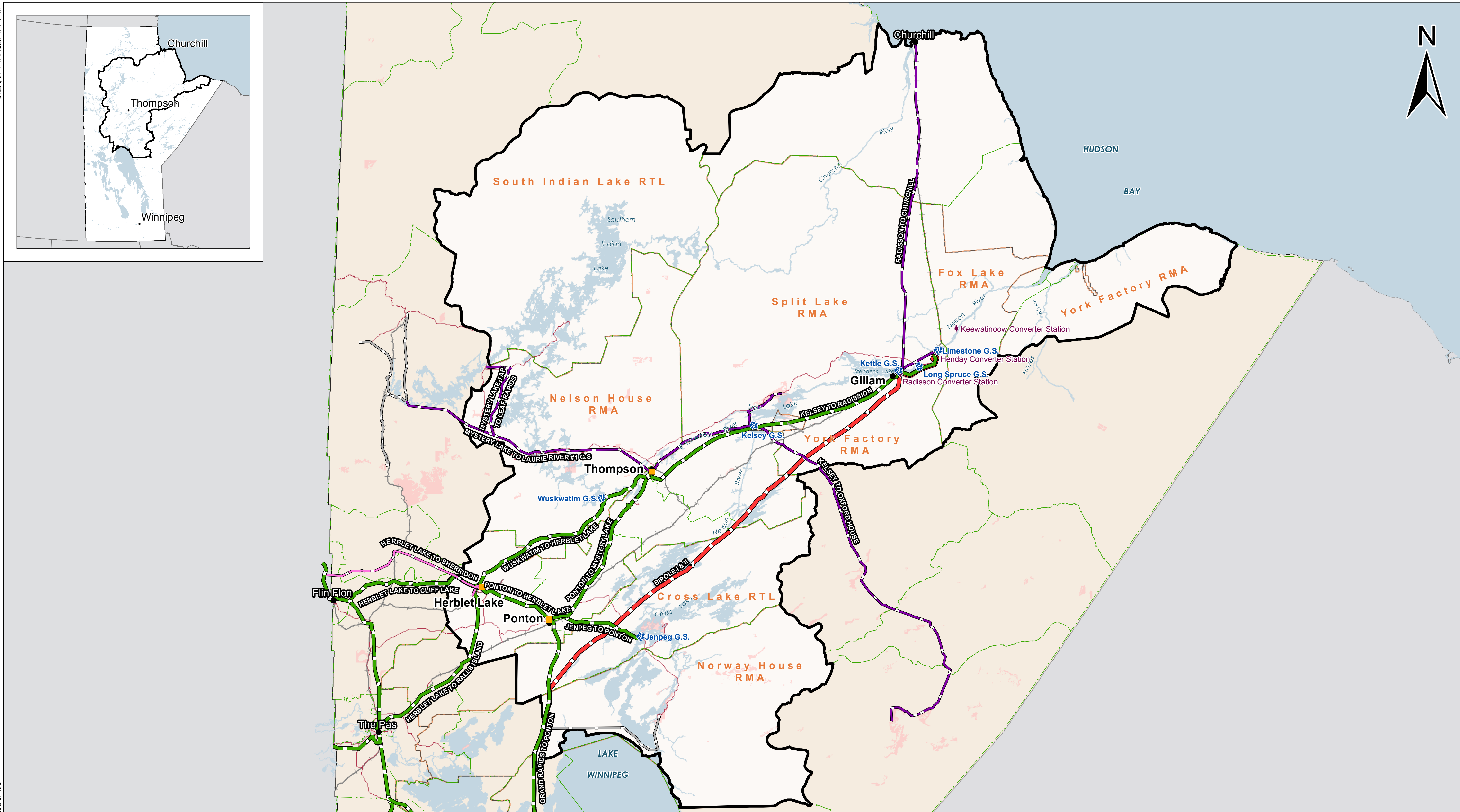
COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	23-MAY-14	
0 30 60 Kilometres / 0 25 50 Miles	VERSION NO: 1.0	QA/QC: RB/MT

Legend

- RCEA Region of Interest
- Generating Station (Existing)
- Converter Station
- Diversions
- Control Structure
- Resource Management Area (RMA)
- Highways
- Rail
- Aboriginal Lands
- Registered Trapline (RTL)

Hydroelectric Development in the RCEA Region of Interest: Generation Components

Map 1-2



DATA SOURCE:
Manitoba Hydro; Government of Manitoba; Government of Canada

CREATED BY:
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COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	23-MAY-14	
	VERSION NO: 1.0	QA/QC: RB/MT

0 30 60 Kilometres
0 25 50 Miles

Manitoba Hydro

Legend

- RCEA Region of Interest
- Major Transmission Sub-station
- Converter Station
- Generating Station (Existing)
- Resource Management Area (RMA)
- Registered Trapline (RTL)
- Highways
- Rail
- Aboriginal Lands

Transmission Line
- 500KV
- 230KV
- 138KV
- 115KV
- 66KV

Hydroelectric Development in the RCEA Region of Interest: Transmission Components

Map 1-3

1.2.1 PHASE I

This report constitutes the Phase I report identified in the Terms of Reference. It is an interim product, developed to demonstrate progress towards the overall RCEA and to provide an early identification of the studies and information being gathered to undertake the final RCEA.

This Phase I Report has been divided into the following five parts:

PART I: Introduction and Approach – this section provides: 1) a description of the requirement for the RCEA and the Terms of Reference for Phase I and Phase II of the RCEA; 2) an overview of the RCEA and a general outline of the Phase I and II Reports; and 3) the spatial and temporal scope of the RCEA and the general methodology for the assessment.

PART II: History of Hydroelectric Development in the Region of Interest – a brief history of hydroelectric development in the Region of Interest including initial planning studies, and the development of generation and transmission facilities.

PART III: People – summarizes at a high level Manitoba Hydro's understanding of the types of socio-economic effects experienced to varying degrees throughout the Region of Interest by type of development (generating stations and transmission facilities) and based on a variety of sources including past environmental impact assessments, past settlement negotiations, perspectives shared by communities and resource user groups, and various community led studies and histories that have been shared with the Corporation. For this Phase I report, socio-economic effects are summarized across all projects and communities. This section also summarizes the mitigation, remediation and compensation measures adopted to address socio-economic effects, including a brief summary of the history of settlement agreements associated with the Projects.

PART IV: Physical Environment – describes key changes to the physical environment resulting from hydroelectric development, including changes to the water regime, ice regime, erosion and sedimentation, and the area flooded. This section also summarizes the available datasets and studies conducted regarding the effects of hydroelectric development on the water regime, ice regime, and erosion and sedimentation in the Region of Interest.

PART V: Water and Land – provides a summary of studies conducted (both pre-and post-hydroelectric development) on the effects to water and land associated with hydroelectric development in the Region of Interest, along with maps showing the locations of these studies. This section also describes the rationale used to select a preliminary list of the key aquatic (water) and terrestrial (land) Regional Study Components (RSCs) that will be assessed. For "water" these include: water quality, fish populations, Lake Sturgeon, fish quality (including mercury and taste, texture and palatability), and marine mammals (whales, seals, and polar bears). For "land" these include: terrestrial habitat, intactness, colonial waterbirds, forest birds, waterfowl, aquatic furbearers, terrestrial furbearers, moose, and caribou.

1.2.2 PHASE II

The scope of the Phase II report (including spatial scope, temporal scope, facilities included, and the topics addressed) will be revised based on input received on the Phase I report. A draft of the Phase II Report will be complete by late fall, 2015.

In particular, the final report submitted at the end of Phase II will expand upon the People, Physical Environment, and Water and Land information provided during Phase I and will include more detailed information and analysis as follows:

People: Phase II will add to the Phase I document by summarizing the views, perspectives, and experiences communities have expressed to Manitoba Hydro in various forms, including but not limited to:

- The NFA Arbitration Claims process;
- Other claims and settlement negotiation processes;
- Aboriginal Traditional Knowledge reports;
- Available post-project evaluations and studies of socio-economic effects, including various and numerous community led studies;
- Environmental Assessments (EAs) and Site Selection and Environmental Assessments (SSEAs) that were conducted for projects in the Region of Interest; and
- Documentation from historic and current (and sometimes ongoing) community engagement processes.

In Phase II, this information will be organized by community. The Phase II report will present mitigation, remediation, and compensation measures undertaken on a community-by-community basis, as well as a description of various historical and ongoing engagement processes. Phase II will also present, to the extent possible, analyses of demographic indicators for the Region of Interest over time, acknowledging both the range of other influencing factors, in addition to hydroelectric development, that have affected these indicators and the difficulty attributing causality among these factors.

Physical Environment: Phase II will expand upon the description of physical change provided in Phase I with more detailed descriptions of Manitoba Hydro's operations, including short-term operations like plant cycling, and detailed mapping of all flooded areas associated with hydroelectric development. Phase II will also include a more in depth analysis of available data along with hydrological conditions to better understand the impact of hydroelectric development. In some cases this may include simulating water levels and flows that would have occurred without hydroelectric development. The description of physical changes to the land resulting from hydroelectric development will be undertaken as part of the Phase II analysis.

Water and Land: The Water and Land sections of the Final Phase II Report will provide more detailed discussion on environmental outcomes and will include:

- Pathways of effects diagrams to provide a visual presentation of the possible linkages between hydroelectric development, impacts to the physical environment, and the subsequent direct and indirect effects to water and land;
- An assessment of the environmental effects of existing hydroelectric developments on the RSCs based on a comparison of pre-hydroelectric development information (where available) and post-hydroelectric development information;
- An assessment of any trends that may be found when comparing data over an extended time-frame (*e.g.*, are Lake Sturgeon populations increasing or decreasing);
- To the extent that they are available, the condition of the RSC will be discussed in the context of appropriate benchmarks and/or thresholds, including any metrics to be identified by Manitoba following the completion of Phase I;
- A description, to the extent possible, of the overall health of the ecosystem; and
- The identification of data gaps in information and, if the data gap can be filled, a process for addressing the data gap will be described.

A detailed description of the scope and methodology for RCEA is provided in Section 1.3.

1.2.3 PUBLIC ENGAGEMENT PROCESS

Early in Phase II, Manitoba and Manitoba Hydro will work to determine an appropriate public engagement process for the RCEA. This process will include opportunities for Aboriginal and other communities in the Region of Interest, as well as other interested parties, to provide their perspectives on the cumulative effects of hydroelectric development in the Region of Interest.

1.3 RCEA SCOPE AND METHODOLOGY

The following describes in greater detail the spatial and temporal scope of the RCEA, and the methodology being used to undertake the RCEA. Notably, the RCEA will use and incorporate, to the extent possible, attributes of contemporary environmental effects assessment and post-project assessment methodology.

There are, however, challenges to undertaking the RCEA and these have influenced the process and methods being employed. Manitoba Hydro development in the Region of Interest has spanned six decades. As noted explicitly in the Terms of Reference, Manitoba Hydro's major northern developments in the Region of Interest were assessed, designed, and constructed to meet the environmental assessment (EA) requirements and societal expectations of the time. Regulatory requirements and societal expectations for environmental assessment in Manitoba have evolved from being nearly absent in the early 1970s (mostly economic considerations), to policy-based project reviews in the late 1970s (Manitoba Environmental Assessment Review Agency), to legislated project reviews in the late 1980s (*e.g.*, *Environment Act*), to assessments with a valued environmental component-based approach for developments assessed in the 2000s (see Figure 1-1 above).

These changes have brought greater requirements related to the types and quantity of data collected. For many of the early developments, the data available would be deemed inadequate by today's standards. As a result, quantitative pre-development information is not always available and/or, if available, has sometimes been collected using different methodologies that preclude the ability to compare pre-and post-development periods. In some cases, where pre-development data are not available, the current environment can be compared to other on-system and off-system areas (recognizing that no two areas are identical) using information from ongoing monitoring programs, such as the Manitoba and Manitoba Hydro Coordinated Aquatic Monitoring Program (CAMP), to provide a comparative assessment of the status of the environment.

Today's planning processes also involve more comprehensive public engagement processes. Manitoba Hydro has moved from a planning process that involved little if any public involvement, to the engagement of local communities in the development of new generation projects and in the routing and assessment of new transmission lines. This, too, has improved the nature and extent of available information and considerably improved understanding about the effects of hydroelectric developments at the local and regional level.

1.3.1 SPATIAL SCOPE/REGION OF INTEREST

The Region of Interest for the RCEA includes the Churchill, Burntwood and Nelson River systems as shown in Map 1-1 above. This area is broader than that initially identified in Recommendation 13.2 of the CEC's Bipole III report (2013) and has been selected because it encompasses the main areas directly affected by Manitoba Hydro developments associated with the Lake Winnipeg Regulation (LWR), Churchill River Diversion (CRD) and associated transmission projects. As discussed below, some aspects studied as part of the RCEA will be assessed on a scale smaller than the Region of Interest (*e.g.*, aquatic components are limited to waterways) while others extend beyond the Region of Interest (*e.g.*, migratory terrestrial species that utilize a broad land base).

1.3.2 TEMPORAL SCOPE

The RCEA will use pre-hydroelectric development information, to the extent that it is available, to describe the conditions prior to development, and the changes that have occurred due to the construction and operation of hydroelectric facilities in the Region of Interest. The key dates for major hydro developments in the Region of Interest, along with the key dates for environmental legislation/policy events in Manitoba since the 1950s are provided in Figure 1-1 above. Additional information is provided in Section 1.3.2.1 below and in Part II.

To the extent that the effects of other non-hydroelectric projects and activities provide important context, additional information that is relevant to understanding the current state of the environment (*e.g.*, effects of provincial highways on measures of terrestrial intactness), or cannot be separated in measures of current condition (*e.g.*, water quality), these projects and activities will also be included. These projects vary for each of the components studied in the assessment.

There are also some hydroelectric developments currently under construction in the Region of Interest—the Bipole III Project, the Keewatinoow Converter Station and the Keeyask Infrastructure Project—and, if approved, the Keeyask Generation and Transmission Projects will begin construction during 2014. The anticipated contributions of these projects to the findings of the Regional Cumulative Effects Assessment will be documented in Phase II based on available monitoring results and predictions provided in each Project's environmental impact statement. The cumulative effects of future hydroelectric developments (*e.g.*, Conawapa) will be addressed separately, and outside of the RCEA, during the regulatory review process for those developments.

1.3.2.1 HYDROELECTRIC FACILITIES INCLUDED

The main hydroelectric facilities included within the Region of Interest, along with their capacity and construction dates (start date and in-service date), are provided in Table 1-1 below. It should be noted that Transmission in-service dates (ISDs) are often earlier than a Generating Station's ISD date as power may be made available as each unit is commissioned. The Generating Station's ISD is the date of the last unit to go into service. There may be some construction activities past the ISD date, such as decommissioning of the work camp and restoration of the site.

Table 1-1: Primary Hydroelectric Development within the Nelson River and Churchill River Watersheds

Generation and Water Regulation			
Project[1]	**Capacity[2] (MW)**	**Start of Construction**	**ISD**
Kelsey GS	292	1958	1961 (first five units): 2 units added in 1969 and 1972. All units re-runnered between 2006–2013
Kettle GS	1220	1968	1974
Churchill River Diversion	n/a	1973	1976
Lake Winnipeg Regulation	n/a	1970	1976
Jenpeg GS	125	1972	1979
Long Spruce GS	980	1973	1979
Limestone GS	1350	1976	1992 (construction was halted in 1978 and resumed in 1985)
Manasan Falls Control Structure			1976
Wuskwatim GS	214	2006	2012
Cross Lake Weir	N/A		1991
Churchill Weir	N/A		1999

Converter Stations		
Project	**Start of Construction**	**ISD**
Radisson Converter Station and Associated Infrastructure	1967	1977
Henday Converter Station and Associated Infrastructure	1970	1985

Transmission[3]		
Project	**Capacity**	**ISD**
Kelsey to Thompson	2–138 kV	1960
Kelsey to Thompson (upgrade of a 1–138 kV line to 230 kV)	230 kV	1972
Kelsey to Radisson	230 KV	1967
Kelsey to Radisson	138 kV	1973

Table 1-1: Primary Hydroelectric Development within the Nelson River and Churchill River Watersheds

Radisson to Limestone	138 kV	1989
Bipole I and II lines[4]	+/-463.5kV, +/-500kV	1971
Long Spruce to Radisson	3-230kV	1977~1979[5]
Long Spruce to Henday	3-230kV	1990
Bipole II line (Radisson to Henday Segment)	+/-500kV	1977
Bipole II back-up line	+/-500kV	1992
Wuskwatim Transmission Project	3-230kV	2012
Thompson to Ponton	230kV	1965~1966[5]
Herblet Lake to Ponton	230kV	1972~1996[5]
Jenpeg to Ponton	230kV	1972
Herblet Lake to Ralls Island	230kV	2012
Ponton to Grand Rapids	230kV	1966
Kelsey to Oxford House	138kV	1993~1997[5]
Kelsey to Split Lake	138kV	1993
Thompson to Laurie River	138kV	1970~1972[5]
Radisson to Churchill	115kV	1987
Herblet Lake to Laurie River	115kV	1920
Herblet Lake to Laurie River line tap	115kV	1995

Projects Under Development or Regulatory Review

Project	**Capacity**	**ISD (Estimated Final ISD)**
Bipole III	+/-500kV	2017
Keewatinoow Converter Station and Associated infrastructure		2017
Keeyask Infrastructure Project	N/A	2014
Keeyask Generation Project	695 MW	2020
Keeyask Transmission Project	138 kV	2019

1. Includes the generation outlet transmission lines associated with each GS.
2. Based on the 63rd Annual Report of the Manitoba Hydro-Electric Board.
3. Construction of transmission projects generally precedes ISD by 3-5 years.
4. Construction of Bipoles I and II were initiated at the same time but Bipole II was completed in 1977 when it was extended to connect to the Radisson and Henday Converter Stations.
5. First date denotes a portion of the line being in service; second date denotes entire line being in service.

1.3.3 RCEA General Methodology

The RCEA will include an assessment of the effects of hydroelectric developments on the physical environment, including changes to the water regime, ice conditions, and shoreline erosion and sedimentation, and will indicate how these changes and other aspects of hydroelectric development (*e.g.*, employment) are linked to direct and indirect effects on People, Land, and Water.

As noted above, the RCEA (Phase II) will be based on a review, synthesis, and analysis of the numerous environmental and socio-economic studies, post-project environmental reviews, environmental impact assessments for proposed developments, and monitoring programs that have been conducted by Manitoba Hydro, Manitoba, Canada, the affected First Nations and others over the last 50 years. These include but are not limited to:

- Pre-hydroelectric development environmental and socio-economic studies conducted for resource management, scientific, or other purposes;
- Post-hydroelectric development studies and datasets completed for resource management, scientific, or other purposes;
- Environmental and socio-economic impact assessment studies conducted for LWR and CRD;
- Post-project monitoring programs to assess and manage impacts of existing facilities including long-term fish population and water quality monitoring studies;
- Environmental assessment studies for all major developments including the Wuskwatim Generation, Wuskwatim Transmission, Bipole III and proposed Keeyask and Conawapa Generation projects (2000 to present);
- Long-term component specific monitoring programs such as water quality monitoring, fish population monitoring, and the monitoring of mercury levels in fish;
- System-wide on-going monitoring programs such as the Coordinated Aquatic Monitoring Program (CAMP);
- Pre- and post-project monitoring programs for the physical environment including the collection of hydrometric data;
- Site-specific studies to address specific issues and concerns expressed by the affected First Nations and communities;
- Studies to determine project effects to quantify losses under the Northern Flood Agreement (NFA) claims process. *It should be noted that the studies conducted by or for individuals, First Nations, communities or organizations are considered confidential and will not be used in the RCEA without the express permission of the party for whom the studies were conducted;*
- Research into specific topics, including methylmercury, Lake Sturgeon, and reservoir greenhouse gases; and

- Community-led Aboriginal Traditional Knowledge studies and other community-based studies that are in the public domain.

Most of the early studies in the late 1970s and early 1980s were focused on specific issues that were identified by affected First Nations and communities. Studies from the mid-1980s to the early 1990s, such as the Federal Ecological Monitoring Program (FEMP) and the Manitoba Ecological Monitoring Program (MEMP) responded to an NFA Claim and were conducted on a more regional scale.

More recently, initiatives like the Manitoba and Manitoba Hydro CAMP (2008 to present) have taken a system-wide, ecosystem-based approach to monitoring aquatic ecosystem health; and the environmental assessment baseline studies for the Wuskwatim Generation, Wuskwatim Transmission, Bipole III, and proposed Keeyask and Conawapa projects (2000 to present) have provided comprehensive information for key topics in the regions where these projects are located.

1.3.3.1 RCEA Approach to People

The RCEA will document Manitoba Hydro and Manitoba's current understanding of the socio-economic effects of past hydroelectric developments, as well as the perspectives, views and experiences communities have shared through various forums since the time of development.

Manitoba Hydro has a long history of interaction with the people and communities living in-proximity to and/or affected by the Lake Winnipeg Regulation (LWR) and Churchill River Diversion (CRD), and associated hydroelectric developments ("the Projects")[1]. Manitoba Hydro's approach to development, and related approach to community engagement, has evolved over time and along with changing societal understandings, values and attitudes regarding the environment, Aboriginal rights and interests, and socio-economic impacts generally.

There exists a wealth of information from various sources related to the socio-economic effects of the Projects. There are many cases where communities have documented their experiences with historic hydroelectric development in their own voices. This would include materials prepared in support of settlement agreement processes, materials prepared more recently in support of current environmental assessment documentation for the Wuskwatim and Keeyask projects, and materials developed for other purposes. Community perspectives on the effects of the Projects have also been shared through oral testimony at recent hearings, including for the Wuskwatim, Keeyask, and Bipole III Projects, and through related public engagement processes. Communities have also shared their perspectives and concerns with Manitoba Hydro through previous and/or ongoing engagement processes, including, for example, through interactions related to ongoing programming such as the Waterways Management Program.

There also exists substantial documentation regarding the processes through which impacts on people and communities have been addressed through mitigation and remedial works, as well as through negotiated settlements with Manitoba Hydro, Manitoba, and, in some cases, Canada. Since many of these

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[1] A listing of the Projects is provided in Section 1.3.2.1.

studies were undertaken in the context of negotiated settlement agreements or claims arbitration they are often confidential.

In light of the various mitigation measures and settlement agreements that have been concluded since construction on the Projects began in the late 1950s, this study seeks through Phase I and Phase II to document Manitoba Hydro's current understanding of socio-economic effects, including the perspectives, views and experiences communities have shared through various forums since the time of development. Both phases of the study will look at impacts in terms of generation ("the Generation Projects") and transmission facilities ("the Transmission Projects"), the latter of which includes converter stations, sub-stations, collector lines, High Voltage Direct Current (HVdc) lines, and lower voltage transmission lines used to provide power to communities. Effects and related mitigation measures will be considered separately for generation and transmission projects because the effects of these types of development are different.

The review and discussion of socio-economic effects will be based on key themes that have emerged through the course of past settlement agreements, past and ongoing community engagement processes, community-based studies, and other processes. These key themes include, but are not limited to:

- Culture, Way of Life, and Heritage Resources;
- Home Relocation;
- Worker Interaction;
- Resource Use;
- Land Use;
- Aesthetics;
- Navigation, Transportation, and Safety;
- Health Concerns;
- Personal Property Loss and Damage; and
- Infrastructure and Services.

Additional themes may be added to the discussion during Phase II based on further review of the available documentation and review of the Phase I document.

1.3.3.2 RCEA Approach to the Physical Environment

The physical environment has been altered by past hydroelectric development within the RCEA Region of Interest. The RCEA will document current understandings about the effects of past hydroelectric developments on the physical environment. This includes changes to the water and ice regimes and the associated changes to shoreline erosion (both mineral soil and peatland) and sedimentation. It will also include physical changes to the land resulting from development of the principal structures, supporting infrastructure, and transmission line rights-of ways associated with hydroelectric development.

Phase I includes a general description of Manitoba Hydro's hydraulic operations and associated effects on water and ice regimes, as well as an estimate of the flooded area associated with each generation facility in the Region of Interest. The Phase I water regime description is based on data records that contain sufficient water level and flow data for both pre- and post-hydroelectric development. Past studies and previous documentation are also referenced, where appropriate. For the ice regime, and in cases where data are more limited, the effects of hydroelectric development are described where possible, but are more qualitative in nature. Erosion and sedimentation is also discussed in Phase I based on a review and synthesis of available information and existing studies for the Region of Interest.

The availability of long-term data varies for the different physical parameters. For the topics of water and ice regime, there has been long-term monitoring of hydrometric data within the Region of Interest that has facilitated the analysis of water level and flow data within distinct hydraulic zones. Similarly, there have been historical studies of shoreline erosion that support the description of physical changes over time relating to hydroelectric development. For physical changes to the land resulting from permanent generation and transmission infrastructure, there has been considerably less work done to monitor and assess these changes in a cumulative manner within the Region of Interest. For this reason, the description of physical changes to the land will be undertaken as part of the Phase II analysis.

Phase II of the RCEA will include a more detailed description of Manitoba Hydro's operations, including short-term operations such as plant cycling. The level of additional analysis in Phase II will vary across the Region of Interest based on the complexity of the hydraulic zone and the availability of data to conduct detailed analyses of change over time. Phase II will include a more in depth analysis of hydrological conditions to better understand the impact of hydroelectric development and, in some cases, this may include simulating water levels and flows that would have occurred without hydroelectric development. Phase II will also include detailed mapping of the flooded areas and other permanent infrastructure associated with hydroelectric development. For shoreline erosion and sedimentation, Phase II will involve further analysis and a summary and synthesis of the findings on the impacts associated with hydroelectric development.

1.3.3.3 RCEA Approach to Water and Land

The Water and Land sections document current understandings about effects of past hydroelectric developments to aquatic and terrestrial environments. Phase I is a comprehensive synthesis of available studies associated with hydro development in the Region of Interest. Phase II will include an assessment of the environmental effects of hydroelectric development based on all available existing information.

For this section, topics that reflect key ecological and social concerns, or are of key importance to the people living in the area, have been selected to focus the assessment and to represent the overall effects of hydro developments within the Region of Interest. The preliminary list of RSCs is provided in Table 1-2 below, along with the rationale for their selection. The list will be reviewed following input received from the review of the Phase I report. Selection of RSCs was based on one or more of the following:

- Overall importance/value to people as identified by residents in the Region of Interest through various forums (*e.g.*, CEC Hearings, ATK reports from the First Nations, NFA Claims);

- Umbrella indicator for groups of species, selected ecosystem components, or ecosystems at one or more spatial scales;
- Importance/value to overall ecosystem function; and
- Known to be susceptible to the direct or indirect effects from hydroelectric developments.

Table 1-2: List of Regional Study Components for Water and Land

Major Ecosystem	Regional Study Component	Rationale
Water	Water Quality	Water quality affects the ability of the aquatic environment to support aquatic life. It is also important to the people who live in the area as a source for drinking water, transportation, recreation, and aesthetics.
	Fish Community	Fish communities were selected due to their ecological importance, as an indicator of aquatic habitat changes, and their importance to the commercial and domestic fisheries in northern communities.
	Lake Sturgeon	Lake Sturgeon was selected as they are culturally important to First Nation members, are a favoured domestic food item in many communities, are a species of conservation concern, and are particularly sensitive to many human activities including hydroelectric development.
	Fish Quality	Mercury in fish flesh was selected due to the importance of fish to the commercial and domestic fisheries in the impacted communities and the effect of mercury on the suitability of fish for consumption (due to the risk to human health).
	Marine Mammals	Marine mammals were selected due to their importance to a variety of stakeholders, including commercial tourism operators and all Manitobans. Polar bear and beluga are also species of conservation concern.
Land	Terrestrial Habitat	Terrestrial habitat was selected because some habitat types are especially important for social and ecological reasons and because human induced changes to terrestrial habitat are a key pathway for effects on the entire terrestrial ecosystem
	Intactness	Intactness was selected because it is often used as an overall indicator of cumulative effects on ecosystems at multiple spatial scales and on wildlife habitat in environmental assessment and monitoring.

Table 1-2: List of Regional Study Components for Water and Land

Major Ecosystem	Regional Study Component	Rationale
	Birds (waterfowl, colonial waterbirds, boreal forest birds)	Waterfowl: were selected due to their importance to resource harvesters, their link to the health of wetland habitats and lower food chain levels, and they can be substantially affected by hydroelectric development. Waterfowl are affected by hydroelectric developments in several ways with the flooding of habitat and water level fluctuations often being the primary pathways to the effects as well as the potential for line strikes. Colonial waterbirds: were selected for several reasons. Some species use some rare or uncommon environmental features for breeding. Colonial birds have been recognized as good indicators of aquatic ecosystem health. Some species are of conservation concern. Flooding and water level fluctuations can result in population and habitat effects. Some species may be particularly vulnerable to collisions with man-made structures (*e.g.*, line strikes). Forest Birds: were also selected for several reasons. Forest birds are culturally significant to local First Nations and Aboriginal peoples. Many species of boreal forest birds are undergoing long-term population declines throughout Canada. Some species are of conservation concern. Hydro developments can directly affect forest birds.
	Furbearers (aquatic and terrestrial)	Aquatic: Aquatic furbearers are important to the people who live in the area as a source of income and food. They are negatively affected by the water impacts of hydro development (*e.g.*, flooding and water level fluctuations). Terrestrial: Terrestrial furbearers were selected due to their economic importance to local people, they are at the top of the food chain and they can be affected by roads, transmission lines, borrow areas, and other land impacts associated with hydro development.
	Caribou	Caribou are an important symbol of Canadian wilderness and can be sensitive to disturbance of the landscape. Their specialized habitat needs may not be well captured by other land RSCs. They are a species of conservation concern.
	Moose	Moose were selected primarily because of their importance to First Nations peoples and sensitivity to habitat fragmentation and increased access for predators and hunters.

Although the Region of Interest provides a boundary for defining which hydroelectric developments are considered in the assessment and the primary region of direct Project effects, the area of interest for each RSC, will be defined by what is ecologically meaningful for that component (*e.g.*, population ranges for wildlife species), and will be presented with associated rationale in the Phase II report. Where required, the areas of interest will extend beyond the Region of Interest to provide context for a specific topic. The assessment areas selected will be large enough to capture the cumulative effects of hydro development, but not so large as to mask the effects on a given component (by making the effects appear unreasonably small as a percentage of the total area considered).

For the purposes of documenting and assessing changes to the Land and Water RSCs, the Region of Interest has been organized into the following four geographic areas:

- Area 1: Warren Landing to the inlet of Split Lake;
- Area 2: Split Lake to the Nelson River estuary;
- Area 3: Opachuanau Lake to Split Lake Inlet (including Southern Indian Lake); and
- Area 4: the Missi Falls Control Structure to the Churchill River estuary (see Map 1-4).

The inland portions of Areas 1 to 4 generally coincide with the boundaries for resource management areas (RMAs), Registered Trapline Districts, ecodistricts and/or watersheds.

Areas 1 to 4 are similar to those used in two major study programs—namely, the Lake Winnipeg, Churchill and Nelson Rivers Study Board (1971–1975) and Manitoba and Manitoba Hydro's CAMP (2007 to present). The exception is Area 3, which combines Southern Indian Lake and the diversion route, which were dealt with separately in the aforementioned studies.

It should be noted that the Phase II analysis undertaken for RSCs may combine areas where appropriate (*e.g.*, for components like intactness) to provide a more complete analysis of the cumulative effects of hydroelectric developments over a broader geographic area.

There is an extensive body of information available for the Water and Land components; however, the utility of the information in quantifying the cumulative effects of hydro developments is limited for some RSCs by the following:

- There is often a lack of pre-development scientific data which precludes the ability to conduct a quantitative assessment of post-development changes for some RSCs. Comparisons of pre- and post-project data are also hindered by analytical or equipment changes that occur over time (e.g., changes in soil or water quality detection limits);
- Differences in the "types" of studies conducted can make comparisons difficult (e.g., resource management studies often target key fish species to monitor their abundance at specific locations over time while impact assessment studies set nets randomly to determine habitat use by the broader fish community); and
- There is often insufficient data to quantify effects on a number of RSCs, particularly RSCs that do not have a direct commercial value (e.g., forest birds).

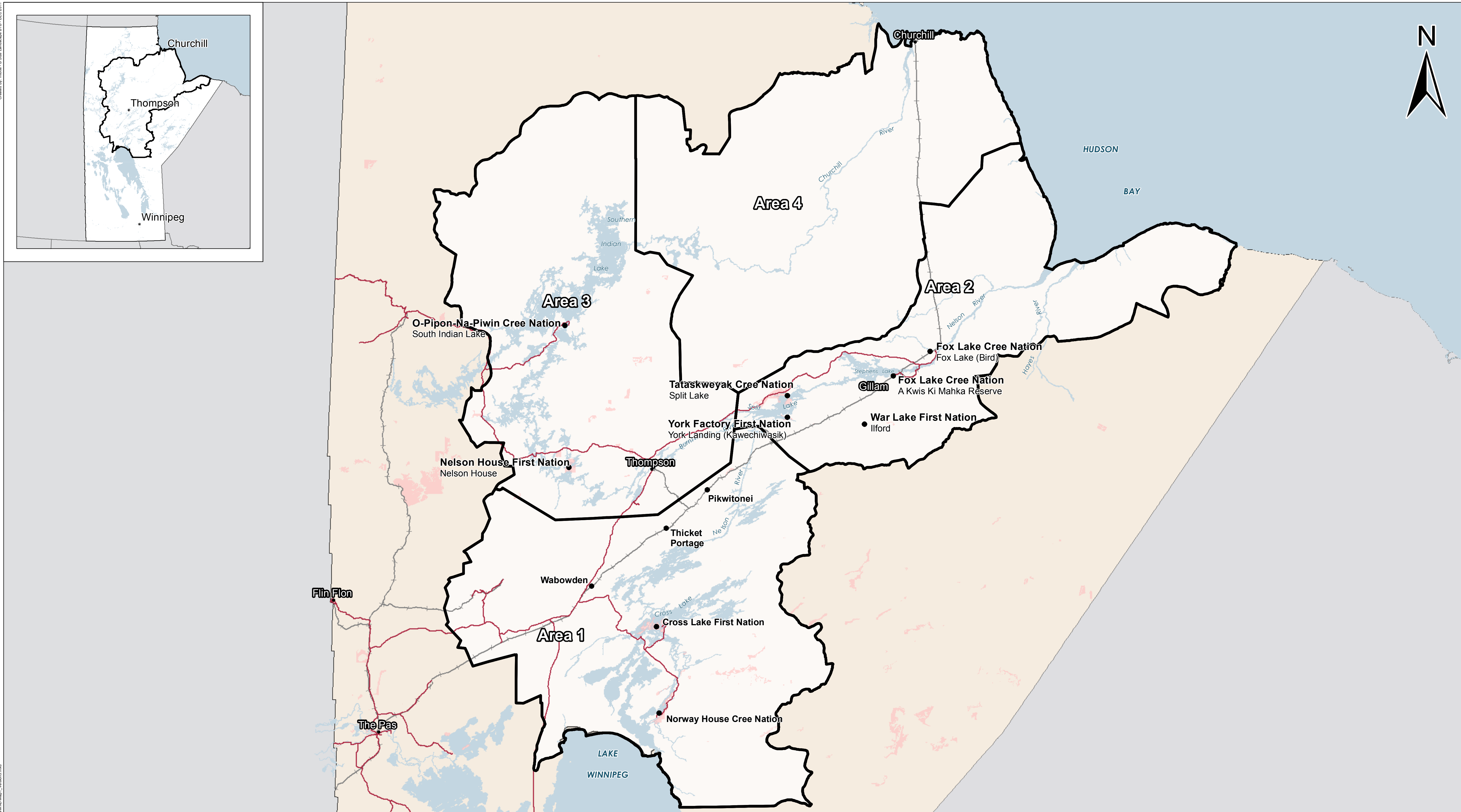
As a result, establishing a pre-development condition from which to evaluate cumulative effects is challenging and not always possible.

The assessment of the cumulative effects of hydro development on some RSCs will also hampered by the following:

- The ability to quantify the effect of hydroelectric developments on some RSCs may be masked by the effects of other projects and activities (*e.g.*, the loss of land due to clearing for hydro developments in an area where large scale forestry operations are located). Similarly, some RSCs have a broad home range and may be affected more by developments outside rather than inside the Region of Interest (*e.g.*, many songbirds migrate from the Region of Interest to areas in Central and South America); and
- Quantifying the effects of hydro developments on RSCs that are harvested either commercially (*e.g.*, aquatic furbearers) or domestically or for sport (*e.g.*, moose) is difficult as populations will reflect the level of harvest and this is often linked to economics (*e.g.*, fur prices) or resource management decisions (*e.g.*, changes in harvest quotas).

Despite these limitations, which are common in assessments spanning a long timeframe, Manitoba Hydro and Manitoba will provide the best information available and will use the best contemporary methodologies for environmental assessments and post-project environmental reviews to meet the objectives of the Terms of Reference.

In particular, following the conclusion of the Phase I report, Manitoba will work to develop metrics, where feasible, of ecosystem health to enhance the assessment of information and data during Phase II. These metrics, where available, will be used as a basis for assessing the health of the current state of the environment.



DATA SOURCE:
Manitoba Hydro; Government of Manitoba; Government of Canada

CREATED BY:
Manitoba Hydro - Hydro Power Planning - GIS & Special Studies

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	15-MAY-14	
0 30 60 Kilometres / 0 25 50 Miles	VERSION NO: 1.0	QA/QC: MT/RDB

Legend

- RCEA Region of Interest
- Highways
- Rail
- Aboriginal Lands

RCEA Region of Interest
Areas 1 to 4

Map 1-4

1.4 LITERATURE CITED

Manitoba Clean Environment Commission. 2013. Report on public hearing Bipole III transmission project June 2013. Manitoba Clean Environment Commission, Winnipeg, MB. 150 pp

Manitoba Clean Environment Commission. 2004. Report on public hearings: Wuskwatim Generation and Transmission Projects. Manitoba Clean Environment Commission, Winnipeg, MB. 151 pp

APPENDIX 1A
TERMS OF REFERENCE

Manitoba Hydro
360 Portage Ave • Winnipeg Manitoba Canada • R3C 0G8
Telephone / *N° de téléphone :* (204) 360-3690 • Fax / *N° de télécopieur :* (204) 360-6135
wabrown@hydro.mb.ca

2014 05 27

Environmental Assessment & Licensing Branch
Manitoba Conservation and Water Stewardship
Suite 160 - 123 Main Street
Winnipeg MB R3C 1A3

Attention: Ms. Tracey Braun

Dear Ms. Braun:

Re: Letter of Confirmation for Regional Cumulative Effects Assessment

By way of this letter, both Manitoba and Manitoba Hydro confirm that they are in agreement with the attached final Terms of Reference to conduct a Regional Cumulative Effects Assessment (RCEA) of hydro-electric developments that includes the Nelson, Burntwood, and Churchill River systems, as defined below and in the Terms of Reference.

The RCEA is being conducted in two phases and is designed to address Recommendation 13.2 of the Clean Environment Commission Report on Public Hearing for the Bipole III Project. In his letter of August 14, 2013, the Minister of Conservation and Water Stewardship specifically committed to implementing this recommendation, which states:

> *"Manitoba Hydro, in cooperation with the Manitoba Government, conduct a Regional Cumulative Effects Assessment for all Manitoba Hydro projects and associated infrastructure in the Nelson River sub-watershed; and that this be undertaken prior to the licensing of any additional projects in the Nelson River sub-watershed after the Bipole III project."*

It is planned that the final RCEA report will be available in late fall 2015. It will be retrospective in nature and will:

- identify, describe and acknowledge the cumulative effects of past Hydro developments;
- describe the current state of the environment in areas affected by Manitoba Hydro's system; and,
- describe a process for continued monitoring of and reporting on the state of the environment into the future.

The final RCEA report will be based on a review and synthesis of past and ongoing studies and monitoring programs, and will include both technical science and Aboriginal Traditional Knowledge to the extent that each is available.

It is intended that an interim product will be available in late May 2014 to demonstrate progress towards the overall RCEA and to provide an early identification of the studies and information being gathered to undertake the final RCEA, and the methods to be employed for the assessment.

Manitoba and Manitoba Hydro are further committed to implementing an appropriate public engagement process. This engagement process will be determined following submission of the interim report and will include opportunities for Aboriginal and other communities in the Region of Interest, as well as other interested parties, to provide their perspectives on the cumulative effects of hydroelectric development in the Region of Interest.

Confirmed this day of May, 2014:

W H B

Manitoba Hydro
Per: William Brown
Manager, Environmental Licensing and Protection

Confirmed this 27 day of May, 2014:

Tracey Braun

Government of Manitoba
Per: Director
Environmental Approval
Conservation and Water Stewardship

Terms of Reference
Joint Approach to Undertaking a Regional Cumulative Effects Assessment for Hydro Developments as per Recommendation 13.2 of the Clean Environment Commission (CEC) Bipole III Report
Manitoba Conservation and Water Stewardship and Manitoba Hydro

Background

The 2013 Clean Environment Commission (CEC) Bipole III Report included a list of non-licensing recommendations to be carried out jointly by Manitoba Hydro (MH) and the provincial government. On behalf of government, the Minister of Conservation and Water Stewardship (CWS) committed to implementing these recommendations.

These Terms of Reference provide a proposed approach to addressing one of the CEC's non-licensing recommendations, specifically number 13.2, which states:

> *"Manitoba Hydro, in cooperation with the Manitoba Government, conduct a Regional Cumulative Effects Assessment for all Manitoba Hydro projects and associated infrastructure in the Nelson River sub-watershed; and that this be undertaken prior to the licensing of any additional projects in the Nelson River sub-watershed after the Bipole III project."*

The CEC report details the rationale for this recommendation. In short, during the Bipole III hearings, some communities expressed concerns regarding effects they have experienced, and continue to experience, as a result of existing MH projects. The CEC noted that "…it became apparent that past hydro-electric developments in northern Manitoba have had a profound impact on communities in the area of these projects, as well as on the environment upstream and downstream." Similar concerns were identified in the CEC's 2004 "Wuskwatim Generation and Transmission Projects" hearing report.

On October 17, 2013, the CEC heard motions from participants in the Keeyask CEC process who were requesting that the Keeyask Generation Project hearing be delayed until the recommended regional cumulative effects assessment is complete. As part of this motions hearing, the CEC noted the volume of study that has been completed to date by Manitoba Hydro in the Nelson River region and suggested that Recommendation 13.2 could readily be satisfied by pulling together and analyzing this information, rather than undertaking new field work or seeking new information.

Consistent with the Recommendation 13.2 and comments made by the CEC on October 17, 2013, these terms of reference will:

- identify the challenges ahead in making such an assessment decades after the developments have occurred;
- identify the scope of the study to address recommendation 13.2;

- describe the approach to be used to address the challenges while still meeting the intent of the recommendation;
- outline the work tasks to be done, who will have the accountability for each task and the timelines for completion;
- describe the desired end product; and,
- set out how the process will be managed between the Manitoba government and MH.

Challenges and Scope

Manitoba Hydro's major northern developments include the Churchill River Diversion (1976), Lake Winnipeg Regulation (1976), Kelsey Generating Station (G.S.) (1961), Kettle G.S. (1974), Long Spruce G.S. (1979) Limestone G.S. (1992) and Bipole I and II (1971 and 1978). These developments were assessed, designed, and constructed to meet the environmental assessment (EA) requirements of the time. Over the many ensuing years, EA practices and assessment procedures have evolved to where they are today.

The key differences between past and current EA practices are: the analysis of whole ecosystems; cumulative effects/impacts assessment; and, the collection of pre-development data that would be used to provide the context from which to measure future environmental impacts. As a result, establishing a pre-development condition from which to evaluate cumulative impacts will be a challenge in addressing the CEC's recommendation. This is not uncommon in cases where areas were developed many decades past.

In addition to assessing cumulative impacts over time, the CEC's recommendation refers to assessing these impacts over space, i.e., regionally. Regional cumulative assessments are typically used as a government's tool to facilitate broad, long-term planning decisions regarding a range of development options for a prescribed area or basin. In the case of the Nelson River sub-watershed, such planning decisions were made over forty (40) years ago and any impacts that may have resulted are largely irreversible at this point in time and/or the environment has now adapted.

Notwithstanding these challenges, the Manitoba government and MH will provide the best information possible to satisfy the objectives of the CEC's Bipole III recommendation 13.2. Also in terms of scope, it is proposed to include areas beyond that identified in the CEC recommendation to include the Churchill, Burntwood and Nelson river systems.

Work Steps, Approach to the Study and Accountability

Given the above, Manitoba and Manitoba Hydro believe that the best option to address Recommendation 13.2 is the development of a plain language "Regional Cumulative Effects Assessment for Hydro Developments on the Churchill, Burntwood and Nelson River Systems" that describes environmental change over time as a result of previous hydro development, including impacts, mitigation measures, community issues, compensation and the current quality of the environment. The report will be based on a review and synthesis of past and ongoing studies and monitoring programs. The proposed region of study is greater than that identified in the CEC report.

Specifically, the final report would:

- identify, describe and acknowledge the cumulative impacts of past Hydro developments;
- describe the current state of the environment in areas affected by Manitoba Hydro's system; and,
- describe a process for continued monitoring of and reporting on the state of the environment into the future.

The report would use and incorporate, to the extent possible, attributes of contemporary environmental effects assessment and post-project assessment methodology. This type of assessment would be very similar to the approach taken from the documents currently being prepared by Manitoba Hydro at the CEC's request for the review of the application for finalization of the *Water Power Act* licence for Lake Winnipeg Regulation.

Phase One

The first phase will be to develop a plain language report entitled "A Response to Recommendation 13.2 – Phase 1: A Summary of Environmental Results" that summarizes and describes what is known about the environment in areas affected by hydroelectric developments that are associated with the lake Winnipeg Regulation and Churchill River Diversion areas. Using text and matrices, it would include:

- A description of all projects/facilities and key points such as area flooded, area of land affected, etc.
- A discussion of the history of Settlement Agreements.
- The preparation of a bibliography of all existing information on the environmental effects associated with hydro development in the Nelson River basin area including effects associated with CRD, LWR, Kelsey, Kettle, Long Spruce, Limestone, Radisson, Henday, Bipole I and II and other transmission components, and all related infrastructure such as water control structures and roads.
- A compilation, synthesis and summary of this information in text format and in matrices. This will essentially provide an organized (by topic and region) summary of all available environmental effects from existing studies.
- A summary of current monitoring information collected since 2008 by Manitoba and Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP) and the long term monitoring program associated with Bipole III.
- Development of metrics, where feasible, of ecosystem health (by Manitoba) to enhance the assessment of information and data during Phase II and based on jointly agreed to regional study components.
- Preparation and submission of an interim report.
- Manitoba and Manitoba Hydro will work together to collect, summarize and document what has been learned through past and current consultation and Aboriginal Traditional Knowledge processes.

The consolidation, organization and synthesis of the vast amount of information and data that have been collected over the last several decades will provide the foundation for assessing the current quality of the environment in areas affected by hydroelectric developments associated with the Lake Winnipeg Regulation and Churchill River Diversion areas – primarily the Churchill, Burntwood and Nelson River systems.

To the extent possible, attributes of contemporary environmental effects assessment and post-project assessment methodology will be used which will be consistent with the approach currently being requested by the CEC for the review of the application for the finalization of the *Water Power Act* Licence for the Lake Winnipeg Regulation.

Accountability for the preparation of the Phase I report will be with MH; but Manitoba will participate jointly in collecting, summarizing and documenting what has been learned through past and current consultation and Aboriginal Traditional Knowledge processes. The Phase I "*Summary of Knowledge Acquired: Phase I of a Regional Cumulative Effects Assessment for Hydro Developments on the Churchill, Burntwood and Nelson River Systems*" will be completed by May 31, 2014 and submitted to the Minister of CWS on behalf of the Manitoba government. The initial Phase I report will provide the basis for the Phase II work.

Upon receipt of the Phase I report from MH, CWS will facilitate an internal review by departmental experts who will be expected to provide technical expertise and recommendations for the assessment. It is expected that Manitoba government will provide input where appropriate to be considered for the enhancement of the Phase II report and will communicate this to MH in a consultative and collaborative manner throughout the summer and fall of 2014.

Phase II

Phase II would include an assessment of the environmental effects of hydro development based on all available existing information, and utilizing to the degree possible the attributes of methodologies for environmental effects assessment and post-project assessment. This assessment would be undertaken by MH and would include:

- Pathways-of-effects diagrams to provide a visual representation of the possible linkages between the projects and the environment.
- An assessment (to the extent possible) of the environmental and socio-economic effects to identified regional study components of previous Hydro development (based on available information and, wherever possible, based on pre-hydro development information);
- A determination of the current quality of the environment in areas affected by Hydro development based on more current monitoring and assessment data and in consideration of available thresholds and benchmarks, as well as conditions in off-system areas, where applicable;
- The identification of gaps in information; and,
- Preparation of an Environmental Assessment and State of Knowledge Report.

The report prepared at the end of Phase II by Manitoba Hydro entitled *"Regional Cumulative Effects Assessment for Hydro Developments on the Churchill, Burntwood and Nelson River Systems: Final Report"* is to be provided to Manitoba in October, 2015, and submitted to the Minister of CWS on behalf of the Manitoba government. Upon receipt of the Phase II report from MH, as with the Phase I report, CWS will facilitate an internal review by departmental experts who will be expected to provide technical expertise and recommendations prior to finalizing the report.

Early in Phase II, Manitoba and Manitoba Hydro will also determine the exact nature and design of any appropriate public engagement processes. Once determined, Manitoba Hydro will provide the funding required to undertake the agreed to public engagement process.

Beyond Phase 2

CWS and MH will continue long term monitoring efforts managed under the Coordinated Aquatic Monitoring Program (CAMP) and the Bipole III monitoring and reporting programs to ensure that the environment is sustainably managed and protected well into the future.

Desired End Product

The desired end product will be a final report that addresses the intent of the CEC's Bipole III hearing report Recommendation 13.2, but that also provides a consolidated, vast, and comprehensive collection of environmental data and community knowledge about the region. It is fully intended that the report will be a resource for government and all Manitobans on the state of the environment in this resource and heritage-rich part of the province.

Process for Collaboration

The CEC recommended that the assessment be done in cooperation between MH and the Manitoba government. Although the major portion of report preparation will be the responsibility of MH, CWS, on behalf of the Manitoba government, will facilitate regular and ongoing input from internal experts as needed throughout each phase of the study (e.g., wildlife, fisheries, Heritage resources, forestry, etc.) and will contribute available information from its records to complete the study.

It is anticipated that a small project management team consisting of representation of both MH and CWS will be established and will meet on a regular basis to check milestones, schedules, and to discuss/resolve issues that may arise. The management team will be co-chaired by MH and CWS.

The management team, through their CWS members, shall request issue-specific technical meetings be held as needed with representatives from the relevant program areas to discuss findings, review technical options, interpret monitoring data, and discuss analyses and recommendations and seek government support/direction as necessary. As mentioned above, CWS will formally facilitate an internal review of both the Phase I and Phase II reports.

Timeline

The total length of the study is anticipated to be from January 2014 through October 2015. Work going beyond the submission of the final Phase II report can be determined outside of these Terms of Reference. An estimated summary of the timelines is provided below. It is possible that these dates may change based on the outcomes of Phase I and implementation experience during the course of Phase 2.

TASK	**ACCOUNTABILITY**	**BY WHEN**
Finalize Terms of Reference	MH and CWS	Jan. 24, 2014
Submit Phase I report to CWS	MH	May 31, 2014
Facilitate TAC review of Phase I report	CWS	Jul. 31, 2014
Project progress/management meetings	CWS and MH	Ongoing (monthly)
TAC meetings	CWS and MH	As needed
Public Engagement	TBD	TBD
Submit Phase II report to CWS	MH	Oct. 31, 2015
Facilitate TAC review of Phase II report	CWS	Nov. 30, 2015
Finalize Phase II report		Dec. 31, 2015

May 2014

PART II: HISTORY OF HYDROELECTRIC DEVELOPMENT IN THE REGION OF INTEREST

Manitoba Hydro

REGIONAL CUMULATIVE EFFECTS ASSESSMENT

PART II

HISTORY OF HYDROELECTRIC DEVELOPMENT IN THE REGION OF INTEREST

TABLE OF CONTENTS

ACRONYMS, ABBREVIATIONS AND UNITS

Acronym / Abbreviation	Term/Unit
AC	Alternating current
AECL	Atomic Energy of Canada Limited
AFP	Augmented Flow Program
CN	Canadian National
CRD	Churchill River Diversion
DC	Direct current
ft	feet
GS	Generating Station
HVdc	High Voltage Direct Current
INCO	International Nickel Company
km	kilometre
kV	kilovolt
LWR	Lake Winnipeg Regulation
MW	megawatt
NCN	Nisichawayasihk Cree Nation
NRPB	Nelson River Programming Board
RCEA	Regional Cumulative Effects Assessment
SIL	Southern Indian Lake

2.0 HISTORY OF HYDROELECTRIC DEVELOPMENT IN THE REGION OF INTEREST

The key dates for all major hydroelectric developments in the Region of Interest, along with the key dates for environmental and socio-economic events in Manitoba since the 1950s are illustrated in Figure 1-1. To provide context for the RCEA, the following gives a high-level overview of the history of hydroelectric development in the Region of Interest.

2.1 PLANNING

Manitoba Hydro has been a key part of Manitoba's economy since the Manitoba Power Commission was established in 1916. Since then, Manitoba Hydro has grown through the construction of new facilities and the purchase of existing facilities as discussed below (see Table 1-1).

The potential for hydroelectric development in the Region of Interest was identified by Manitoba and Canada early in the last century. In 1913, the Department of Mines (Canada) conducted a comprehensive geological survey of the drainage basins of the Churchill and Nelson rivers to determine the power potential of Manitoba's northern rivers. At the time, the key challenge for developing this power was a lack of available technology for transmitting energy over long distances. However, the report (McInnes 1913) formed the basis for further studies that ultimately led to the development of Manitoba's northern water power resources.

A substantial amount of planning regarding potential ways to meet the Province's future power needs was conducted by Manitoba during the 1940s and 1950s. In 1947, Manitoba Water Resources Branch initiated surveys of the upper reaches of the Nelson River and concluded that approximately 160 MW of potential power was available between Warren Landing and Cross Lake. In the 1950s, studies were also conducted at several locations by Manitoba Department of Mines and Natural Resources including Long Spruce to Limestone Rapids (Verner 1955), Devils Rapids to Birthday Rapids (Verner 1955), Birthday Rapids to Butnau River (Verner 1956), and the Churchill River and Burntwood River systems (Gould 1958) as well as several other areas.

In 1958, Canada and Manitoba jointly funded the Lakes Winnipeg and Manitoba Board to determine if the regulation of Lake Winnipeg could be used to reduce flooding around Lake Winnipeg. The study found that although regulation could provide flood control, that the benefits from flood control by itself could not be justified from an economic perspective. However, the Board concluded that Lake Winnipeg Regulation (LWR) would be valuable for hydroelectric development if the total capacity of the Nelson River hydroelectric plants reached several hundred megawatts.

In the early 1960s, Manitoba needed to increase its energy production to meet growing provincial demand either through thermal or hydroelectric production. During this timeframe, advances were made in the field of High Voltage Direct Current (HVdc) power transmission which would allow power to be transferred more efficiently from the north. Subsequently, Manitoba and Canada formed the Nelson River Programming Board (NRPB) in 1963, which "*investigated the power potential of the Nelson River and considered the merits of diverting a substantial portion of the flows from the Churchill River via the Rat and Burntwood rivers into the lower Nelson River to augment the power potential of sites at Kettle Rapids, and downstream areas. A follow-up program was conducted in 1964 and, in December 1965, the NRPB recommended that the Government consider a Phase I plan of hydroelectric generation*" (Tritschler 1979). The Phase 1 plan consisted of the following:

- The regulation of Lake Winnipeg (now known as Lake Winnipeg Regulation or LWR);
- The diversion of flows from the Churchill River (via the Rat and Burntwood rivers) into the Nelson River (now known as the Churchill River Diversion or CRD);
- A generating station at Kettle Rapids on the lower Nelson River (now known as the Kettle GS); and
- The construction of converter stations and an HVdc transmission line from the Kettle GS to southern Manitoba (now known as Bipole I).

The NRPB indicated the Phase I plan was the lowest cost option that would be economically feasible for hydroelectric development in northern Manitoba and would be fully compatible with, and would facilitate, the development of hydroelectric power in the north. The NRPB stated that the storage capacity in Lake Winnipeg and Southern Indian Lake (SIL) would be required to maximize the financial benefits of the developments. At SIL, both a high level and a low level diversion were being considered: both options would cause substantial flooding on SIL but the high level CRD would require the entire community of South Indian Lake to be moved and would cause adverse environmental impacts as far upstream as Granville Lake. As discussed in Section 2.2 below, the high level diversion was not approved by the government of Manitoba but the low level diversion was subsequently authorized.

As discussed below, all four of the recommended projects were constructed between 1966 and 1976: Bipole I (completed in 1971); Kettle Rapids GS (1966 to1974); Lake Winnipeg Regulation (1970 to 1976), and the Churchill River Diversion (1973 to 1976). It should be noted that construction of Bipole II was initiated at the same time as Bipole I as it was more efficient to build them at the same time. Bipole II was then extended to connect to the Radisson and Henday Converter Stations which was completed in 1977. These large projects required supporting infrastructure to be able to convert and distribute power to end users and to access and maintain the facilities.

2.2 HYDROELECTRIC DEVELOPMENT 1950 TO 1976

The Kelsey GS was the first generating station constructed on the Nelson River. Construction of the station and associated infrastructure occurred between 1958 and 1961. Associated infrastructure included an airstrip and a 23 km long rail spur line linked to the CN Bayline, to provide access to the construction site. Initially, the Kelsey GS consisted of a five-unit 160 MW development with the sole purpose to provide power to International Nickel Company's (INCO) mining and smelting operations in the Moak Lake and Mystery Lake areas and to Thompson. A sixth unit was installed in 1969 and a seventh unit in 1972. All 7 units were re-runnered between 2006 and 2013 and the current capacity of the Kelsey GS is 292 MW. To deliver the power to Thompson, two-138 kV transmission lines were constructed and in-service by 1960. One of the 138 kV transmission lines was upgraded to 230 kV in 1972. A 129 km long 230 kV transmission line was constructed in 1967 from the Kelsey GS to the future site of the Radisson Converter Station. An additional 138 kV transmission line between the Kelsey GS and the Radisson Converter Station became operational in 1973 and was completed in 1977. The lines increased the capacity and reliability of power to Thompson and to INCO's operations. A transmission line was also constructed to provide construction power for the future Kettle GS and to supply power to Gillam, which was rapidly expanding as the centre for hydroelectric development in the north.

Manitoba Hydro applied for an interim licence to develop the high level CRD in April 1968. There was strong opposition from the public and the following year, the Manitoba government stated that the high level CRD would not be approved. Manitoba subsequently commissioned a study of the Lake Winnipeg Regulation project (G.E. Crippen and Associates Ltd. 1970). Concurrently, Manitoba Hydro commissioned a study of an alternative low level CRD (Underwood McLellan and Associates Ltd. 1970).

The LWR project was reviewed again and approved in 1970 and was operational by 1976 (installation of the generating units at Jenpeg GS was completed in 1979). The Project consists of the following:

- The 125 MW Jenpeg GS and Control Structure which regulates the Nelson River West Channel portion of Lake Winnipeg's outflow;
- A series of diversion channels (Two-Mile, Eight-Mile, and Ominawin Bypass) that increase the outflow capacity from Lake Winnipeg into the Nelson River; and
- The Kiskitto Dam and Inlet Control Structure which separate Kiskitto Lake from the backwater effects of LWR (which would result in flooding) and provides a regulated inflow.

In December 1972, an interim licence to proceed with the low-level CRD was issued to Manitoba Hydro by the Water Resources Branch of the Manitoba Department of Mines, Resources and Environmental Management. In May 1973, Manitoba granted Manitoba Hydro an "Interim License for the Diversion of Water from the Churchill River to the Nelson River, and the Impoundment of Water on the Rat River and Southern Indian Lake." Construction contracts were awarded in 1973, and the diversion was in operation in 1976.

The water diverted from the Churchill River was to be used at four potential generating stations along the Burntwood River (totalling more than 700 MW) and at seven existing and potential sites on the lower Nelson River adding nearly 2,000 MW of dependable capacity.

The CRD has three main components:

- A control dam at Missi Falls (the natural outlet of SIL), which raises the lake's level by 9 ft. (3m) and controls the outflow to the lower Churchill River;
- An excavated channel from South Bay of SIL to Issett Lake, which creates a new outlet that allows water to flow from the Churchill River into the Rat River-Burntwood River-Nelson River systems; and
- A control structure on the Rat River at the outlet of Notigi Lake which regulates the flow into the Burntwood River-Nelson River systems.

By 1979, Manitoba Hydro had determined that the CRD could convey higher flows than stipulated in the Interim License without exceeding the water level constraints in the Interim License. The conditions set in the licence provide safeguards for communities affected by the Churchill River Diversion. The licence conditions limiting Notigi outflows were set based on anticipated downstream inundation levels at certain flows. After construction was completed, initial operations revealed that impacts downstream of Notigi in open water were about as expected and ice impacts were much less than expected. This led to a decision to explore higher diversion flows. An initial winter flow test was approved and conducted in 1979. In subsequent years, further "Test Programs", were requested and approved and took place primarily during the winter, but also during the summer of 1981. This permitted the exploration of the physical capabilities of the diversion channel and the lower Churchill River.

After this testing phase, approvals to deviate from the terms of the Interim Licence have been the same for each winter and summer period since 1986. This mode of operation has become known as the Augmented Flow Program (AFP). The AFP has operated as a component of CRD as granted by Manitoba, since 1982 as an annual deviation from the Interim Licence.

The 1,220 MW Kettle GS was the second station on the Nelson River and the first on the lower Nelson River. With an operating head of 30 m (98 ft.), Kettle GS became the largest hydroelectric station in Manitoba at the time. Construction of the station began in 1966 and was completed in 1974. The project included transmission facilities to move the power into the transmission system and the Radisson Converter Station which converted power from AC to DC. The converter station was constructed south of the Kettle GS and became operational in 1971 (all work was completed by 1977).

The 980 MW Long Spruce GS was fully operational in 1979 with the first of the station's ten units coming into service in 1977. The station is operated as a run-of-the-river plant to pass the water that the Kettle GS releases. When the Long Spruce GS became operational, the Radisson Converter Station converted part of the power from the generating station to DC for transmission to southern Manitoba. However, only half of the power generated at Long Spruce GS could be converted at the Radisson Converter Station, so the Henday Converter Station was constructed 42 km northeast of Radisson. Constructing the Henday Converter Station also created additional conversion capacity for potential future stations. The Henday Converter Station was constructed between 1970 and 1985 and began transforming power from Long Spruce in 1978.

A second high voltage transmission line, Bipole II, was also developed during this time period to accommodate the additional power generated at Long Spruce GS. Bipoles I and II share the same right-of-way for much of their route. Bipole I, completed in 1971, begins at the Radisson Convertor Station and is 895 km in length; Bipole II, completed in 1977 (Radisson to Henday segment), begins at the Henday Converter Station and is 937 km in length. Under a 1966 agreement, development of these lines was undertaken as a federal-provincial initiative. The federal government was represented by AECL, which financed, designed and constructed the two HVdc transmission lines (Bipoles I and II) to connect the Radisson and Henday Converter Stations to the Dorsey Converter Station, located north of the City of Winnipeg near Rosser. The province was represented by Manitoba Hydro and the company agreed to pay back the initial financing for the lines over the next 50 years, but it repaid the full amount by 1992.

In addition to the above, two sets of three 230 kV transmission lines were constructed to further connect the Long Spruce GS to the Radisson and Henday Converter Stations and were completed in 1977 and 1990, respectively.

2.3 HYDROELECTRIC DEVELOPMENT 1976 TO 2014

Limestone Generating Station and Associated Infrastructure

In 1976, construction began on the Limestone GS, downstream from the Long Spruce GS on the Nelson River. The first stage cofferdam, the temporary town site at Sundance, a rail spur and road from Split Lake to the Long Spruce GS, and additions to the Henday Converter Station were being constructed when a decision was made in 1978 to post-pone the construction due to decreased provincial load growth.

Construction of the Limestone GS (1,350 MW capacity) re-started in 1985 and construction was completed in 1992. In 1989, a 40 km extension of an existing 138 kV line from Radisson Converter Station to the Limestone GS was constructed to act as an emergency back-up for the station. A 9 km back-up for the Bipole II HVdc line, originating at the Henday Converter Station and extending across the Nelson River, was added in 1992.

Wuskwatim Generating Station and Associated Infrastructure

The most recently developed generating station in northern Manitoba, the 214 MW Wuskwatim GS, was commissioned in 2012 on the Burntwood River between Nelson House and Thompson. The Wuskwatim project was developed as a partnership agreement with Nisichawayasihk Cree Nation (NCN). The Wuskwatim GS is owned by the Wuskwatim Power Limited Partnership, a legal entity involving NCN and Manitoba Hydro. The partnership agreement represents a major shift in the way projects are developed in Manitoba. The first of its kind in Canada, the partnership with NCN demonstrates a movement towards collaborative development of projects. The participation of NCN in the entire process resulted in a project that included Aboriginal Traditional Knowledge in both the assessment and monitoring phases. The resulting project limited flooding to 0.5 square kilometres and minimized environmental effects to the maximum extent possible. This development is also the first generating station in Manitoba to have undergone both an *Environment Act* (Manitoba) and a *Canadian Environmental Assessment Act* (Canada) approval process.

The development of the Wuskwatim GS required new transmission lines and stations to deliver electricity into the existing transmission system. The points of connection are at Thompson (at a new station called Birchtree Station) and at Herblet Lake Station at Snow Lake. A 230 kV transmission line was also constructed from Herblet Lake Station to the existing Rall's Island Station at The Pas (ISD of 2012), the majority of which is outside of the Region of Interest. One 45 km, 230 kV transmission line runs from Birchtree Station to Wuskwatim GS, while two single-circuit 230 kV lines (~137 km each) run from Wuskwatim GS to Herblet Lake Station on a shared right-of-way.

2.4 PROJECTS UNDER DEVELOPMENT OR REGULATORY REVIEW

Bipole III , Riel , Keewatinoow, and Associated Infrastructure

Manitoba Hydro is currently constructing the Bipole III Transmission Project which consists of a third HVdc transmission line, originating at the new Keewatinoow Converter Station, to be located near the planned Conawapa GS and terminating at a new Converter Station (Riel) located immediately east of the City of Winnipeg. The Riel Converter Station and the majority of the Bipole III line are outside the Region of Interest. Apart from the Bipole III line and new converter stations, the Project will require new 230 kV transmission lines linking the Keewatinoow Converter Station to the Henday Converter Station and to Long Spruce GS. The Bipole III Project underwent an *Environment Act* (Manitoba) review process.

The power transmitted by Bipole III will originate at existing generating stations on the lower Nelson River (Kettle GS, Long Spruce GS, and Limestone GS). As described above, the existing generating stations are linked to Bipoles I and II via the transmission lines to the Radisson and Henday Converter Stations. The Keewatinoow Converter Station and associated transmission lines will add flexibility and reliability, ensuring that the power generated is transmitted into the transmission system. The connections include five 230 kV transmission lines. One 230 kV transmission line will extend from Long Spruce GS to the Keewatinoow Converter Station. Four 230 kV transmission lines will extend from Henday to the Keewatinoow Converter Station.

Keeyask Infrastructure Project

The Keeyask Infrastructure Project began in early 2012 and involves access road construction and camp development for the Keeyask Generation Project. It is being undertaken by the Keeyask Hydropower Limited Partnership, which consists of Manitoba Hydro and investment entities representing the four First Nations in the vicinity of the project – Tataskweyak Cree Nation and War Lake First Nation (working together as the Cree Nation Partners), York Factory First Nation, and Fox Lake Cree Nation.

The Keeyask Infrastructure Project will provide for timely and efficient construction of the Keeyask Generation Project, should it receive all necessary regulatory approvals. It was undertaken as a separate project, in advance of the Keeyask Generation Project, to achieve the following objectives:

- To provide early business opportunities for the Keeyask Cree Nations;
- To provide early and more employment opportunities for First Nation members, northern Aboriginal people and other northern and Manitoba workers;
- To provide more time for Cree Nation businesses to develop their management capabilities; and
- To accelerate investment to support the promotion of sustainable growth in the Province of Manitoba.

Keeyask Generation and Transmission Projects

The Keeyask Generation Project is a potential future development which is located upstream of the Kettle GS and downstream of the community of Split Lake. The proposed project, which has undergone review by federal and provincial regulators, including a hearing conducted by the Clean Environment Commission, would be developed by the Keeyask Hydropower Limited Partnership. The project consists of a 695 MW Generating Station, transmission facilities, access roads, and supporting infrastructure. Technical science and Aboriginal Traditional Knowledge were used in the planning stage, the impact assessment phase, and, if the project proceeds, will be used in the environmental monitoring phase. The current first unit in-service date for the project is 2019, with all units online by 2020. Construction is scheduled to begin in the summer of 2014.

The Keeyask Transmission Project is being undertaken by Manitoba Hydro and will provide construction power and generation outlet transmission capacity for the proposed Keeyask Generation Project.

A decision on whether to include the Keeyask Generation and Transmission Projects in the final RCEA will be determined once the project has received the required licences or authorizations to undertake construction and operation.

2.5 OTHER TRANSMISSION DEVELOPMENTS IN THE RCEA REGION OF INTEREST

In addition to the above, there are other transmission projects within the Region of Interest that supply power to communities and developments in the area. Some of the developments were constructed by other companies prior to the development on the Nelson River. For example, the Hudson Bay Mining and Smelting Company Ltd. initially supplied power to support mining operations and communities in the immediate area, including Snow Lake. In 1973, Manitoba Hydro took over their power operations at Snow Lake, and assumed full responsibility for all transmission and distribution in the Region of Interest.

Apart from the generating stations and converter stations described above, other lower voltage stations are required to operate the transmission system, and transform power to lower voltages to supply power to communities. Major sub-stations include the Thompson Birchtree Station, which was constructed as part of the Wuskwatim Generation and Transmission Projects, Ponton Station and Herblet Lake Station.

Other lower voltage sub-stations, which can convert power to lower voltages for use in the communities, are located in Churchill, Gillam, Ilford, Thompson (Thompson Burntwood, Thompson INCO, Thompson Mystery Lake), Nelson House, Leaf Rapids, South Indian Lake, Split Lake, Cross Lake, Norway House, Snow Lake, Stall Lake, and Chisel Lake. All of the communities in the Region of Interest are now connected to the transmission system.

A 270 km long 138 kV transmission line from Gillam (Radisson) to the community of Churchill was completed in 1987. In 1993, a 138 kV transmission line from the Kelsey GS to Split Lake was also completed. Service to South Indian Lake is provided from a lower voltage sub-transmission line from the Leaf Rapids Station.

The Ponton Station, located south of Thompson, is an important node in the 230 kV transmission network. A 230 kV transmission line completed in 1965/1966 runs from Thompson Mystery Lake Station to Ponton Station. Ponton Station is also linked to the Jenpeg GS by a 230 kV transmission line, as well as to Herblet Lake Station, north of the community of Snow Lake, by another 230 kV transmission line. The Herblet Lake Station is also an important node in the 230 kV transmission network. Apart from the line to Ponton Station, Herblet Lake Station is linked to Flin Flon via a 115 kV and a 230 kV transmission line, both of which are primarily outside of the RCEA Region of Interest. The station also connects the two 230 kV transmission lines from Wuskwatim GS to Rall's Island Station (part of Wuskwatim Transmission Project) in The Pas, which is outside of the RCEA Region of Interest.

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PART III: PEOPLE

REGIONAL CUMULATIVE EFFECTS ASSESSMENT

PART III

PEOPLE

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF MAPS

Page

ACRONYMS, ABBREVIATIONS AND UNITS

Acronym/Abbreviation	Term/Unit
AEA	Adverse Effects Agreement
AIP	Agreement-in-Principle
AMP	Access Management Plan
ATEC	Atoskiwin Training Consortium
ATK	Aboriginal Traditional Knowledge
CASIL	Community Association of South Indian Lake
CDI	Community Development Initiative
CIA	Comprehensive Implementation Agreement
CLFN	Cross Lake First Nation
CRD	Churchill River Diversion
dBA	decibel
DFO	Department of Fisheries & Oceans Canada
DMP	Debris Management Program
DNC	Direct Negotiated Contract
EIS	Environmental Impact Statement
EMFs	Electric and Magnetic Fields
ft	feet
FEMP	Federal Ecological Monitoring Program
FLCN	Fox Lake Cree Nation
GS	Generating Station
HNTEI	Hydro Northern Training & Employment Initiative
HRB	Historic Resources Branch
HRPP	Heritage Resources Protection Plan
HVdc	High Voltage Direct Current
KCN	Keeyask Cree Nations
km	kilometer
LNRSSC	Lower Nelson River Sturgeon Stewardship Committee

Acronym/Abbreviation	Term/Unit
LWR	Lake Winnipeg Regulation
m	meter
MIA	Master Implementation Agreement
NAC	Northern Affairs Community
NCN	Nisichawayasihk Cree Nation
NFA	Northern Flood Agreement
NFC	Northern Flood Committee
NHCN	Norway House Cree Nation
OPCN	O-Pipon Na Piwin
ppb	parts per billion
PDA	Project Development Agreement
PEP	Public Engagement Program
RCEA	Regional Cumulative Effects Assessment
RMA	Resource Management Area
RMB	Resource Management Board
RTD	Registered Trapline District
SIL	South Indian Lake
SSEA	Site Selection and Environmental Assessment
SWAP	System Wide Archaeological Program
TCN	Tataskweyak Cree Nation
TDF	Transmission Development Fund
TLA	Transmission Line Agreement
TLE	Treaty Land Entitlement
TSS	Total Suspended Solids
WKTC	Wuskwatim & Keeyask Training Consortium
WLFN	War Lake First Nation
WMP	Waterways Management Program
YFFN	York Factory First Nation

3.0 PEOPLE

3.1 STUDY APPROACH

Manitoba Hydro has a long history of interaction with the people and communities living in-proximity to and/or affected by the Lake Winnipeg Regulation (LWR) and Churchill River Diversion (CRD), and associated hydroelectric developments ("the Projects")[1]. Manitoba Hydro's approach to development, and related approach to community engagement, has evolved over time and along with changing societal understandings, values and attitudes regarding the environment, Aboriginal rights and interests and socio-economic impacts generally.

There exists a wealth of information from various sources related to the socio-economic effects of the Projects. There are many cases where communities have documented their experiences with historic hydroelectric development in their own voices. This would include materials prepared in support of settlement agreement processes, materials prepared more recently in support of current environmental assessment documentation for the Wuskwatim and Keeyask Projects, and materials developed for other purposes. Community perspectives on the effects of the Projects have also been shared through oral testimony at recent hearings, including for the Wuskwatim, Keeyask and Bipole III Projects. Communities have also shared their perspectives and concerns with Manitoba Hydro through previous and/or ongoing engagement processes, including, for example, through interactions related to ongoing programming such as the Waterways Management Program (WMP) (discussed below in Section 3.4.2.7.1).

There also exists substantial documentation regarding the processes through which impacts on people and communities have been addressed through mitigation and remedial works, as well as through negotiated settlements with Manitoba Hydro, Manitoba and, in some cases, Canada. Since many of these studies were undertaken in the context of negotiated settlement agreements or claims arbitration they are confidential. In other cases, studies cannot be used without the permission of the community in question.

In light of the various mitigation measures and settlement agreements that have been concluded since construction on the Projects began in the late 1950s, this study seeks through a Phase I and Phase II approach to document Manitoba Hydro's current understanding of socio-economic effects, including the perspectives, views and experiences communities have shared through various forums since the time of development. Both phases of the study will look at impacts in terms of generation ("the Generation Projects") and transmission facilities ("the Transmission Projects"), the latter of which includes converter stations, sub-stations, collector lines, High Voltage Direct Current (HVdc) lines, and lower voltage transmission lines used to provide power to communities.

The sections below provide a more detailed description of the Phase I and Phase II.

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[1] A listing and description of the Projects included in the scope of the RCEA are defined in Section 1.3.2.1.

3.1.1 PHASE I

This Phase I document outlines the communities identified as being in the Region of Interest. This document also summarizes at a very high level Manitoba Hydro's understanding of the types of socio-economic effects experienced to varying degrees by communities affected by the Projects. As noted above, this understanding comes from various sources including past environmental impact assessments, past settlement negotiations, perspectives shared by communities and resource user groups, and various community led studies and histories that have been shared with the Corporation. Given the timeframe available to complete Phase I, this document is primarily intended to introduce the types of effects that will be discussed in greater detail in Phase II. Socio-economic effects are not presented by community with a few unique exceptions (*e.g.*, household relocation) but rather are summarized across the Projects and across all communities. This document also introduces the mitigation, remediation and compensation measures adopted to address socio-economic effects, including a brief summary of the history of settlement agreements associated with the Projects.

3.1.2 PHASE II

Phase II of this study is intended to document in a more thorough and meaningful way the views, perspectives and experiences communities have expressed to Manitoba Hydro and the Province of Manitoba in various forms, including but not limited to:

- The Northern Flood Agreement (NFA) Arbitration Claims process;
- Other claims and settlement negotiation processes;
- Available post-project evaluations and other studies of socio-economic effects, including community led studies[1];
- Aboriginal Traditional Knowledge (ATK) studies;
- Environmental Assessments, and Site Selection and Environmental Assessments (SSEAs) that were conducted for the Projects and, in some cases, related public review processes; and
- Documentation from historic and current (and sometimes ongoing) community engagement processes.

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[1] Examples of community studies that will be reviewed in Phase II include, but not be limited in any way to; *Split Lake Cree Post Project Environmental Review* (Manitoba Hydro – Split Lake Cree Joint Studies, Volumes One to Five, August 1996); *Forgotten Nation in the Shadow of the Dams Grievance Statement* (Fox Lake Cree Nation, April 1997); *Post Project Assessment of Kelsey and Lake Winnipeg Regulation Impacts on Wabowden* (October 31, 1990); *Relocation and Rebuilding: The Social Impacts of Hydro-Projects on the Community of South Indian Lake* (Universite du Quebec, 2009); *Cross Lake Environmental Impact Assessment Study, Volume 1: Key Issues and Impacts* and *Volume 2: Evaluation of Mitigation Options* (Nelson River Group, 1986); *Towards Assessing the Effects of Lake Winnipeg Regulation and Churchill River Diversion on Resource Harvesting in Native Communities in Northern Manitoba*, (P.J. Usher and M.S. Weinstein, 1991).

Given the substantial history, number of communities involved and breadth of materials available on this topic it was not possible to present this information in a thorough way for Phase I of this study. In Phase II, all efforts will be made to present community perspectives and concerns in the spirit and manner in which they were shared.

In Phase II, information on socio-economic effects will be presented by community. This will include a summary of information and perspectives shared with Manitoba Hydro and Manitoba by community. The Phase II report will also present mitigation, remediation and compensation measures specific to each community, as well as a description of various historical and ongoing engagement processes. Phase II will also present, to the extent possible, analysis of demographic indicators for the communities over time, acknowledging the range of other influencing factors additional to hydroelectric development that have affected these indicators.

The information provided in Phase I is preliminary and will be expanded as part of Phase II. As such, as work progresses in Phase II additional effects may be identified and discussed.

3.2 COMMUNITIES IN THE REGION OF INTEREST

Map 3-1 highlights the location of communities[1] located in the Region of Interest (see Map 1-1) as well as their Resource Management Areas (RMAs)[2] and Registered Trapline Districts (RTDs)[3]. Communities in northern Manitoba fall into three distinct types – First Nation communities, Northern Affairs Communities (NACs), and industrial towns and cities. The vast majority of the population in the region live in these communities with only a very small portion living in remote areas.

As can be seen on the map, there are a total of eight First Nations, eight NACs, four towns and one city in the Region of Interest. These groupings are summarized in Table 3-1.

Table 3-1: Communities in the Region of Interest

First Nations	Northern Affairs Communities	Towns	City
Nisichawayasihk Cree Nation (NCN)	Nelson House	Town of Gillam	City of Thompson
Tataskweyak Cree Nation (TCN)	Pikwitonei	Town of Churchill	
York Factory First Nation (YFFN)	Wabowden	Town of Snow Lake	
Fox Lake Cree Nation (FLCN)	Thicket Portage	Town of Leaf Rapids	
War Lake First Nation (WLFN)	Ilford		
Norway House Cree Nation (NHCN)	Norway House		
O-Pipon-Na-Piwin (OPCN)	Herb Lake Landing		
Cross Lake First Nation (CLFN)	Cross Lake		

[1] For the purpose of this study a community refers to specific commonly recognized geographic locations where people live together.

[2] A RMA is a mutually agreed geographical area, usually the RTD, that includes both Crown and/or Reserve and/or community lands. In the RMAs, Resource Management Boards (RMBs) make recommendations on land and resource uses to Manitoba on Provincial Crown land and to the First Nation or community on Reserve or community lands. Objectives of the Boards include land use and natural resource management planning and the facilitation of consultation, communication and the exchange of information through the joint review of provincial natural resource allocations and dispositions. Provisions for RMAs are set out in various settlement agreements. (Government of Manitoba, April 2014. http://www.gov.mb.ca/ana/interest/agreements.html.)

[3] A RTD means an area designated as a registered trapline district by the regulations set out under *The Wildlife Act* 1987, Government of Manitoba 2013.

3.2.1 OTHER COMMUNITIES

In addition to the communities identified above, Manitoba Hydro has a settlement agreement (2006) with the Pickerel Narrows Community Association that includes CRD and LWR (as well as other projects) in the definition of Project used to define effects addressed by the agreement. Pickerel Narrows is excluded from this study because it is located outside the Region of Interest, is not affected by LWR and is only minimally and infrequently affected by the CRD. The average post-CRD levels on Granville Lake are comparable to pre-CRD levels, with the exception of higher-flow events on the upper Churchill River which are not affected by CRD.[1]

The Shamattawa First Nation has raised concerns with Manitoba Hydro regarding the effects of hydroelectric development on resources within the community's RTD. These concerns are not related to direct effects on water levels and flows, but rather potential indirect effects on migratory species (such as caribou and fish) that move from affected waterways into the Shamattawa RTD. Manitoba Hydro remains open to discussing these concerns and has agreed to review any further information that would assist in better understanding the community's concerns. The extent to which there are indirect effects on aquatic and terrestrial resources within the Shamattawa RTD (*e.g.*, for migratory species like caribou), will be explored in the water and land components of Phase II of this study. The community has also raised concerns with what they view as an infringement on their traditional territory via the establishment by Manitoba of the YFFN Resource Management Area through the settlement agreement process between Manitoba, Canada, Manitoba Hydro and the YFFN.

3.2.2 THE MÉTIS

There are Métis people who reside in communities in the Region of Interest. Adverse effects experienced by Métis residing in the Region of Interest have been addressed through the various community and resource user group settlement agreements (discussed below in Section 3.4), as well as by various mitigation measures (discussed below in Section 3.4). Information gleaned from more recent studies undertaken by the Manitoba Métis Federation, including through Traditional Knowledge studies completed for the Wuskwatim, Keeyask and Bipole III projects, will be presented in Phase II of this study.

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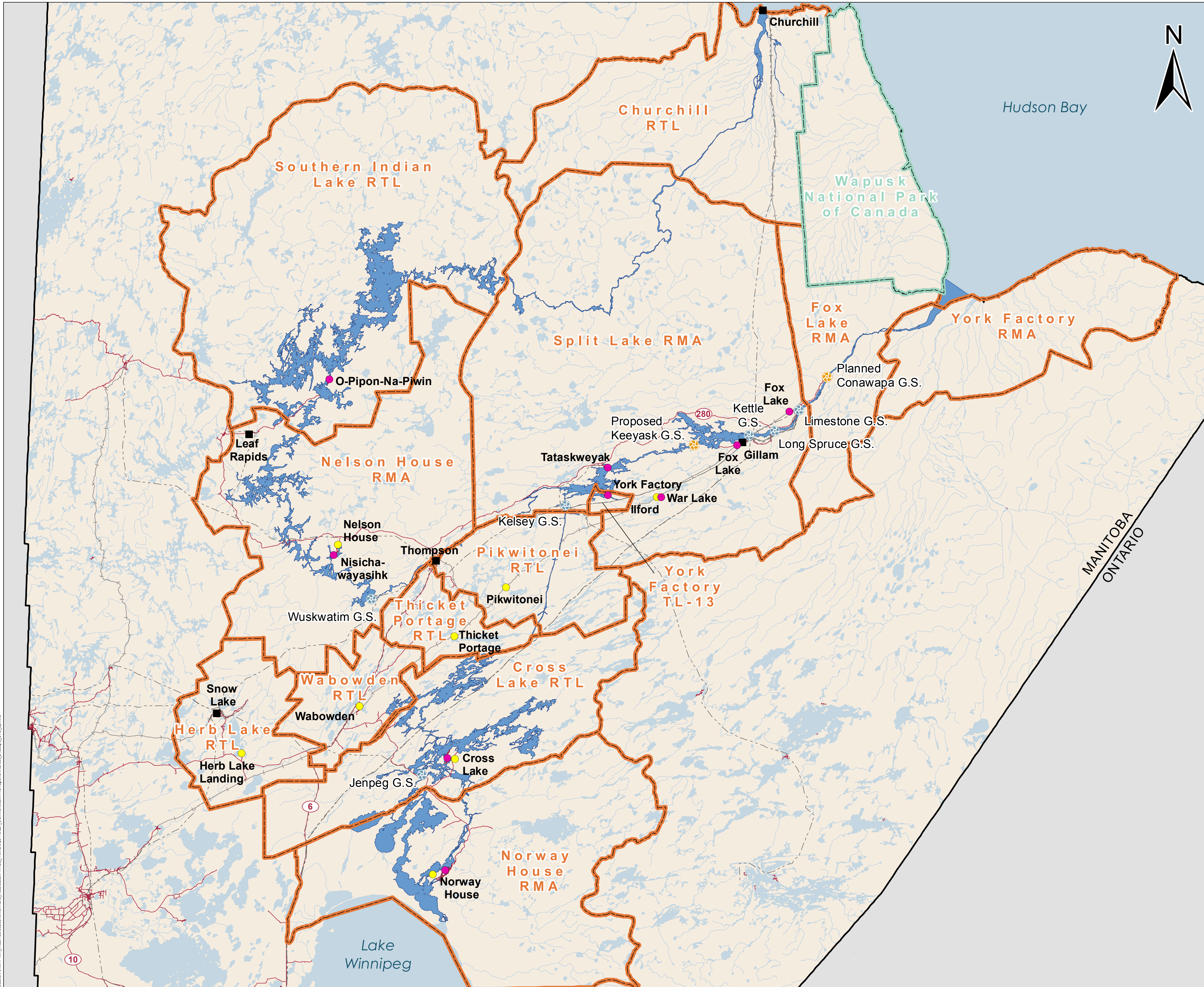
[1] The maximum post-CRD backwater effect at the outlet of Granville Lake (downstream of Pickerel Narrows) is 0.23 m (0.8 ft). The backwater effects diminish as you move upstream of the outlet of Granville Lake and are largest during low flow conditions on the upper Churchill River along with high Southern Indian Lake levels which occur infrequently (a backwater effect greater than 0.1 m (0.3 ft) has occurred less than 10 percent of the time. The backwater effect diminishes as Upper Churchill River flows increase and Southern Indian Lake levels decrease.



Manitoba Hydro

Legend

- Towns/Cities
- First Nations
- Northern Affairs Communities
- Generating Station (Existing)
- Generating Station (Planned)
- Resource Management Areas (RMA) Registered Trapline Sections (RTL)
- Waterbodies Affected by Hydroelectric Development
- Highway
- Rail
- Transmission Lines

DATA SOURCE:
Province of Manitoba, Government of Canada

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	16-APR-14	27-MAY-14
0 30 60 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Communities in the Region of Interest

Map 3-1

3.3 HISTORIC CONTEXT OF DEVELOPMENT

Aboriginal peoples have a strong cultural and spiritual connection to the land and water, and possess constitutionally protected rights. Manitoba Hydro has large investments in areas where Aboriginal peoples live and harvest resources, practice their culture and traditional way of life, and exercise their rights. The development of the Manitoba Hydro system has affected the environment used by Aboriginal peoples and communities in northern Manitoba. While some 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.

Most of the Projects were evaluated, debated and constructed during a time when the social, political and legal environment was quite different than today. Decisions about LWR, CRD, Kelsey Generating Station (GS), Kettle GS, Long Spruce GS and Limestone GS occurred in an era when there was much less understanding of the effects of developments on people and the environment, and when there was, for the most part, a marked absence of environmental regulations and legislation. Notably, approval of these Projects predated the *Constitution Act* (1982), *The Environment Act (Manitoba)* [1987], the *Canadian Environmental Assessment Act* (1992), and *The Sustainable Development Act* (Manitoba) [1997]. These developments also occurred at a time when economic, development and other interests (*i.e.*, flood and drought reduction on Lake Winnipeg) of predominantly southern society took precedent over the interests of potentially affected northern populations.

As a result, Manitoba Hydro's approach to development during this time period was very different than today. While in line with then practices of the day and consistent with government requirements, past projects involved much less engagement and consultation than would be considered acceptable today and considerably less upfront planning with respect to minimizing environmental impacts. Avoidance, mitigation and enhancement measures were not always identified in advance of project construction or 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 and appreciation of Aboriginal peoples and their experience with the development process was 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 societal understandings and appreciations developed, Manitoba Hydro increasingly became involved in environmental initiatives and in efforts to understand and address Aboriginal grievances and claims over past projects. The Corporation has established a range of mitigation, remediation and compensation measures to address past effects. Today, Manitoba Hydro is working towards long-term relationships with Aboriginal peoples founded on trust and shared interests. This includes implementation of policies, programs and activities aimed at increasing Aboriginal participation in corporate activities such as employment, business and partnership opportunities in new developments, maintaining regular contact with communities, managing community specific issues, including supporting and promoting the safety of people using affected waterways.

Manitoba Hydro acknowledges that some of the changes brought about by our projects are irreversible and that, as would be expected, some members of various communities may not feel that established mitigation and compensation measures are sufficient to address losses that were experienced.

3.3.1 THE HISTORY OF THE SETTLEMENT AGREEMENTS

The sections below summarize the various collective settlement processes Manitoba Hydro has participated in as part of its efforts to resolve historic grievances over time. Information is provided that is relevant to the Projects under consideration in this study, 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, individual settlements for personal property loss and damage have been entered into. These arrangements are described in later sections.

3.3.1.1 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 of interest, concern and discussion. 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 on the two Projects 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 communities represented by the NFC were the Split Lake (now Tataskweyak Cree Nation [TCN]), Nelson House (now Nisichawayasihk Cree Nation [NCN]), York Factory, Norway House and Cross Lake Bands. 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 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) establishing 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 the Project which was defined to include CRD, LWR and all existing and planned generating stations on the Nelson and Burntwood Rivers.

The NFA established a process by which easements could be granted to Manitoba Hydro over reserve land in order to facilitate the construction and ongoing operation of the components of the Project. As part of the easement process, First Nations would be entitled to select replacement land on the basis of four acres for every acre of land taken up by the easement and pending selection. 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, cultural preservation, and a range of remedial and compensatory measures, including 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 trap lines, which were adjacent to and generally utilized by members of each First Nation, and the rivers and lakes traditionally used.

Notwithstanding the significant amount of work carried out by the Lake Winnipeg, Churchill and Nelson River Study Board, not all of the effects of CRD and LWR were known at the time the NFA was negotiated and signed. This uncertainty resulted in the creation of an arbitration process as a forum to resolve unsettled claims. The NFA provided for the costs of such processes to be borne by the governments and Manitoba Hydro, and established a reverse onus requiring Manitoba Hydro to prove that the effects or damage alleged had not been caused by the Project.

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 agreement clauses. The implementation process was very costly and with the exception of resolving most issues of quantifiable losses, resulted in minimal issue resolution, 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 did result in a significant number of retroactive and interim compensation arrangements and/or settlement agreements, as well as related programming. These arrangements and agreements 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. For NCN, YFFN, TCN and Norway House Cree Nation (NHCN), these agreements as well as any outstanding claims were, subject to certain specific exceptions, fully and finally resolved through the negotiation of Comprehensive Implementation Agreements (CIAs). As discussed below, CLFN has chosen to pursue ongoing implementation of the NFA.

3.3.1.2 Comprehensive Implementation Agreements

In 1986, the NFC recommended that CIAs or settlements be developed with each First Nation, thereby resolving all then outstanding claims under the NFA. The NFC proposed Global Negotiations. The Global Negotiations resulted in the Proposed Basis of Settlement. The Proposed Basis of Settlement did not proceed. At that point, Split Lake (now TCN) suggested that the Band 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 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 1997 (the agreement with NHCN is known as a Master Implementation Agreement [MIA]).

While each CIA/MIA is unique, they all 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 exchange (of significantly greater magnitude than under the NFA), the establishment of RMAs, consultation processes for any proposed future developments and environmental monitoring.

3.3.1.3 Ongoing Implementation of the NFA at Cross Lake

From 1994 to 1997, Canada, Manitoba and Manitoba Hydro engaged in negotiations with Cross Lake to reach a CIA. In 1997, CLFN indicated that it did not wish to enter into a CIA and rather decided 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 agreement have been addressed through a range of measures including various cash settlements, the construction of remediation or mitigation works at Cross Lake, and ongoing programming. Examples 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, safe portage initiative, personal property damage claims, archaeology assistance, resource harvesting agreements, gardening and alternative foods program, school hot lunch program, 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.

3.3.1.4 Other Settlement Agreements

Around the same time Manitoba Hydro was negotiating the CIAs with the NFA communities, efforts also got underway to resolve grievances over project impacts with other communities throughout northern Manitoba. Agreements have been negotiated between Manitoba Hydro and the Province of Manitoba with the Community Association of South Indian Lake (CASIL) [1992], South Indian Lake Housing Association (1992), Fox Lake Cree Nation (FLCN) [2004] and War Lake First Nation (WLFN) [2005], as well as the NACs of Cross Lake (1990 and 2010), Nelson House (2006) and Wabowden (1992). Agreements were also reached with the Town of Churchill (1997) and the City of Thompson (1976 and 1982). 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 (2003) setting out principles and understandings to guide settlement negotiations which are ongoing.

Manitoba Hydro has also entered into agreements with various resource user groups, and individual resource users. As a noted above, a number, but not all, of these were completed in the context of NFA arbitration claims. These agreements are discussed further in Section 3.3, and will be discussed in greater detail during Phase II of this study.

In addition, Manitoba Hydro has entered into subsequent agreements with the CIA communities and the CLFN regarding other issues[1].

3.3.2 MANITOBA HYDRO'S APPROACH TO NEW DEVELOPMENTS

As noted above, the planning and development processes for today's projects are very different. The project planning process involves early and extensive engagement with people and communities in the vicinity of proposed projects, particularly Aboriginal peoples, and there is a concerted effort to prevent and reduce, as much as possible, potential impacts through improved project design, and the implementation of project mitigation and community based programming.

With regards to new generation projects, efforts are made to enhance project benefits as much as possible, especially for local communities, through measures like income opportunities and training, employment and business opportunities. These opportunities are sought at all stages of the Project. The costs for all of these activities are estimated and incorporated into long-term capital cost estimates so that the financial implications of a project are understood as well as its environmental and social implications.

As well, efforts are made to negotiate Adverse Effects Agreements (AEAs) in advance with each potentially affected Aboriginal community. AEAs include mitigation measures, community based programming and cash compensation to avoid, offset or compensate for anticipated project effects.

The Wuskwatim and Keeyask Generation Projects are examples of this new approach. In June 2006, NCN signed the Wuskwatim Project Development Agreement (PDA). In May 2009, all four of the Keeyask Cree Nations (KCN) – TCN, WLFN, YFFN, FLCN – signed the Joint Keeyask Development Agreement. The terms of these agreements provide communities with a range of benefits including an income opportunity through part ownership of the project, pre-project training, business opportunities and employment opportunities, joint management of environmental processes, AEAs, and ongoing community involvement opportunities. A community ratification process, including referenda, was held prior to the signing of both agreements.

With regard to new transmission projects, Manitoba Hydro employs a Site Selection and Environmental Assessment (SSEA) process to route and site transmission facilities to minimize project effects on people and the environment. Through the SSEA process, Manitoba Hydro attempts to balance route and site

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[1] This has included, but is not limited to, the amendment of pre-determined compensation clauses, which govern the amount of compensation paid during times of deviation from established water regime parameters, to address unusually high water events and the full range of Manitoba Hydro's operating regime.

selection for transmission projects from biophysical, socio-economic and technical (engineering and cost) perspectives. The Corporation seeks to avoid negative environmental impacts and enhance benefits whenever possible and practical. Where impacts cannot be avoided, routes that best lend themselves to mitigation and to limiting potential negative effects are selected. The process provides impact avoidance and management opportunities at every stage in the process from pre-licensing through post-construction. The SSEA process refines and systematically reduces a study area for a proposed project to the best single balanced choice of a route/site with input from an on-going Public Engagement Program (PEP).

As with Generation Projects, Manitoba Hydro also tries to enhance benefits associated with Transmission Projects through various measures including employment and business opportunities. This can include contracting opportunities and the purchase of local goods and services. In addition, Manitoba Hydro uses local community members as environmental monitors and community liaisons during construction. For the Wuskwatim Transmission Project, Manitoba Hydro developed a Transmission Development Fund (TDF) to provide enduring annual benefits for community development purposes to Aboriginal and small or remote communities in the vicinity of the Project. TDF monies have been used for a variety of community related initiatives such as repairing community facilities, supporting youth programs in the communities and investing monies for future projects. Manitoba Hydro also developed the Community Development Initiative (CDI) for the Bipole III Project to provide direct benefits to communities in the vicinity of the project. CDI funds are to be used to support community development projects that benefit a broad segment of the community.

3.4 HISTORIC SOCIO-ECONOMIC EFFECTS, MITIGATION AND COMPENSATION MEASURES ASSOCIATED WITH THE PROJECTS

Development of the Projects has resulted in positive and negative effects on individuals and communities. While communities and Manitobans gained from new access to reliable and low cost power as well as economic development opportunities (training, employment and business opportunities), people in the region have also experienced negative or adverse effects arising from environmental changes, the influx of workers and related experiences of abuse and discrimination, an increased rate of modernization, and marginal participation in decision-making. Other effects include the following:

- The use of lands for hydroelectric purposes;
- Damage and loss of personal property;
- Loss of recreational opportunities (including natural beaches);
- Loss of or damage to cultural and spiritual sites;
- Exacerbated exposure and damage to grave sites;
- Lost income from commercial fishing and trapping;
- A loss of historical and spiritual connection to the land;
- Debris and navigational hazards;
- Interference with the exercise of traditions, practices and customs integral to cultural identity, including the transmission of knowledge and traditional teachings; and
- Concerns about heightened mercury concentrations in fish.

The nature, magnitude and duration of effects experienced is quite different for the Generation Projects than the Transmission Projects.

With regard to effects associated with the Generation Projects, a number of community led studies and histories have expressed the profound changes construction and operation activities have brought for local residents. Effects have also been well documented in various environmental assessment and post project assessment documents, as well as in various materials related to adverse effects negotiations. Publicly available studies and materials will be documented and reviewed in Phase II of this study.

Compared to today, there is not as much documentation regarding historic transmission developments. As it continues to evolve, the SSEA process has incorporated increasing opportunities to avoid impacts through careful routing, and for potentially affected parties to share information and concerns regarding both local issues and routing opportunities. One of the goals of the SSEA process is to avoid, wherever possible, environmentally, socially and culturally sensitive land uses[1]. As such, transmission effects are largely addressed through avoidance of sensitive land uses to the extent possible during the SSEA process.

In the socio-economic context, construction related effects from Transmission Projects are generally temporary and short-term in duration. Operational effects include the physical presence of the facility, as well as other issues such as increased access along the right-of-way and public concerns related to the perceived effects of Electric and Magnetic Fields (EMFs) on health, all of which can be of concern particularly to people in the vicinity of the project.

3.4.1 PATHWAYS OF EFFECTS

To understand the effects of a generation or transmission project on the socio-economic environment, a number of things 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. This in turn can affect the ability of people to access resources that are used to sustain people and communities and that support a unique culture and way of life. Physical changes can also affect heritage resources that are important to people and communities. 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. Effects on people and communities can also occur through construction activities and expenditures from a project, including through short term employment, business opportunities and the in-migration of workers. Figure 3-1 highlights the different pathways of effects relating to the socio-economic environment.

The effects of a project will vary depending on location (undeveloped lands versus more intensely developed lands) and the stage of development (pre-construction, construction, operations and maintenance, and decommissioning).

The socio-economic environment in the Region of Interest 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 region. Looking retrospectively, it is not always possible to separate the impacts of these other developments, events and policies from hydroelectric development.

[1] These would include, but not be limited to such sites such as cultural sites, heritage resources, cemeteries and burial sites, Reserve Lands, communities, residences, cabins, recreational sites, Treaty Land Entitlements (TLE) and infrastructure such as airports and float plane bases.

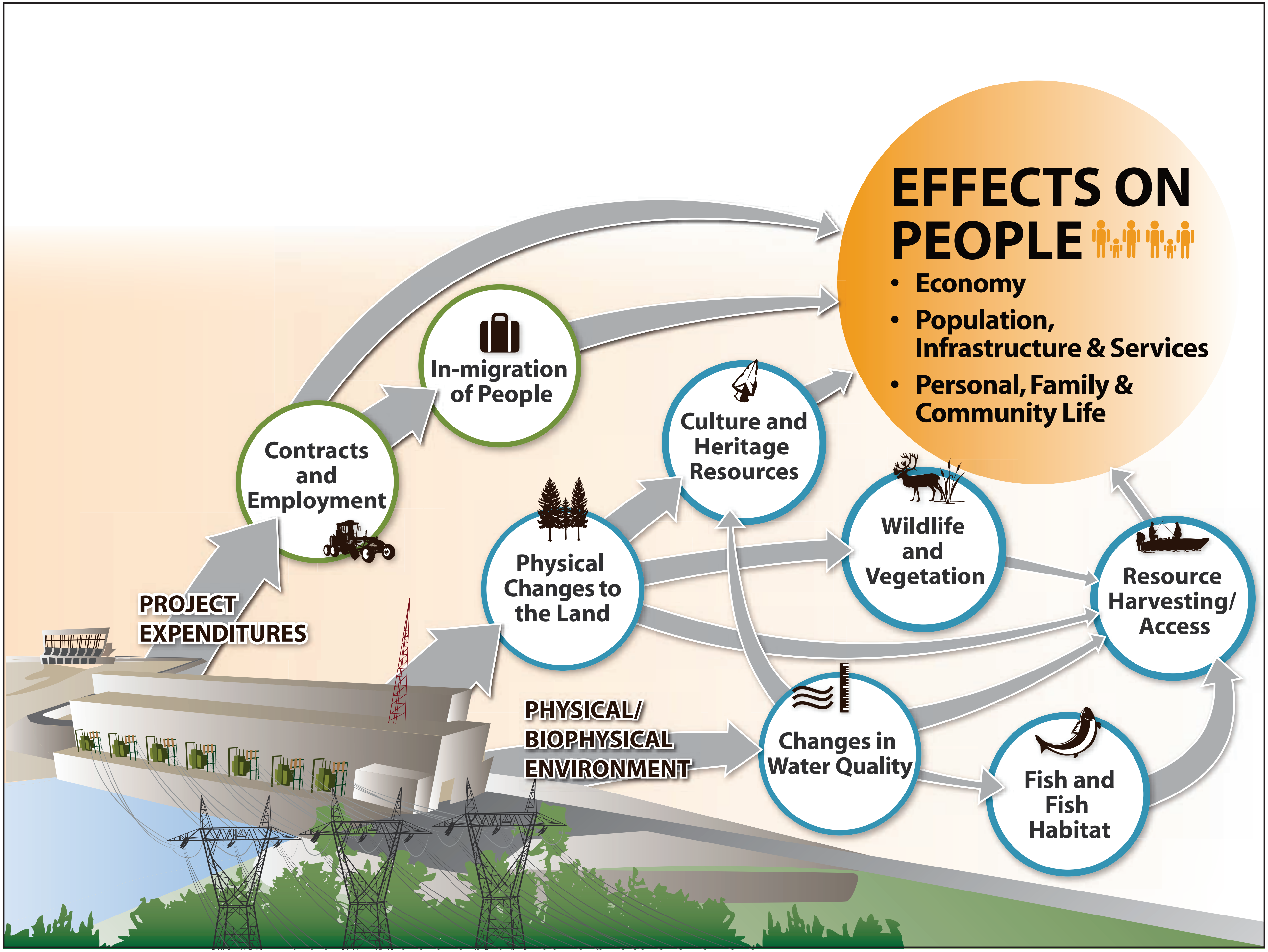

Figure 3-1: Pathways of Effect in the Socio-economic Environment

3.4.2 SUMMARY OF SOCIO-ECONOMIC EFFECTS, MITIGATION AND COMPENSATION IN THE REGION OF INTEREST

This section summarizes Manitoba Hydro's understanding of the types of socio-economic effects, by theme, experienced by communities in the Region of Interest. As noted above, these understandings have been informed not only by our own studies but also the perspectives and experiences of affected individuals, groups and communities which have been shared in a variety of forums. While it is acknowledged that the nature and scope of generation and transmission effects are quite different, the two are discussed together by topic. Where impacts could not be avoided, the materials summarize the general mitigation, remediation and compensation measures taken to address specific effects.

Information is presented for the affected communities as a whole across the region. The impacts described below vary in nature and magnitude by community, and by proximity to and type of development. As well, not all communities in the Region of Interest experienced all of the described effects. As noted above, information on project effects will be provided on a community-by-community basis for Phase II of this study. The information provided is preliminary and will be expanded as part of Phase II. Given the breadth of existing materials that will be reviewed during Phase II, additional effects may be identified and discussed.

The Cross Lake and Churchill Weirs were important mitigation efforts undertaken to address a number of socio-economic effects. These measures are discussed in sections 4.2 and 4.2.2.4.

3.4.2.1 CULTURE, WAY OF LIFE AND HERITAGE RESOURCES

3.4.2.1.1 GENERATION PROJECTS

Hydroelectric development 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) that affect one's ability to exercise customs, practices and traditions and attachments to the land that have been forged over generations. Because of their inherent link to place, cultural practices and pursuits are not always replaceable or transferable to alternative locations and, as such, related effects cannot always be mitigated.

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 waterways affected by the Generation Projects. 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 via settlement agreements or through the negotiated CIAs. These arrangements will be discussed in further detail as part of Phase II.

With respect to more recent projects such as the Wuskwatim and Keeyask Generation Projects, in-vicinity communities have been involved far earlier in the planning process in an effort to resolve issues at the planning and design stage. AEAs have been negotiated in advance of development. In the case of Keeyask, for example, agreements with the four First Nations are intended to provide appropriate replacements, substitutions or opportunities to offset anticipated project induced adverse effects on practices and traditions integral to cultural identity. The agreements include programming intended to promote healing and well-being, provide opportunities for traditional lifestyles and healthy food consumption, and strengthen cultural identity.

Cultural Ceremonies

Also in relation to the Wuskwatim and Keeyask Generation Projects, cultural and site ceremonies have been held at key planning and construction milestones to help mitigate the effects of the projects on culture and heritage and to demonstrate respect for the land and water.

Archaeological Programming

Since development of both the CRD and LWR Projects in the early 1970s, 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 the Generation Projects include:

- Archaeological mitigation efforts are underway for the Hunting River Burial Site (Nelson River) in collaboration with the Province, Pikwitonei Community Council, and CLFN;
- CRD Archaeological Program, which is a cooperative venture, involving the HRB in partnership with Manitoba Hydro, NCN, O-Pipon Na Piwin (OPCN), the Manitoba Museum, the University of Winnipeg, and Manitoba Aboriginal and Northern Affairs Department. Since 1990, the partnership has identified, studied, preserved, and protected archaeological sites and human remains in support of the management of Cree cultural heritage resources affected by the CRD in northern Manitoba. It is the longest running archaeological project in Canada;
- 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 (1,988 mi) of shoreline and is virtually unknown archaeologically. The program is a

cooperative venture that also includes the participation of the Manitoba Museum, and 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 the Province's 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 to heritage resources within specific areas of Manitoba affected by past hydroelectric development 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 has been undertaken at the Chipiy Naya site and cemetery around the Anglican Church on TCN Reserve Land, to protect human remains threatened by erosion. This work was undertaken in partnership with the community.

In addition to the above, there are specific measures in certain settlement agreements to restore, maintain, and protect culturally important sites. For example, as part of the Wuskwatim AEA with NCN, provisions were included for a process and funding to develop and implement a plan to relocate Wesahkechak's (a Cree and Ojibwa cultural hero) Footprints to their original home. Located in the Nelson House RMA, the site included two depressions resembling human footprints or moccasin prints which are located near a related cultural site called Wesahkechak's Chair (Linklater, 1994). The CRD flooded the original site of the Footprints and Chair. Prior to the flooding, the rock containing the Footprints was removed from its original location (NCN Implementation Newsletter, December 2011). In 2011, the Footprints were relocated in a vertical outcrop overlooking Footprint Lake near their original location (NCN Implementation Newsletter, December 2011). Further information on measures to protect important cultural and spiritual sites will be provided in Phase II.

With regards to new projects, including the Wuskwatim and Keeyask Generation Projects, Heritage Resources Protection Plans (HRPPs) are and will be in place to address found, discovered or disturbed human remains and heritage objects during construction, operation and decommissioning activities. HRPPs include details on the process in place if heritage objects or human remains are discovered, including halting work until appropriate actions have been taken. Further to the HRPP is a protocol agreement between the Province of Manitoba, NCN and the Wuskwatim Power Limited Partnership, whereby *"…the custody, control and management of heritage objects of an aboriginal origin and aboriginal human remains that are not required for forensic purposes will be managed by and between NCN and Manitoba…"* (Agreement for a Protocol for the Protection of Heritage Resources and Aboriginal Human Remains Related to the Wuskwatim Generating Station, dated August 11, 2006). During the operation phase of Keeyask Project, if approved, the protection and preservation of heritage resources are commitments under the Joint

Keeyask Development Agreement. Tangible artifacts recovered during the years of Keeyask archaeological field studies will be repatriated to TCN and displayed and interpreted in a museum to be developed through their Keeyask AEA.

3.4.2.1.2 Transmission Projects

Construction of transmission facilities can cause changes to the physical environment which can affect culture. Activities such as clearing of a right-of-way and the excavation of soils for tower foundations can result in changes to the cultural landscape by inhibiting activities in areas that sustain culture, desecrating sites and areas of cultural and spiritual value, and destroying features that sustain cultural expression and thought. In addition, construction can result in direct and indirect effects on culturally sensitive sites and areas. The latter can include loss of the ability to conduct traditional activities, disturbance to areas where domestic resource use activities such as gathering of plants occurs and inadvertent damage to unknown heritage resources of importance to a community. Operations of transmission facilities can cause ongoing and/or inadvertent disturbance to cultural processes and the cultural landscape. This can occur through loss of areas used for traditional activities, such as the gathering of medicinal plants and berries, as some view transmission lines and EMFs as negatively affecting the power of the plant. It can also occur through the inadvertent damage to unknown heritage resources and by increased access by outsiders to areas and sites of cultural importance.

Addressing Effects on Culture, Way of Life and Heritage Resources

Similar to Generation Projects, all heritage resources are protected by the *Heritage Resources Act (*1986*),* as well as Manitoba's Policy *Respecting the Reporting, Exhumation and Reburial of Found Human Remains* (1987). Through the SSEA process, Manitoba Hydro tries to avoid sites and areas of importance to people. The latter includes avoiding known heritage resources and sites of importance to local people. Manitoba Hydro prepares project specific Environmental Protection Plans (EnvPPs) which are intended to minimize effects on people and the environment. EnvPPs contain measures to protect known and unknown heritage resources, as well as sites of importance to local people. In addition, for more recent projects such as the Wuskwatim Transmission Project and the Bipole III Project, HRPPs are being prepared in advance of construction. Also for the Wuskwatim Transmission Project, cultural and site ceremonies have been held at key planning and construction milestones to help mitigate the effects of the Project on culture and heritage and to demonstrate respect for the land. For Bipole III a ceremony has been held with FLCN. Similar discussions are underway with other communities.

Manitoba Hydro also employs people from local communities to assist in monitoring and act as community liaisons during construction of its transmission facilities.

3.4.2.2 Home Relocation

3.4.2.2.1 Generation Projects

Relocation of communities or a portion of households within a community is a substantial socio-economic effect. Relocation can result in long term effects on the cultural, spiritual, social, economic and political aspects of people's lives (Royal Commission Report on Aboriginal Peoples, October 1996). There are two examples where the relocation of some community households resulted from the development process: at SIL and at Gillam. This had a major impact on the individuals and communities involved. High level background on these relocations is provided below. Further information, including community perspectives on the experience will be provided in Phase II.

SOUTH INDIAN LAKE

Pre-CRD, the community of SIL was situated on both sides of a narrows between South Bay in the south and Southern Indian Lake to the north. The site was ideal for habitation as it provided good wind protection and rapid freezing to accommodate both winter and summer movement over water.

Based on file correspondence, pre-CRD, the existing school, nursing station, Bay store and about 40% of the population were located on the west side of the narrows; 60% on the east side. As a result of CRD, the SIL community was to experience: 1. flooding of its lakeshore, including a small number lower lying homes near the shoreline, and 2. effects to ice conditions and open water sites on the lake surrounding the community resulting from fluctuating water levels during the winter period. The geographical layout of the community, on both sides of the narrows, required residents to cross the ice in the course of normal daily activity.

Solutions considered to address these challenges included:

- Construction of a dam to keep the water level constant on the lakeshore surrounding the community;
- Construction of a bridge from one side of the narrows to the other allowing inhabitants free access across in the winter; and
- Construction of a new town site on the east side of the Lake and relocation of west side residents.

Cost and logistical considerations, as well as general community development planning, led Manitoba and Manitoba Hydro to pursue a partial relocation program. The relocation approach was to move, replace or pay for all homes on the west side of the channel at the Old Post community on SIL, and relocate all people who wanted to move to the new SIL community on the east side of the channel. Approximately 96 lots were developed for replacement homes.

Based on file correspondence, in response to community concerns a local relocation committee was elected in June 1968 to represent the community in upcoming meetings regarding the Project. Specific discussions regarding a new community town site on the east side of the channel were occurring by 1971 and a community plan to be developed by Manitoba Department of Northern Affairs was initiated at that time. The development of a community plan included, among other things, community consultation, siting and scheduling of a new town site and house construction. The community plan was completed and documentation indicates that new house and community construction started near the end of the 1973/74 fiscal year. By the end of December 1974, there were no homes left to relocate from the west side of the narrows. Over time the community has expressed ongoing concerns regarding the impact of this relocation and subsequent social changes experienced.

This issue will be further explored in Phase II of this study.

GILLAM

The FLCN, then as part of the York Factory Band, is a signatory to the 1910 Adhesion to Treaty #5. By the mid 1920s, FLCN Members were living in and around Gillam, which had been established during the construction of the "Bay Line" railway. In 1947, the FLCN was recognized by Canada as a separate Band. Historic documentation indicates that following settlement at Gillam, the FLCN began pursuing a Reserve at that location for the use and enjoyment of its Members.

Beginning in the 1960s, Manitoba Hydro redeveloped Gillam as the Corporation's key operations and service centre in northern Manitoba for the purpose of administering and operating the Nelson River Projects. At this time, FLCN families residing in Gillam were purportedly labeled by government as "squatters" despite their long-standing residence in the area. Homes lived in by FLCN Members were demolished or moved, and residents were relocated. Many members moved to surrounding areas. Approximately 51 FLCN families remained in Gillam when Manitoba Hydro redeveloped the community.

The community of Bird was established as a Reserve in 1985 and, in 2010, a small urban reserve was legally recognized at Kettle Crescent in Gillam. The community continues to pursue Reserve Land in and around Gillam for the use and benefit of its members.

This issue will be further explored in Phase II of this study.

3.4.2.3 WORKER INTERACTION

In the absence of mitigation measures, a sudden influx of large non-local and temporary workforces into or near to remote and often small and traditional communities has been associated with social, economic, cultural and health impacts for the host community. These same effects are associated with the creation of more permanent town sites housing outside workers on a more permanent basis.

The influx of both transient and more permanent non-local workforces can be associated with inappropriate spending on alcohol and drugs, incidences of racism, increased incidents of violence and exploitation, increased demand and strain on local services and infrastructure and increased traffic on roads.

In relation to the Projects, worker interaction concerns have largely been associated with the Generation Projects and converter stations, and related to larger construction camps and more permanent settlements. Phase II of this study will review community specific concerns and experiences with worker interaction issues in relation to the Projects.

3.4.2.3.1 ADDRESSING WORKER INTERACTION EFFECTS

In terms of newer developments, and starting with Keeyask, a concerted effort is being made to address potential negative worker interactions in the Gillam area through a Worker Interaction Sub-Committee. In addition to this, Manitoba Hydro is working with the FLCN through a Harmonized Gillam Development process to address ongoing issues of mutual interest, while working to build "a community where all residents live, work, play, and prosper together." The Harmonized Gillam Development process recognizes that Fox Lake must preserve and enhance its identity in Gillam, which requires an ongoing effort and long-term commitment from Manitoba Hydro and the FLCN, as well as from the Town of Gillam.

3.4.2.4 RESOURCE USE

Hydroelectric development 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 or construction of a right-of-way, and reduced wildlife or plant populations. The sections below describe the types of resource use effects associated with the Projects.

3.4.2.4.1 GENERATION PROJECTS

Development of the Generation Projects has 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 practice 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 use groups). It is also reflected in the significant number of studies that have been completed on resource use. Appendix 3A provides a listing of resource use studies that are publicly available at the current time.

Phase II of this study will summarize the specific resource use effects experienced by each community, as well as related settlements. The sections below describe at a high level effects on domestic and commercial fisheries, trapping and hunting, and gathering of medicinal and other plants/berries.

DOMESTIC AND COMMERCIAL FISHERIES

Impacts on fish populations are one of the most studied effects of northern hydroelectric development, from both an environmental and a socio-economic perspective. The volume of study on this topic reflects the importance of the resource to local communities as well as the extent of community concerns that have been voiced. 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.

Fish communities in areas affected by the Generation Projects have responded differently to hydroelectric depending on the effects to the water regime. As a result, related project effects on associated domestic and commercial fisheries varied as well. A listing of the studies on fish populations that will be considered as part of Phase II is provided in Part V, Water and Land. A listing of the community specific studies on resource harvesting, including domestic and commercial fisheries, that will be considered as part of Phase II is provided as Appendix 3A.

In addition to concerns about the fisheries, communities affected by the Generation Projects 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 (the University of Manitoba and in one study Department of Fisheries & Oceans Canada [DFO]) to test the fish in several communities (for additional information see Fish Quality, Section 5.2.4).

Addressing Effects on Fish Populations and the Fisheries (Domestic and Commercial)

Settlement Agreements

Manitoba Hydro has entered into several settlement agreements that specifically address effects on commercial and domestic fishing activities. These arrangements will be reviewed by community as part of Phase II. 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 available for members.

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, South Indian Lake Fishermen's Association and the Ilford Community Council.

As well, the Keeyask AEAs with TCN, WLFN, FLCN and YFFN provide for a suite of offsetting programs to provide appropriate replacements, substitutions or opportunities to offset Project effects on practices, customs and traditions integral to the First Nations' distinctive cultural identity. This includes programming to provide members with substitute opportunities to hunt, fish and trap for food.

Ongoing Process with the South Indian Lake Community (O-Pipon-Na-Piwin Cree Nation)

SIL has expressed substantial concern regarding the health of the local fishery, including regarding population declines observed in recent years. Since 2003, in response to concerns from the SIL Fisherman's Association regarding the health of the commercial fishery, Manitoba Hydro has been working with SIL groups (including OPCN) and Manitoba Water Stewardship to implement an ongoing environmental monitoring program for the Lake. At one time, Manitoba Hydro also provided funding to improve the utilization of the SIL region by local residents for traditional and commercial resource harvesting activities. Environmental monitoring programming is still occurring with the intent of gaining a better understanding of the current state of the Southern Indian Lake environment.

Lake Sturgeon Stewardship and Enhancement Program

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

- Determining the status of Lake Sturgeon populations throughout areas affected by the Corporation's operations and identifying factors that may be limiting populations;
- Funding and conducting research relating to Lake Sturgeon in Manitoba and hydroelectric facilities;
- Minimizing 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; and
- Educating the public and raising awareness.

Nelson River Sturgeon Board

The Nelson River Sturgeon Board was established in 1993 for a 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 GS.

The mandate of the Board is to provide for the subsistence and cultural needs of the communities and to provide for the preservation of declining Lake Sturgeon stock. As part of a five-year review of the initiative, programming with respect to education in both schools and the communities will be expanded. In addition, 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.

Lower Nelson River Sturgeon Stewardship Agreement (2012–present)

The Lower Nelson River Sturgeon Stewardship Committee (LNRSSC) is a committee of interested stakeholders committed to implementing measures to protect and enhance sturgeon populations in the Lower Nelson River from the Kelsey GS to Hudson Bay, as well as the Hayes, Gods and Echoing Rivers and tributaries along the Nelson River that are important to these populations. The LNRSSC 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 participate as a non-voting member. Committee activities will take into consideration the Lake Sturgeon Management Strategy for Manitoba being developed by Manitoba Conservation and Water Stewardship.

HUNTING, TRAPPING AND GATHERING

Potential effects on resource use activities such as hunting, trapping and gathering of medicinal plants/berries from Generation Projects are caused by changes to habitat and disruption/loss of plant species of importance, and changes to the number and location of species. Project construction and 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.*, caused by fluctuating water levels and related shoreline erosion, debris and other navigational hazards along affected waterways). These pathways have reduced opportunities and increased costs and time for trappers and hunters to undertake this traditional pursuit.

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 any destruction of wildlife 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, 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, compensation for the loss of fur production resulting from development and to encourage efficient use of existing fur resources. The program also provided for, and where appropriate, improvements to portages and 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 the Manitoba Department of Northern Affairs.

As part of a settlement of a specific claim under the NFA (Claim 22) 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 includes 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 Community Council, the South Indian Lake Trapper's Association, and trappers from Thicket Portage and Wabowden.

Both the Keeyask and Wuskwatim Generation Projects provide for compensation arrangements to be made directly with affected commercial trappers. As noted above, under the Keeyask AEAs each of the four Nations (TCN, WLFN, FLCN and YFFN) has Offsetting Programs that allows them to provide appropriate replacements, substitutions or opportunities to offset Project effects on practices, customs and traditions integral to the First Nations' distinctive cultural identity. This includes programming to provide members with substitute opportunities to hunt, fish and trap for food.

As noted in Section 3.4.2.7.1, the WMP is undertaken to enhance safety and accessibility along affected waterways for downstream communities.

3.4.2.4.2 Transmission Projects

Development of transmission facilities can impact domestic and commercial resource harvesting including fishing, hunting, trapping, gathering of medicinal and other plants/berries and fuel wood, wild rice harvesting, outfitting, mining, forestry, recreation and tourism by Aboriginal people and others. Disturbance can arise from a direct impact on a resource as a result of noise and other disturbances, as well as through physical changes to the land such as a loss of habitat and plants. It can also occur through undesired access to the resource from others. Positive and negative effects can occur if access to a resource is improved for area users. Manitoba Hydro uses existing highways, roads, trails and man-made features to access a right-of-way during construction and operations where possible. Access is required along transmission line rights-of-way and is generally restricted to rights-of-way to the extent possible.

The SSEA process seeks to minimize effects on all forms of resource use, including trapping and domestic resource use, recreation and tourism developments/activities, and mining and forestry operations. Trapping and domestic resource use are discussed in detail further below.

Trapping

During construction of a transmission project, activities can temporarily displace wildlife from the area in proximity to the facilities because of sensory disturbances. After construction of a transmission line, some trappers may benefit from improved access to their traplines, although trappers have also expressed concerns that increased access can lead to harvesting from outsiders. In 2010, as part of the Wuskwatim Transmission Project, Manitoba Hydro initiated a two year pilot project on assessing the effects of transmission line construction and operations on furbearers and trapline harvest. The results of this pilot project will be reviewed as part of Phase II of this study.

Domestic Resource Use

Construction of Transmission Projects and, in particular transmission lines, can disrupt domestic resource use (*e.g.*, hunting, trapping, fishing, plant and berry harvesting) in areas in proximity to the facility. As noted above, negative effects can arise through direct impacts on the resource as a result of construction or through undesired access by others. In terms of domestic hunting, wildlife species sensitive to disturbance may temporarily move away from the area resulting in short term decreases in domestic harvesting levels. In terms of domestic fishing and hunting, other concerns that have been raised are increased access to hunting and fishing areas by outsiders, and the negative effects on desired wildlife and fish species. Other concerns related to increased access are increased risk of theft and vandalism. In some instances, increased access can be a benefit to resource area users.

Potential effects from transmission lines may also occur because of disruption or loss of plant species and populations important to Aboriginal and other people. As with hunting and fishing, construction has the potential to increase access which can result in loss of important plant species and communities through pressure on the resource by non-community members.

Operation of transmission lines can also result in increased access in areas used for domestic resource use activities. Some resource users benefit from improved access to resource use areas during the project operations phase. However, improved access can also result in increased pressure on the resource base if more people frequent the area. This could result in increased disturbance to wildlife along a right-of-way and potentially have a negative effect on hunting.

In addition, operations of transmission lines (and related right-of-way maintenance) can negatively affect plants valued by Aboriginal people (*e.g.,* medicinal plants and berries). Effects include loss of plant species and communities as a result of the use of maintenance equipment outside of winter months, as well as the use of herbicides to control undesirable species. As a result of plant loss, Aboriginal people may have to travel further to find plants for food and medicine.

Addressing the Effects of Transmission Facilities on Resource Use

As noted above, in the 1980s, Manitoba Hydro introduced a Trapline Compensation Policy to reimburse registered trapline holders for disturbance during construction of transmission facilities. In 2002, Manitoba Hydro's Trapline Compensation Policy was revised to include a notification component. The policy, called the Trapper Notification/Compensation Policy, compensates registered trapline holders affected by construction of new transmission facilities 115 kV and greater based on a 10 km (6.2 mi) disturbance zone. As part of the notification program, registered trapline holders in the vicinity of a potential new transmission facility are notified during the SSEA process. Manitoba Hydro also contacts registered trapline holders during the regulatory review of a new project to review project plans, record additional information, discuss employment and business opportunities, and the timing of project activities on the trapline, and to begin discussing settlement (if eligible). Prior to construction, a compensation amount is determined with eligible holders of registered traplines for the disturbance during the period of construction, and agreements are entered into by Manitoba Hydro and the registered trapline holder(s). Compensation may include trapline improvements, employment opportunities, equipment replacement and a monetary settlement. It is also paid for any damage to equipment, buildings and trapping trails during construction. Trapline holders are requested to remove trapping equipment if required.

In terms of domestic hunting and fishing, species may move away from the area during construction due to noise. Construction of transmission lines in northern Manitoba typically occurs during the winter months which is during the off season for hunting.

Following construction and operations of a transmission line, opportunities for increased access along the right-of-way may exist in some areas. Based on past experience, some resource harvesters felt that transmission lines may lead to increased risk of theft, vandalism and reduction of harvest due to others accessing the area. Others felt that increased access to resource use areas can be a benefit. To address concerns regarding new access, Manitoba Hydro began preparing Access Management Plans (AMPs) prior to construction beginning with the Wuskwatim Transmission Project.

In northern Manitoba, right-of-way use is generally more intensive in the winter months when people may use a right-of-way for recreational purposes. Increased access is generally less in the spring, summer and fall when the ground is not frozen and access is more difficult. In addition, as maintenance activities in northern Manitoba are generally conducted in the winter when the ground is frozen, effects on domestic resource use are minimized.

It should be noted that Aboriginal peoples have expressed concerns about the effects of transmission lines on medicinal plants and berries. Although winter construction and operations may prevent destruction of plants and berries, many Aboriginal people view plants and berries under a transmission line as being not safe to consume. For Bipole III, the location of traditional plants and berry harvesting important to communities and individuals has been identified through community engagement processes, as well as through ATK studies, and incorporated into the SSEA process.

3.4.2.5 LAND USE

Hydroelectric development can affect land use through the taking of land for flooding or right-of-way purposes. Effects on land use are related to and can overlap with effects on recreational activities and sites, resource use activities and sites and cultural and heritage activities and sites. As these are described above, the sections below attempt to avoid duplication.

3.4.2.5.1 GENERATION PROJECTS

LOSS OF RESERVE LAND

Inundation of Reserve Land due to flooding, and the potential future loss of land due to erosion, has been addressed through the granting of an easement over land below a severance line (*i.e.*, easement boundary line) in accordance with provisions set out in the NFA, CIAs and other settlement agreements. Reserves were created generally 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 geotechnical criteria of 100 year water level, wind and wave events and shoreline composition which determines erodibility.

Under the NFA, any Reserve Land taken was to be compensated by replacement land at 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.

Should a portion of a new Generation Project affect a Treaty Land Entitlement (TLE) selection, discussions are undertaken with the affected First Nation and the Provincial government regarding a transfer arrangement to provide Manitoba Hydro with permanent right to access, use and maintain its facilities and rights-of-way.

3.4.2.5.2 TRANSMISSION PROJECTS

Based on experience with SSEA studies, concerns related to land use typically cover a broad spectrum. Some relate to specific project effects, while others reflect the perception of land use conflicts and enjoyment of land and property. Site-specific land uses such as sites of cultural significance, recreational sites, Reserve Lands, communities, residences and cabins are generally avoided, wherever possible, through the SSEA process. Concerns also arise regarding the routing of a line on Crown Lands where Aboriginal peoples have a history of traditional land and resource use, TLE selections, or RMAs.

ADDRESSING EFFECTS ON LAND USE

As noted above, the SSEA process is used to avoid these types of impacts during the planning stages and prior to development. Should a portion of a transmission line route affect a TLE selection, discussions are undertaken with the affected First Nation and the Provincial government regarding a transfer arrangement to provide Manitoba Hydro with permanent right to access, use and maintain its facilities and rights-of-way. Off reserve, Crown lands typically fall within the jurisdiction of the Provincial government.

3.4.2.6 THE WAY THE LANDSCAPE LOOKS (AESTHETICS)

The Projects have resulted in physical and visual alterations to the landscape, including the water and waterways. The presence of generation infrastructure or a transmission line 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 and the Project (distance and line of sight);
- The activity 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 a number of communities 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 regarding the disruption caused by physical infrastructure in the water. Visual impacts are strongly related to impacts on culture, spirituality and way-of-life.

3.4.2.6.1 Addressing the Effects of Generation Facilities on the Way the Landscape Look (Aesthetics)

Changes to the landscape from Generation Projects that affect the way the landscape looks include the development of construction sites (*e.g.*, dykes) and excavation/development of borrow areas. Construction effects to the way the landscape looks are limited in duration and more recently, to the extent feasible, Manitoba Hydro strives to return disturbed areas to their previous state through decommissioning *(e.g.*, rehabilitation of borrow areas using native plant types to the extent feasible).

Following construction of the Wuskwatim GS, extensive tree planting was conducted in areas in the vicinity of the GS not required for operations. Work areas and borrow pits were rehabilitated once construction of the generating station was completed. In addition, an area of one of the borrow pits required for construction has been set aside for growing and harvesting berries by resource harvesters.

With respect to the Keeyask Project, measures have been adopted to address changes to the way the landscape looks and the loss of the rapids. These measures include construction of a park/rest area with boat launches at the construction site and a video of the rapids taken before construction will be available at the GS once the station is in operation.

3.4.2.6.2 Addressing the Effects of Transmission Facilities on the Way the Landscape Look (Aesthetics)

The SSEA process seeks to avoid to the extent possible site-specific issues of concerns such as the aesthetic quality associated with communities, recreational sites and parks. Although transmission facilities are considered essentially permanent features on the landscape, routing and mitigation measures can minimize aesthetic effects. The latter includes vegetative screens and buffers, and structure placement.

3.4.2.7 Navigation, Transportation and Public Safety

Development of the Projects has resulted in substantial adverse effects to navigation, transportation and public safety. As a result, significant effort has been made to establish related mitigation measures to ensure ongoing and safe use of affected waterways and areas. Maintaining public safety is paramount to Manitoba Hydro.

3.4.2.7.1 Generation Projects

Changes to water levels and flows caused by the Generation Projects have had a direct effect on navigation, transportation and public safety. Changes to water levels and flows have resulted in shoreline erosion (which makes accessing the shoreline difficult is certain locations), debris accumulation and navigation dangers (*e.g.*, floating debris). While these natural processes occur in all waterways, hydroelectric development can increase erosion and debris accumulation rates. Woody debris resulting from hydroelectric development and water regime changes has inhibited access to shorelines and bays and 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 Project affected waterways has altered the quality and timing of ice cover which can adversely affect winter travel for resource harvesting and recreation. Shorter periods of ice cover, slush ice and ice jams have caused hazards for travelers 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

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 has a Waterways Management Program (WMP) in place to support and promote the safety of people travelling on waterways affected by Hydro's operations. This program was initiated to address issues as a result of development of hydroelectric generating stations on the Saskatchewan and Nelson River systems including waterways affected by LWR and the CRD. The Program includes boat patrols, debris management, and safe ice trails. The Program extends beyond the communities affected by LWR and the CRD.

In the early stages of the WMP, there were a number of community requests for access to safe harbors as a safety refuge during severe storm events. Marking of these sites and clearing of debris to allow safe, unencumbered access provides boaters with a safe alternative in these severe conditions. Removal of debris provides safe unhindered access to facilitate travel within traditional resource use areas. Efforts to create safe harbors and access to important shorelines and portages are generally debris removal initiatives that improve safe travel within affected waterways.

Boat Patrols

The purpose of the boat patrol program is to patrol affected waterways to reduce floating debris making 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 the Projects). 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 and CRD, 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 on shore. Mobile 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 burned late in season, typically after the first snowfall to minimize the risk of 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 Trails

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 safe ice trails provide a safe alternative to traveling 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 has a Water Level Forecast Notice Program in place to inform 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 publically available on the Manitoba Hydro website since the late 1990s.

3.4.2.7.2 TRANSMISSION PROJECTS

Transmission lines do not cause flooding or affect water regimes, and hence do not affect travel along waterways. As well, transmission lines do not affect navigation along waterways as Manitoba Hydro follows or exceeds Canadian Design Standards so as not to impede navigation. Although Manitoba Hydro does not encourage travel along its rights-of-way, it can be expected that some travel for varying purposes does occur which can lead to concerns about public safety. Effects from Transmission Projects on Public Safety are discussed below.

ADDRESSING THE EFFECTS OF TRANSMISSION FACILITIES ON PUBLIC SAFETY

Protection measures that Manitoba Hydro uses to ensure public safety include posting signs regarding the dangers of high voltage transmission lines. A formal application and approval from user groups including industries is required for secondary use of a Manitoba Hydro right-of-way. The application form includes information on the applicant, purpose for use and identification of equipment to be used in the right-of-way. Manitoba Hydro can deny secondary uses of its rights-of-way.

3.4.2.8 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 (investments can result from increased government spending associated with project induced tax revenues). 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 sections below summarize health effects documented in relation to the Projects.

3.4.2.8.1 GENERATION PROJECTS

Human health issues considered in the context of the Generation Projects during Phase I include water quality and potable water, and mercury. Issues associated with patterns of traditional food consumption and food security have been discussed earlier in the Resource Use section (Section 3.4.2.4). During Phase II, additional perspectives on potential health effects that have been shared with Manitoba Hydro will be summarized.

WATER QUALITY AND POTABLE WATER

Water quality affects the ability of the aquatic environment to support aquatic life. 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.

Water quality has been affected along the CRD, LWR and lower Nelson waterways through the creation of reservoirs and water diversions. These Projects led to increased or decreased flows, flooding and changes in source water from the Churchill River system into the Nelson River. This is an issue of concern for its effects on fish habitat and other ecosystem elements, and a community concern for drinking water.

Concerns regarding potable water raised by the NFA communities pre-date development of the Generation Projects, and are acknowledged by the Government of Canada as their 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*". It is important to note that, regardless of location, direct drinking of surface water is not a recommended practice. Health Canada indicates that all untreated water should be boiled for one minute before consumption (Health Canada, 2008).

As noted in Section 5.2.1, water quality data have been collected by different agencies at several sites. The results of these studies and data will be presented in Phase II of this study.

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 [TSS] 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 the provision of potable water if additional expenditures were incurred because of hydroelectric impacts. Disputes between Canada and Manitoba about what this meant and the costs eligible for reimbursement were resolved and Manitoba Hydro has met and is meeting its reimbursement obligations to Canada.

Ongoing concerns raised by the 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). Concerns regarding elevated mercury levels in fish can be a source of stress and anxiety for local residents. If not addressed, such concerns can result in altered dietary habits as residents seek to avoid foods they believe to be contaminated with mercury. At the time of development, there was little understanding within the scientific community regarding the link between hydroelectric development and mercury. Mercury became a key issue in the late 1970s as understandings increased and research demonstrated the increased mercury levels flooding caused (particularly CRD-related). Although levels have generally declined since flooding and, in most cases, have reached pre-LWR/CRD levels, it remains an issue of concern in many communities.

Addressing Community Concerns Regarding Mercury

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

In 1986, DFO began a joint five-year program (FEMP) 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 Nation communities across Canada done by Health Canada between 1976 and 1990 as part of a national program to test First Nations. Communities in northern Manitoba included Split Lake and York Landing, Nelson House, SIL, Norway House and Cross Lake. Health Canada tested First Nation communities until 1999. Following that, testing was conducted at the request of a community.

While the results of the FEMP will be reviewed in detail as part of Phase II, at a summary level 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 ppb. Similarly, of those people tested in Norway House, 97% had values in the normal range. Eighty percent of the residents tested in SIL had values in the normal range, while 90% tested in Nelson House were in the normal range. Additional testing for mercury was conducted at the request of NCN between 2000 and 2001. No one tested was "at risk" as mercury levels of those above the normal range were well below levels that are considered to be of concern. The Health Canada Final Report did note limitations 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 the communities ranged from 15% to 52%. Another limitation to the data noted is that the annual reporting of test results obscured any seasonal patterns that may have occurred.

For the Keeyask Project, AEAs include programs which provide opportunities for Members to continue to fish and provide a supply of wholesome food fish to Members from alternative unaffected locations. These programs were developed recognizing both community concerns about the effects of methyl mercury on human health, and the desire to continue to fish and provide healthy fish to their Members. As well, the Keeyask Hydropower Limited Partnership has committed to fund and implement a Risk Management Plan to further manage the mercury effects of the Project on human health. The plan is intended for those who use wild food (primarily fish) from areas affected by the Project and includes relevant AEA programming described above, as well as an extensive mercury and human health communication strategy developed and delivered in collaboration with Manitoba Health, Health Canada and KCN community health care providers. This communication strategy will include outcomes of Project monitoring activities.

The Wuskwatim Generation Project EIS predicted no Project induced change in mercury levels. As part of operational phase monitoring, the Wuskwatim Power Limited Partnership is monitoring mercury in fish (as well as aquatic furbearers) to confirm the EIS prediction of no change. The results of this monitoring will be communicated to NCN through the Partnership Monitoring Advisory Committee.

3.4.2.8.2 TRANSMISSION PROJECTS

Human health issues that may arise during construction of transmission facilities include noise, vibration and dust, and consequences of accidental spills of hazardous materials such as fuel. In general, transmission line construction related effects are short-term in duration. Noise is temporary and intermittent in nature, and typically falls within provincial noise level guidelines.

Depending on where a transmission line right-of-way is located, concerns during operations can include perceived health effects from EMFs, audible noise and herbicide use. Audible noise refers to the noise generated by the line once in operation.

EMFs

EMFs are invisible lines of force surrounding any wire carrying electricity, and are produced by all electric tools and appliances, household wiring, and power lines. A transmission line produces an electric field, a magnetic field and corona. Corona and an electric field can cause electrical effects, the most common of which are radio interference, television interference, AN, and induction on nearby metallic objects.

Addressing the Effects of EMF's from Transmission Facilities

Many studies on EMFs have been completed worldwide. The general consensus of the worldwide scientific community is that a public health risk from exposure to these fields has not been established. Position statements adopted by Federal and Provincial health agencies express the same view. A health and EMF expert's consensus statement on human health effects of EMFs (Manitoba Clean Environment Commission, March 2001) suggests that "*the weight of scientific evidence does not support the conclusion that extremely low frequency EMFs such as those produced by power lines are a cause of adverse effects on human health*". The consensus statement also notes "*research to date has not confirmed any biophysical mechanisms that would link properties of power and frequency fields to the initiation or promotion of cancer or any other adverse effect on human health*". International studies including the World Health Organization (2007) have concluded that there is insufficient scientific evidence to show exposure to EMFs from transmission lines can cause adverse health effects such as cancer. Health Canada (2008) states that there is no conclusive evidence of any harm caused by exposures at levels normally found in Canadian living environments.

While Manitoba Hydro is sensitive to public concerns regarding potential health effects from EMFs, there is at present no scientific evidence to justify modification of existing practices respecting facilities for the generation, transmission and distribution of electricity. Manitoba Hydro recognizes that concerns regarding EMFs can be a source of stress and anxiety for communities and individuals, and continues to undertake the following actions regarding the issue:

- Monitoring of worldwide research programs on EMFs;
- Participation in and support of on-going health and safety research on the local, national and international levels; and
- Maintenance of active communications and provision of technical information to interested parties, including the public and agencies responsible for public and occupational health and the environment.

Audible Noise

Operation of a transmission line involves the production of corona discharges which can result in audible noise and low frequency electrical interference through radio noise. The level will vary with time, subject to the operating mode and loading conditions, as well as the final line design, conductor conditions and weather. With respect to audible noise, provincial guidelines in Manitoba specify maximum 1-hour equivalent noise levels for residential and commercial areas of 55 dBA and 45 dBA, for daytime and night-time periods respectively.

Addressing the Effects of Audible Noise from Transmission Facilities

The audible noise level from a transmission line decreases by about 3 to 4 dBA for each doubling of distance from the line. Manitoba Hydro's transmission lines comply with the provincial guidelines in terms of audible noise.

Although not directly related to health, during operations, transmission lines can create electric interference on radio and television equipment. Electrical interference is not normally a problem but if it is, the most common cause is loose electrical hardware in the transmission line. Individual sources of such interference can be eliminated by proper construction and maintenance methods (*e.g.*, tightening of hardware components). Manitoba Hydro meets the requirements of the *Radio Communications Act* (R.S., 1985, c. R-2 [as amended to 2007-07-09] and the Radio Communication Regulations (SOR/96-484, Registration 05 November 1996 [as amended to 2011-02-17]). Manitoba Hydro also meets the requirements of the Industry Canada's Interference-Causing Equipment Standard – ICES-004 Issue 3, December, 2001 – Alternating Current High Voltage Power Systems. In the event that electrical interference issues are encountered in the vicinity of the transmission line, Manitoba Hydro will identify the interference source, assess and test the signal reception equipment, and will rectify any issues caused by the line through repair of the line.

HERBICIDES

Vegetation management is required to ensure that re-growth in the right-of-way and at the stations does not interfere with the operation of the transmission line. Herbicides are not used during construction. During operations, vegetation management can involve a variety of methods including hand cutting *(e.g.*, utilizing chainsaws, brush saws, axes, or brush hooks), mechanical shear blading (using "V" or "KG" blades), brush mowing with rotary and drum cutters (typically rubber-tired equipment), and herbicide treatment. An integrated vegetation management and weed control approach is used within a right-of-way to control and reduce potential tree and weed problems. Herbicide treatments are formulated to target only broad-leafed plants (trees and weeds) leaving grasses unaffected.

Addressing the Effects of Herbicides used for Transmission Facilities

Permits for herbicides use are obtained on an annual basis by Manitoba Hydro. The process involves public notification as part of the formal permit application to Manitoba Conservation Pesticide Approvals Branch. All herbicide applications are completed and supervised by licensed applicators and in accordance with conditions specified in a Pesticide Use Permit. Herbicide application rates are established by Manitoba Hydro's Chief Forester in accordance with product label instructions. Only herbicides which have been approved in the Pesticide Use Permit are used. Manitoba Hydro maintains a typical list of herbicide foliage treatments and has developed application guidelines that it adheres to for its activities.

Manitoba Hydro's vegetation management procedures are well established with respect to herbicide application requirements and obtaining the Pesticide Use Permits. On provincial Crown lands, a work permit issued under *The Forest Act* is required and owners adjacent to a right-of-way are typically notified in advance. Manitoba Hydro's Chief Forester coordinates the necessary approvals and is responsible for obtaining the necessary Pesticide Use Permits and submitting Post Seasonal Control Reports as per Manitoba Regulation 94-88R under *The Environment Act*.

In sensitive areas, such as areas of medicinal plant and berry collection, clearing of vegetation is generally limited to manual or other types of selective clearing methods.

3.4.2.9 Personal Property Loss and Damage

Development of the Projects has resulted in losses and damage of personal property.

3.4.2.9.1 Generation Projects

Generation Project induced changes to the water regime, and resultant erosion and navigation hazards, 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, boat loss or damage, and other personal items.

Addressing Personal Property Loss and Damage

Under the NFA, members of the five signatory First Nations were eligible to make claims for losses associated with "the Project." Under the agreement, Manitoba Hydro has to establish that "the Project" did not cause nor contribute to a negative effect where any claim is made either by the Band or by an individual because of an actual or perceived negative effect of "the Project." 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 devolved to the community level and funds were provided for the same. Addressing individual claims of personal property loss and damage includes compensation and/or repair or replacement of damaged equipment and property.

Both the Wuskwatim and Keeyask Generation AEAs provide for compensation for personal property loss and damage as well.

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.

3.4.2.9.2 Transmission Projects

Manitoba Hydro requires a right-of-way for its Transmission Projects. Land rights are typically secured through Crown Land Reservations for public lands and by easement on private lands. These arrangements allow Manitoba Hydro to acquire the right to construct, operate, maintain and repair the line within the right-of-way.

Addressing Personal Property Damage

Lands within the proximity or affected by the Transmission Projects may be either public and/or private. For the granting of an easement on private lands for the right-of-way landowners will be compensated.

Manitoba Hydro has a Property Compensation Policy in place for private lands that allows private landowners to continue to use the land as long as the activities do not compromise safety or the integrity of the transmission line. In addition, if a private landowner suffers property damage during the construction period, or as a result of maintenance or repair work, Manitoba Hydro will investigate and repair any damage to a landowner's property. As outlined in Section 3.4.2.4.2, Manitoba Hydro also compensates registered trapline holders through its Trapline Compensation Policy which includes compensation if equipment is damaged.

3.4.2.10 Infrastructure and Services

3.4.2.10.1 Generation Projects

Construction of the Generation Projects involved the development of related supporting infrastructure and projects to facilitate construction and, in some instances, operations of the projects. Apart from the Transmission Projects such as converter stations and transmission lines, which are also discussed in this section, some of the Generation Projects involved the development of rail spurs, telecommunications towers and roads. For example, given that no road access was available when the Kelsey GS was being developed in the 1950s, a 23 km (14.3 mi) rail spur line was built to connect the site to the Canadian National Bayline. Other examples of supporting infrastructure include the road from Gillam to the site of the Long Spruce GS, and the road from Long Spruce to Sundance, the latter which was initially developed to house workers for the construction of the Limestone GS.

As noted above, in the 1960s Gillam was redeveloped into an industrial town to service and support Manitoba Hydro development on the Nelson River. The development of Gillam has brought with it a range of services available to the community and surrounding region including a local hospital, kindergarten to grade 12 school and recreational facility.

Supporting projects and infrastructure will be discussed in more detail in Phase II of this study.

Concerns related to the effects of a Generation Project on local existing infrastructure and services generally relate to increased use of that infrastructure (*e.g.*, increased traffic on area roads) and demand for community based services such as emergency and health services during construction activities. Other concerns relate to the in-migration of construction workers into communities as a result of a project *(e.g.*, worker interaction), described above.

Addressing Effects on Infrastructure and Services

Potential effects and mitigation measures for infrastructure are generally subject to Manitoba Hydro procedures for contact and discussion with responsible authorities. Manitoba Hydro works with local service providers to establish mitigation measures related to effects on infrastructure and services. These measures have varied by project and have included, for example, the creation of construction camps to house workers and the provision of recreational and other services at site to reduce off-site visits. Where appropriate, contribution arrangements have been made with local governments to address incremental costs associated with construction activities (*e.g.,* highway upgrades in advance of development).

3.4.2.10.2 Transmission Projects

Transmission lines can cross or be in proximity to existing infrastructure installations such as Provincial Trunk Highways, Provincial Roads, railways and airports. The nature and extent of impact, and routing measures required, relate to the type of infrastructure a project may cross or be in proximity to. Concerns relate to disruption, damage and interference.

Depending on the magnitude of the project, concerns related to the effects of a transmission project on services during construction can be similar to those associated with a generation project. For example, with the development of converter stations which can take several years to construct and involve large workforces, there can be concerns related to increased demand for community based services such as emergency and health services, as well as increased traffic on area roads.

During operations, effects to community infrastructure and services is generally limited given the limited extent of maintenance activities.

Addressing the Effects of Transmission Facilities on Infrastructure and Services

Potential effects and mitigation measures for infrastructure are generally subject to Manitoba Hydro procedures for contact and discussion with responsible authorities. Manitoba Hydro has design protocols and procedures in place to mitigate any potential effects. Potential effects on services from transmission development are dependent on factors such as proximity of the line to the community, hiring practices (extent of the non-local workforce), and workforce accommodations (mobile construction camps versus local accommodations).

3.4.2.11 Employment, Training, Business and Income Opportunities

Development of the Projects has presented both short and long-term employment and business opportunities. With regards to the Generation Projects this has included construction employment, operational employment at the various generating stations, operational business opportunities (*e.g.*, snow clearing), seasonal employment under the WMP, shorter term employment and business opportunities associated with construction of projects and various mitigations measures (*e.g.*, Cross Lake Weir) and employment associated with the implementation of the NFA, CIAs and other settlement agreements.

Unlike the Generation Projects, the Transmission Projects have presented primarily short-term local employment opportunities during construction activities (primarily during the winter months), at varying skill levels. The Transmission Projects have in some cases occurred over long distances and because of this, the amount of training and employment in any one area has been limited. Economic benefits have also arisen through contracting and other business and employment opportunities and, indirectly, through the provision of goods and services to the construction workforce. During operations, workforce requirements generally involve Manitoba Hydro operations and maintenance personnel, and contractor staff as required. Maintenance activities can involve short-term contracts for brush clearing to maintain rights-of-way. Indirect effects can include the purchases of meals and fuel which may produce a small economic benefit to nearby communities.

3.4.2.11.1 Enhancing Employment, Training, Business and Income Opportunities

Manitoba Hydro has a range of programs and policies designed to encourage and enhance Aboriginal representation in our projects and operational work force, and to promote the participation of northern Aboriginal business in our construction and operations activities. These programs and policies have evolved over time, and recently include, for example:

- **The Hydro Northern Training and Employment Initiative (HNTEI):** Pre-project training, designed to train and prepare northern Aboriginal people for employment in a wide range of occupations during the construction of both the Wuskwatim and proposed Keeyask Projects, was offered through the Wuskwatim and Keeyask Training Consortium (WKTC). Pre-project training was offered through Atoskiwin Training and Employment Centre (ATEC) for NCN Citizens. Funded by Manitoba Hydro and the Provincial and Federal governments, WKTC facilitated HNTEI and provided Project based funding to five First Nations and two Aboriginal organizations, who in turn offered training to their citizens.
- **Pre-Placement Training Initiative:** Developed initially to prepare Aboriginal candidates to acquire minimum qualifications for entry into Manitoba Hydro's Electrical, Mechanical, Station Operator and Power Line Training Programs, this initiative was later expanded to also include access to professional and technical job categories such as information technology, human resources, engineering, commerce, fleet services, linemen and technicians.
- **Northern Purchasing Policy:** Hydro's Northern Purchasing Policy promotes the participation of northern and northern Aboriginal businesses through information exchange, scoping initiatives, restricted tendering or negotiation, and preferential prioritization of contract award.
- **Aboriginal Educational Funding Program:** Manitoba Hydro provides bursaries and scholarships specifically for Aboriginal students in a wide range of disciplines. Recipients of the Aboriginal Educational Funding Program receive priority consideration for summer employment opportunities.
- **New Generation Projects**: include significant efforts to maximize local employment, business and training opportunities. This includes local hiring preferences within the collective agreement governing construction activities *(i.e.,* the Burntwood Nelson Agreement). For Keeyask and Wuskwatim Generation Projects, income opportunities have been made available to the partnering communities.
- **New Transmission Projects:** generally speaking, new transmission construction employment is governed by a collective labour agreement known as a Transmission Line Agreement (TLA), which dictates that all non-supervisory staff for a given project must be new hires for the project. Hiring preferences are put into each northern contract and vary depending upon the location of the project and resulting contract. For Northern Projects, first preference hiring would be Northern Aboriginals.

In addition to measures Manitoba Hydro has taken, the Federal and Provincial governments have also taken steps to encourage Aboriginal participation in historic hydroelectric development. This includes measures taken for the Limestone Project such as the Limestone Training and Employment Agency.

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APPENDIX 3A
RESOURCE USE STUDIES

The following provides a preliminary list of documents related to resource use in the Region of Interest. This list is not complete and will be expanded during the preparation of the Phase II Report. It should be noted that a large number of studies were conducted in response to specific claims filed against Manitoba, Manitoba Hydro, and/or Canada. The reports associated with these studies that were conducted by the claimants are not included in the bibliography and will not be used without the express permission of the First Nation, community, organization and/or individual that the study was conducted for.

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PART IV: PHYSICAL ENVIRONMENT

Manitoba Hydro

REGIONAL CUMULATIVE EFFECTS ASSESSMENT

PART IV

PHYSICAL ENVIRONMENT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

ACRONYMS, ABBREVIATIONS AND UNITS

Acronym/Abbreviation	Term/Unit
%	percent
AEMP	Aquatic Effects Monitoring Plan
CAMP	Coordinated Aquatic Monitoring Program
cfs	cubic feet per second
cms	cubic metres per second
CRD	Churchill River Diversion
CS	Control Structure
DFO	Department of Fisheries and Oceans
EIS	Environmental impact statement
et al.	and others
FEMP	Federal Ecological Monitoring Program
ft	feet
GIS	Geographic Information System
GS	Generating Station
i.e.	in other words
km	kilometre
km^2	square kilometre
LWCNRSB	Lake Winnipeg, Churchill and Nelson Rivers Study Board
LWR	Lake Winnipeg Regulation
m	metre
m/y	metre per year
m^3	cubic metre
m^3/m	cubic metre per metre
MB	Manitoba
MCWS	Manitoba Conservation and Water Stewardship
MEMP	Manitoba Ecological Monitoring Program
mi	mile
MW	megawatts
NFA	Northern Flood Agreement
NHP	National Hydrometric Program
PEMP	Physical Environment Monitoring Program

Acronym/Abbreviation	Term/Unit
RCEA	Regional Cumulative Effects Assessment
SIL	Southern Indian Lake
TSS	Total Suspended Solids
WPLP	Wuskwatim Power Limited Partnership
WSC	Water Survey of Canada

4.0 PHYSICAL ENVIRONMENT

4.1 INTRODUCTION

The physical environment has been altered by past hydroelectric development within the RCEA Region of Interest. The RCEA will document current understandings about the effects of past hydroelectric developments on the physical environment. This includes changes to the water and ice regimes and the associated changes to shoreline erosion (both mineral soil and peatland) and sedimentation. It will also include physical changes to the land resulting from development of the principal structures, supporting infrastructure, and transmission line rights-of ways associated with hydroelectric development.

Phase I includes a general description of Manitoba Hydro's hydraulic operations and associated effects on water and ice regimes, as well as an estimate of the flooded area associated with each generation facility in the Region of Interest. The Phase I water regime description is based on data records that contain sufficient water level and flow data for both pre- and post-hydroelectric development. Past studies and previous documentation are also referenced, where appropriate. For the ice regime, and in cases where data are more limited, the effects of hydroelectric development are described where possible, but are more qualitative in nature. Erosion and sedimentation is also discussed in Phase I based on a review and synthesis of available information and existing studies for the Region of Interest.

The availability of long-term data varies for the different physical parameters. For the topics of water and ice regime, there has been long-term monitoring of hydrometric data within the Region of Interest that has facilitated the analysis of water level and flow data within distinct hydraulic zones. Similarly, there have been historical studies of shoreline erosion that support the description of physical changes over time relating to hydroelectric development. For physical changes to the land resulting from permanent generation and transmission infrastructure, there has been considerably less work done to monitor and assess these changes in a cumulative manner within the Region of Interest. For this reason, the description of physical changes to the land will be undertaken as part of the Phase II analysis.

Phase II of the RCEA will include a more detailed description of Manitoba Hydro's operations, including short-term operations such as plant cycling. The level of additional analysis in Phase II will vary across the Region of Interest based on the complexity of the hydraulic zone and the availability of data to conduct detailed analyses of change over time. Phase II will include a more in depth analysis of hydrological conditions to better understand the impact of hydroelectric development and, in some cases, this may include simulating water levels and flows that would have occurred without hydroelectric development. Phase II will also include detailed mapping of the flooded areas and other permanent infrastructure associated with hydroelectric development. For shoreline erosion and sedimentation, Phase II will involve further analysis and a summary and synthesis of the findings on the impacts associated with hydroelectric development.

4.2 WATER REGIME

This section describes the effect of hydroelectric development on the water regime and ice regime in the RCEA Region of Interest.

Waterbodies (lakes, rivers, streams, creeks, *etc.*) and their associated water and ice regimes are part of the physical environment. The term 'water regime' refers to the pattern and frequency of water levels and flows in a river system. The water regime is driven by the amount of precipitation in a river system's drainage basin or watershed, which is the area of land that drains into a river system. Other factors that can affect the water regime include upstream water regulation, water withdrawals, evaporation and groundwater flow. During winter and spring, ice also plays a significant role, including periods of freeze-up and spring break-up. Man-made components such as channel excavations, control structures, diversions, and forebays also affect the water regime.

The RCEA Region of Interest covers part the Churchill, Burntwood and Nelson River systems which have been affected by hydroelectric development. The region includes the area affected by LWR from the outlet of Lake Winnipeg to Hudson Bay and the area affect by the CRD Project. Most of the inflow to these two major river systems is also influenced by upstream regulation from other agencies. The Rat-Burntwood River system is included because it is impacted by the CRD and is a tributary to the Nelson River.

Within the RCEA Region of Interest, Manitoba Hydro operates the following components that affect the water regime:

- The CRD diverts the majority of the Churchill River flow into the Rat River-Burntwood River-Nelson River system to augment the hydroelectric potential of generating stations along the route. This project diverts flow from one river to another, causing increased water levels and flows on one river system and decreasing water levels and flows on the other;
- LWR is a series of channels that increase the Lake Winnipeg outflow capacity by about 50% and a control structure to regulate the outflow. LWR was built for flood reduction on Lake Winnipeg and to enhance power production, especially during the winter;
- Three control structures regulate outflows as part of CRD and LWR and six generating stations (Jenpeg is both a generating station and a control structure). A forebay or impoundment area is created immediately upstream from each generating station or control structure; and
- Three weirs each with a different function. The Cross Lake Weir increases the average water level and reduces the range of water levels on Cross Lake. The Manasan Falls Control Structure, which includes a weir, reduces the risk of ice jam flooding in Thompson. The Churchill Weir increases upstream water levels on the Churchill River to enhance access, improve and maintain fish habitat, and ensure a potable water source for the Town of Churchill.

A summary of hydroelectric development along the Churchill, Burntwood, and Nelson rivers is provided in Table 4-1. Flooded areas represent Manitoba Hydro's current estimate based on available topographic information. To help describe the effects of these projects, Manitoba Hydro divided the Region of

Interest into 12 zones as shown in Map 4-1. Each of the 12 zones is affected by hydroelectric development in a unique way. Zones 1, 2 and 3 are within RCEA Area 1; zones 10, 11 and 12 are within RCEA Area 2; zones 4, 6, 7, 8 and 9 are within Area 3; and zone 5 is in RCEA Area 4 (see Map 1-4). Each Water Regime zone is described in the following sections along with a corresponding map of the area.

Table 4-1: Summary of Hydroelectric Developments along the Churchill and Nelson Rivers

Project	RCEA Area	Water Regime Zone	Capacity [MW]	Year Completed	Flooded Area (sq. mi.)	Normal Maximum Forebay Level (ft)
Upper Nelson River						
LWR	Area 1	Zone 1	N/A	1976	25	N/A
Jenpeg GS	Area 1	Zone 1	125	1979		714.0
Kelsey GS	Area 1	Zone 3	292	1961	63.5	605.0
Churchill River Diversion / Burntwood River						
CRD	Area 3	Zone 4,6	N/A	1976	293	N/A
Wuskwatim GS	Area 3	Zone 8	214	2012	<0.2	767.7
Lower Nelson River						
Kettle GS	Area 2	Zone 11	1220	1974	85.3	463.0
Long Spruce GS	Area 2	Zone 11	980	1979	5.6	362.0
Limestone GS	Area 2	Zone 11	1350	1992	0.8	280.0
Total		-	4181	-	473.4	-

Hydrometric data refer to water levels and flows obtained from gauging stations operated by either Water Survey of Canada or Manitoba Hydro. Both agencies are part of the National Hydrometric Program (NHP); a cooperative endeavor between the federal, provincial, and territorial governments to provide accurate, timely, and standardized data and information on the current and historic availability of surface water. The parties recognize the value of cooperative water monitoring activities for reasons including operational and cost efficiencies. Final data, or published data, is generated through several levels of reviews to verify compliance to applicable standards.

Water Survey of Canada (WSC) gauge data is accessible online at:

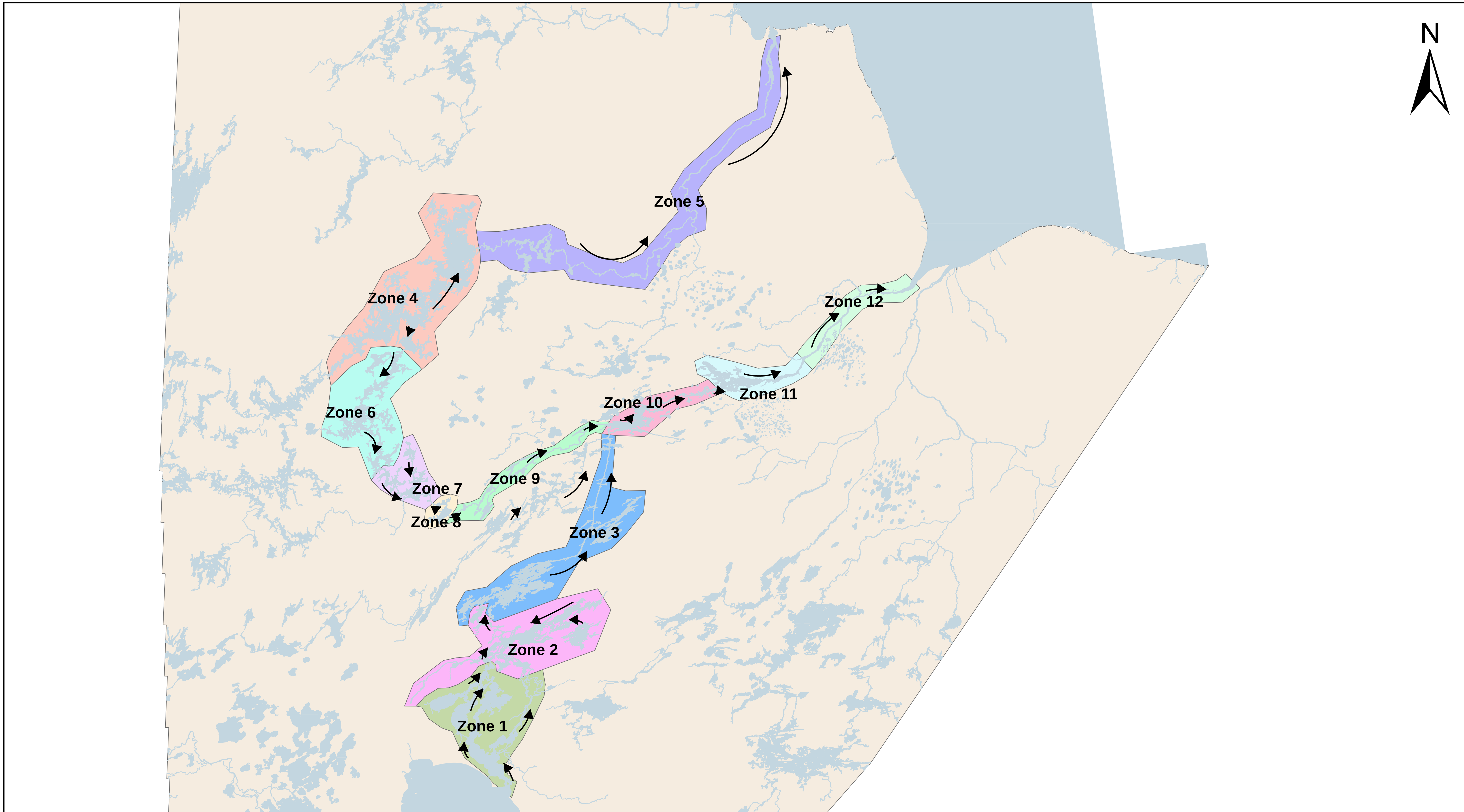
- http://www.wateroffice.ec.gc.ca/index_e.html.

Manitoba Hydro also monitors water levels in the forebay and discharge at each of its generating stations. Data from gauges operated by Manitoba Hydro is accessible online for the current year at:

- http://www.hydro.mb.ca/corporate/water_regimes/hydrological_data.shtml.

The collection of hydrometric data is critical for understanding the availability, variability, and distribution of water resources. It provides the basis for decision making on the management of the resource. In some cases, historic hydrometric data also provide the ability to quantify changes to water and ice regimes on waterways affected by hydroelectric development. The Phase I water regime description is based on data records which contain sufficient water level and flow data pre- and post- hydroelectric development. Gauges with longer records are used where available and provide better estimates of the effects of development. The amount of pre-development data is limited because other than longer term records at a few sites, many gauging stations in Northern Manitoba were established in the 1950s and 1960s, sometimes only a few years before hydroelectric development. These earlier records contain data gaps and were often more limited because of access and recording equipment issues. In cases where the data is more limited, the effects of hydroelectric development on the water regime are described where possible but are more qualitative. Also, comparisons of data can sometimes lead to incorrect conclusions regarding the effects of hydroelectric development. This is because differences in hydrological conditions in the periods of record pre- and post-development can affect flows and water levels regardless of whether hydroelectric development took place. More in depth analysis will be investigated in Phase II of this study.

Phase II of the RCEA will include a more detailed description of Manitoba Hydro's operations, including short-term operations such as plant cycling and their effect on the water regime. The level of detail in Phase II will vary across the zones based on the complexity of the water regime. As a result, Phase II of the study may in some cases include more in depth analysis, including simulating water levels and flows that would have occurred without hydroelectric development. Phase II will also include detailed mapping of all the flooded area associated with hydroelectric development.



DATA SOURCE:
Manitoba Hydro

CREATED BY:
Hydraulic Operation Department
Hydraulic Licencing and Support

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	13-May-14	27-MAY-14
0 30 60 Kilometres / 0 25 50 Miles	VERSION NO: 1.0	QA/QC: BSS/RDB/ZZZ

Legend

Flow Direction

Hydraulic Zones

Zones

- Zone 1
- Zone 2
- Zone 3
- Zone 4
- Zone 5
- Zone 6
- Zone 7
- Zone 8
- Zone 9
- Zone 10
- Zone 11
- Zone 12

RCEA Hydraulic Zones

Map 4-1

4.2.1 ZONE 1 – OUTLET LAKES AREA

This zone begins at the northeast end of Lake Winnipeg, and extends approximately 60 mi (100 km) north to just upstream of Jenpeg. The Outlet Lakes Area includes the East and West Channels of the Nelson River (Map 4-2). The Nelson River West Channel includes Playgreen Lake, Kiskittogisu Lake, Kiskitto Lake and the Jenpeg forebay. The Nelson River East Channel begins at Little Playgreen Lake and extends 60 mi (100 km) until reaching Pipestone Lake, immediately upstream of Cross Lake. The Nelson River West Channel accounts for approximately 85% of the outflow from Lake Winnipeg, while the unregulated East Channel carries the remaining 15%.

LWR was completed in 1976 and the final unit at Jenpeg was commissioned in 1979. The Outlet Lakes Area includes the following major LWR channels and structures:

- Diversion Channels;
  - Two-Mile Channel;
  - Eight-Mile Channel; and
  - Ominawin Bypass Channel.
- Jenpeg Control Structure and Generating Station; and
- Kiskitto Dam.

Two-Mile Channel provides a second outlet for water to flow out of Lake Winnipeg to Playgreen Lake. Eight-Mile Channel avoids a flow constriction on the Nelson River West Channel by connecting Playgreen Lake with the southern end of Kiskittogisu Lake and uses Kiskittogisu Lake as a second flow path for Lake Winnipeg outflows. The Ominawin Bypass Channel and work completed in the Kisipachewuk Channel upstream from Jenpeg provide additional outflow capacity from Kiskittogisu Lake to the West Channel of the Nelson River. The control structure at Jenpeg regulates the Nelson River West Channel portion of Lake Winnipeg's outflow. The Kiskitto Dam and Inlet Control Structure prevent flooding of Kiskitto Lake from backwater effects of the Jenpeg forebay, while regulating inflow. An outflow diversion channel, along with the Black Duck Control Structure, provides an outflow from Kiskitto Lake.

4.2.1.1 MANITOBA HYDRO OPERATIONS

LWR was an initiative of the Province of Manitoba that Manitoba Hydro implemented to reduce flooding on Lake Winnipeg, while enhancing the generation of hydroelectric power, especially during the winter. The diversion channels listed above that make up LWR allow about 50% more water to flow out of Lake Winnipeg. In wet periods, LWR has increased the flow of water from Lake Winnipeg and has kept the water level of the lake lower than it would have been without LWR in place. LWR is important to energy production in Manitoba because it provides Manitoba Hydro the ability to time Lake Winnipeg outflows and generation along the Nelson River with seasonal load requirements. Because it takes several weeks for the effect of flow changes at Jenpeg to reach the lower Nelson River, LWR is not useful for short-term operations but rather is used to match seasonal load requirements.

When the water level on Lake Winnipeg is between 711 ft and 715 ft (216.7 m and 217.9 m), system energy requirements drive LWR operations. When the water level on Lake Winnipeg exceeds 715 ft, Manitoba Hydro must maximize the discharge of water at Jenpeg until the level is restored to 715 ft. If the water level drops below 711 ft on Lake Winnipeg, the Minister of Conservation and Water Stewardship determines how outflows should be managed.

4.2.1.2 DATA

Manitoba Hydro measures water levels in the Jenpeg forebay and measures discharge through the Jenpeg powerhouse and spillway. The following gauging stations contain continuous water level or flow data both prior to and after hydroelectric development:

- Water Level
  - 05UB001 – Nelson River at Norway House (1913-2013);
  - 05UB005 – Playgreen Lake at Entrance to East Nelson River (1967-2013);
  - 05UB007 – Kiskittogisu Lake near Norway House (1967-1987);
  - 05UB017 – Kiskittogisu Lake at Whiskey Jack Landing (1987-2013); and
  - 05UB013 – Kiskitto Lake near Norway House (1971-2013).
- Flow
  - 05UB008 – Nelson River East Channel below Sea River Falls (1967-2013).

4.2.1.3 JENPEG FOREBAY

LWR increased the average water level in the Jenpeg forebay and increased the range of water levels from 7 ft (2.1 m) (681-688 ft) to 12 ft (3.7 m) (702-714 ft). The impoundment resulted in about 25 sq mi (65 sq km) of flooding, all of which is contained in the Jenpeg forebay which extends from Jenpeg upstream to the outlets of Kiskittogisu Lake (Manitoba Hydro 2007). This area experiences wetting and drying with varying water levels depending on water supply conditions and Jenpeg operations. Cycling of flows at Jenpeg will be investigated as part of Phase II of this study.

Water levels in the Jenpeg forebay range between 702 ft and 714 ft (214.0 m and 217.6 m) approximately 95% of the time (Figure 4-1). Operations differ between the open water and winter periods with water levels typically much higher during the open water period than during the winter. Water levels are above 710 ft (216.4 m) during the open water period 70% of the time and are below this during high flow periods to increase discharge out of Lake Winnipeg. Water levels are below 706 ft (215.2 m) during the winter period 70% of the time with higher forebay levels occurring during low flow periods to reduce Lake Winnipeg outflows. These high or low flow periods can persist over a period of years.

During very low flow years, the Jenpeg GS forebay is generally kept higher all year to reduce outflows from Lake Winnipeg. This causes water levels in the channel upstream of Jenpeg GS to be higher despite the low flow conditions. Conversely, during high flow years when Lake Winnipeg is near or above 715 ft

(217.9 m), the Jenpeg GS forebay is lowered to maximize discharge out of Lake Winnipeg as required by licence. As a result, despite the high flows, water levels in the Jenpeg GS forebay are lower.

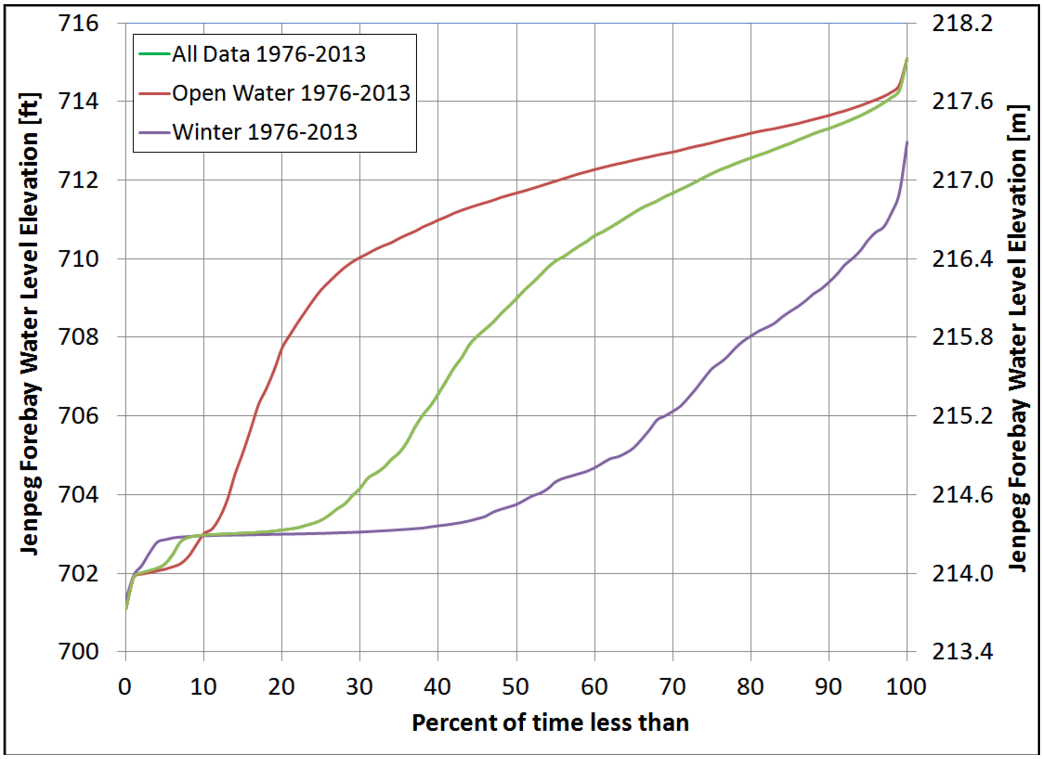


Figure 4-1: Jenpeg Forebay Daily Water Level Duration Curve

4.2.1.4 LAKE WINNIPEG TOTAL OUTFLOW

LWR allows for regulation of the majority of Lake Winnipeg's outflow along the Nelson River West Channel though operation of Jenpeg. Prior to LWR, the Saskatchewan Nelson Basin Board published a monthly record of total outflow from Lake Winnipeg from 1913-1967 (Canada, Alberta, Saskatchewan and Manitoba 1972). Using a similar methodology, Manitoba Hydro developed a record of total Lake Winnipeg outflow from 1967-1976 using the record of Lake Winnipeg water levels (Ad Hoc Committee on Lake Winnipeg Datum 1982) and Canadian Inland Water Branch rating curves (Inland Waters Branch 1969). Total outflow post-LWR is calculated as the sum of the total Jenpeg outflow and the flow in the East Channel of the Nelson River from WSC station 05UB008. The total outflow from Lake Winnipeg post-LWR has been higher on average in the winter and more consistent throughout the year (Figure 4-2). Although LWR can affect the seasonal timing of Lake Winnipeg outflows, it does not affect the long-term average. Rather, differences in hydrology have caused the long-term average outflow post-LWR to be approximately 4.4% higher than the pre-LWR period.

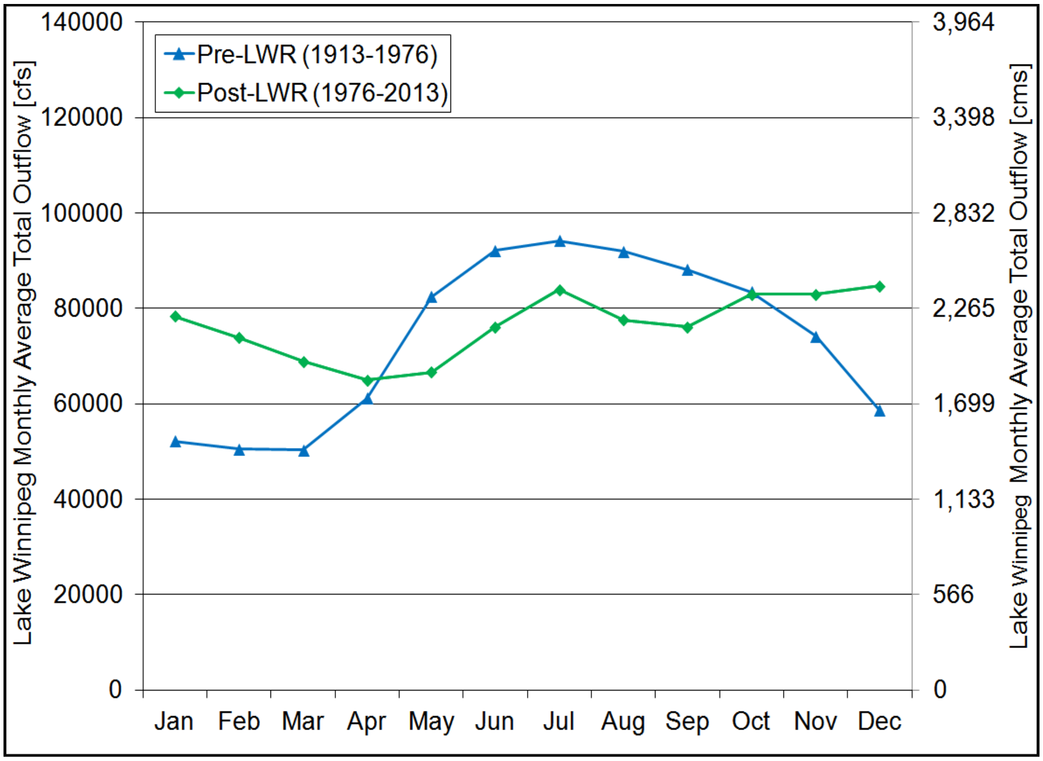


Figure 4-2: Monthly Average Lake Winnipeg Total Outflow

4.2.1.5 KISKITTOGISU LAKE

Prior to LWR, Kiskittogisu Lake had a single inlet at the north end with water levels in the lake primarily influenced by a backwater effect from the Nelson River West Channel. The water regime of Kiskittogisu Lake changed to become a flow-through system with the addition of Eight-Mile Channel. Post-LWR, the Jenpeg forebay water level and flow in the Nelson River West Channel affect water levels on Kiskittogisu Lake. The pre-LWR water level record at WSC station 05UB007 includes open water data from 1967-1970 and data all year from 1971 to July 1975 when water levels were affected by the removal of the final plug in the Ominawin Bypass Channel. In this period, in which there were generally above average inflows from Lake Winnipeg, mean monthly Kiskittogisu Lake levels averaged 710.7 ft (216.6 m) (range: 709.1-712.9 ft or 216.1-217.3 m). Post-LWR, water levels were collected on Kiskittogisu Lake at station 05UB007 from 1976 to 1987 until WSC relocated the gauge in 1987 to station 05UB017. The mean monthly water level with LWR is 711.1 ft (216.7 m) (range: 706.2-714.2 ft or 215.3-217.7 m). Pre- and post-LWR monthly averages in Figure 4-3 suggest that LWR increased the range of water levels on Kiskittogisu Lake, creating higher summer water levels and lower winter water levels.

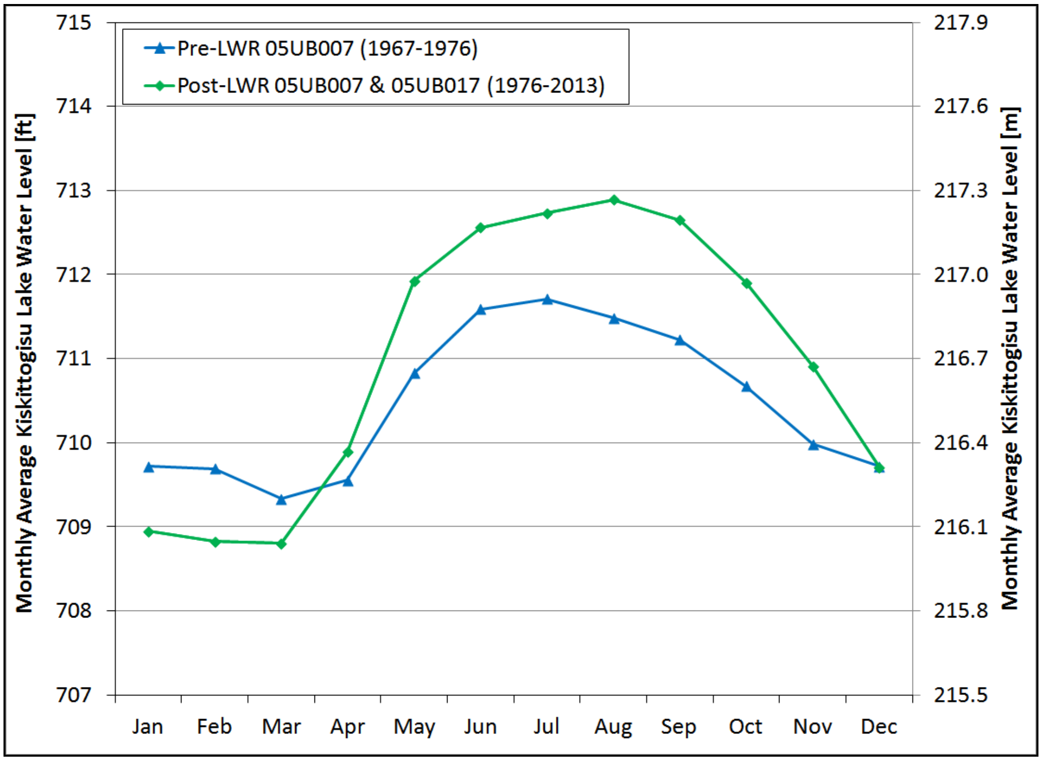


Figure 4-3: Monthly Average Kiskittogisu Lake Water Levels

4.2.1.6 PLAYGREEN LAKE

Prior to LWR the water level on Lake Winnipeg drove the water level on Playgreen Lake. Post-LWR, Lake Winnipeg remains the primary driver of water levels on the lake; however, some influence is now also provided by the Jenpeg forebay. Water level records for the southern basin of Playgreen Lake at WSC station 05UB005 prior to LWR are only available for parts of a few summers. For this reason, station 05UB001 (Nelson River east channel at Norway House) is used as a proxy for Playgreen Lake levels as it has been in operation since 1913 and water levels at the two locations have a strong correlation (Figure 4-4). Prior to LWR, the mean monthly water level at station 05UB001 was 712.1 ft (217.0 m) and the water level range on the lake was between 708.8 ft (216.0 m) and 716.5 ft (218.4 m). Post-LWR, the mean monthly water level is 0.5 ft (0.15 m) higher at 712.6 ft (217.2 m) and the water level range on the lake is reduced to between 710.4 ft (216.5 m) and 715.4 ft (218.1 m). Lake Winnipeg outflows are 4.4% higher post-LWR so based on the data it is not clear whether the higher levels are because of LWR or wetter conditions in the post-LWR period (Figure 4-2). This will be investigated further as part of Phase II of this study. As shown in Figure 4-5, the seasonal water level pattern has remained the same.

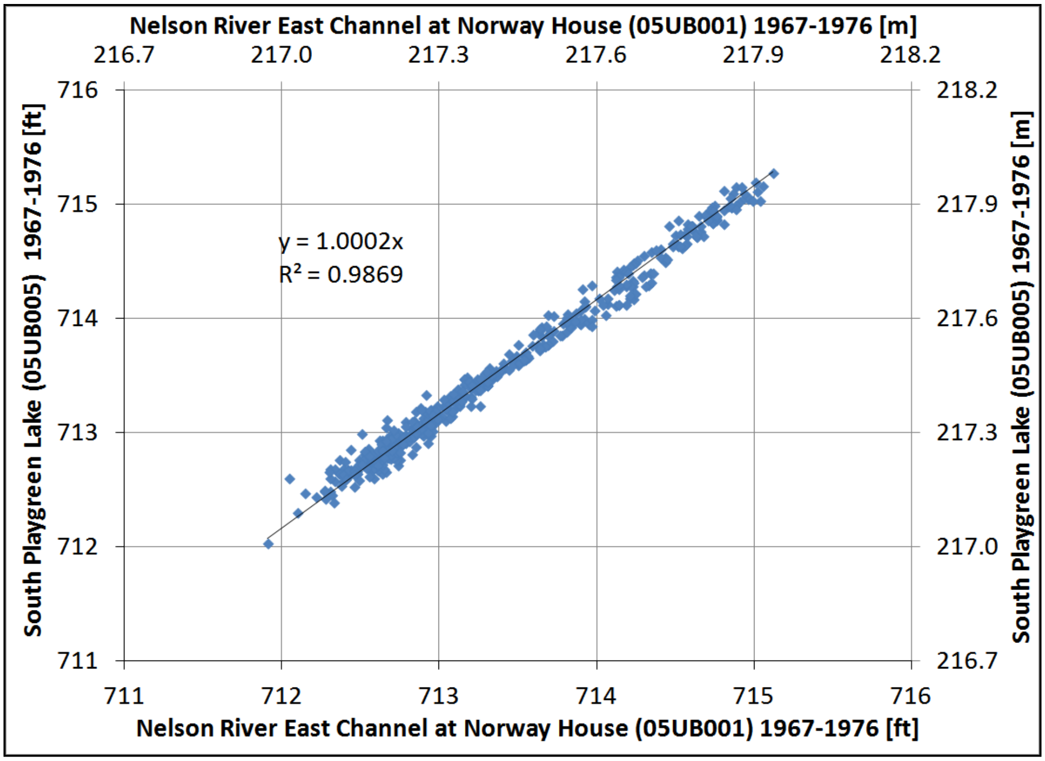


Figure 4-4: Correlation Between Water Levels at Stations 05UB001 and 05UB005

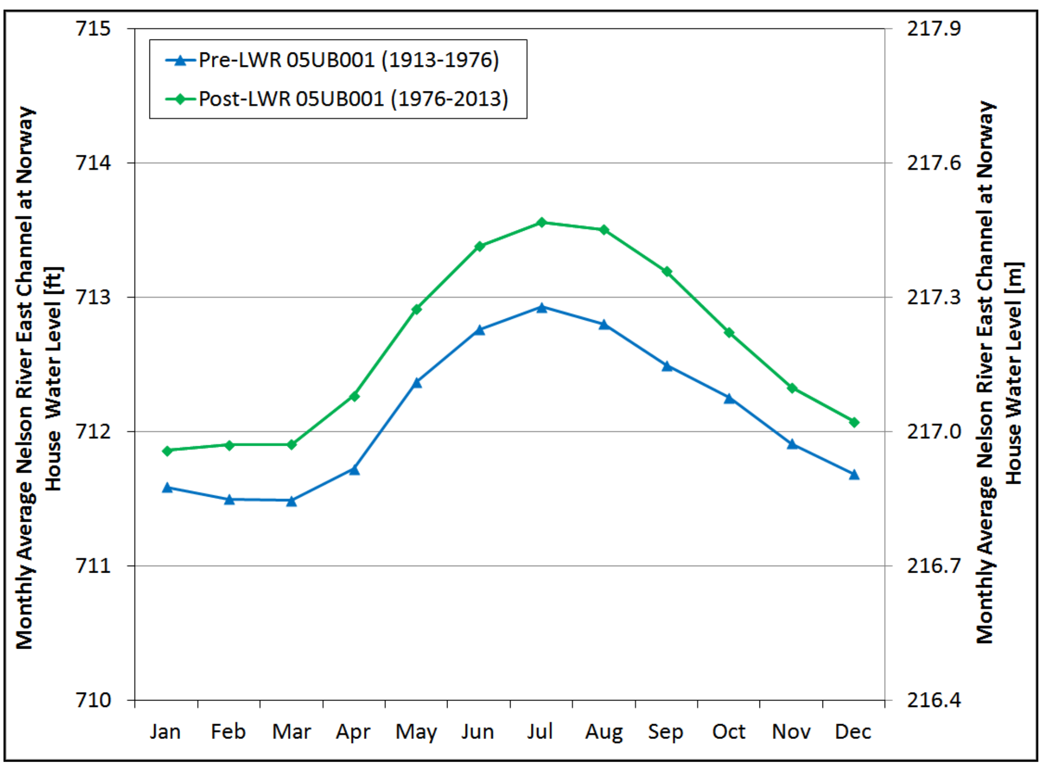


Figure 4-5: Monthly Average Nelson River East Channel at Norway House Water Levels

4.2.1.7 NELSON RIVER EAST CHANNEL

Flow in the Nelson River East Channel is unregulated and remains a function of the upstream water level in Playgreen Lake. As a result, LWR influences flow in the channel when Jenpeg operations affect the water level on Playgreen Lake. Although WSC has reported flows for the Nelson River East Channel at station 05UB008 since 1967, WSC currently reports flows based on the water level at upstream station 05UB001 (Nelson River East Channel at Norway House). As a result, the longer record of water levels at station 05UB001 can be used as a proxy for flows along the East Channel. LWR has therefore reduced the range of flows along the Nelson River East Channel, while keeping the seasonal pattern the same (Figure 4-5). The available data also indicates that East Channel flows have been slightly higher post-LWR. However, because Lake Winnipeg outflows are 4.4% higher since regulation began in 1976, it is not clear whether higher East Channel flows are because of LWR or wetter conditions in the period of record post-LWR. This will be investigated further as part of Phase II of this study.

4.2.1.8 KISKITTO LAKE

WSC reports water level data for Kiskitto Lake at station 05UB013. The control structures operating at Kiskitto Lake maintain water levels within the natural historical range of 686.6 ft (209.3 m) and 702.0 ft (214.0 m) as shown in Figure 4-6 (Lake Winnipeg, Churchill and Nelson River Study Board 1975).

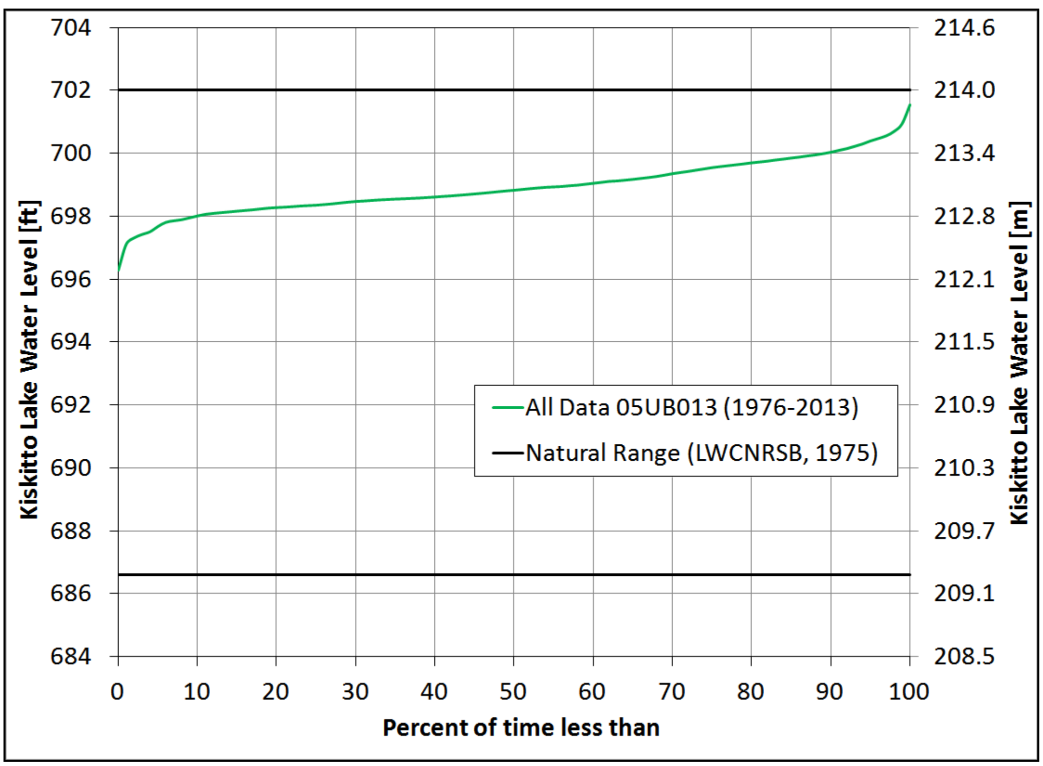


Figure 4-6: Kiskitto Lake Daily Water Level Duration Curve Compared to Natural Range from LWCNRSB 1975 Report

4.2.1.9 ICE CONDITIONS

During the design of LWR, Manitoba Hydro recognized that a flow reduction could be required each year to decrease water velocity, allowing a stable ice cover to form in the channels upstream from Jenpeg. River sections that remain open allow ice crystals called frazil ice to form and be carried downstream where they may be deposited along the channel causing a flow restriction or a clog in GS intakes. The LWR Ice Stabilization Program was initiated in 1984 following a major ice blockage in 1983. Reductions of flow due to ice jams in the channels upstream of Jenpeg can also result in significant loss of generation at all stations downstream from Jenpeg GS along the Nelson River.

The primary objective of the Ice Stabilization Program is to maximize Lake Winnipeg discharge capabilities during the winter months. The program also considers flow on the lower Nelson River during freeze-up, performance at the Jenpeg GS during freeze-up and through the winter, and the safety and well-being of other waterway users. The Ice Stabilization Program involves detailed monitoring of water levels, water temperatures, weather forecasts and ice conditions in the Outlet Lakes Area and on Cross Lake. Another component of the program is the Jenpeg Ice Boom, originally installed in 1988. The ice boom provides a leading edge that initiates the upstream progression of ice while virtually eliminating ice accumulation in front of the Jenpeg powerhouse (Zbigniewicz 1997). The flow reduction as part of the Ice Stabilization Program has varied each year depending on flow and weather conditions. In lower flow years, when flows are below 60,000 cfs (1,700 cms), a flow reduction is not required because water velocities are low enough to allow formation of a stable ice cover. In higher flow years, the flow reduction can be as high as 35,000 cfs (990 cms) and the duration is typically one to two weeks.

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DATA SOURCE: Manitoba Hydro		
CREATED BY: Hydraulic Operations Department, Hydraulic Licencing and Support		
COORDINATE SYSTEM: UTM NAD 1983 Z14N	DATE CREATED: 05 May 14	REVISION DATE: 27-MAY-14
0 5 10 Kilometers / 0 4 8 Miles	VERSION NO: 1.0	QA/QC: BSS/RDB/ZZZ

Manitoba Hydro

Zone 1 - Outlet Lakes Area
RCEA Area 1

Map 4-2

4.2.2 ZONE 2 – CROSS LAKE AND SURROUNDING AREA

Zone 2 begins just downstream from the Jenpeg GS at Cross Lake and extends downstream along the Nelson River to just upstream from Sipiwesk Lake (Map 4-3). Waterbodies within this zone include Duck Lake, Pipestone Lake, Cross Lake and Walker Lake. The Cross Lake Weir, constructed in 1991, is the only Manitoba Hydro structure in this zone.

4.2.2.1 MANITOBA HYDRO OPERATIONS

Manitoba Hydro affects the water regime in this zone through operation of LWR and Jenpeg (previously described in Section 4.2.1). The downstream boundary of Zone 2 is located upstream from any hydraulic influence of the Kelsey GS.

4.2.2.2 DATA

Continuous water level data is available for Cross Lake at WSC station 05UD001 (Cross Lake at Cross Lake) from 1918-present. The monthly record of total Lake Winnipeg outflow (Figure 4-2) represents the inflow to Cross Lake with the exception of some minor local inflow. Continuous water level records are not available for Pipestone Lake, Walker Lake, or Duck Lake prior to LWR.

4.2.2.3 CROSS LAKE

Prior to LWR, Cross Lake water levels followed a typical seasonal pattern (Figure 4-7) with generally higher levels in the summer months and lower levels during the winter months. The mean monthly water level was 679.7 ft (207.2 m) (range: 674.7-685.0 ft or 205.6-208.8 m).

The LWR project altered the Cross Lake water regime by changing the seasonal timing of water levels and increasing water level fluctuations. The average monthly water level variation increased from 0.6 ft (0.2 m) pre-LWR, to 1.0 ft (0.3 m) post-LWR but before installation of the Cross Lake Weir (1976 to 1991). Post-LWR, there are higher average flows and water levels in winter and lower average flows and water levels during summer as compared to pre-LWR conditions (Figure 4-7).

During the post-LWR period but prior to installation of the Cross Lake Weir (described in Section 4.2.2.4), the average Cross Lake water level was 678.6 ft (206.8 m), which is 1.1 ft (0.3 m) lower than the pre-LWR record. The long-term average Lake Winnipeg total outflow during this period was approximately 61,100 cfs (1,730 cms), 17% lower than the long-term pre-LWR average (Figure 4-7). Mean monthly water levels post-LWR but before installation of the Cross Lake Weir were approximately 4 ft (1.2 m) lower during the mid-summer months (June to August) and over 1 ft (0.3 m) higher in the winter months (December to February). The lowest water levels observed during this period occurred during the summer and were 673.0 ft (205.1 m), 1.7 ft (0.5 m) lower than the lowest levels in the pre-LWR record. However, WSC did not operate station 05UD001 from September 1933 through June 1950, which coincides with the lowest recorded water levels on Lake Winnipeg and would have produced very low water levels on Cross Lake. As part of an environmental impact assessment study completed in 1986, The Nelson River Group estimated that the lowest mean monthly pre-LWR water level would have been 673.2 ft (205.2 m) in April 1941 (Nelson River Group 1986). The maximum water level remained the same as the maximum pre-LWR at 685.0 ft (208.8 m). Lower water levels and the seasonally reversed water level pattern prompted the Cross Lake Weir Project discussed below.

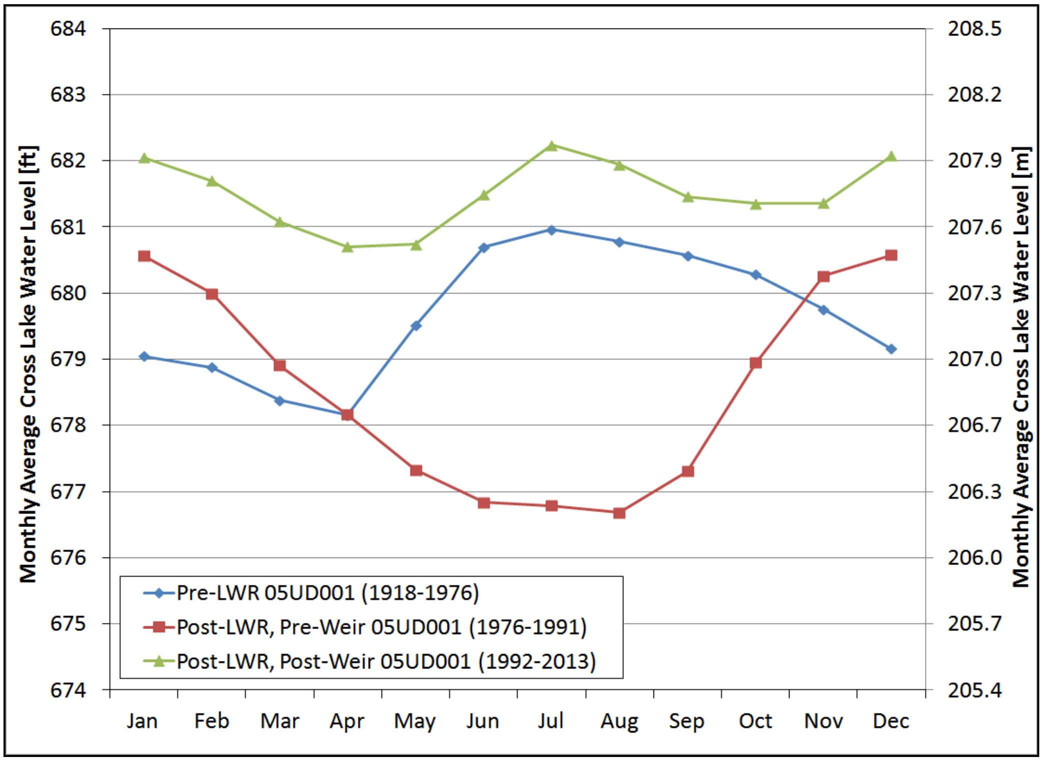


Figure 4-7: Monthly Average Cross Lake Water Levels

4.2.2.4 Cross Lake Weir Project

The Cross Lake Weir was developed to mitigate 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. The mean monthly water level after completion of the weir rose to 681.5 ft (207.7 m), 1.8 ft (0.5 m) higher than the pre-LWR average. The increase is partially attributable to the weir but also partially because since 1992 the average total Lake Winnipeg outflow has been 19% higher than the pre-LWR average because of wetter conditions. Also, since installation of the weir, the seasonality of water levels has more closely resembled natural conditions (Figure 4-7). A seasonal flow reversal is still found to occur in low to average flow years, while in high flow years the seasonal flow pattern remains similar to the natural condition (Figure 4-8). The Cross Lake weir helps to mitigate the effects of higher flows by allowing greater discharge at high lake levels than was possible under natural conditions. Installation of the weir reduced the magnitude of water level variations, including those experienced during the Ice Stabilization Program. The average monthly water level variation reduced from 1.0 ft (0.3 m) post-LWR prior to installation of the weir to 0.7 ft (0.2 m) with the weir, which is close to the pre-LWR average of 0.6 ft (0.2 m).

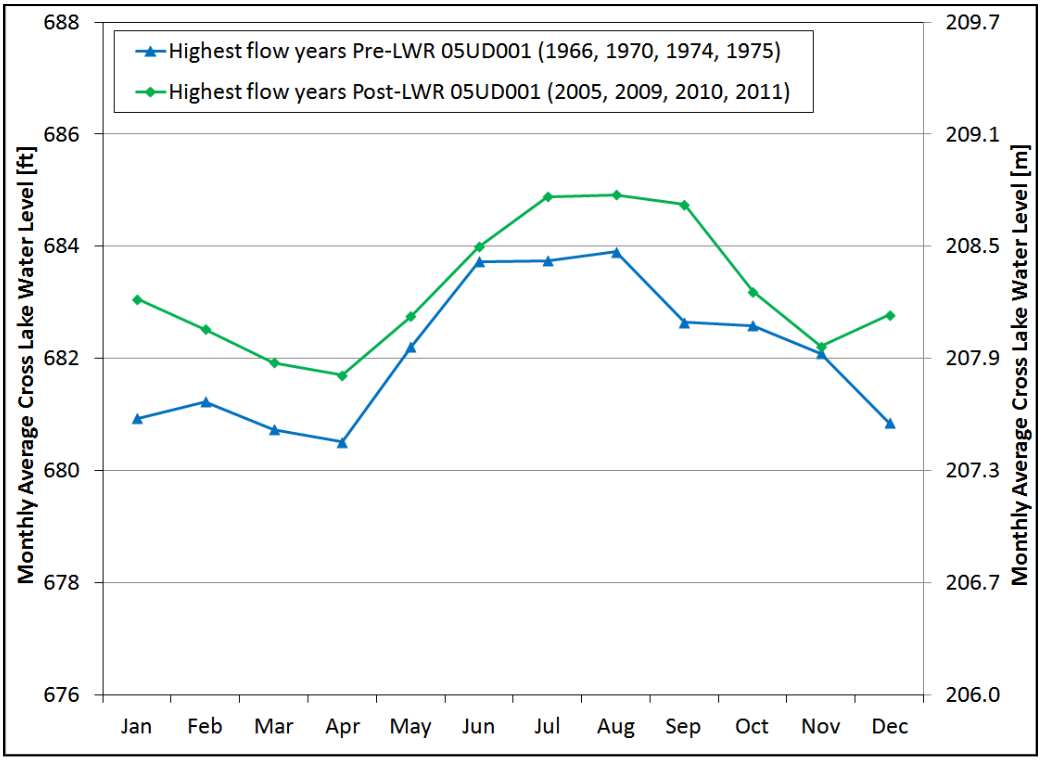


Figure 4-8: Monthly Average Cross Lake Water Levels During High Flow Years

4.2.2.5 PIPESTONE, WALKER, AND DUCK LAKES

Pipestone Lake is located on the East Channel of the Nelson River just upstream from Cross Lake. Water levels on Pipestone Lake are generally a function of water levels on Cross Lake, while flow in the Nelson River East Channel also has a minor influence on lake levels. As a result, LWR impacts Pipestone Lake in a similar manner to Cross Lake.

Walker Lake is located approximately 25 mi (40 km) east of Cross Lake and is connected to it by the Walker River. Midway along the Walker River between Cross Lake and Walker Lake is a set of rapids that have long been known to be reversing. The flow direction on Walker River depends on the elevation of Cross Lake relative to Walker Lake. When Cross Lake elevation is above 681 ft (207.6 m) it has a direct influence on the level of Walker Lake (Manitoba Hydro 1998). When Cross Lake is below this level, Walker Lake level is only a function of local inflows. As a result, LWR periodically affects Walker Lake because LWR affects the frequency, duration, and timing of high water level events on Cross Lake.

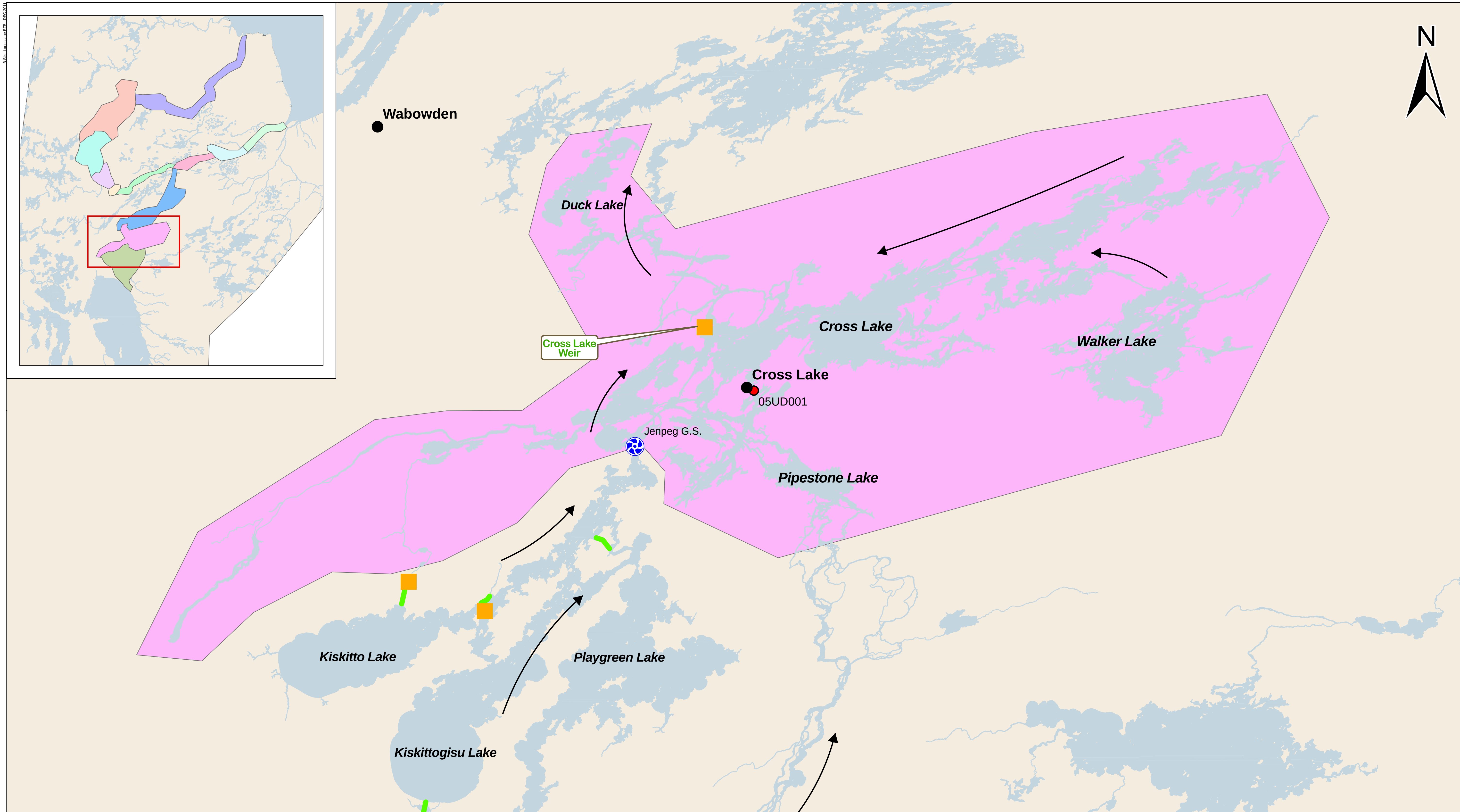
Duck Lake is located downstream from Cross Lake along an area where the Nelson River splits into two channels, just upstream from Sipiwesk Lake. LWR affects Duck Lake in a similar manner to Cross Lake including a changed seasonal flow pattern and greater water level variation.

4.2.2.6 ICE CONDITIONS

The Ice Stabilization Program discussed in Section 4.2.1 can affect ice conditions on Cross Lake. This is because Jenpeg operations can increase water level fluctuations and potentially contribute to the formation of slush ice on Cross Lake. As the lake is heavily used during the winter for transportation, operating decisions are made in a manner that attempts to reduce the potential to create slush ice. Large increases in water levels on Cross Lake after freeze-up can also increase the amount of slush ice on the lake. As a result, Manitoba Hydro now increases Jenpeg outflows to the target winter flow prior to freeze-up to allow Cross Lake to freeze at a higher level. Other factors such as heavy snowfall during the freezing period can also influence slush ice conditions.

An ice thickness study was undertaken for Cross Lake in 1983 to establish whether or not Lake Winnipeg Regulation contributed to the severity of slush ice by reducing ice thickness:

> The study demonstrated that in many areas, including the western main body of the lake, the northern area, downstream from the East Channel entrance and the southern part of the community, the increased West Channel flow with LWR has resulted in increased ice thickness. Throughout the rest of the lake including the central and northern reaches within the community, none of the natural or Manitoba Hydro influenced factors considered seemed to have a consistent effect on ice thicknesses one way or another (Manitoba Hydro 1983).



Manitoba Hydro

DATA SOURCE:
Manitoba Hydro

CREATED BY:
Hydraulic Operation Department
Hydraulic Licencing and Support

COORDINATE SYSTEM:
UTM NAD 1983 Z14N

DATE CREATED: 05-May-14

REVISION DATE: 27-MAY-14

VERSION NO: 1.0

QA/QC: BSS/RDB/ZZZ

0 5.5 11 Kilometres
0 4.5 9 Miles

Legend

- Towns
- Existing Generating Station
- Control Structures
- Gauging Stations
- Channels
- Flow Direction

Zone 2 - Cross Lake and Surrounding Area
RCEA Area 1

4.2.3 Zone 3 – Sipiwesk Lake to Kelsey GS

Zone 3 includes Sipiwesk Lake and Nelson River from the outlet of Sipiwesk Lake to the Kelsey GS (Map 4-4). Some of the other lakes in this zone include Landing, Hunting, Prud'homme, Cauchon, and Goose Hunting lakes, which are all tributaries to the Nelson River. The Kelsey GS was constructed between 1957 and 1961 to supply the International Nickel Company's mining and smelting operations and to supply electricity to the City of Thompson.

4.2.3.1 Manitoba Hydro Operations

Operation of both LWR and the Kelsey GS affect the water regime in this zone. LWR affects the seasonal timing of inflows to Sipiwesk Lake. Kelsey affects water levels on the Nelson River and surrounding lakes upstream to and including Sipiwesk Lake. For the first 16 years of operation (1960 to 1976) Kelsey had no effect on flows because it was operated as a run-of-the-river plant, using the flow of the river as it occurred. Starting in 1977, Kelsey operations became more integrated in the whole hydroelectric system and were:

> modified to more effectively utilize the pondage (reservoir storage of limited capacity) of Kelsey's forebay on an infrequent basis to supplement flows over a period of about a month or so, or to increase the gradient out of Sipiwesk Lake to alleviate winter hydraulic restrictions (Manitoba Hydro-Split Lake Cree Joint Studies 1996).

Flow changes at Kelsey immediately affect the water level upstream from the GS and the effect moves progressively upstream to Sipiwesk Lake. Hourly water level variations at the Kelsey forebay generally influence water levels from the generating station to the outlet of Sipiwesk Lake. Changes to the daily average flow at Kelsey can affect Sipiwesk Lake and several other lakes which are tributaries to the Nelson River.

4.2.3.2 Data

Manitoba Hydro has a continuous record of daily water levels in the Kelsey forebay since August 1957. Flows in this zone have been monitored at WSC station 05UE004 (Nelson River below Sipiwesk Lake) from 1951-1958, and by Manitoba Hydro at Kelsey since 1960. Water levels have also been monitored at WSC station 05UD006 (Sipiwesk Lake at Forestry Dock) since 1965.

4.2.3.3 KELSEY GS

Based on the short record of data available, impoundment of the Kelsey forebay increased water levels by approximately 30 ft (9.1 m). Impoundment flooded 63.5 sq mi (164.5 sq km) of land, increasing the surface area of the rivers and lakes between Sipiwesk Lake and Kelsey from approximately 233 to 297 sq mi (603 to 769 sq km). Since construction was completed in 1961, the Kelsey forebay is normally controlled to operate just below its upper licensed limit of 605 ft (184.4 m) to optimize power production (Figure 4-9). For power production reasons, the forebay is drawn down periodically but typically not below 600 ft (182.9 m) (Figure 4-9).

The monthly average discharge at Kelsey pre- and post-LWR in Figure 4-10 shows that LWR increased winter flows at Kelsey. Although LWR can also increase flows during the open water season under flood conditions, the available record indicates that on average LWR decreased open water flow. Long-term average flow, which is not affected by hydroelectric development, is approximately 89,000 cfs (2,520 cms) in the pre-LWR period (1951-1976) and 78,000 cfs (2,210 cms) in the post-LWR period (1977-2013).

Manitoba Hydro completed a more detailed characterization of the water regime in this zone in 2005 including an assessment of the potential effects of the Kelsey Re-runnering Project which was completed in 2013 (Manitoba Hydro 2005).

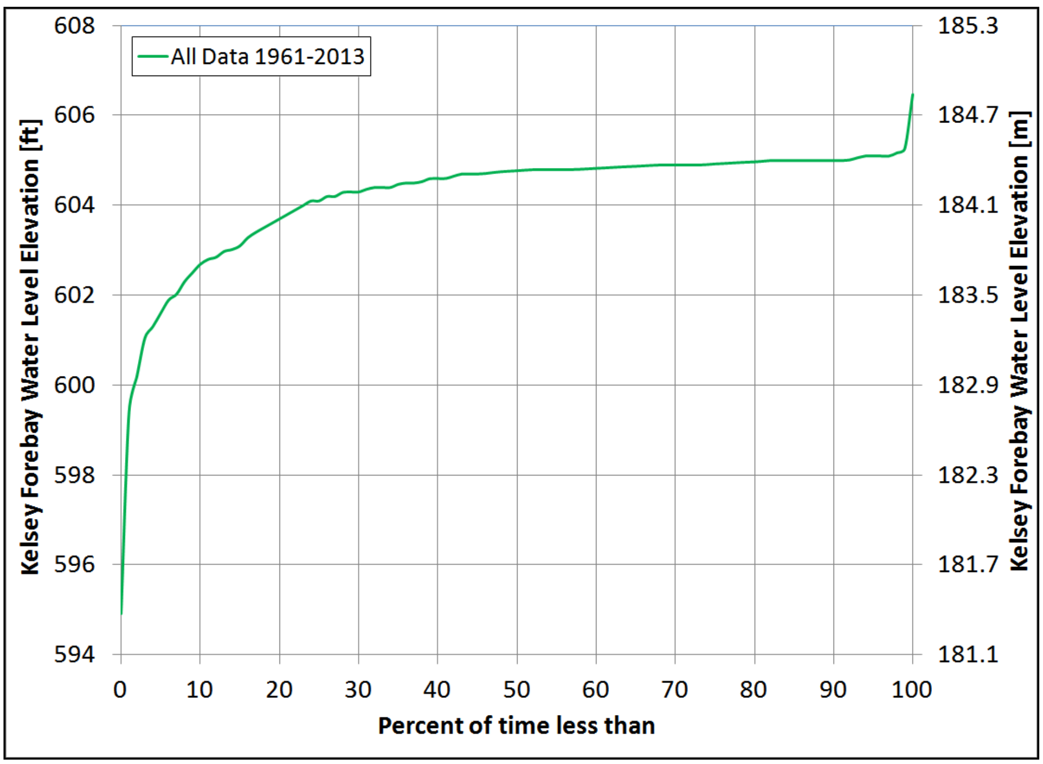


Figure 4-9: Kelsey Forebay Daily Water Level Duration Curve

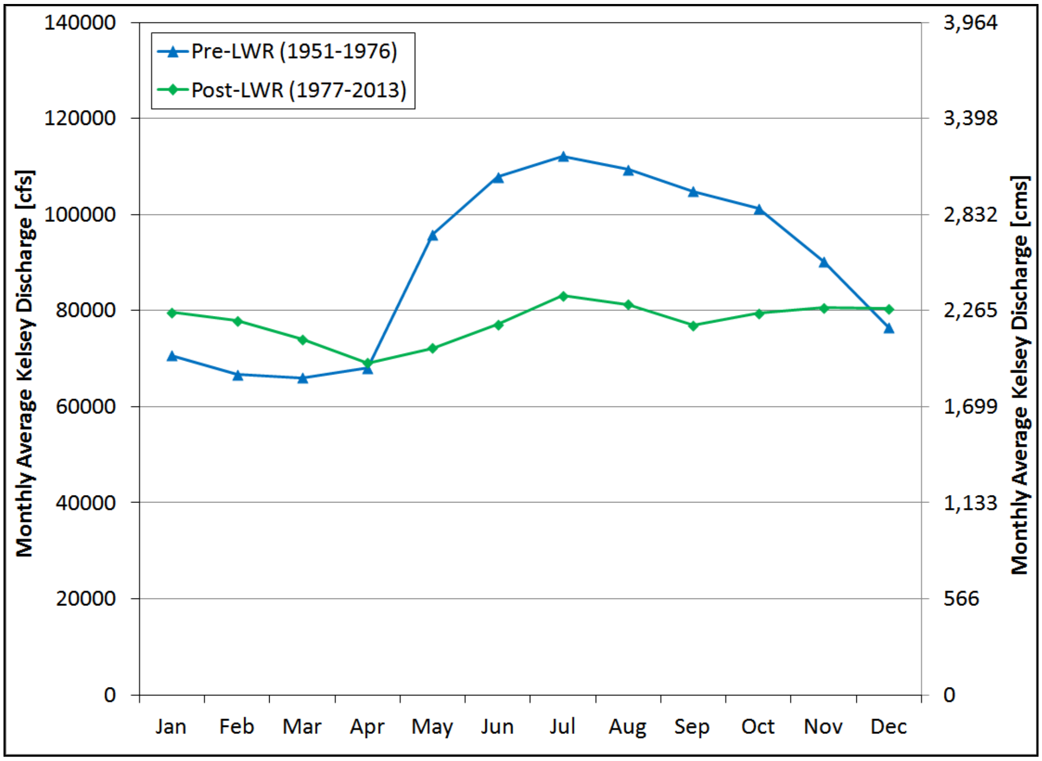


Figure 4-10: Monthly Average Kelsey Discharge

4.2.3.4 SIPIWESK LAKE

Water level data for Sipiwesk Lake is only available prior to impoundment of the Kelsey forebay during parts of 1952 and 1954. Flow measurements were also taken at a location 4 mi (6.4 km) below Sipiwesk Lake during the 1952 and 1954 hydrometric program (Manitoba Department of Mines and Natural Resources 1952, 1954). Comparing water levels prior to and after Kelsey impoundment under similar flow conditions, it appears that the Kelsey GS increased the average water level on Sipiwesk Lake by approximately 10 ft (3.0 m). The Federal Ecological Monitoring Program (FEMP) estimated that that impoundment of the Kelsey GS increased the water level on Sipiwesk Lake by 3.3 to 6.6 ft (1.0 m to 2.0 m) (Environment Canada, Department of Fisheries and Oceans 1992). In a Post-Project Assessment of Kelsey and Lake Winnipeg Regulation Impacts on Wabowden, it is estimated that, prior to the development at Kelsey, the long term median monthly level of Sipiwesk Lake was 596.0 ft (181.7 m) (MacKay *et al.* 1990). The long-term median monthly level is 610.6 ft (186.1 m) in the available record after 1965.

The available data presented in Figure 4-11 is divided into years pre- and post-LWR. Similar to the effects on Cross Lake, LWR has reversed the seasonal water level pattern on Sipiwesk Lake in low to average flow years. Based on the available data, it would appear that the average water level on Sipiwesk Lake was higher prior to LWR. However, these higher water levels were the result of flows being approximately 25% higher in the pre-LWR period of record (1965-1976) when compared to the post-LWR period of record (1976-2013). Based on the available record of data, the Sipiwesk Lake average monthly water level variation increased from 0.7 ft (0.2 m) pre-LWR to 1.1 ft (0.3 m) post-LWR.

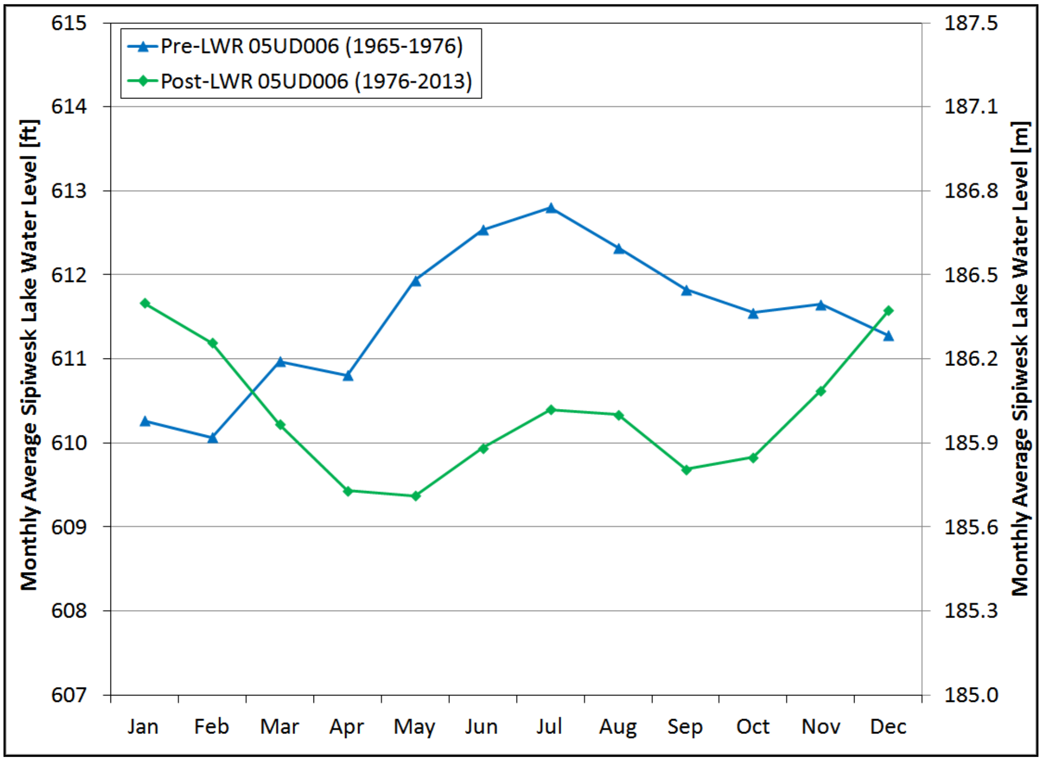


Figure 4-11: Monthly Average Sipiwesk Lake Water Levels

4.2.3.5 Ice Conditions

Impoundment of the Kelsey forebay decreased water velocities between Sipiwesk Lake and Kelsey. As a result, rapids areas that used to remain open year round now freeze over with a stable thermal ice cover. Also, in years with large water level variations in the Kelsey forebay during the winter, ice conditions may be affected including potentially contributing to slush ice conditions.

LWR has the potential to contribute to slush ice conditions by increasing water level fluctuations on Sipiwesk Lake.

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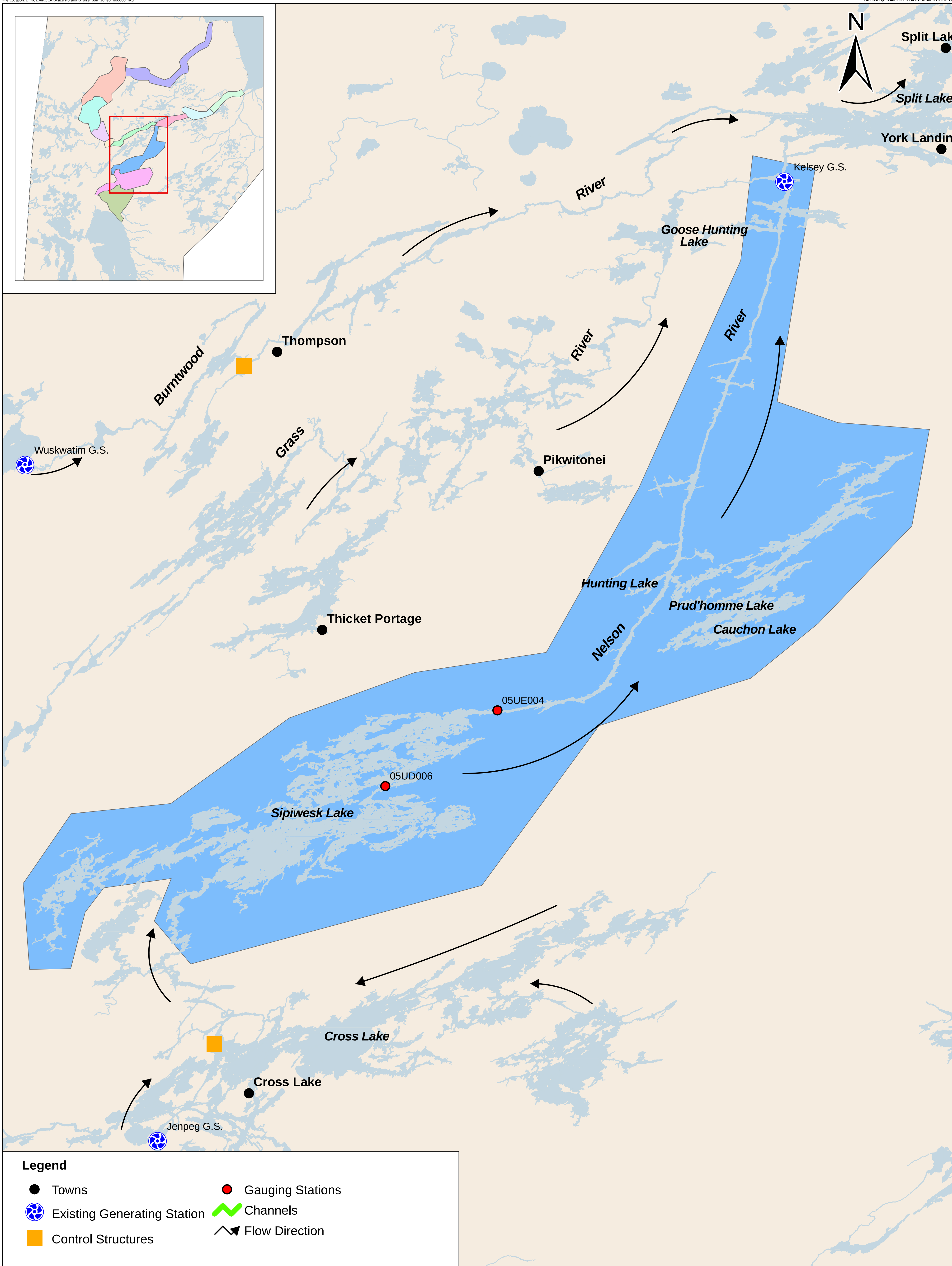
Created By: bsinclair - B Size Portrait BTB - DEC 2011



Manitoba Hydro

DATA SOURCE: Manitoba Hydro		
CREATED BY: Hydraulic Operations Department Hydraulic Licencing and Support		
COORDINATE SYSTEM: UTM NAD 1983 Z14N	DATE CREATED: 05 May 14	REVISION DATE: 27-MAY-14
0 7 14 Kilometers 0 5.5 11 Miles	VERSION NO: 1.0	QA/QC: BSS/RDB/ZZZ

Zone 3 - Sipiwesk Lake to Kelsey G.S. RCEA Area 1

4.2.4 ZONE 4 – LEAF RAPIDS TO SOUTHERN INDIAN LAKE

Zone 4 includes the upper Churchill River from Leaf Rapids to Southern Indian Lake (SIL) (Map 4-5). Starting from Leaf Rapids, the Churchill River runs approximately 20 mi (32 km) before reaching Opachuanau Lake, which is connected to SIL.

Two of the three main components of the CRD are located in this zone. The Missi Falls Control Structure (CS) controls the outflow at the natural outlet of SIL and raised the water level on the lake. The South Bay Diversion Channel is an excavated channel from the South Bay of SIL to Issett Lake and creates a new outlet to allow Churchill River water to flow into the Rat River and Burntwood River System. The Notigi CS is the third main component of CRD and is described in Section 4.2.6.

4.2.4.1 MANITOBA HYDRO OPERATIONS

Following joint federal-provincial studies (Canada, Manitoba 1965), Manitoba Hydro in February 1966 announced its intention to divert the Churchill River as part of an overall plan of northern hydro development. Instead of harnessing the hydroelectric potential by building plants right on the Churchill River, a considerable economic advantage was gained by diverting most of the Churchill River water into the Burntwood and Nelson River systems to use at the generating stations on the lower Nelson River.

CRD is a key feature of hydroelectric development in Manitoba and is responsible for on average 25% of the flow to Manitoba Hydro's system. Manitoba Hydro controls all outflow from SIL through operations at the Missi Falls CS and Notigi CS. The majority of flow is diverted through Notigi while discharge at both Missi Falls and Notigi typically remain constant for long periods of up to several months at a time. SIL is used as a seasonal reservoir as it is typically filled during the open water period to store water for use during the winter when the lake is typically drawn down. Operating decisions are made such that flow releases through Notigi and Missi control structures result in maximized system generation, while staying within applicable limits for flows and water levels. This is especially important during winter when Lake Winnipeg outflows are restricted by ice. Flow conditions on the Nelson River also influence CRD operating decisions. For example, CRD flows though Notigi are sometimes reduced during periods when the Nelson River is experiencing flood conditions. In these instances, water is either stored in SIL (if license conditions permit) or released at Missi Falls CS into the lower Churchill River.

4.2.4.2 DATA

WSC reports a continuous water level record for SIL since 1956 at station 06EC001 (Southern Indian Lake near South Indian Lake). Manitoba Hydro also measures water levels in the Missi Falls and Notigi forebays and has measured discharge through the control structures since 1976.

4.2.4.3 SOUTHERN INDIAN LAKE

CRD increased the average water level on SIL by 9 ft (2.7 m) and increased the area of SIL from 843 to 898 sq mi (2,180 to 2,330 sq km) by flooding approximately 55 sq mi (140 sq km) of land. Increased water levels also created a backwater effect that influences water levels as far upstream as the outlet of Granville Lake at Leaf Rapids. Granville Lake is not considered an affected waterbody because, based on hydraulic modeling, backwater effects greater than 0.1 m (0.3 ft) have occurred less than 10 percent of the time (Manitoba Hydro 2010). Backwater effects on Granville Lake only occur when low flow conditions on the upper Churchill River are combined with high water levels on SIL. CRD also affects flow patterns within SIL. While all of the water used to flow out the natural outlet at Missi Falls, the majority of inflowing water now flows south via the South Bay Diversion Channel. As shown in Figure 4-12, the available data indicates that the seasonal water level pattern on SIL is similar to the pre-CRD pattern. Pre-CRD data also includes effects from the Island Falls GS in Saskatchewan which was completed in 1930 and results in higher winter flows than natural conditions.

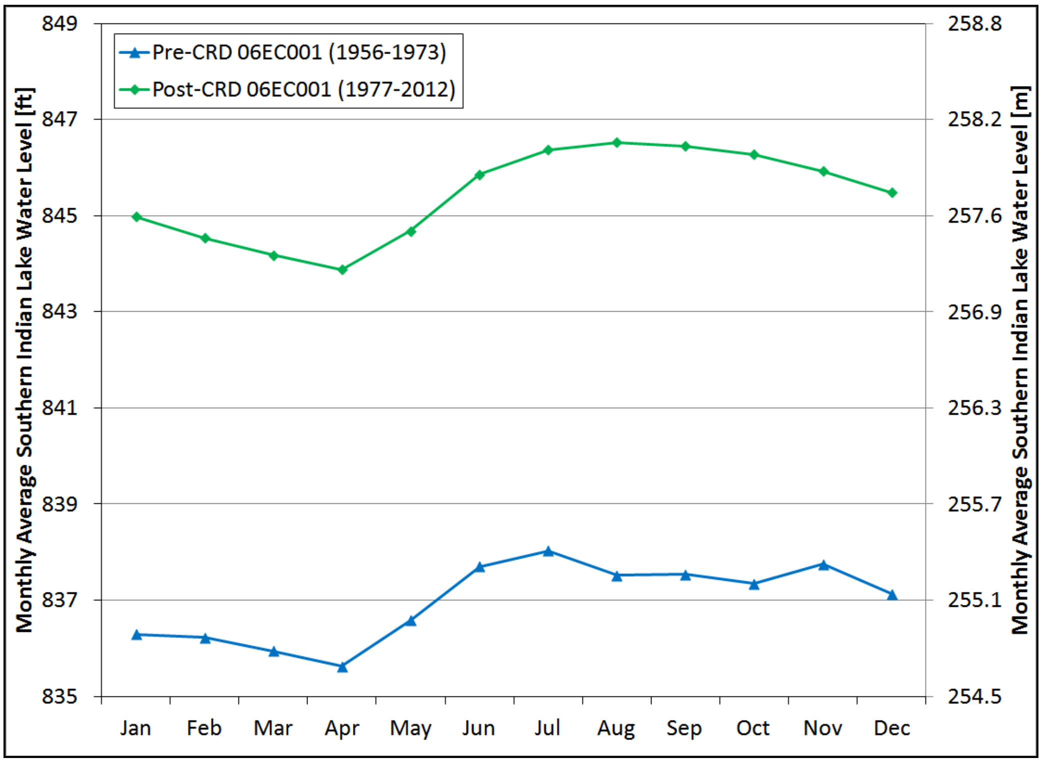


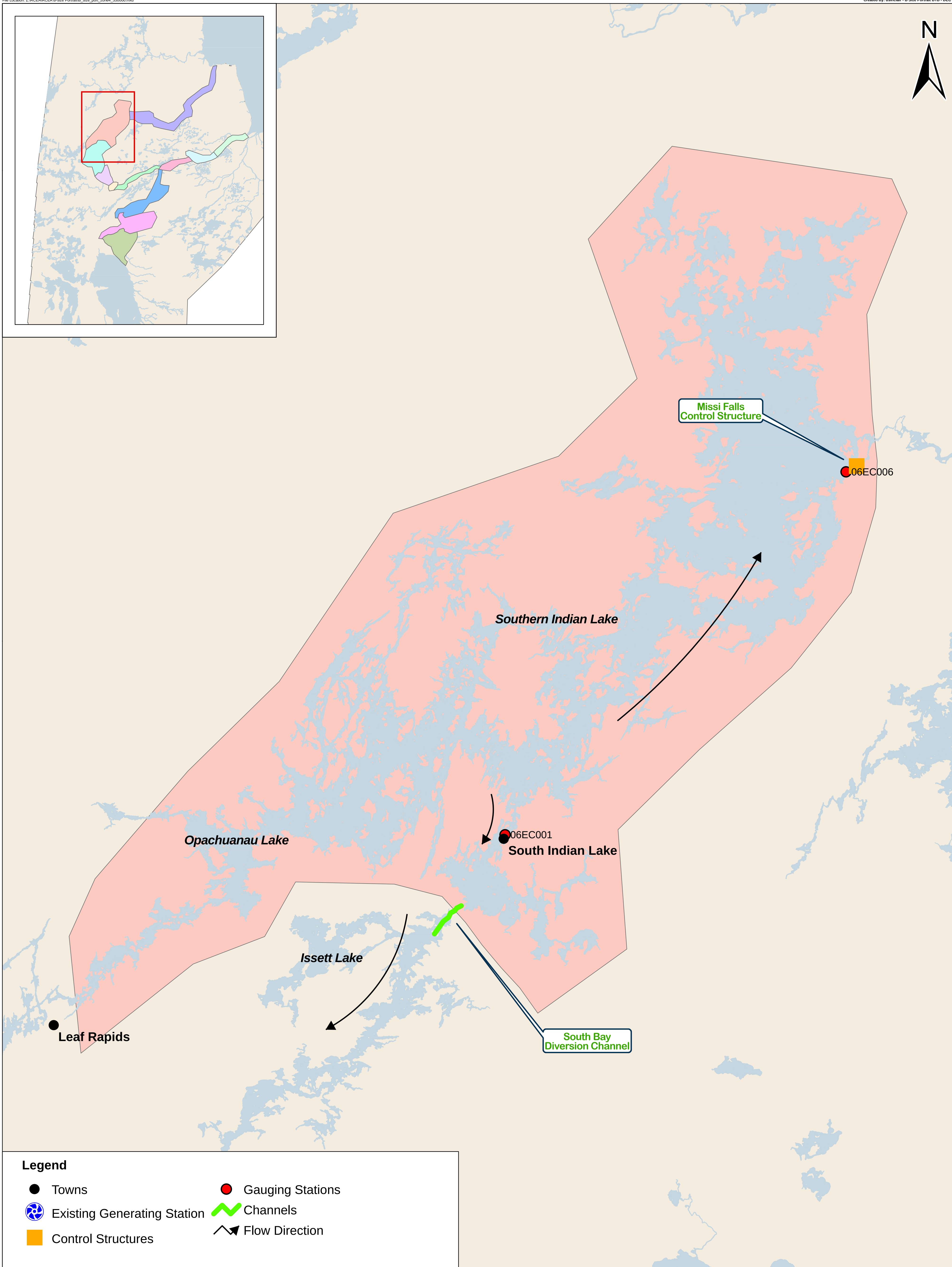
Figure 4-12: Monthly Average Southern Indian Lake Water Levels

4.2.4.4 Ice Conditions

Pre-CRD, the ice cover on Southern Indian Lake was usually formed in late fall and used extensively as a road bed for winter transportation especially in the vicinity of the settlement, South Indian Lake. Post-CRD, the only forecasted change to ice cover was in the vicinity of the South Indian Lake Settlement where the ice cover was expected to be poor or non-existent (Lake Winnipeg, Churchill and Nelson Rivers Study Board 1975).

File Location: Z:\RCEA\RCEA B-size Portrait\B_size_port_zone4_550000.mxd

Created By: bsinclair - B Size Portrait BTB - DEC 2011



Manitoba Hydro

DATA SOURCE: Manitoba Hydro			
CREATED BY: Hydraulic Operations Department, Hydraulic Licencing and Support			
COORDINATE SYSTEM: UTM NAD 1983 Z14N		DATE CREATED: 05 May 14	REVISION DATE: 28-MAY-14
0 6 12 Kilometers; 0 5 10 Miles		VERSION NO: 1.0	QA/QC: BSS/RDB/ZZZ

Zone 4 - Leaf Rapids to Southern Indian Lake
RCEA Area 3

Map 4-5

4.2.5 ZONE 5 – LOWER CHURCHILL RIVER

Zone 5 covers the lower Churchill River from the Missi Falls CS to the Churchill Weir just upstream from the Churchill River Estuary (Map 4-6). Major lakes in this zone include Partridge Breast, Thorsteinson, Northern Indian, and Fidler.

4.2.5.1 MANITOBA HYDRO OPERATIONS

The operation of CRD substantially reduces average inflows to the lower Churchill River from Southern Indian Lake resulting in lower water levels in both the lakes and river sections. Despite the reduction in inflows, high flow conditions still occur in some years on the lower Churchill River and operation of CRD sometimes causes rapid flow increases. This will be investigated in more detail as part of Phase II of this study.

4.2.5.2 DATA

WSC measures lower Churchill River discharge at two locations in this zone. Station 06FB001 (Churchill River below Fidler Lake) and station 06FD001 (Churchill River above Red Head Rapids) have operated since 1960 and 1971 respectively.

4.2.5.3 LOWER CHURCHILL RIVER DISCHARGE

On average, 28,000 cfs (790 cms) is diverted from the Churchill River system into the Nelson River system at SIL. Flow contributions from the remainder of the Churchill River basin between SIL and Hudson Bay are such that average flow below Fidler Lake is 9,200 cfs (260 cms) and above Red Head Rapids is 12,900 cfs (370 cms). Figures 4-13 and 4-14 show that river discharge pre- and post-CRD have a similar seasonal pattern with peaks occurring during the open water season and the lowest flows observed during the winter.

4.2.5.4 CHURCHILL WEIR

The Churchill Weir is a mitigatory structure designed to increase water levels on the Churchill River to ensure a potable water source and to enhance recreation and aquatic habitat. The structure was built 10 km (6.21 mi) south of the Town of Churchill, just upstream of Mosquito Point. The structure consists of an overflow section and two dyke sections. The overflow section also features a fishway segment at the lowest point of the weir. The east dyke incorporates the Goose Creek fishway and an emergency flood relief section. These works were completed in October 1999.

4.2.5.5 ICE CONDITIONS

CRD resulted in reduced winter discharge and reduced water velocities along the lower Churchill River. Lower velocities result increased area with ice cover. There would also be less ice accumulation by shoving and thickening at the leading edge which typically occurs downstream of fast flowing open water river sections.

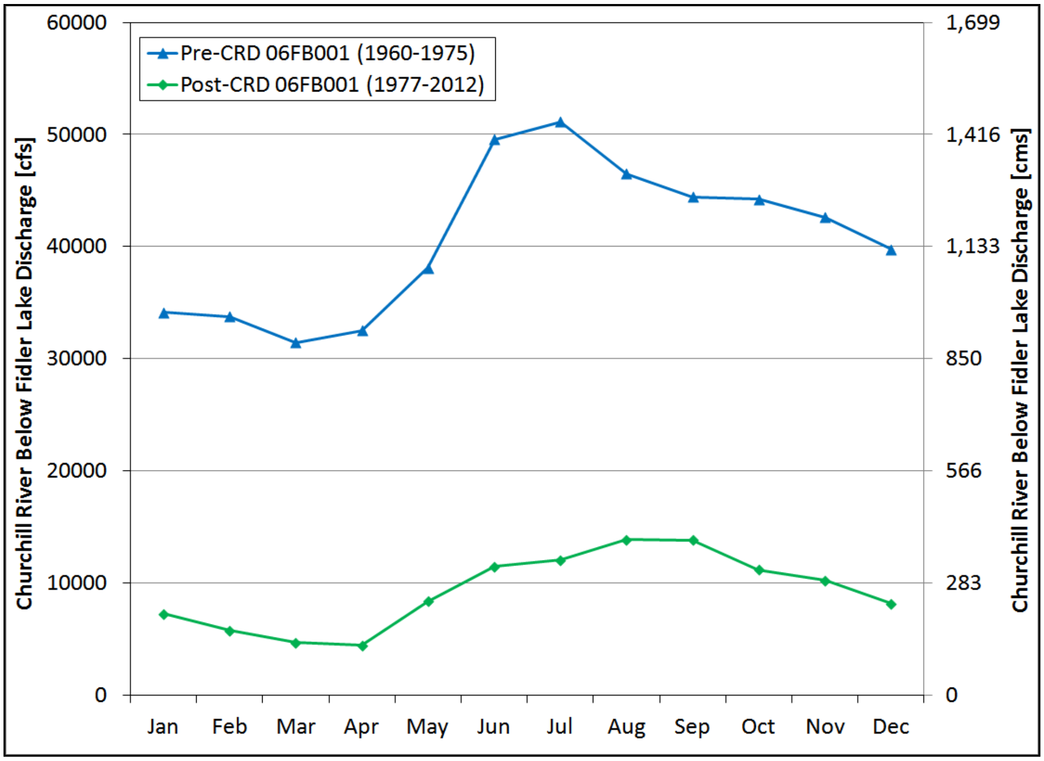


Figure 4-13: Monthly Average Churchill River Below Fidler Lake Discharge

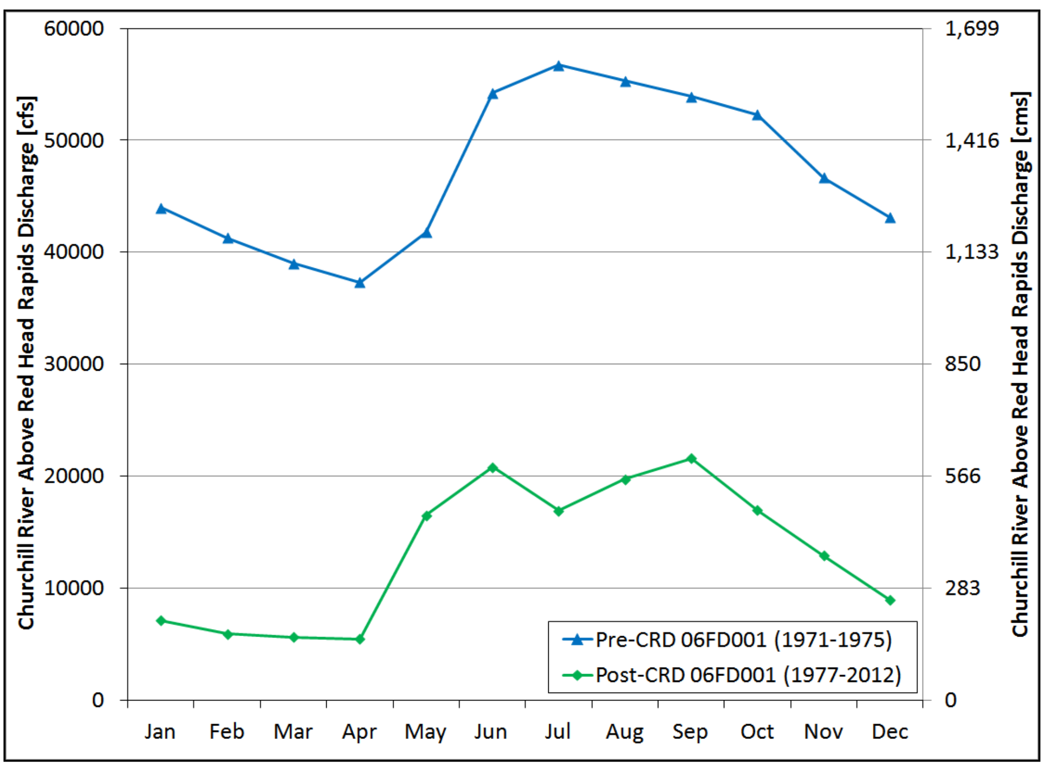
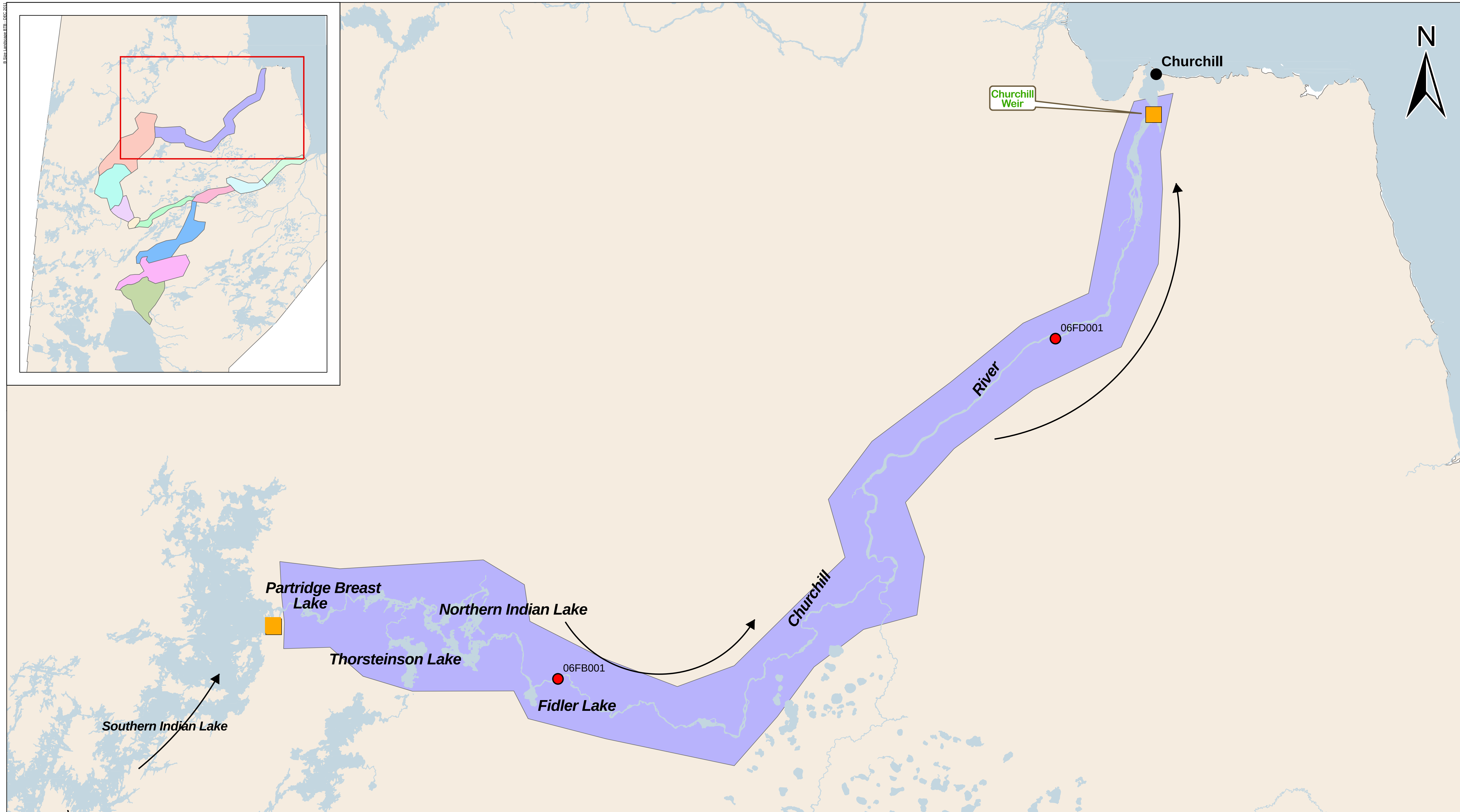


Figure 4-14: Monthly Average Churchill River Above Red Head Rapids Discharge



Manitoba Hydro

DATA SOURCE:
Manitoba Hydro

CREATED BY:
Hydraulic Operation Department
Hydraulic Licencing and Support

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	05-May-14	27-MAY-14
0 10 20 Kilometres / 0 9.5 19 Miles	VERSION NO: 1.0	QA/QC: BSS/RDB/ZZZ

Legend

- Towns
- Existing Generating Station
- Control Structures
- Gauging Stations
- Channels
- Flow Direction

Zone 5 - Lower Churchill River
RCEA Area 4

Map 4-6

4.2.6 Zone 6 – South Bay Channel to Notigi Control Structure

This zone covers the Rat River system from the excavated outlet at the South Bay of SIL to the Notigi CS (Map 4-7). Major lakes in this zone include Issett, Rat, and Notigi.

Notigi CS is the third main component of CRD. It is a control structure on the Rat River that regulates the diversion flow from SIL into the Burntwood-Nelson River system. The other components of CRD including the Missi Falls CS and the South Bay Diversion Channel are described in Section 4.2.4.

4.2.6.1 Manitoba Hydro Operations

A general description of CRD is provided in Zone 4 Section 4.2.4.1, including descriptions of Notigi CS operations.

4.2.6.2 Data

Manitoba Hydro maintains a record of daily water levels in the Notigi forebay since just before impoundment in 1974. There are four months of continuous data from January to April, 1974, in this area prior to first impoundment. Manitoba Hydro has also monitored discharge through Notigi since CRD began operation.

4.2.6.3 Isset Lake – Rat Lake – Notigi Forebay Area

The majority of flooding as a result of the CRD Project occurs in this zone. Increased flows through the area and increased water levels because of impoundment upstream from the Notigi CS caused 175 sq mi (453 sq km) of flooding. Based on limited data before impoundment of Notigi, it appears that CRD increased water levels approximately 50 ft (15.2 m) just upstream from the Notigi CS. The mean monthly post-CRD water level in Notigi CS forebay has ranged between 834.5 and 847.3 ft (254.4 and 258.3 m), while the seasonal pattern has been to peak in late summer and decline throughout the winter (Figure 4-15). Mean monthly discharge at Notigi has ranged between approximately 14,000 cfs and 35,000 cfs (400 and 990 cms). Figure 4-16 shows that Notigi discharge is typically higher in the winter months and lower in the spring and summer. Figure 4-17 shows that 70% of the time Notigi discharge has been between 25,000 cfs and 35,000 cfs (710 and 990 cms) .

4.2.6.4 Ice Conditions

CRD resulted in an increase of water level upstream of Notigi CS, thus reducing the water velocity in most upstream areas and improving ice cover formation during the winter. Immediately upstream of Notigi, velocities are higher and an open water zone exists throughout the winter.

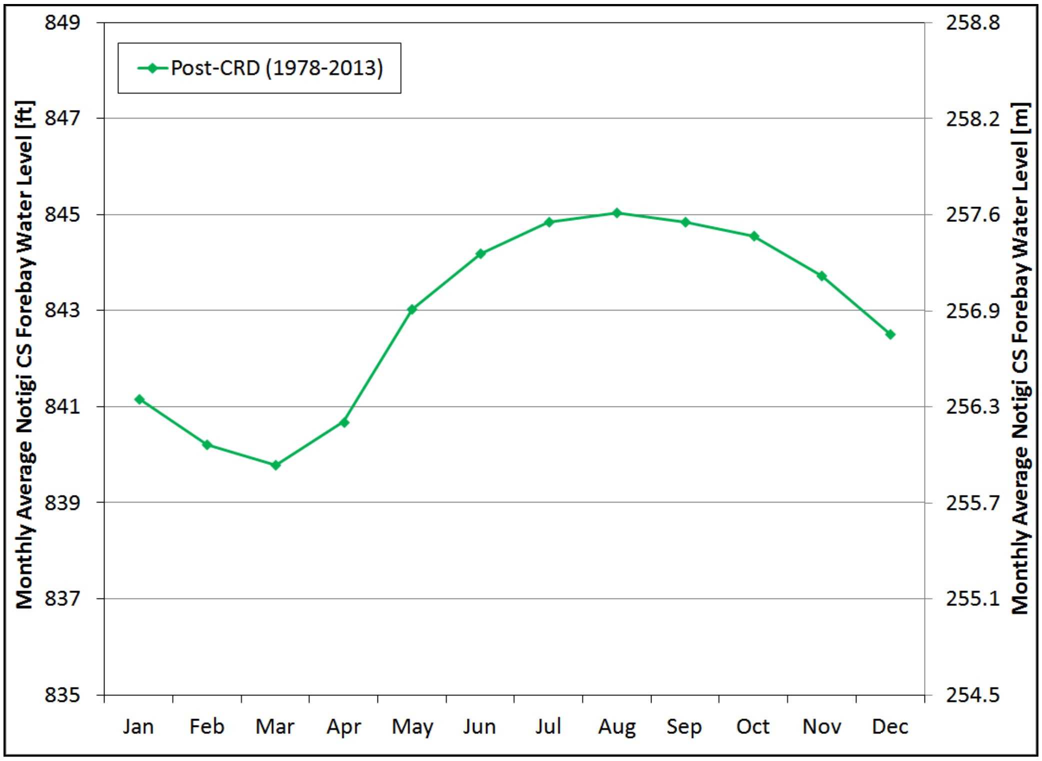


Figure 4-15: Monthly Average Notigi Forebay Water Levels

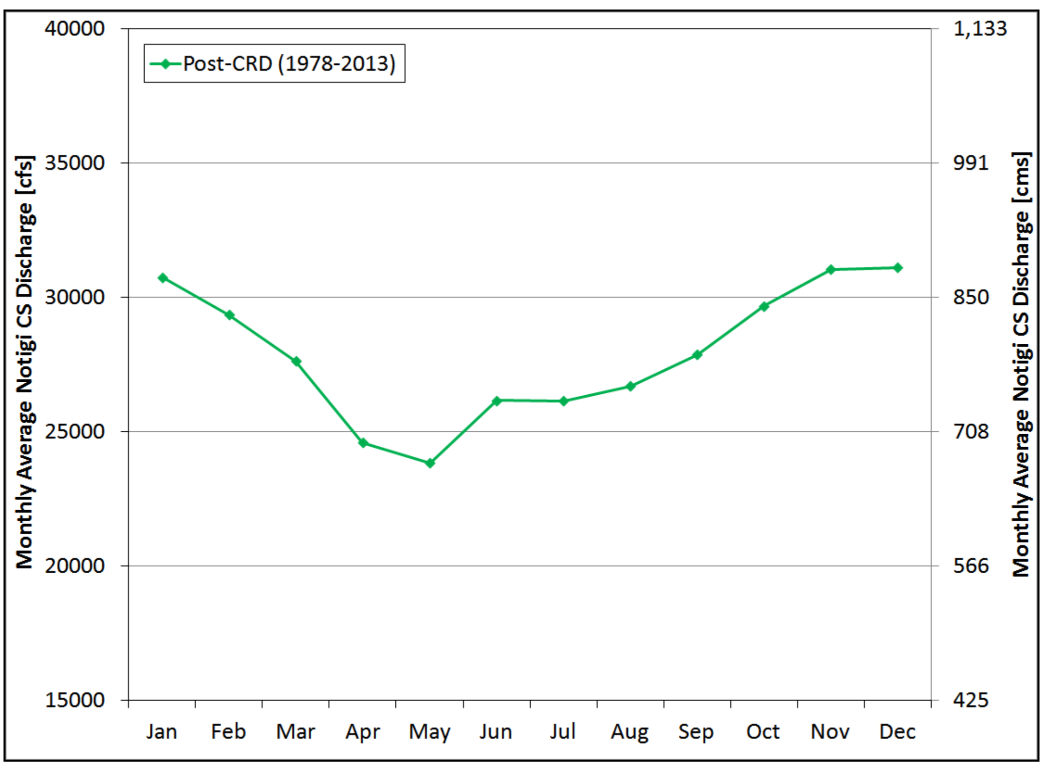


Figure 4-16: Monthly Average Notigi Discharge

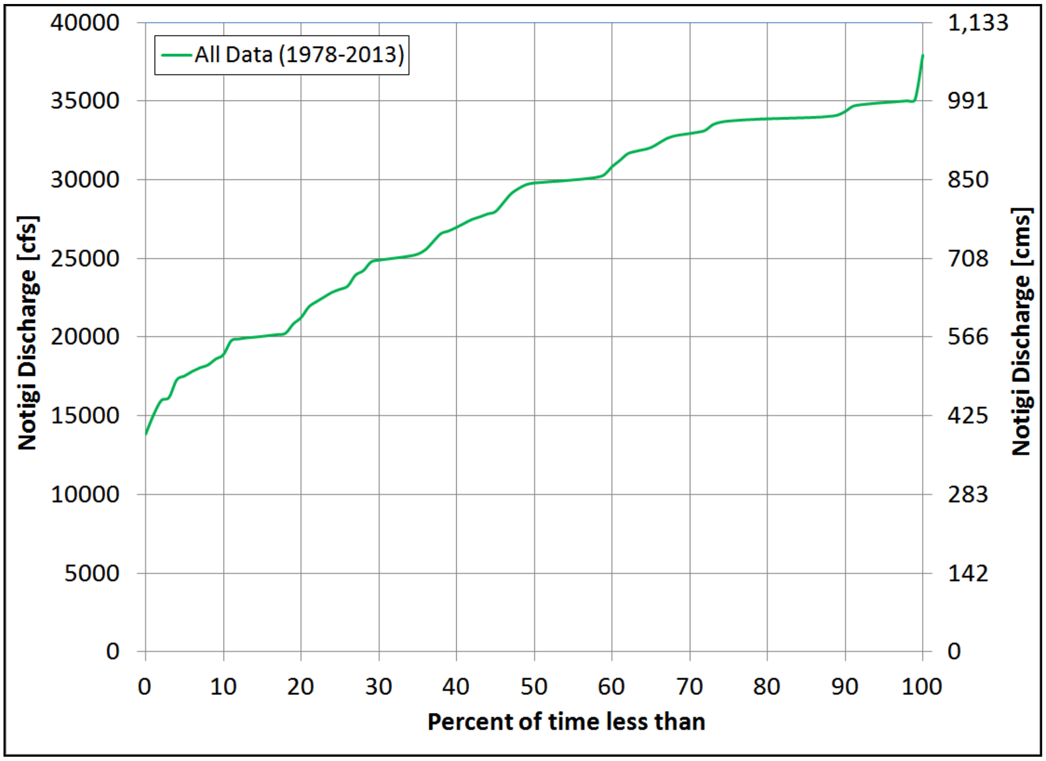


Figure 4-17: Notigi Discharge Duration Curve

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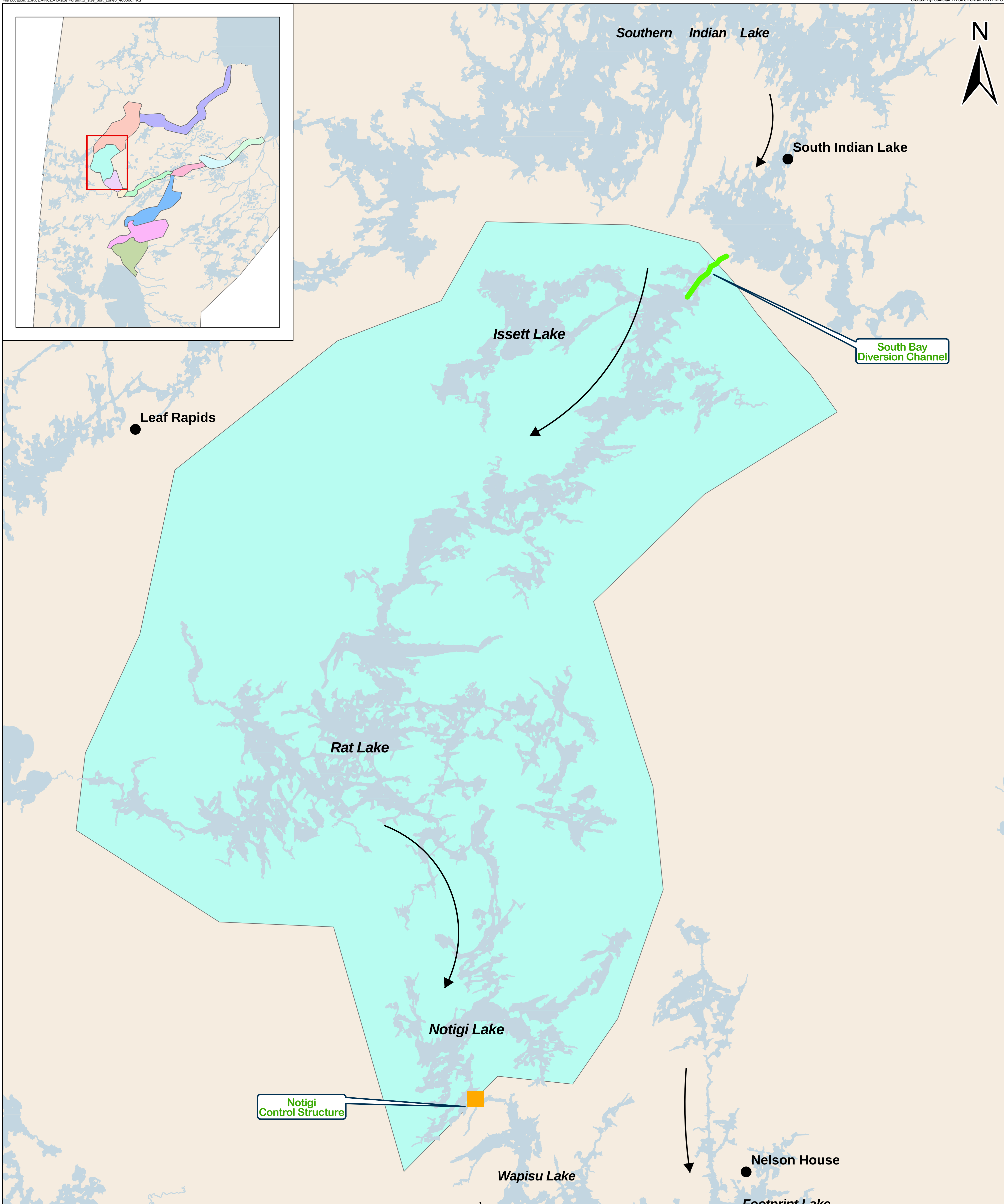
Created By: bsinclair - B Size Portrait BTB - DEC 2011



Legend

- Towns
- Existing Generating Station
- Control Structures
- Gauging Stations
- Channels
- Flow Direction

DATA SOURCE:	Manitoba Hydro
CREATED BY:	Hydraulic Operations Department Hydraulic Licencing and Support
COORDINATE SYSTEM:	UTM NAD 1983 Z14N
DATE CREATED:	05 May 14
REVISION DATE:	28-MAY-14
Scale	0 – 4.5 – 9 Kilometers; 0 – 3.5 – 7 Miles
VERSION NO:	1.0
QA/QC:	BSS/RDB/ZZZ

Zone 6 - South Bay to Notigi Control Structure
RCEA Area 3

Map 4-7

4.2.7 ZONE 7 – NOTIGI CONTROL STRUCTURE TO EARLY MORNING RAPIDS

Zone 7 covers the Rat/Burntwood River system from the Notigi CS to Early Morning Rapids (Map 4-8). Major lakes in this zone include Wapisu Lake, Threepoint Lake, Footprint Lake and Osik Lake.

4.2.7.1 MANITOBA HYDRO OPERATIONS

Manitoba Hydro operation of CRD, specifically Notigi CS, regulates the inflow to this zone. This zone is upstream of the water level influence from the Wuskwatim GS. CRD resulted in substantially higher flows in this zone and therefore increased water levels above the natural range. The operation of Notigi CS has resulted in a reversal of seasonal flow patterns depicted by higher flows during the winter than in summer (Figure 4-16). Higher water levels also created a backwater effect up the Burntwood River to Gate Falls and up the Footprint River to Osik Lake. From the Notigi CS to Split Lake, CRD flooded 31.6 sq mi (81.8 sq km) of land.

4.2.7.2 DATA

The only continuous water level data available in this zone prior to operation of CRD is located at Footprint Lake station 05TF001 which has been operated by WSC since 1960.

4.2.7.3 FOOTPRINT LAKE

Analysis of the available data indicates that CRD raised the average water level of Footprint Lake by 14.3 ft (4.4 m), from 782.3 ft to 796.6 ft (238.4 m to 242.8 m). Figure 4-18 shows that CRD changed the seasonal pattern so that higher water levels typically now occur in the winter while they used to occur during the summer. Figure 4-19 shows that 90% of the time the pre-CRD range of water levels was 8.3 ft (2.5 m) while post-CRD the range has been reduced to 6.8 ft (2.1 m). The monthly average water level variation on Footprint Lake also reduced from 1.2 ft (0.4 m) pre-CRD to 0.9 ft (0.3 m) post-CRD.

4.2.7.4 ICE CONDITIONS

Higher flows created by CRD in this zone resulted in higher velocities along part of the Burntwood River, which likely resulted in larger areas remaining ice free year-round. The Wuskwatim EIS contains a detailed description of ice conditions along the Burntwood River in this zone.

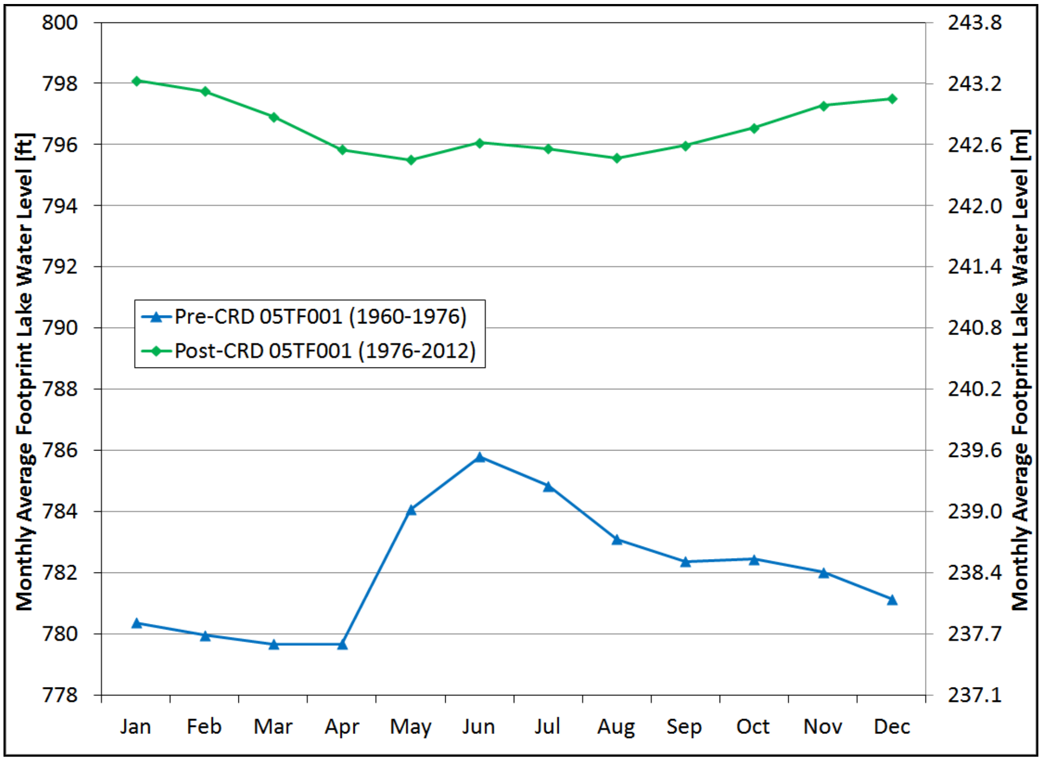


Figure 4-18: Monthly Average Footprint Lake Water Levels

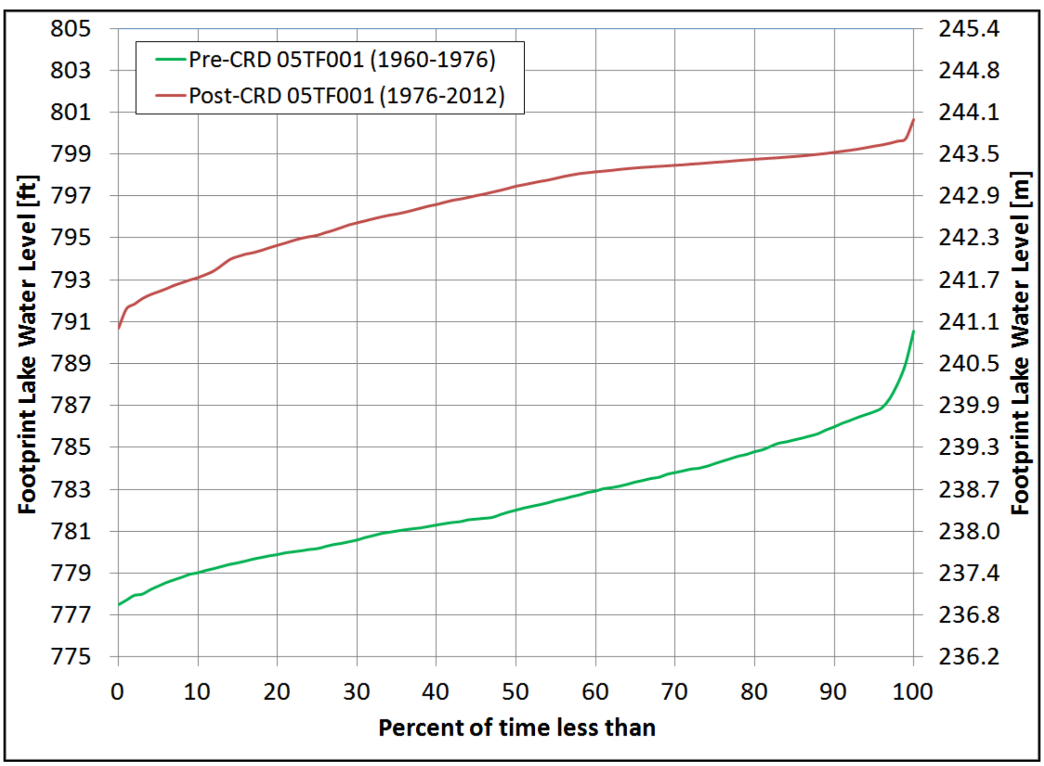
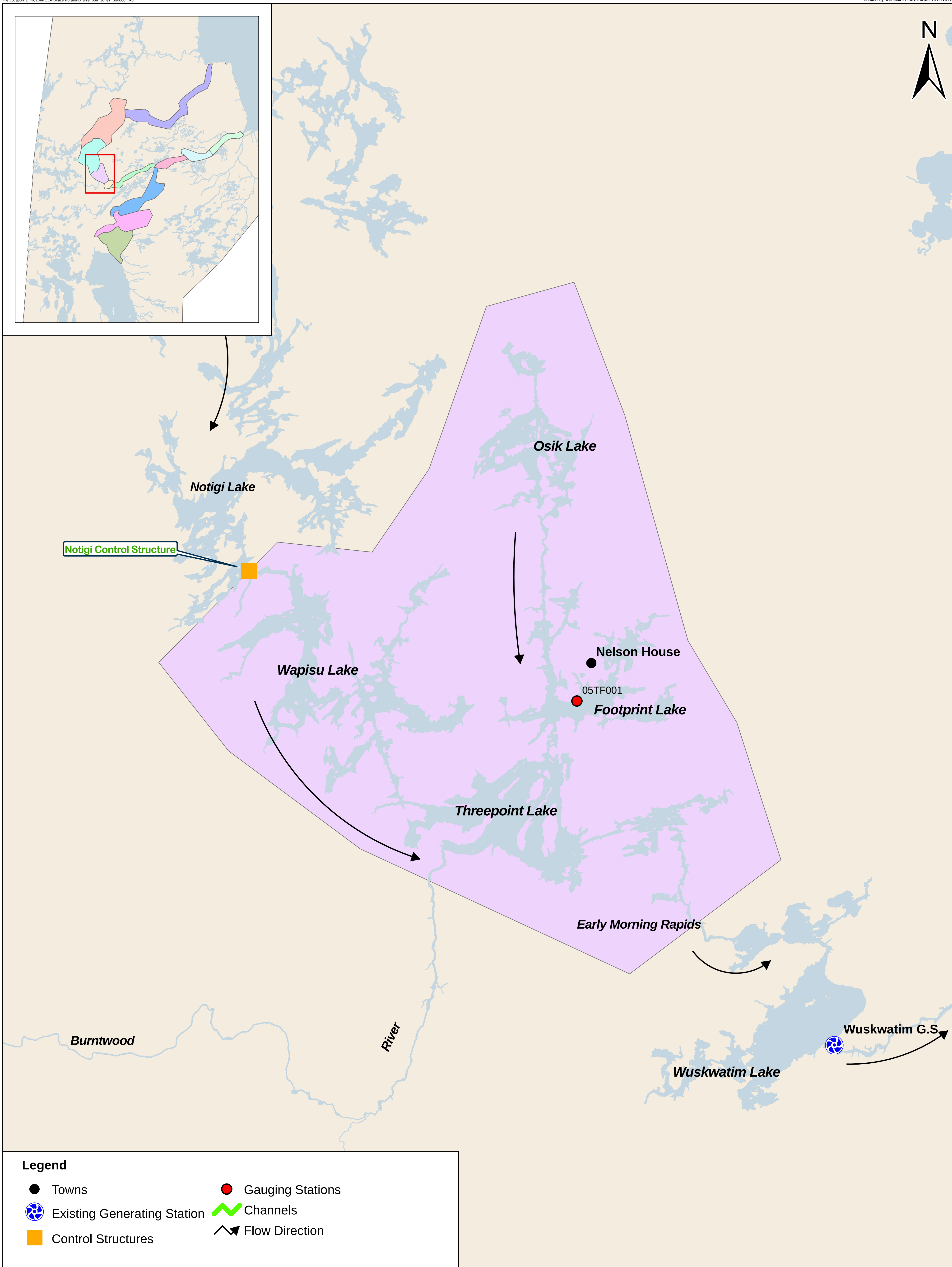


Figure 4-19: Footprint Lake Water Level Duration Curve

File Location: Z:\RCEA\RCEA B-size Portrait\B_size_port_zone7_300000.mxd

Created By: bsinclair - B Size Portrait BTB - DEC 2011



Manitoba Hydro

DATA SOURCE: Manitoba Hydro	
CREATED BY: Hydraulic Operations Department, Hydraulic Licencing and Support	
COORDINATE SYSTEM: UTM NAD 1983 Z14N	DATE CREATED: 05 May 14 / REVISION DATE: 28-MAY-14
0 3.5 7 Kilometers; 0 2.5 5 Miles	VERSION NO: 1.0 / QA/QC: BSS/RDB/ZZZ

Zone 7 - Notigi Control Structure to Early Morning Rapids
RCEA Area 3

Map 4-8

4.2.8 ZONE 8 – EARLY MORNING RAPIDS TO WUSKWATIM GS

Zone 8 covers the portion of the Burntwood River between Early Morning Rapids and the Wuskwatim GS, which includes Wuskwatim Lake (Map 4-9). The Wuskwatim GS was completed in 2012 and is owned by the Wuskwatim Power Limited Partnership (WPLP), a legal entity involving Nisichawayasihk Cree Nation and Manitoba Hydro.

4.2.8.1 MANITOBA HYDRO OPERATIONS

CRD operations cause increased flows and water levels, flooding 11 sq mi (28 sq km) in this zone. Also, because inflows from Notigi are typically higher in the winter as shown in Figure 4-16, CRD resulted in a seasonal change where water levels are now typically higher along the Burntwood River during the winter. Before CRD, water levels were highest in the summer. Operation of Wuskwatim GS affects water levels as far upstream as the downstream end of Early Morning Rapids.

4.2.8.2 DATA

There is no continuous data available for this zone prior to operation of CRD. WSC reports a water level on Wuskwatim Lake since 1995 at station 05TF006 (Wuskwatim Lake near Thompson). Manitoba Hydro now monitors the water level of Wuskwatim Lake as part of operating the Wuskwatim GS.

4.2.8.3 WUSKWATIM GS AND LAKE

Impoundment of the Wuskwatim forebay resulted in less than 0.5 sq km (less than 0.2 sq mi) of flooding between Wuskwatim Lake and the generating station. Operation of the Wuskwatim GS eliminated the seasonal variance of water levels on Wuskwatim Lake as water levels are kept within a 0.25 m (0.8 ft) range between 233.75 m and 234.0 m (766.9 ft and 767.7 ft). Water levels on Wuskwatim Lake ranged 1.8 m (5.8 ft) from 232.7 m to 234.4 m (763.3 ft to 769.1 ft) prior to construction of the Wuskwatim GS but post-CRD. The Water Regime Section of the Wuskwatim EIS contains more detailed information on conditions before and after construction of Wuskwatim GS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003).

4.2.8.4 ICE CONDITIONS

Higher flows created by CRD in this zone resulted in higher velocities along parts of the Burntwood River, which likely resulted in larger areas remaining ice free all year. The Wuskwatim EIS contains a detailed description of ice conditions along the Burntwood River and any effects of the Wuskwatim GS on ice conditions.

Manitoba Hydro

DATA SOURCE:
Manitoba Hydro

CREATED BY:
Hydraulic Operation Department
Hydraulic Licencing and Support

COORDINATE SYSTEM:
UTM NAD 1983 Z14N

0 1.5 3 Kilometres
0 1 2 Miles

DATE CREATED:
05-May-14

REVISION DATE:
27-MAY-14

VERSION NO:
1.0

QA/QC:
BSS/RDB/ZZZ

Legend

- Towns
- Existing Generating Station
- Control Structures
- Gauging Stations
- Channels
- Flow Direction

Zone 8 - Early Morning Rapids to Wuskwatim G.S.
RCEA Area 3

4.2.9 ZONE 9 – WUSKWATIM GS TO SPLIT LAKE INLET

This zone covers the portion of the Burntwood River downstream from the Wuskwatim GS to the inlet of Split Lake (Map 4-10). Major lakes in this zone include Opegano, Ospwagan, Birch Tree, Mystery, and Apussigamasi.

4.2.9.1 MANITOBA HYDRO OPERATIONS

Manitoba Hydro operation of CRD regulates the inflow to this zone which is the main driver for water levels. CRD causes substantially higher flows in this zone and has therefore increased water levels above the natural range, flooding 20.2 sq mi (52.3 sq km) of land. Wuskwatim GS operations also contribute to minor water level fluctuations as far downstream as Birchtree Lake (Manitoba Hydro 2003).

4.2.9.2 DATA

In this zone WSC has operated flow station 05TG001 (Burntwood River near Thompson) since 1956. Based on the available record, CRD has increased flows in the Burntwood River from a long-term average of approximately 4,000 cfs to 30,000 cfs (110 cms to 850 cms). Also, CRD has changed the seasonal flow pattern so that the highest flows typically now occur during the winter while flows used to peak during the summer (Figure 4-20).

4.2.9.3 MANASAN FALL CONTROL STRUCTURE

The Manasan Falls Control Structure is a passive control structure designed to reduce the risk of inundation due to ice in the City of Thomson on the Burntwood River. The project consists of an ice boom across the river upstream of a groin/gap structure, a by-pass channel with a concrete overflow weir and a flood channel protected with a fuse plug dyke. The project was initially constructed in 1976 followed by rehabilitation in 1986 and an incorporation of safety features in 1988.

4.2.9.4 ICE CONDITIONS

The higher flows created by CRD in this zone results in higher velocities along the Burntwood River, which likely resulted in larger areas remaining ice free all year.

> The present water regime consists of fast flowing reaches, which remain ice free, and connecting lakes or slow velocity reaches which freeze over early in the winter. Each year, a competent ice cover quickly forms on major lakes in this reach, including Wapisu Lake, Threepoint Lake, Wuskwatim Lake, Opegano Lake, and Birch Tree Lake. Other sections of the river remain open, and produce large volumes of frazil ice, which either accumulate on the leading edge of the downstream ice cover, resulting in advancement of the cover upstream, or deposits under the cover forming a hanging ice dam (Manitoba Hydro 2003).

The Wuskwatim EIS contains a detailed description of ice conditions along the Burntwood River and any effects of the Wuskwatim GS on ice conditions.

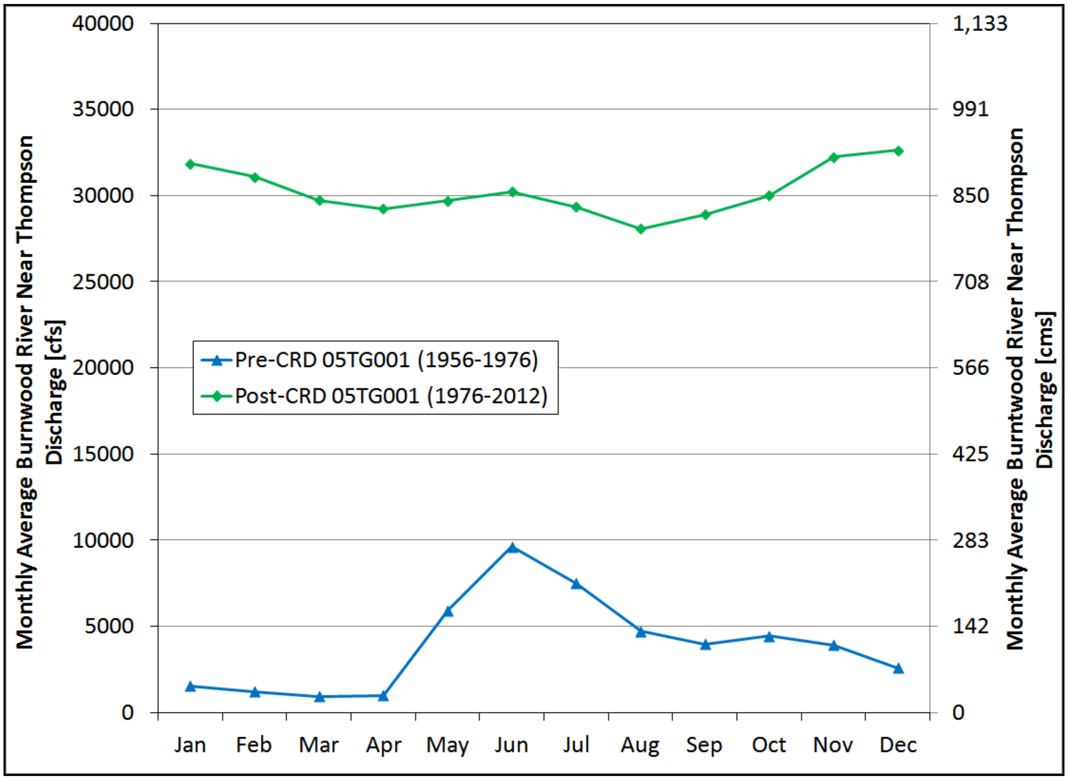
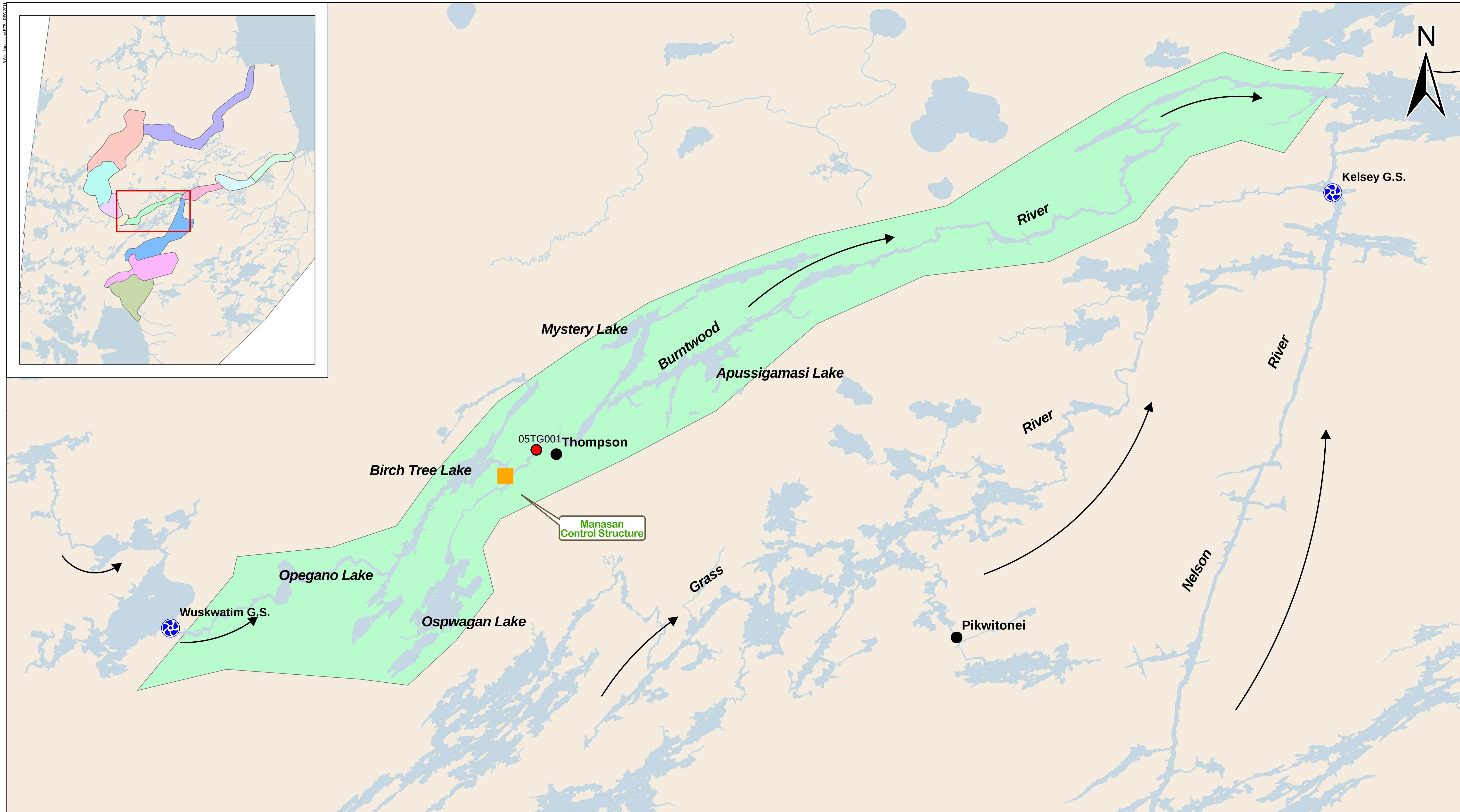


Figure 4-20: Monthly Average Burntwood River Near Thompson Discharge



DATA SOURCE: Manitoba Hydro			
CREATED BY: Hydraulic Operation Department Hydraulic Licencing and Support			
COORDINATE SYSTEM: UTM NAD 1983 Z14N		DATE CREATED: 05-May-14	REVISION DATE: 27-MAY-14
0 4.5 9 Kilometres / 0 3.5 7 Miles		VERSION NO: 1.0	QA/QC: BSS/RDB/ZZZ

Legend

- Towns
- Existing Generating Station
- Control Structures
- Gauging Stations
- Channels
- Flow Direction

Zone 9 - Wuskwatim G.S. to Split Lake Inlet
RCEA Area 3

Map 4-10

4.2.10 Zone 10 – Split Lake to Gull Rapids

Zone 10 covers the lower Nelson River including Split Lake to just upstream of Stephens Lake (Map 4-11). Major lakes in this zone include Split, Clark, and Gull lakes. There are currently no structures related to hydroelectric development in this zone, although the proposed Keeyask GS would be located at the downstream end of this zone at Gull Rapids.

4.2.10.1 Manitoba Hydro Operations

Manitoba Hydro's operation of CRD, LWR, and Kelsey GS influences inflows to this zone. LWR changes the seasonal timing of Nelson River inflows to match seasonal load requirements at Manitoba Hydro's major generating stations along the lower Nelson River. CRD increases the average inflow and also influences the seasonal timing of inflows from the Burntwood River. Kelsey had no effect on inflows to this zone prior to 1976 because it was operated as a run-of-the-river plant. Starting in 1977, Kelsey operations were:

> modified to more effectively utilize the pondage (reservoir storage of limited capacity) of Kelsey's forebay on an infrequent basis to supplement flows over a period of about a month or so, or to increase the gradient out of Sipiwesk Lake to alleviate winter hydraulic restrictions. Kelsey operations can have short duration effects on Split Lake water levels and flows (Manitoba Hydro-Split Lake Cree Joint Studies 1996).

4.2.10.2 Data

WSC reports the daily average water level for Split Lake since 1954 at station 05UF003 (Split Lake at Split Lake).

4.2.10.3 Split Lake

The Keeyask Hydropower Limited Partnership reports that:

> Split Lake is relatively large with numerous small islands and an approximate surface area of 116 sq mi (300 sq km). Water levels are influenced by the amount of water flowing in to the lake and the narrow constriction at the outlet that controls the lake's discharge. The levels on Split Lake typically fluctuate between 545 ft and 551 ft (166.1 m and 167.9 m) in any given year, but water levels may vary greatly from one year to the next, depending on the water supply from the Nelson River drainage basin and CRD (Keeyask Hydropower Limited Partnership 2012).

From the outlet of Split Lake to Stephens Lake, which is located just below Gull Rapids, there are both lake and river sections which are described in more detail in the Keeyask EIS along with the potential effects of the Keeyask GS. The average Split Lake water level was 547.4 ft (166.8 m) pre-CRD/LWR. Post-CRD/LWR, the average Split Lake water level is 1.2 ft (0.4 m) higher at 548.6 ft (167.2 m). The seasonal pattern was changed post-CRD/LWR as the highest water levels typically now occur during the winter, while they used to occur during the summer (Figure 4-21).

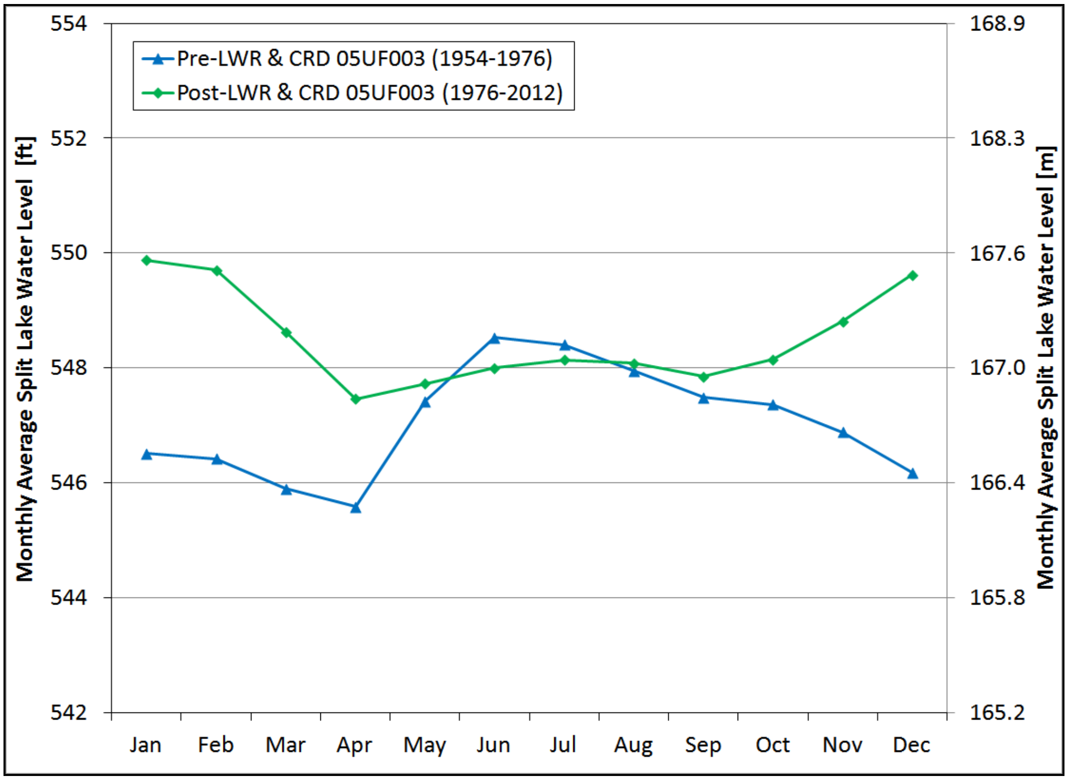
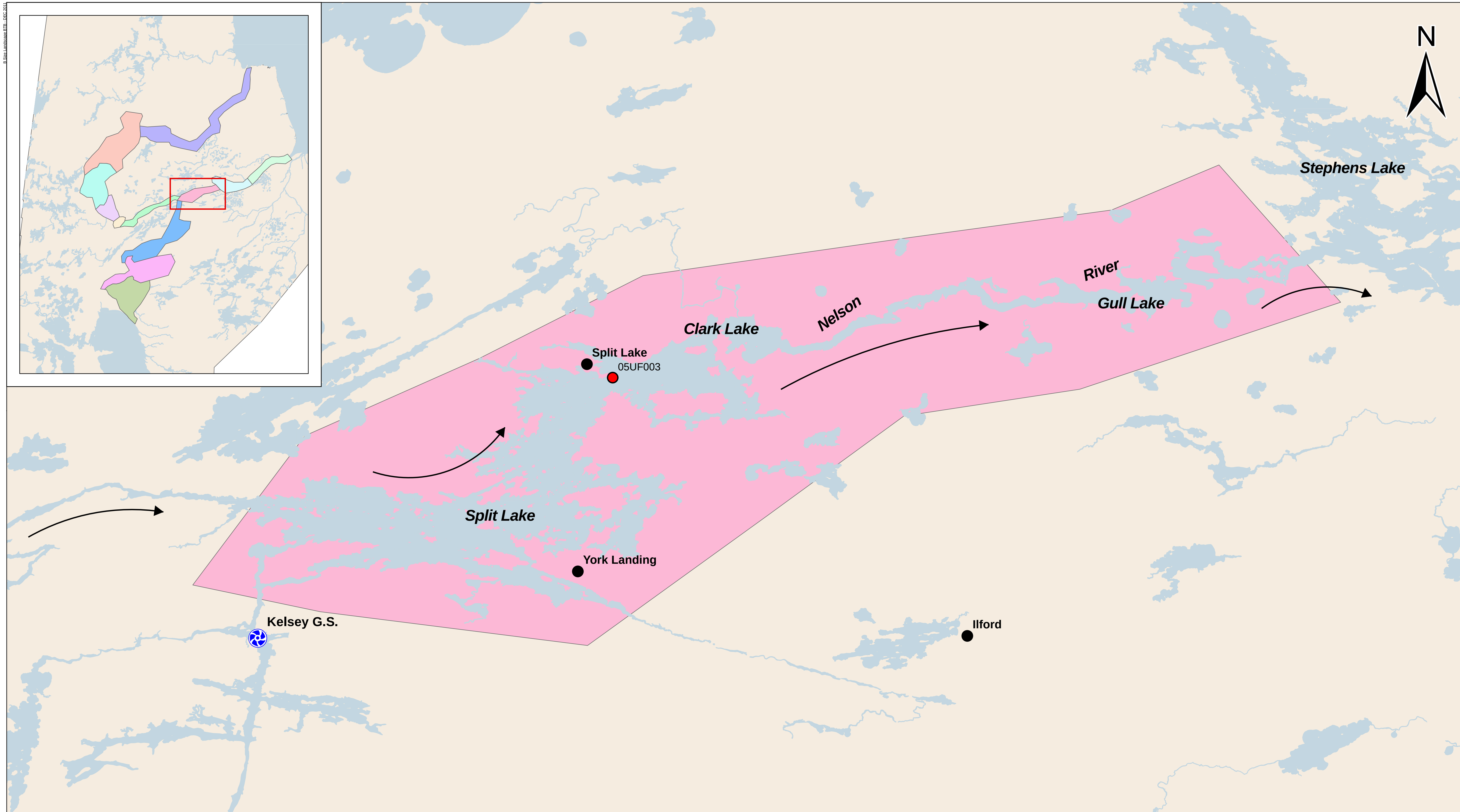


Figure 4-21: Monthly Average Split Lake Water Level

4.2.10.4 Ice Conditions

On Split Lake, water level fluctuations can cause thin ice, slush ice, and premature breakup. Drops in water levels can leave thin ice attached to shores (Manitoba Hydro 1996). A detailed description of existing ice conditions from Split Lake to Stephens Lake is contained in the Keeyask EIS which indicates that higher velocities in this reach have a substantial impact on overall ice formation processes (Keeyask Hydropower Limited Partnership 2012). Hydroelectric development caused higher winter flows and velocities, which would likely have resulted in larger areas remaining ice free all year.



Manitoba Hydro

DATA SOURCE:
Manitoba Hydro

CREATED BY:
Hydraulic Operation Department
Hydraulic Licencing and Support

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	05-May-14	27-MAY-14
0 3.5 7 Kilometres / 0 2.5 5 Miles	VERSION NO: 1.0	QA/QC: BSS/RDB/ZZZ

Legend

- Towns
- Existing Generating Station
- Control Structures
- Gauging Stations
- Channels
- Flow Direction

Zone 10 - Split Lake to Gull Rapids RCEA Area 2

4.2.11 ZONE 11 – STEPHENS LAKE TO LIMESTONE GS

Zone 11 covers Stephens Lake and the lower Nelson River downstream to the Limestone GS. Zone 11 includes Manitoba Hydro's three biggest generating stations, Kettle, Longspruce and Limestone, and their associated forebays (Map 4-12). The Kettle GS is located just downstream from Stephens Lake near the town of Gillam and was completed in 1974. The Long Spruce GS is located 10 mi (16 km) downstream from Kettle GS and was completed in 1979. The Limestone GS is located 14 mi (23 km) downstream from Long Spruce GS and was completed in 1992.

4.2.11.1 MANITOBA HYDRO OPERATIONS

Operation of Kettle GS, Long Spruce GS, and Limestone GS controls water levels in the zone regardless of inflows to Stephens Lake. Long Spruce and Limestone are operated as a run-of-the-river generating stations, while flow is governed by releases from Kettle GS. The level of Stephens Lake is controlled for optimum energy production within the Manitoba Hydro system through operation of Kettle GS. This includes a daily and weekly cycling pattern that allows Manitoba Hydro to match energy production to consumption patterns. Flows are increased each morning during the work week and maintained until late afternoon or evening when they are decreased to reach lowest levels overnight. There is a similar daily pattern on the weekend although flows are lower because there is less energy demand. On a weekly cycle Stephens Lake is generally drawn down during the work week when energy demand is higher and the lake is re-filled over the weekend.

4.2.11.2 DATA

There is no continuous water level data in this zone prior to hydroelectric development. Manitoba Hydro has records of forebay water levels and discharge at Kettle, Long Spruce, and Limestone since the stations were completed. Discharge data is also available through WSC.

4.2.11.3 STEPHENS LAKE / KETTLE FOREBAY

The Kettle GS increased water levels on the Nelson River immediately upstream by approximately 103.3 ft (31.5 m) (Manitoba Hydro-Split Lake Cree Joint Studies 1996) and flooded approximately 85.3 sq mi (221 sq km) of land, creating what is now known as Stephens Lake. The part of Stephens Lake just upstream from Kettle GS is known as the forebay. The current normal maximum forebay elevation is 463 ft (141.1 m), while the minimum operating level is 453 ft (138.1 m), although 95% of the time the forebay elevation is above 457 ft (139.3 m) as (Figure 4-22). Prior to 2001, the forebay was rarely operated above 461 ft (140.5 m) during the open water season due to freeboard deficiencies, which were corrected during the summer of 1998.

4.2.11.4 LONG SPRUCE FOREBAY

Impoundment of the Long Spruce forebay is mostly contained within the natural river banks and flooded approximately 5.6 sq mi (14.5 sq km) to just downstream from Kettle GS. The forebay is typically operated at just below 361 ft (110.0 m) during the open water period and just below 362 ft (110.3 m) during the winter. Water levels remain above 359 ft (109.4 m) in the forebay 95% of the time (Figure 4-23).

4.2.11.5 LIMESTONE FOREBAY

The majority of the Limestone forebay is contained by the natural river banks. The project flooded 0.8 sq mi (2.2 sq km) of land, affecting water levels to just downstream of Long Spruce GS. The Limestone GS forebay is typically operated between 278 ft and 280 ft (84.7 m and 85.3 m) (Figure 4-24).

4.2.11.6 ICE CONDITIONS

Prior to hydroelectric development, ice generated along the fast flowing Nelson River resulting in an ice cover generally progressing upstream from the Nelson River Estuary (Carson 1982). Impoundments created by these three generating stations reduced water velocities and allowed most of the forebay areas, including Stephens Lake, to freeze over with stable thermal ice covers. The areas immediately downstream from the generating stations typically remain open for a short distance because of higher water velocities and turbulence.

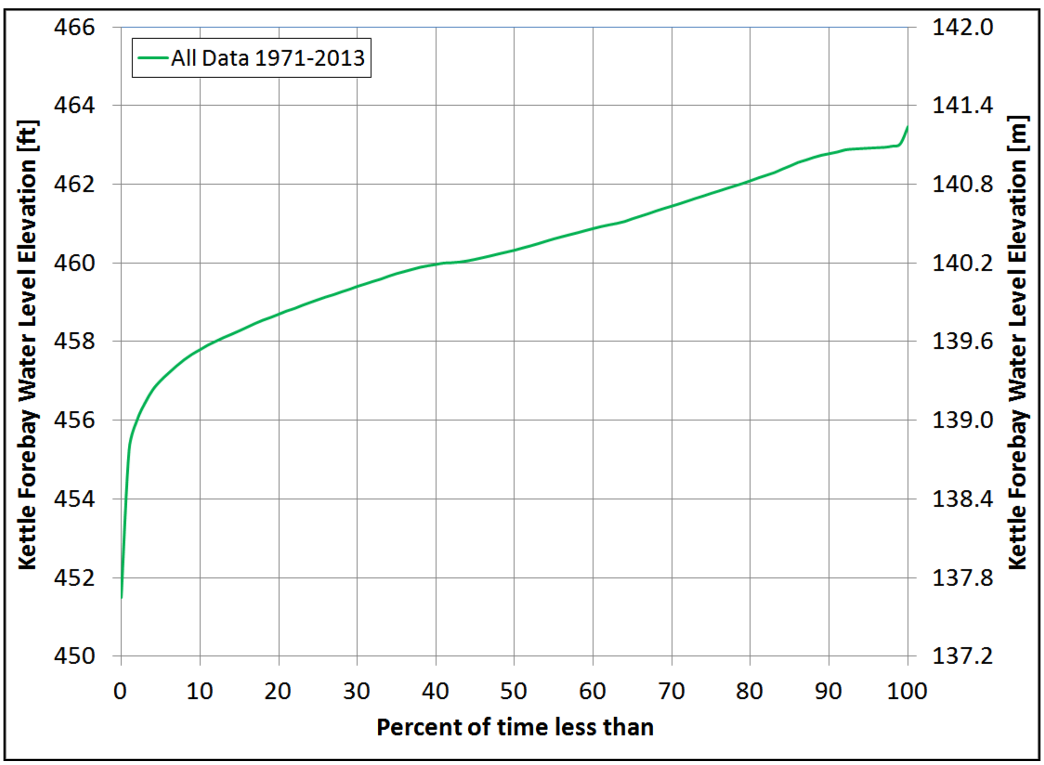


Figure 4-22: Kettle Forebay Daily Water Level Duration Curve

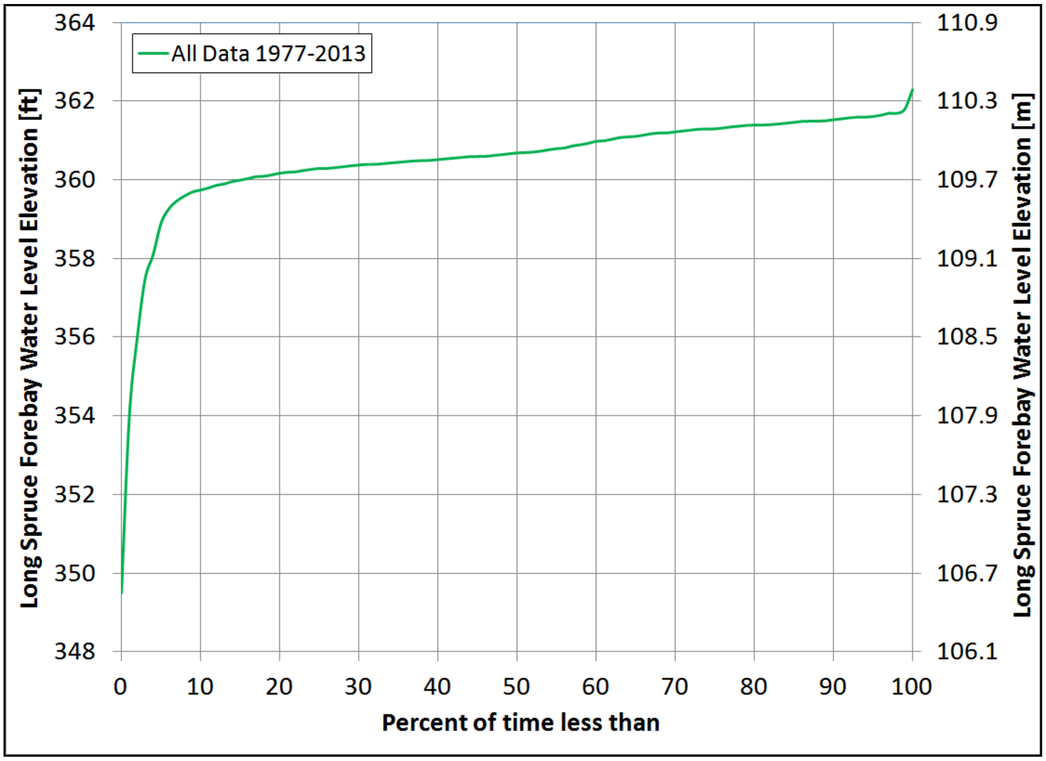


Figure 4-23: Long Spruce Forebay Daily Water Level Duration Curve

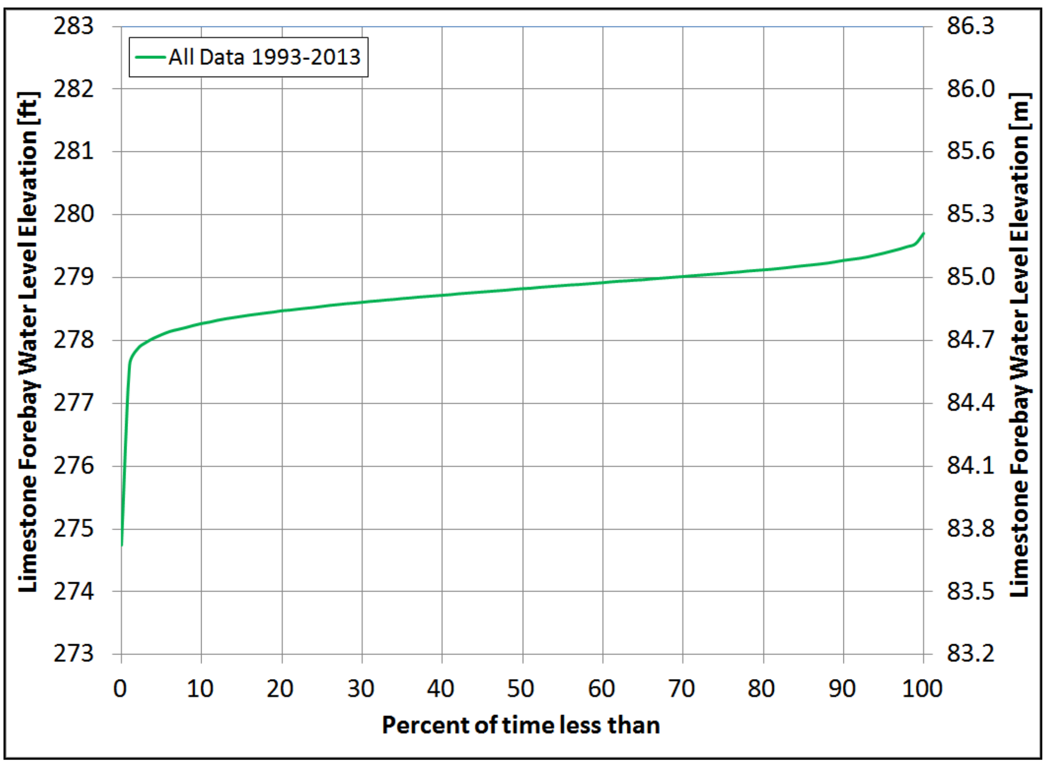
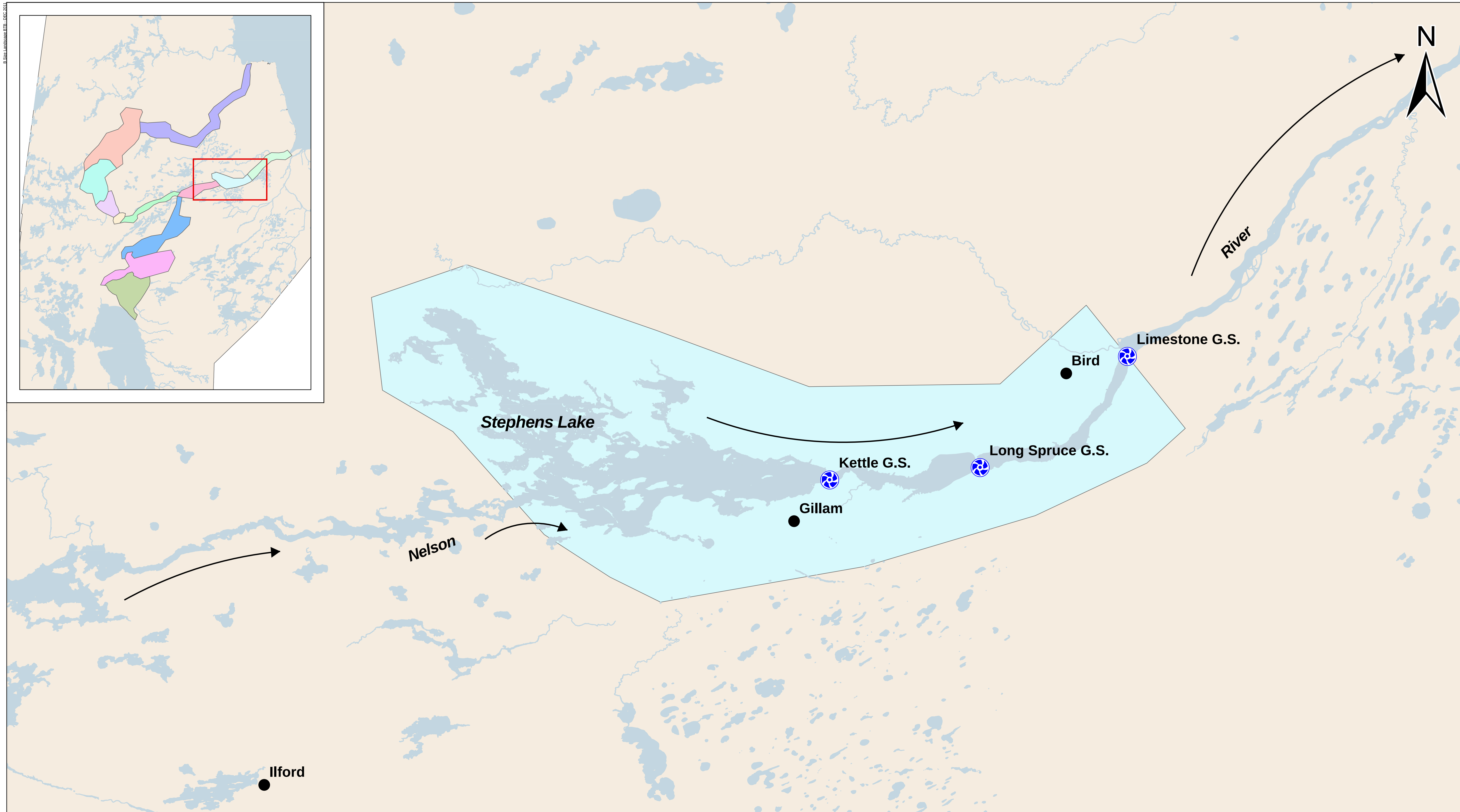


Figure 4-24: Limestone Forebay Daily Water Level Duration Curve



Manitoba Hydro

DATA SOURCE:
Manitoba Hydro

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Hydraulic Operation Department
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0 4.5 9 Kilometres
0 3.5 7 Miles

VERSION NO: 1.0

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Legend

- Towns
- Existing Generating Station
- Control Structures
- Gauging Stations
- Channels
- Flow Direction

Zone 11 - Stephens Lake to Limestone G.S.
RCEA Area 2

Map 4-12

4.2.12 Zone 12 – Limestone GS to Gillam Island

Zone 12 covers the lower Nelson River from the Limestone GS to Gillam Island (Map 4-13). There are no major lakes in this zone. Gillam Island is the upstream extent of tidal influence from the Nelson River Estuary. There are currently no hydroelectric structures located in this zone although the planned Conawapa GS would be located approximately 18 mi (29 km) downstream from the Limestone GS.

4.2.12.1 Manitoba Hydro Operations

Operation of CRD, LWR, and the three generating stations along the Lower Nelson River affect water levels and flows in this zone. CRD and LWR affect the magnitude and seasonal pattern of flows, while short term fluctuations are caused by operations at Kettle, Long Spruce, and Limestone generating stations.

4.2.12.2 Data

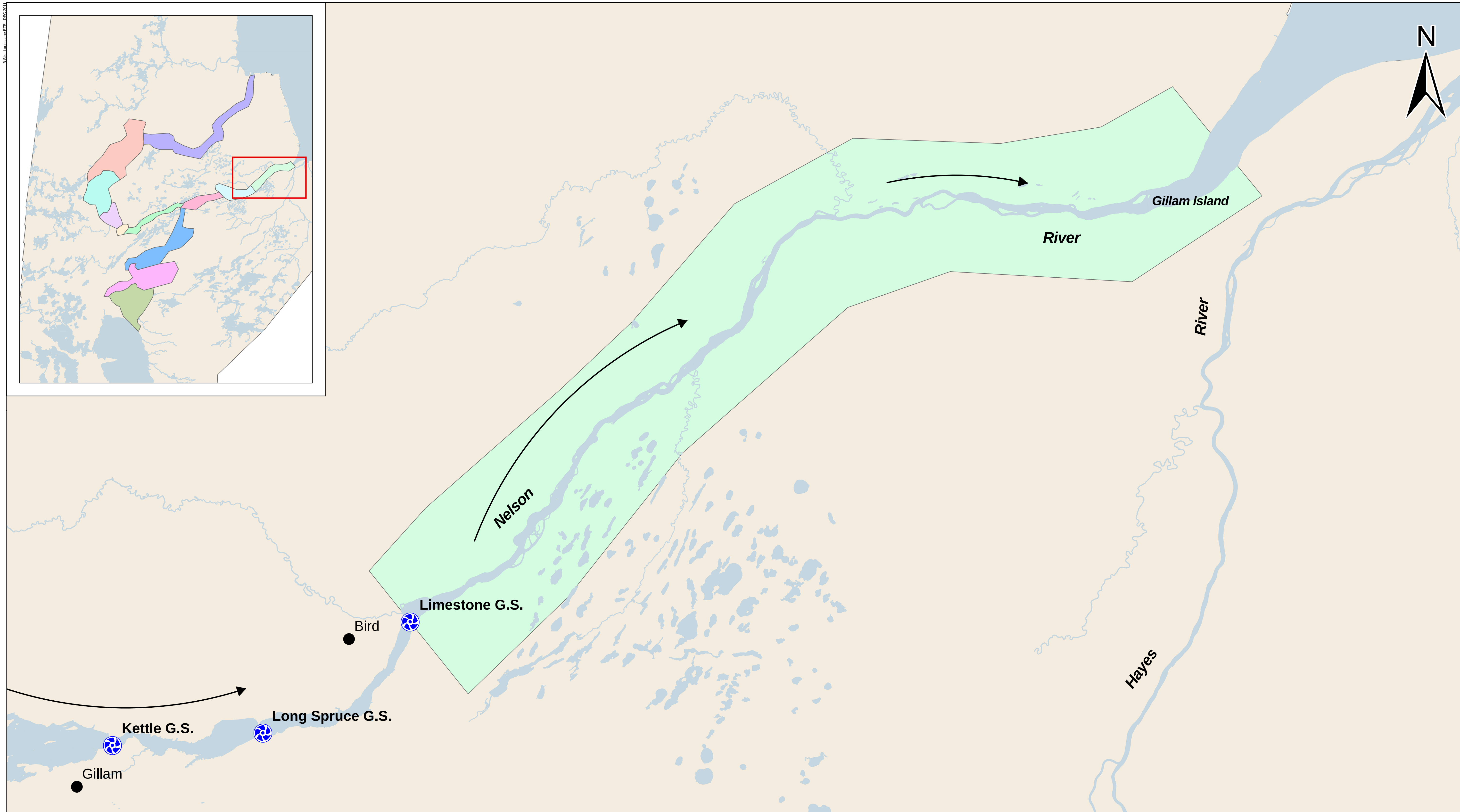
There is no continuous water level data in this zone prior to hydroelectric development. Manitoba Hydro measures the discharge at Limestone GS, which is the primary inflow to the zone, and the water level immediately downstream from the generating station since 1990. Manitoba Hydro has also measured water levels for a number of seasons at several locations in this zone as part of baseline studies for the planned Conawapa GS.

4.2.12.3 Limestone to Gillam Island

Manitoba Hydro development has increased daily water level fluctuations and average flows and water levels in this zone. Flows are also higher in the winter than under natural conditions and water level variations are increased due to flow releases at Limestone GS, which are driven by outflow from Kettle GS and routed through Long Spruce GS.

4.2.12.4 Ice Conditions

Prior to hydroelectric development, the ice cover generally progressed upstream from the Nelson River Estuary. This process was the result of ice accumulation at the leading edge, shoving and thickening with ice generated from the fast flowing upstream open water river sections. While this process still occurs, the amount of time required for the ice cover to progress upstream has typically increased. Forebay impoundments created by hydroelectric development reduced the amount of fast flowing river sections that generated ice and contributed to the ice cover progression. Hydroelectric development also increased water level fluctuations during the ice-covered period and this can affect the strength and stability of the ice cover and change surface ice conditions (Environment Canada, Department of Fisheries and Oceans Canada 1992).



Manitoba Hydro

DATA SOURCE:
Manitoba Hydro

CREATED BY:
Hydraulic Operation Department
Hydraulic Licencing and Support

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	05-May-14	27-MAY-14

Scale	VERSION NO:	QA/QC:
0 4.5 9 Kilometres / 0 3.5 7 Miles	1.0	BSS/RDB/ZZZ

Legend

- Towns
- Existing Generating Station
- Control Structures
- Gauging Stations
- Channels
- Flow Direction

Zone 12 - Limestone GS to Gillam Island
RCEA Area 2

Map 4-13

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4.3 EROSION AND SEDIMENTATION

This section summarizes the available studies to date on the effect of hydroelectric development on shoreline erosion and sedimentation processes in the RCEA Region of Interest.

The RCEA Region of Interest covers an area known as the outlet lakes (downstream of the Lake Winnipeg outlet), the Rat/Burntwood River system and parts of the Churchill and Nelson rivers watersheds. The water regime in these areas was affected by the construction of hydroelectric generating stations and the LWR and the CRD projects. Flooding and changes to the water regime (water depth and velocity) can initiate scouring, slumping, nearshore downcutting, peatland disintegration, and shoreline recession at locations that are susceptible to shoreline erosion processes (*i.e.*, shoreline is not bedrock controlled). As the eroded and disintegrated mineral and organic material and the resurfaced peat enter the waterway, they contribute to sedimentation processes, which includes entrainment, transportation, deposition and compaction of sediment in the waterway.

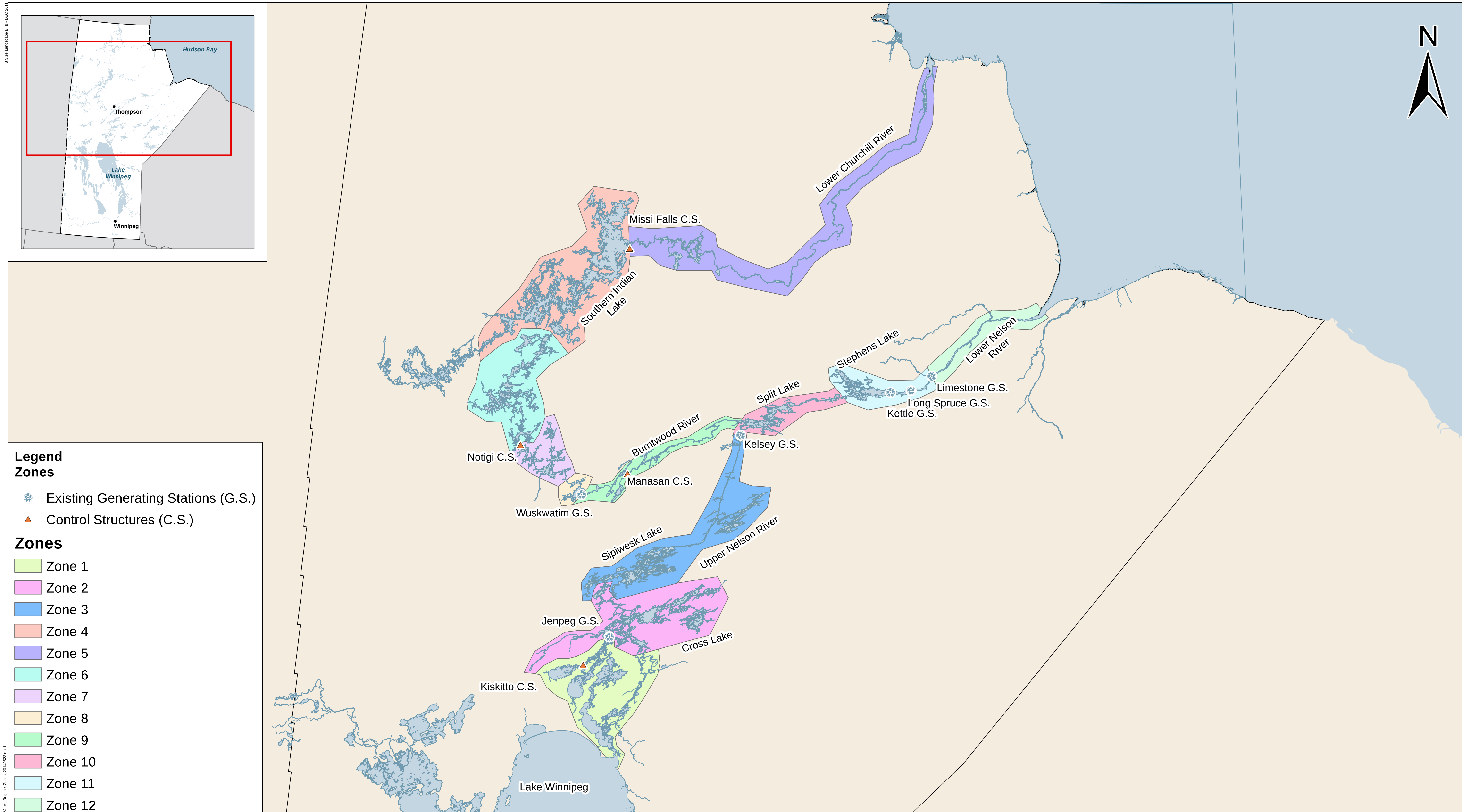
The RCEA Region of Interest for erosion and sedimentation is divided into 12 zones, similar to the water regime study area, because changes to the water regime are the primary drivers for changes to the erosion and sedimentation regime. These 12 zones are shown in Map 4-14. Zones 1, 2 and 3 are within the RCEA Area 1; zones 10, 11 and 12 are within the RCEA Area 2; zones 4, 6, 7, 8 and 9 are within the RCEA Area 3; and zone 5 is in the RCEA Area 4 (see Map 1-4).

The effect of hydroelectric development on shoreline erosion and sedimentation processes in the RCEA Region of Interest will be assessed in two phases. The purpose of Phase I is to inventory the studies on erosion and sedimentation in each zone and to provide some indication as to the types and extent of physical impacts associated with hydroelectric development. Efforts have been made to include all relevant studies, but in some cases, there may be additional studies that have not been reviewed at the time of submitting the Phase I report. The Phase I report consists of the review of erosion and sedimentation information available in the RCEA Region of Interest and provides a synthesis of the existing studies in this area. The Phase I study methodology consists of the following steps:

- Develop an inventory of the existing studies that may contain useful sedimentation and erosion data. The sources consisted of fieldwork reports, laboratory reports, shoreline monitoring reports, water quality studies, and academic research conducted by Manitoba Hydro and its consultants, universities, individuals, and federal/provincial organizations;
- Review the reports for their relevance to the sedimentation and erosion component of the RCEA; and
- Create a document that details a zone-wise chronologic account of studies that can be used in Phase II of this study.

Phase II will involve further analysis of the results from the available studies combined with compilation and analysis of existing data (*e.g.*, monitoring data, air photos) to generate information on physical impacts. The further compilation and analysis in Phase II will be primarily focused at selected sites of interest. The sites would be selected based on a review of the Phase I results and through a discussion with the project team. Priorities will be identified by Manitoba Hydro and the provincial government taking into consideration the availability of data and the feasibility to conduct the analysis at these locations. The Phase II report will include a summary and synthesis of the findings on the impacts of erosion and sedimentation processes associated with hydroelectric development. In this phase, the information gaps identified through the synthesis will also be identified. The Phase II study methodology consists of the following steps:

- Develop a complete electronic inventory of the existing erosion and sedimentation data. The data sources compiled in Phase I will be revisited, and additional studies that have not been reviewed at the time of submitting the Phase I report will be added;
- Develop sediment/turbidity and erosion monitoring station maps in a GIS environment that will include all the monitoring locations from pre-development to present. For each station, a summary of the erosion and sedimentation data including the period of measurements and measured parameters will be developed;
- Assess (to the extent possible) changes in the erosion and sedimentation regime associated with the existing hydroelectric development based on available information for pre- and post-development;
- Present the current trends and rates of shoreline erosion and sedimentation to the extent that is feasible with the available information; and
- Identify gaps in the data and information and develop plans to address the gaps.



Manitoba Hydro

DATA SOURCE:
Manitoba Hydro

CREATED BY:
Water Resources Engineering - Sediment & Ice Studies

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0 30 60 Kilometres / 0 25 50 Miles	VERSION NO: 1.0	QA/QC: RDB / MRK

RCEA
Erosion and Sedimentation Zones

Map 4-14

4.3.1 OVERVIEW OF MAJOR STUDIES

Erosion and sedimentation processes in the RCEA Region of Interest have been the focus of several studies including the Lake Winnipeg, Churchill and Nelson Rivers Study Board (LWCNRSB), Federal Ecological Monitoring Program (FEMP), Split Lake Cree-Manitoba Hydro Joint Studies, and Environmental Impact Statement (EIS) studies for pre- and post-hydroelectric development in northern Manitoba.

Most of the water quality studies conducted in the RCEA Region of Interest also reported sediment data including suspended sediment and turbidity. The majority of these studies were conducted as a part or follow-up to the LWCNRSB, FEMP, and MEMP (Manitoba Ecological Monitoring Program) studies. A more recent aquatic monitoring program initiated by Manitoba Hydro in partnership with the Province of Manitoba is the Coordinated Aquatic Monitoring Program (CAMP). There is also ongoing water quality monitoring conducted by MCWS (Manitoba Conservation and Water Stewardship) which includes Total Suspended Solids (TSS) and turbidity at a number of sites. Not all of the water quality studies where suspended sediment and/or turbidity has been measured are cited in the erosion and sedimentation section of this report since a comprehensive list of these studies are provided in the Water Quality sections.

Each of these studies mentioned above may cover the entire RCEA Region of Interest or a portion of it. A brief description of these studies is presented in the following sections to avoid duplicating information in each of the zones.

4.3.1.1 LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD (LWCNRSB)

In 1971, prior to developments associated with the CRD and LWR, Manitoba and Canada initiated the LWCNRSB to determine the effects that LWR, the CRD and the development of hydroelectric power along the CRD route would have on other water-related resource uses. The study took over three years to complete. The results were compiled in eight technical appendices, one technical report (LWCNRSB 1975) and a summary report.

The Physical Impact Study (Water Resources Branch 1974) represents the most comprehensive erosion and sedimentation study covering the RCEA Region of Interest. The study deals with the physical impacts on shorelines and inundated terrain along the Churchill and Nelson rivers resulting from the CRD and LWR.

4.3.1.2 FEDERAL ECOLOGICAL MONITORING PROGRAM (FEMP)

In 1986, Environment Canada and the Department of Fisheries and Oceans (DFO) coordinated a five-year monitoring program in northern Manitoba. This program was directed towards meeting some of the federal obligations under the Northern Flood Agreement (NFA), a four-party agreement concerned with the effects of large-scale hydroelectric development on the local inhabitants of the impacted area. Environment Canada and DFO published the findings of the five-year monitoring and research program as a series of ecological reports.

The main erosion-related research was conducted by Kellerhals Engineering Services Ltd. (1987, 1988), a two-phase study investigating how the CRD and LWR have affected river and lake morphology. Phase I was a detailed review of previous studies combined with a brief field inspection (Kellerhals Engineering Services Ltd. 1987). The study identified the main areas of concern for sediment, erosion, and deposition along with monitoring recommendations on a region-by-region basis. The study area for Phase II of this program (Kellerhals Engineering Services Ltd. 1988) was restricted primarily to the CRD route downstream of the Notigi control structure (CS), with a brief look at the lower Churchill River using maps and air photos to quantify morphologic changes.

4.3.1.3 SPLIT LAKE CREE – MANITOBA HYDRO JOINT STUDIES

The primary objective of these studies was to establish an environmental baseline by assessing the impacts of past hydroelectric development on the Split Lake Cree and extending this knowledge to anticipate the impacts of future hydroelectric developments and evolving environmental conditions in the study area. The study area comprised of an estimated 48,500 km^2 (12 million acres) of land and waters around Split Lake and extended past the Churchill River to the north, to Fidler Lake on the west, the CN rail line to the east and Sipiwesk Lake to the south.

Manitoba Hydro and Split Lake Cree undertook the environmental review jointly. Phase I of this study included a review of environmental impacts of hydroelectric development observed by the Split Lake Cree, scientific literature and identification of knowledge/data gaps. A major part of this study was to quantify the effect of erosion, subsequent nearshore sediment deposition, and substrate changes on the water quality parameters. Phase II provided the conclusions and a summary of above investigations.

4.3.1.4 ENVIRONMENTAL IMPACT STATEMENT STUDIES

Manitoba Hydro conducts EIS studies as key requirements of the preliminary planning of hydroelectric projects to meet federal and provincial regulatory requirements ever since the Environment Act became enacted. The process includes identification and extensive study of potential effects on the environment and people along with the development of follow-up monitoring programs.

Manitoba Hydro has submitted these assessments for the previously developed Limestone and Wuskwatim GSs as well as the proposed Keeyask Generating Station. An EIS study is also underway for the planned Conawapa Generating Station. Numerous sediment and erosion studies are available in the reaches affected by these developments.

4.3.1.5 COORDINATED AQUATIC MONITORING PROGRAM (CAMP)

Manitoba Hydro, in partnership with the Province of Manitoba, initiated a long-term monitoring program with a mandate to track aquatic ecosystem health using scientifically defensible methods to monitor the environmental effects associated with hydroelectric development in Manitoba. Water and sediment sampling are essential parts of this program and provide data consisting of turbidity, TSS, and sediment composition and deposition processes within a water body. An extensive amount of data has been accumulated since the inception of CAMP in 2007.

4.3.2 ZONE 1 – OUTLET LAKES AREA

4.3.2.1 AREA OVERVIEW

The outlet lakes area includes the East and West channels of the Nelson River as shown in Map 4-15. The West Channel covers a distance of approximately 60 mi (100 km) from the outlet of Lake Winnipeg to the Jenpeg GS and includes Playgreen Lake, Kiskittogisu Lake, Kiskitto Lake, and the Jenpeg forebay. The Nelson River East Channel begins at Little Playgreen Lake and covers 60 mi (100 km)until reaching Pipestone Lake just upstream from Cross Lake.

4.3.2.2 EROSION

The LWCNRSB divided Zone 1 into several reaches, which were classified into ten shoreline types (Water Resources Branch 1974). In general, throughout this zone bedrock shorelines are irregular and form promontories while erodible organic and granular shorelines form continuous sweeping arcs.

Kellerhals Engineering Services Ltd. (1987) summarized the erosion studies done to that date within the outlet lakes area. Little erosion monitoring work has been completed in this area since their review. One exception is the work undertaken by Bill Straight in 2003 as part of a woody debris and bank recession study in the Jenpeg forebay, which was later updated in 2012 (J. Tutkaluk, *pers. comm.* 2014).

Baracos and Galay (1972) discussed the construction and operation of the Two-Mile and Eight-Mile channels. Erosion due to wind-generated waves on Lake Winnipeg and Kiskittogisu Lake were expected to be substantial at the south end of the Two-Mile channel and north end of the Eight-Mile Channel, respectively. Any material eroded from the channels was expected to be dominantly clay, which would be transported downstream on the Nelson River to stillwater areas such as the Jenpeg and Kelsey reservoirs.

Galay and Baracos (1974) conducted follow-up work on the Eight-Mile Channel. Their work dealt with the present and future condition of dykes along the channel and dealt with the role that high water levels on Kiskittogisu Lake would have on shoreline displacement along the south end of the lake. It was recommended that dykes paralleling the south shore of Kiskittogisu Lake be constructed to prevent the southward displacement of the shore due to erosion by wind-induced waves.

According to Kellerhals Engineering Services Ltd. (1987), Manitoba Hydro was monitoring the Eight-Mile and Two-Mile channels annually with approximately five cross sections monitored at each channel, and some soundings were collected in the outlet areas. Substantial erosion was reported to have occurred during the first two years of operation, but much less since. Cross sections of both channels have been surveyed every two years since the project was completed and the results are published in summary reports.

Kellerhals Engineering Services Ltd. (1987) indicates that a broad environmental assessment of project effects on Playgreen Lake was conducted by MacLaren Plansearch Inc. (1985). The study was mainly concerned with the effects of LWR on the commercial fishery of Playgreen Lake. The study determined the pre- and post-project shoreline stability of Playgreen Lake and of the northern end of Lake Winnipeg. On Playgreen Lake, a comparative analysis of air photos dating back to 1946 for eight sites showed highly variable bank retreat rates ranging from 1.34 to 11.6 m/y. No changes in shore erosion rates attributable to LWR could be detected on either the Lake Winnipeg north shore or on Playgreen Lake. Large erosion rates were observed at the entrance to the Two-Mile Channel.

Kellerhals Engineering Services Ltd. (1987) discussed the predominance of low, flat organic terrain surrounding Kiskittogisu Lake. They indicated that the effects of the increased water levels associated with regulation had not yet been monitored along this lakeshore.

Northwest Hydraulic Consultants Ltd. (1987) considered the Lake Winnipeg outlet channels as one of the top three main sources of increased sediment due to hydroelectric development. Shoreline erosion on Southern Indian Lake and bank erosion along the Burntwood River route of the diversion were the other two main sediment sources.

J.D. Mollard and Associates Ltd. assessed whether there were any identifiable changes in air photos in the Norway House Reserve area before and after the regulation of Lake Winnipeg (JDMA 1994). Ten different sets of air photos were examined ranging in scale from 1:6,000 to 1:63,000, acquired between 1955 and 1990. No shore erosion could be identified along lakeshores or river channels near the Norway House settlement using air photos taken before and after LWR. The most visible shoreline changes were in land use, with an increase in the number of houses and docks observed from 1973 to 1990.

4.3.2.3 SEDIMENTATION

The LWCNRSB documented the baseline sediment conditions prior to the CRD and LWR within the study area (LWCNRSB 1975a). In this study, sediment and water quality data collected by federal and provincial agencies prior to 1972 were utilized along with the data collected in 1972 and 1974 in Two-Mile Channel, Playgreen Lake, Eight-Mile Channel, Norway House, Kiskitto Lake, Kiskittogisu Lake, Kisipachewuk Rapids, Warren Landing, and in the area of the Jenpeg GS (Morelli 1975). Koshinsky (1973) studied limnology and fisheries of the outlet lakes area and compared water quality and suspended sediment in the outlet lakes and Lake Winnipeg.

Prior to LWR, suspended sediment data was collected by Manitoba Hydro in the area of Warren Landing and at the entrance and exit of Two-Mile and Eight-Mile Channel locations in Lake Winnipeg, and Playgreen and Kiskittogisu lakes. Manitoba Hydro documented suspended sediment, light penetration, wave action, wind velocity and direction, and flow in the outlet lakes area from 1971 to 1977 in several reports (Manitoba Hydro 1974, 1975, 1977a, b).

A report prepared by Manitoba Hydro (1985a) presented the 1984 sedimentation program sampling results for the Playgreen Lake area and provided a comparison to previous historic data. The 1984 bedload measurements conducted in Two-Mile and Eight-Mile channels were presented in a Manitoba Hydro report (Manitoba Hydro 1985b). In 1985, MacLaren Plansearch Inc. completed a comprehensive study of South Playgreen Lake to assess the impacts of LWR on the commercial fishery on Playgreen Lake. As part of this study, comparison of the pre- and post-regulation sediment regime was undertaken using sediment cores, grab samples, suspended sediment concentration, and satellite images. The rate of sedimentation and type of bottom sediments throughout most of Playgreen Lake were also assessed (MacLaren Plansearch 1985a, b, c).

The Nelson River near Norway House has been monitored since 1972 for a variety of water quality parameters including TSS and turbidity (currently monitored by Manitoba Water Conservation and Water Stewardship). Assessments of changes resulting from hydroelectric development, including analysis of TSS and/or turbidity, have also periodically been undertaken (Morelli 1975; Playle 1986; Playle and Williamson 1986; Duncan and Williamson 1988; Grapentine *et al.* 1988; Playle *et al.* 1988; Baker and Davies 1991; Ramsey 1991; Williamson and Ralley 1993).

Suspended sediment and turbidity were also collected as part of the FEMP water quality data collection program from 1987 to 1989 (Environment Canada and DFO 1992a, b). To more effectively utilize the sediment data collected by different agencies, an annotated atlas of sediment sampling stations in the LWCNR area was prepared (Environment Canada and DFO 1989b). This atlas describes the key characteristics (location, period of record, and frequency of sampling) of the stations of federal, provincial and Manitoba Hydro. Kellerhals Engineering Services Ltd. conducted a study to synthesize the existing knowledge at the time to determine the location, extent, and significance of river morphological changes in the FEMP study area (Kellerhals Engineering Services Ltd. 1987, 1988). Field survey data, aerial photo interpretation, and analysis of data available in 1987 formed the basis for this assessment. Northwest Hydraulic Consultants Ltd. was also hired under the FEMP studies to assess the sediment effects resulting from the LWCNR hydroelectric projects. The study included assessment of sediment type, sediment sources, transport routes and depositional sites, and sediment mixing (Northwest Hydraulic Consultants Ltd. 1988a, b). Temporal changes in turbidity and suspended solids were assessed in Playgreen Lake/Norway House and Kiskittogisu Lake for 1973-1977, 1972-1999, and 1987-1997 (Northwest Hydraulic Consultants Ltd. 1988a).

MCWS has been monitoring water quality at the Jenpeg GS since 2001 (*unpubl. data*).

A more recent ongoing sediment monitoring program was initiated by Manitoba Hydro on South Playgreen Lake under the CAMP. Sediment data including TSS, discrete and continuous turbidity, bedload, and bed material have been collected in the open water season of 2013 and winter 2013/2014 (CAMP 2014a). Since 2009, water quality, including TSS and turbidity, has been monitored in Playgreen and Little Playgreen lakes every three years under the CAMP (CAMP 2014b, CAMP *unpubl. data*). Ongoing water quality monitoring is also conducted at the Jenpeg GS as a cooperative undertaking by Manitoba Hydro and MCWS.

Manitoba Hydro

DATA SOURCE:
Manitoba Hydro

CREATED BY:
Water Resources Engineering - Sediment & Ice Studies

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	23-MAY-14	04-JUN-14

0 5.5 11 Kilometres
0 5 10 Miles

VERSION NO:	QA/QC:
1.0	RDB / MRK

Legend

- Existing Generating Stations (G.S.)
- Control Structures (C.S.)

RCEA
Erosion and Sedimentation Zone 1

Map 4-15

4.3.3 Zone 2 – Cross Lake and Surrounding Area

4.3.3.1 Area Overview

This zone begins just downstream of the Jenpeg GS at Cross Lake and extends further downstream along the Nelson River to just upstream of Sipiwesk Lake as shown in Map 4-16. Duck Lake, which is a lake along an arm of the Nelson River just upstream of Sipiwesk Lake, is also in this zone. Other lakes in the zone include Pipestone Lake, which is between the Nelson River East Channel and Cross Lake, and Walker Lake, which is a tributary to Cross Lake. The Cross Lake Weir is the only Manitoba Hydro in-stream structure in this zone.

4.3.3.2 Erosion

Cole (1974) assessed the anticipated effects of LWR on shorelines at Cross Lake. At strategic sites throughout the Cross Lake community, 20 shore profiles were surveyed and presented along with descriptions of the shore materials and vegetation. Most of the shoreline was classified as bedrock-controlled with shallow overburden. It was determined that project-related changes to water levels and flows, although changed seasonally, would not be of sufficient magnitude to cause substantial soil erosion from such low bedrock shorelines. The limited fetch across the east channel of the Nelson River in this area was also expected to limit the amount of erosion.

The effects of LWR on shoreline stability were predicted to be minimal by the LWCNRSB (1975), and no erosion problems had been reported up to 1987 according to Kellerhals Engineering Services Ltd. (1987). The main predicted physical changes associated with LWR were expected to be changes to shoreline vegetation initiated by the modified seasonal water level regime. However, considerable shore remediation has been carried out in recent years on Cross Lake (J. Tutkaluk, *pers. comm.* 2014).

4.3.3.3 Sedimentation

Morelli (1975) summarized pre-development suspended sediment and turbidity data collected from 1972 to 1974 in Cross Lake, Eve Falls, Minago River mouth, and Bladder Rapids areas. The effects of the LWCNR hydroelectric projects on Cross Lake sediment regime were predicted by the LWCNRSB (1975a). In a limnology and fisheries study report, Koshinsky (1973) compared turbidity in the east basin of Cross Lake with of that section of the lake receiving the Nelson River discharge.

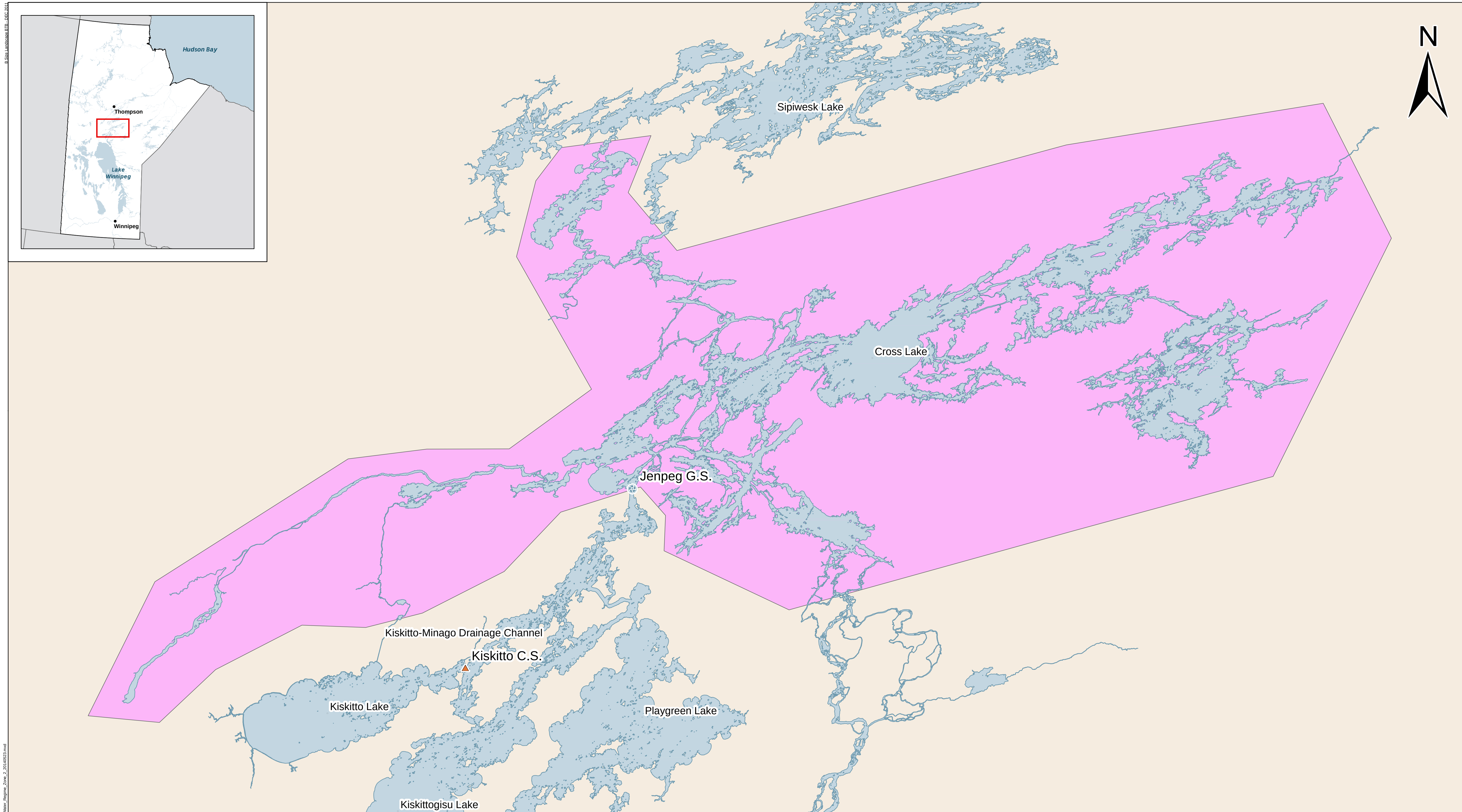
Turbidity values, as an indication of suspended sediment concentration in water, collected in Cross Lake for the periods of 1972-1976 (before development) and 1976-1984 (after development) were compared to investigate the effects of LWR on water quality (Playle and Williamson 1986).

Water quality data collection for Walker Lake was conducted in 1981 (Gaboury and Patalas 1981, 1982).

Suspended sediment and turbidity were also collected as part of the FEMP water quality data collection program from 1987 to 1989 (Environment Canada and DFO 1992a, b). Kellerhals Engineering Services Ltd. conducted a study to synthesize the existing knowledge at the time to determine the location, extent, and significance of river morphological changes through the FEMP study area (Kellerhals Engineering Services Ltd. 1987, 1988). Berger and Ramsey (1991) compared turbidity and suspended sediment data from 1972-1973 with the data for the period of 1987-1989 on the Nelson River mainstem in Sipiwesk Lake.

Northwest Hydraulic Consultants Ltd. assessed the sediment effects resulting from the LWCNR hydroelectric projects. The study included assessment of sediment type, sediment sources, transport routes and depositional sites, and sediment mixing. Temporal changes in turbidity and suspended solids were assessed for the periods 1975-1984 and 1970-1999 (Northwest Hydraulic Consultants Ltd. 1988a, b).

Water quality data including suspended sediment and turbidity for Walker Lake and Cross Lake near the community have been monitored under CAMP (CAMP 2014b, CAMP *unpubl. data*).



Manitoba Hydro

DATA SOURCE:
Manitoba Hydro

CREATED BY:
Water Resources Engineering - Sediment & Ice Studies

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	23-MAY-14	27-MAY-14
0 5 10 Kilometres / 0 4.5 9 Miles	VERSION NO: 1.0	QA/QC: RDB / MRK

Legend

- Existing Generating Stations (G.S.)
- Control Structures (C.S.)

RCEA
Erosion and Sedimentation Zone 2

4.3.4 Zone 3 – Sipiwesk Lake to Kelsey GS

4.3.4.1 Area Overview

This zone includes Sipiwesk Lake and the Nelson River from the outlet of Sipiwesk Lake to the Kelsey GS as shown in Map 4-17. Some of the other lakes in this zone include Landing, Hunting, Prud'homme, Cauchon, and Goose Hunting lakes, which are all tributaries to the Nelson River. The Kelsey GS was constructed to supply the International Nickel Company's mining and smelting operations and to supply electricity to the City of Thompson.

4.3.4.2 Erosion

As part of the Physical Impact Study, the impact of altered water regimes was surveyed at Sipiwesk Lake and the Kelsey forebay (Water Resources Branch 1974). The summaries in the two paragraphs below are based on information provided in Section 7 of the Physical Impact Study.

The construction of the Kelsey GS impounded the shoreline of Sipiwesk Lake in 1960. The readjustment process involved shoreline vegetation being impacted to the maximum water level along with increased shoreline erosion and nearshore sedimentation. About 5% of the shoreline was predominantly steep bedrock outcrop where no impact was observed. Over about 10% of the shoreline, impacts were slight and consisted of a narrow band of dead trees. Moderate impacts were observed over about 35% of the shoreline and consisted of vegetation being impacted. Severe erosion was observed over about 50% of the shoreline, characterized by erosion and flooding extending inland.

The Kelsey forebay was impounded during the summer of 1960 by the Kelsey GS. The readjustment process took several forms: erosion of till banks where the water level had risen well above the previous stable shoreline, severe undercutting of banks near the upper end of the channel, impacting shoreline vegetation to maximum water level, increased shoreline erosion with resulting increased nearshore sedimentation, and rapid erosion of mid-stream islands. Impacts were slight over 20% of the shoreline where dead vegetation was the main impact. Moderate impacts occurred over 40% of the shoreline where impacts took the form of dead vegetation and erosion. Severe impacts were observed on over 40% of the shoreline, where dead vegetation, erosion, severe bank undercutting were observed.

In addition to the summaries above, descriptions and photographs illustrating erosion impacts on Sipiwesk Lake and the Kelsey forebay were provided in several sections of the Physical Impact Study (Water Resources Branch 1974). These two areas were used several times throughout the text to illustrate examples of disappearing islands, floating peat islands and other floating peat features (*e.g.*, islands 120 m by 150 m across still intact five years after flooding). The extreme water level fluctuations on Sipiwesk Lake were thought to be the main reason for the fen destruction observed throughout the lake.

JDMA (1992b) measured shoreline erosion rates around Sipiwesk Lake using historical air photos. The Sipiwesk Lake erosion measurements were also presented by JDMA (1992c). Pre-Kelsey forebay erosion measurements were made by comparing air photos acquired in 1930, 1946 and 1950, with average rates of erosion of 0.5 m/y. In this pre-development period, about half of the shoreline displayed erosion rates up to 0.5 m/y, while the other half showed rates between 0.5 and 1.0 m/y. Post-development erosion rates were measured between air photos dated from 1971 and 1978. The overall average rate of erosion was 3.3 m/y. However, some concerns were expressed regarding the accuracy of the post-development measurements, particularly related to photo scale, photo quality, challenges with identifying the shoreline at some locations, and changes in water level between photo acquisition dates.

4.3.4.3 SEDIMENTATION

Sediment data for the Grass River are limited to the Manitoba Hydro survey programs on the Grass River upstream of Kelsey GS for the open water season from 1969 to 1972 (Manitoba Hydro 1970, 1971, 1973). During August 1972, a limnological survey of Kettle reservoir and the Nelson River between Prud'homme Lake and Kelsey was conducted (Crowe 1973). The purpose of the survey was to document physical, chemical and biological characteristics of the two reservoirs and to compare a new reservoir (Kettle) with an established one (Kelsey). Hecky and Harper (1974) reported suspended sediment concentrations collected in Sipiwesk Lake and the Grass River in the open water season of 1973.

Suspended sediment and turbidity data collected in the Kelsey reservoir and Sipiwesk Lake between 1972 and 1974 was reported by Morelli (1975). Pre-LWR suspended sediment and turbidity in Sipiwesk were studied Lake by the LWCNRSB (1975a) A comparison was made between turbidity, as an indication of magnitude of suspended sediment in water, in Sipiwesk Lake for the periods of 1972-1976 (before development) and 1976-1984 (after development) to investigate the effects of LWR and the CRD on water quality (Playle and Williamson 1986).

Suspended sediment and turbidity were also collected in Sipiwesk Lake and Kelsey reservoir area as part of the FEMP water quality data collection from 1987 to 1989 (Environment Canada and DFO 1992a, b). Turbidity and suspended sediment collected in Sipiwesk Lake between 1972 and 1973 were compared with data for the period of 1986-1987 (Ramsey *et al.* 1989).

Northwest Hydraulic Consultants Ltd. assessed the sediment effects resulting from the LWCNR hydroelectric projects. The study included assessment of sediment type, sediment sources, transport routes and depositional sites, and sediment mixing (Northwest Hydraulic Consultants Ltd. 1988a, b).

Suspended sediment and turbidity in Sipiwesk Lake and the Nelson River upstream of Kelsey GS are monitored every three years under CAMP (CAMP *unpubl. data*). The historical water quality monitoring site located near the outlet of Sipiwesk Lake continues to be monitored three times per year by MCWS.

DATA SOURCE: Manitoba Hydro		
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COORDINATE SYSTEM: UTM NAD 1983 Z15N	DATE CREATED: 23-MAY-14	REVISION DATE: 27-MAY-14
0 8.5 17 Kilometres / 0 7 14 Miles	VERSION NO: 1.0	QA/QC: RDB / MRK

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- Existing Generating Stations (G.S.)
- Control Structures (C.S.)

RCEA
Erosion and Sedimentation Zone 3

Map 4-17

4.3.5 ZONE 4 – LEAF RAPIDS TO SOUTHERN INDIAN LAKE

4.3.5.1 AREA OVERVIEW

This zone includes the upper Churchill River from Leaf Rapids to Southern Indian Lake as shown in Map 4-18. Starting from Leaf Rapids, the Churchill River runs approximately 20 mi (32 km)before reaching Opachuanau Lake which is connected to Southern Indian Lake.

Two of the three main components of the CRD are located in this zone. The Missi Falls CS controls the outflow at the natural outlet of Southern Indian Lake and raised the water level on the lake. The South Bay Diversion Channel is an excavated channel from the South Bay of Southern Indian Lake to Issett Lake and creates a new outlet to allow Churchill River water to flow into the Rat River and Burntwood River system.

4.3.5.2 EROSION

The LWCNRSB divided Zone 4 into nine reaches, which were classified into 14 different shoreline types (Water Resources Branch 1974). In general, low lacustrine relief and the occurrence of granular material characterized the northern portion of Southern Indian Lake, whereas the southern reaches were characterized by the high occurrence of bedrock-controlled shorelines.

The Freshwater Institute of Fisheries and Oceans Canada carried out a detailed, long-term monitoring study of the effects of the CRD on Southern Indian Lake. Results up to about 1982 were published in a special issue of the Canadian Journal of Fisheries and Aquatic Sciences (Vol. 41, No. 4, April 1984). As background for the other studies in the special issue, Newbury *et al.* (1984) provide a brief summary of hydroelectric development, geography of the Southern Indian Lake region, and changes in the hydraulic regime of the Churchill River and Southern Indian Lake. Satellite images of Southern Indian Lake acquired before and after impoundment were used to illustrate how the eroded materials were suggested to have dramatically increased the turbidity of the lake.

Newbury and McCullough (1984) summarized the results of an erosion study on Southern Indian Lake. The study was aimed at the quantification of observed erosion rates over the entire lake shoreline to obtain an estimate of the total weight of mineral materials added to the lake annually and to predict the total period of shoreline instability. Results of the study were also published by Newbury *et al.* (1978), Newbury and McCullough (1982, 1983) and McCullough and Newbury (1985). Permafrost is widespread in the lacustrine clay and glacial till shorelines surrounding the lake, and since impoundment, the combined processes of permafrost melt and wave erosion have caused considerable shoreline retreat. Seventeen sites on Southern Indian Lake were selected in 1975 for erosion monitoring during and following impoundment. Each site was surveyed on several cross-sectional lines running perpendicular to the shoreline and extending 50 m inland. Acoustic and line soundings were taken at each site to a distance of 500 m offshore. The volume of eroded material at each site was obtained from the change in the surveyed cross sections. Shorelines formed in fine-grained overburden contributed large amounts of suspended sediment to the main body of the lake, with long plumes of sediment observed moving from the eroding shorelines into the main body of the lake. In general, it was suggested that the creation of stable shorelines and the reduction of sediment input to the lake to pre-impoundment conditions would require many decades in the large basins and centuries in the less exposed regions of the lake.

McCullough (1978) described the system of shoreline classification developed for Southern Indian Lake and he compared it with a biophysical land classification system developed for general ecological land classification applications. This shoreline classification system was developed for the LWCNRSB to map shorelines along the Nelson, lower Churchill and Rat-Burntwood rivers.

McCullough (1987) presented preliminary results of a study of nearshore sedimentation processes at Southern Indian Lake. The erosion portion of the study involved the use of 1970 and 1983 aerial photographs to plot shoreline maps and bank profiles at 17 sites. Seven to 16 profiles were drawn at each site equidistantly spaced to sample a reach of 0.5 to 1.0 km. From 15 to 84 m^3/m of shoreline was eroded at each site over the thirteen-year period.

McCullough (1990) discussed sedimentation and erosion within Southern Indian Lake and within the Notigi reservoir. Emphasis in the discussion was placed on the erosion of low energy shorelines. In the first years after the impoundment of Southern Indian Lake, erosion at low energy sites was negligible. Typically, several years were required to break apart the moss and root-fibre matte at the land-water interface. By 1980, minor toe erosion was more commonly apparent at the shoreline. It was suggested that substantial erosion of the more protected shorelines would begin only after the protective vegetation matte was destroyed, and would peak later in the life of the reservoir.

Hecky and McCullough (1984) examined the pre- and post-impoundment sediment balance of Southern Indian Lake and found that shoreline instability had increased the sediment input to the lake by a factor of 20, with most of the sediment deposited near the eroding shores. However, they also found evidence that these nearshore deposits could be temporary and that the sediment could eventually remobilize and become part of the lake's general suspended load. They anticipated that this would cause unnaturally high lake turbidity to persist after the shorelines had become more stable. At one site where shore erosion ceased after encountering bedrock, the nearshore deposits disappeared over a period of three years.

Baracos and Galay (1974) investigated the channel connecting South Bay to Issett Lake. The Churchill River is diverted across the Churchill-Nelson divide along this channel. The excavation traversed a wide variety of materials ranging from bedrock to peat and silts with high organic content. Bedrock outcrops were expected to limit the tendency for the channel to shift where shoreline instability or erosion takes place. However, Kellerhals Engineering Services Ltd. (1987) noted that the South Bay Diversion Channel had seen little erosion monitoring, and the field reconnaissance in October 1986 indicated considerable shoreline instability, large areas of standing dead trees and many large floating fens.

Baracos and Galay (1973a) investigated the effects from raising the level of Southern Indian Lake due to the CRD on the shoreline at the settlement of South Indian Lake. Set-back lines were presented based on a consideration of flooding, erosion and bank stability assuming that no protective works were constructed. Topographical and soil information were obtained from 83 cross sections surveyed along shorelines near the settlement of South Indian Lake. Two cemeteries on the east shore had been located close to the lake for access, and in areas where the soil was easy to excavate. It was recommended that riprap protection or relocation be considered.

As part of the erosion monitoring program conducted by Manitoba Hydro along the CRD (Manitoba Hydro 1982a, 1983a, 1984, 1985a, 2001b), two erosion monitoring sites on Southern Indian Lake and one on Opachuanau Lake were surveyed for several years beginning in 1981. The sites on Southern Indian Lake were located near the Missi Falls CS and near the settlement of South Indian Lake. However, as each of these sites was bedrock-controlled at the high waterline they were no longer surveyed. The available transect surveys for these sites have been compiled by Manitoba Hydro (2001b), with the final survey completed in 1992.

4.3.5.3 SEDIMENTATION

Numerous water quality and shoreline erosion studies were conducted in Southern Indian Lake. These studies, although focused on water quality (in relation to aquatics) and shoreline erosion, provided an assessment of TSS in the pre- and post-CRD environments. A majority of these studies were conducted as a part or follow-up to the LWCNRSB or FEMP studies. A limited amount of sedimentation data is available for this zone in the form of turbidity, suspended sediment content and mapped deposition zones. A summary of the studies documenting these observations is given below.

Cleugh (1974) divided Southern Indian Lake into eight regions and included the pre-diversion conditions and presented his assessment of the diversion effects on the hydrography of each region. Afterwards, he established the baseline water quality parameters, including TSS and turbidity.

Hecky (1974) provided the Southern Indian Lake basin history and implications of inundations and diversion on the sedimentary environment of the lake. This study included information on the grain size distribution of sediments found at the lake bottom. In another study, Hecky *et al.* (1974) documented a few TSS measurements at selected stations and established a relationship between the Secchi disk depths and TSS. Hecky and Ayles (1974) surveyed Wood Lake, a relatively small lake draining into the Churchill River downstream of Southern Indian Lake in 1973, with the intention that it might serve in the future as a reference lake. Hecky *et al.* (1979) published the physical data, including suspended sediment concentration, collected at nine stations on Southern Indian Lake and neighboring lakes for the two years prior to diversion (1974 and 1975), for the year of impoundment and diversion (1976), and for two years after diversion. Hecky *et al.* (1981) created sediment budgets for Southern Indian Lake.

Manitoba Hydro (1982) conducted water sampling for suspended sediment and chemical analysis over the whole diversion route, including Southern Indian Lake in 1981.

Limited TSS data can be extracted from the work by Guildford (1985) on the depression in primary productivity due to the suspended sediment and dissolved humic matter in Southern Indian Lake. In an aquatic study, Fudge and Bodaly (1984) assessed the Lake Whitefish egg survival after determining the amount of sedimentation on post-impoundment spawning beds in Southern Indian Lake.

Hecky and McCullough (1984) discussed the effects of impoundment and diversion on the sediment budget of Southern Indian Lake. The lake was divided into six regions; each region had undergone different degrees of increase in suspended sediment. McCullough and Newbury (1985) measured the transient nearshore deposition and its effect on turbidity in Southern Indian Lake.

The effect of the CRD on water quality was investigated by comparing pre-development (1972-1976) and post-development (1976-1984) water chemistry data over the entire diversion route, including Southern Indian Lake. The findings of this comparison were published in water standards and studies report (Playle and Williamson 1986).

Penner *et al.* (1987) compiled a summary of all the suspended sediment and bed material data that had been collected up to 1985 in Manitoba by the Manitoba Water Resources Branch and Water Survey of Canada. Data collected by Freshwater Institute personnel was also referred to in this report.

Guildford *et al.* (1987) documented a few TSS values while evaluating the effect of eroding shorelines in Southern Indian Lake on depressed primary productivity and phytoplankton biomass due to reduced light penetration caused by the increased suspended sediments.

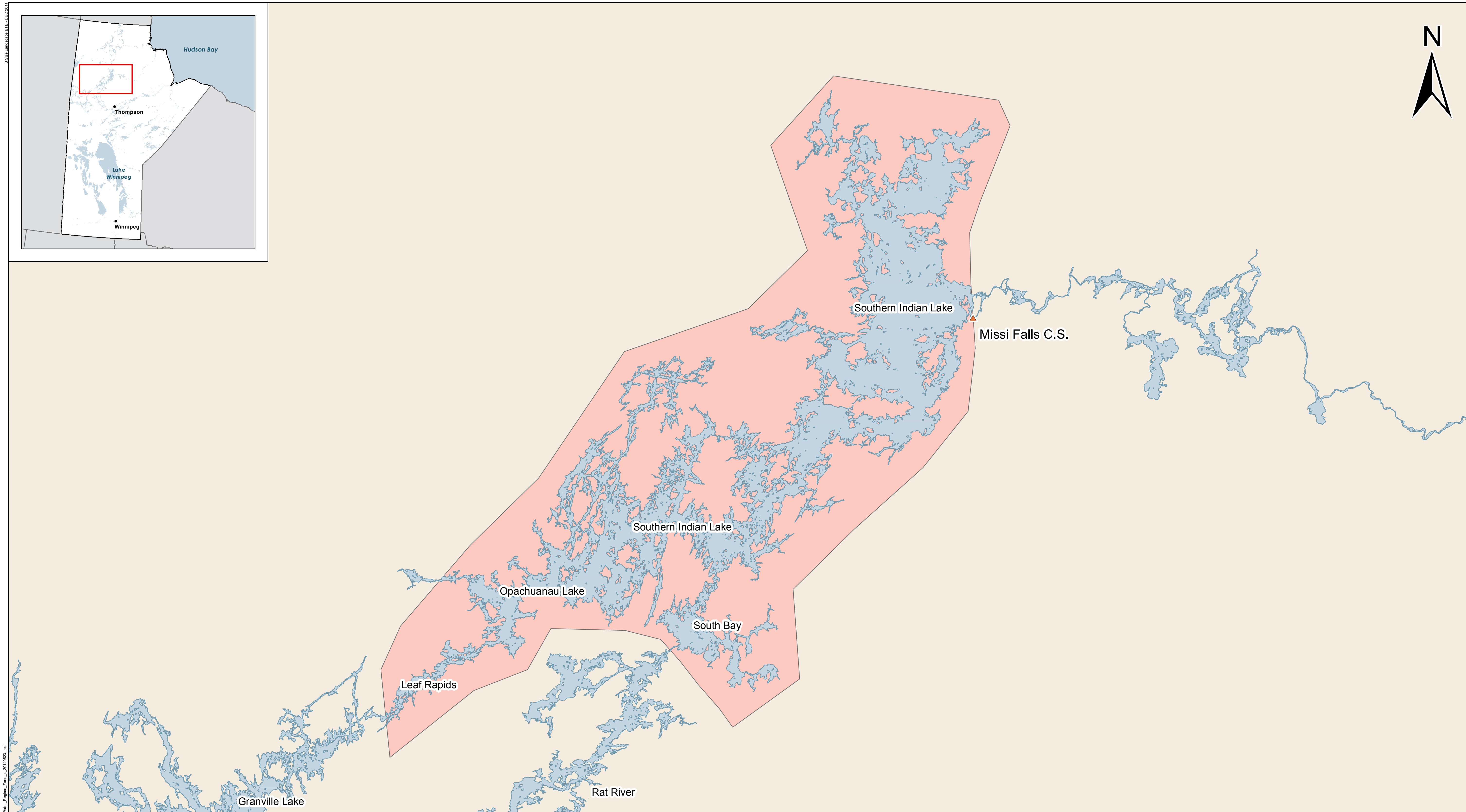
McCullough (1987) discussed shoreline evolution in Southern Indian Lake as a part of a Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the CRD. The preliminary results of nearshore sedimentation processes at Southern Indian Lake are documented in this report. Sediment cores were taken from the bed within 100 meters offshore to measure sediment deposition at representative locations along the shoreline. This information was used to estimate the weight of deposited material.

Bodaly *et al.* (1987) presented the results of sediment, fish and limnological sampling done in 1981-82, along the CRD route. The report presented the data and correlation between various quantities, including suspended sediments. This report was included as a technical appendix to the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the CRD. Jackson (1988) reported the grain size distribution of sediments in Southern Indian Lake.

FEMP reports (Environment Canada and DFO 1987, 1988, 1989a, b, c, 1990) documented the sedimentation studies, observations, and assessments initiated under this program. The related activities included sediment budget analysis, morphological assessment, and sediment coring for quantitative assessment of sedimentation along the diversion route, including Southern Indian Lake. Some TSS and Secchi disk readings were also noted. (Environment Canada and DFO 1992a, b, c).

North/South Consultants Inc. (2013) published the results of sedimentation investigations conducted in Southern Indian Lake during 2011-2012. Sediment traps were placed on the lake bottom in the fall of 2011 before the lake froze and were left there over the winter. The equipment was removed in March before the ice melted. Monitoring equipment was placed in four areas: Loon Narrows, Sandhill Bay, a bay near the Community Channel, and an area north of the Missi Falls CS. The authors made an estimate of the material accumulated in winter 2011-2012 on the bottom of the lake. These results could not be directly compared with the 1978-1981 studies (Fudge and Bodaly 1984) because of the precise location of the traps and some aspects of the design of the traps. The composition of the collected sediment in traps was dominated by clay and silt with low organic content.

Since 2008, suspended sediment and turbidity have been sampled in Southern Indian Lake and Opachuanau Lake under CAMP (CAMP 2014b, CAMP *unpubl. data*).



Manitoba Hydro

DATA SOURCE:
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0 8.5 17 Kilometres / 0 7 14 Miles	VERSION NO: 1.0	QA/QC: RDB / MRK

Legend

Control Structures (C.S.)

RCEA
Erosion and Sedimentation Zone 4

4.3.6 ZONE 5 – LOWER CHURCHILL RIVER

4.3.6.1 AREA OVERVIEW

As shown in Map 4-19, this zone covers the lower Churchill River from the Missi Falls CS to the Churchill Weir just upstream from the Churchill River estuary. Major lakes in this zone include Partridge Breast Lake, Thorsteinson Lake, Northern Indian Lake, and Fidler Lake.

4.3.6.2 EROSION

The LWCNRSB divided the lower Churchill River into ten reaches (Water Resources Branch 1974; LWCNRSB 1975). This study provided an overview of the physical setting of the lower Churchill River followed by detailed descriptions of each reach. The substantially reduced flows associated with the CRD were expected to decrease the width of the river channel and result in the subaerial exposure of many previously subaqueous surfaces.

Kellerhals Engineering Services Ltd. (1988) conducted a cursory examination of the morphological changes that took place along the lower Churchill River. Changes in morphology were evaluated visually by comparing pre- and post-CRD air photos. In certain locations, it was possible to make quantitative measurements of changes from the air photos using a digitizing tablet. Four sites along the lower Churchill River were examined in detail. The results indicated that the depleted flows have resulted in an approximate 30% decrease in average channel width. A large percentage of side and back channels were no longer occupied by the river, nor were many low-lying wetland areas. The size of most tributary fans had enlarged considerably. This appeared to be caused by both the exposure of previously submerged areas and, in a few locations, by the deposition of coarse textured materials transported by tributary streams. Channel incision and increased bank erosion were evident near the apex of two tributary streams. These processes resulted in locally substantial sediment production. In general, the observed morphological changes were relatively minor and were progressing at very slow rates. This was primarily due to the many bedrock controls along the lower Churchill River and to the incised nature of some channel reaches.

4.3.6.3 SEDIMENTATION

Pre-development sediment data is available on the Churchill River downstream of Missi Falls for the open water seasons of 1969 to 1972 (Manitoba Hydro 1970, 1971, 1973). Water sampling for salinity determination and sediment in suspension on the Churchill River estuary was reported by Manitoba Hydro (1968).

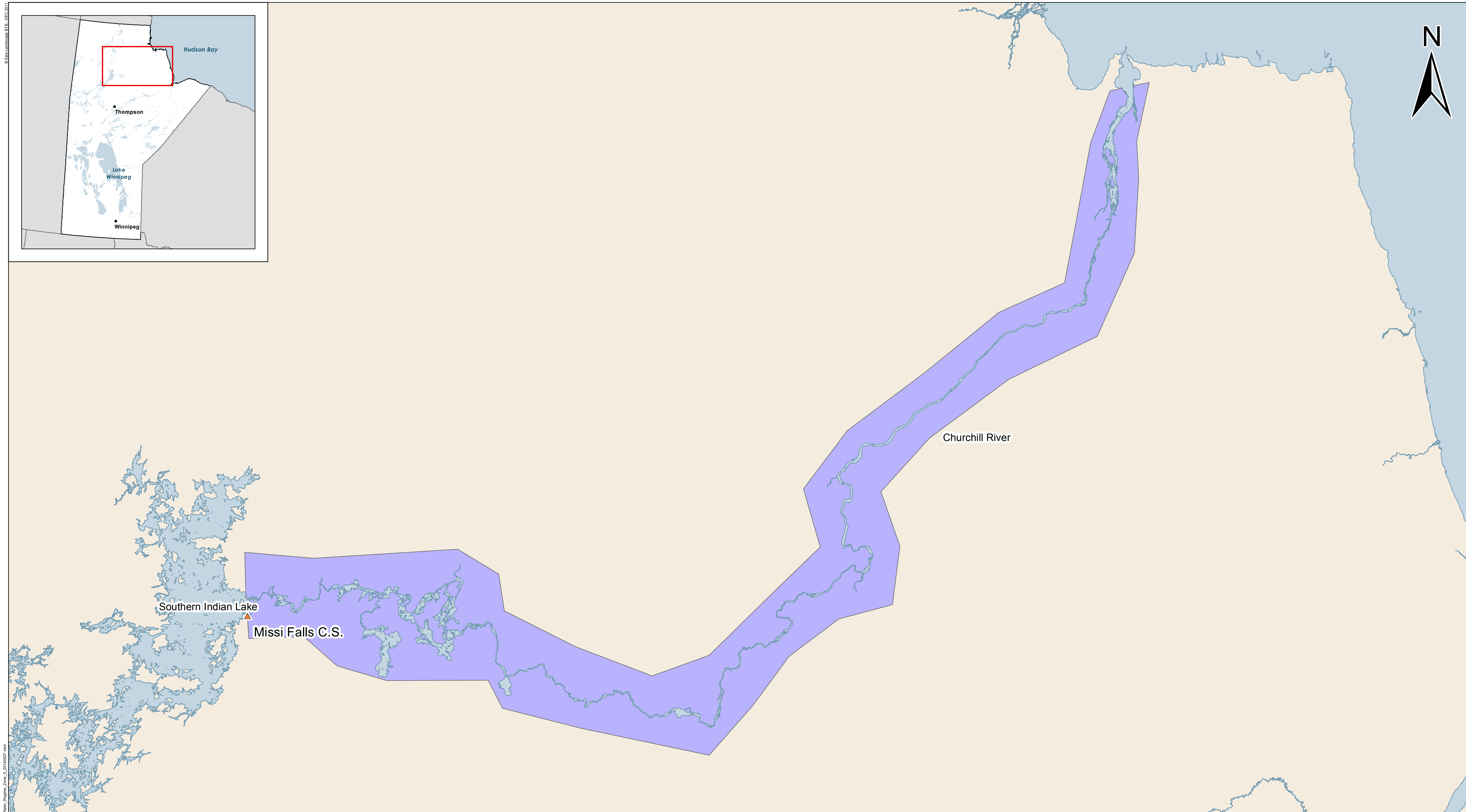
Sedimentation processes in the lower Churchill River, Partridge Breast, Northern Indian, Fidler and Billard lakes, and the Churchill River estuary were investigated and presented in the LWCNRSB report (1975). This report did not suggest significant changes in the sediment regime in these waterbodies after the diversion.

Cleugh (1974), in a study prepared for LWCNRSB, reported physical parameters of water (including suspended sediment) at Missi Falls, Wood Lake, and the lower Churchill River and lakes (Partridge

Breast, Northern Indian, and Fidler lakes) collected between February and September of 1973. Also, suspended sediment data collected on the lower Churchill River for the water intake at the Town of Churchill was reported by Manitoba Hydro (1977c). Turbidity and suspended sediment concentration were measured between 1972 and 1974 on the lower Churchill River at Missi Falls and Fidler Lake, Oldman River at Northern Indian Lake, Gauer River at Thorsteinson Lake, Little Churchill River at Rescluse Lake, Beaver River near mouth, and water intake for the Town of Churchill (Morelli 1975).

Guilbault *et al.* (1979) compare pre-CRD (1961-1976) and post-CRD (1976-1977) water quality parameters including turbidity on the lower Churchill River below Fidler Lake. The effect of the CRD on water quality of the Churchill River was also investigated by comparing water chemistry data for pre-development (from 1972 to 1976) and post-development (1976-1984) by Playle and Williamson (1986). Environment Canada (1982) published chemical, physical and biological surface water quality data collected during 1980 and 1981 for Manitoba. In this report, turbidity values were reported for the Churchill River upstream of Red Head Rapids. Water sampling for suspended sediment and chemical analysis were collected on the Churchill River at Missi Falls from July to October, 1981, by Manitoba Hydro (Manitoba Hydro 1982).

Since 2008, Northern Indian Lake and the Churchill River above the confluence with the Little Churchill River have been monitored for water quality parameters (including suspended sediment) four times annually under CAMP, and Partridge Breast, Fidler, and Billard lakes and the lower Churchill River at Red Head Rapids have been monitored every three years; the Churchill reservoir will be monitored in 2014/15 as part of CAMP (CAMP 2014b, CAMP *unpubl. data*).



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Legend

▲ Control Structures (C.S.)

RCEA
Erosion and Sedimentation Zone 5

4.3.7 ZONE 6 – SOUTH BAY CHANNEL TO NOTIGI CONTROL STRUCTURE

4.3.7.1 AREA OVERVIEW

This zone covers the Rat River system from the excavated outlet at the South Bay of Southern Indian Lake to the Notigi CS as shown in Map 4-20. Major lakes in this area include Issett, Rat, and Notigi. Notigi CS is the third main component of the CRD. It is a control structure on the Rat River that regulates the diversion flow into the Burntwood-Nelson River system.

4.3.7.2 EROSION

The LWCNRSB referred to the portion of the Rat River drainage system encompassing the river itself from Issett Lake to the Notigi CS and the adjoining lakes and major inflowing rivers as the Notigi reservoir (Water Resources Branch 1974). The terrain around the Notigi reservoir is generally bedrock-controlled with local areas of thicker overburden. LWCNRSB (1975) suggested that the effect of the diversion of the Churchill River into the diversion route would be greatest along the Rat River from Issett Lake to Karsakuwigamak Lake, where the river would be changed into a lake characterized by bedrock shorelines and actively eroding clay banks.

As part of the erosion monitoring program conducted by Manitoba Hydro along the CRD (Manitoba Hydro 1982a, 1983a, 1984, 1985a, 2001b), only one erosion monitoring site has been monitored within Zone 6. The site is located on Notigi Lake, just upstream of the Notigi CS. Surveys were completed in 1981 and then at least once each year from 1983 to 2001. At this location, the profile consists of silt-clay rhythmites with a blocky structure.

As described for Zone 5, McCullough (1990) discussed sedimentation and erosion within Southern Indian Lake and within the Notigi reservoir. The Notigi reservoir has almost 2,000 km of shoreline, mostly along irregular, narrow bays or protected by a complex array of islands. In the first years after impoundment, the Notigi reservoir produced little sediment. However, the limited available sediment concentration data showed that data from the summers of 1986 and 1987 were higher than in 1984. It was suggested that substantial erosion of the more protected shorelines common on Notigi reservoir would begin only after the protective vegetation matte was destroyed, and that it would peak later in the life of the reservoir.

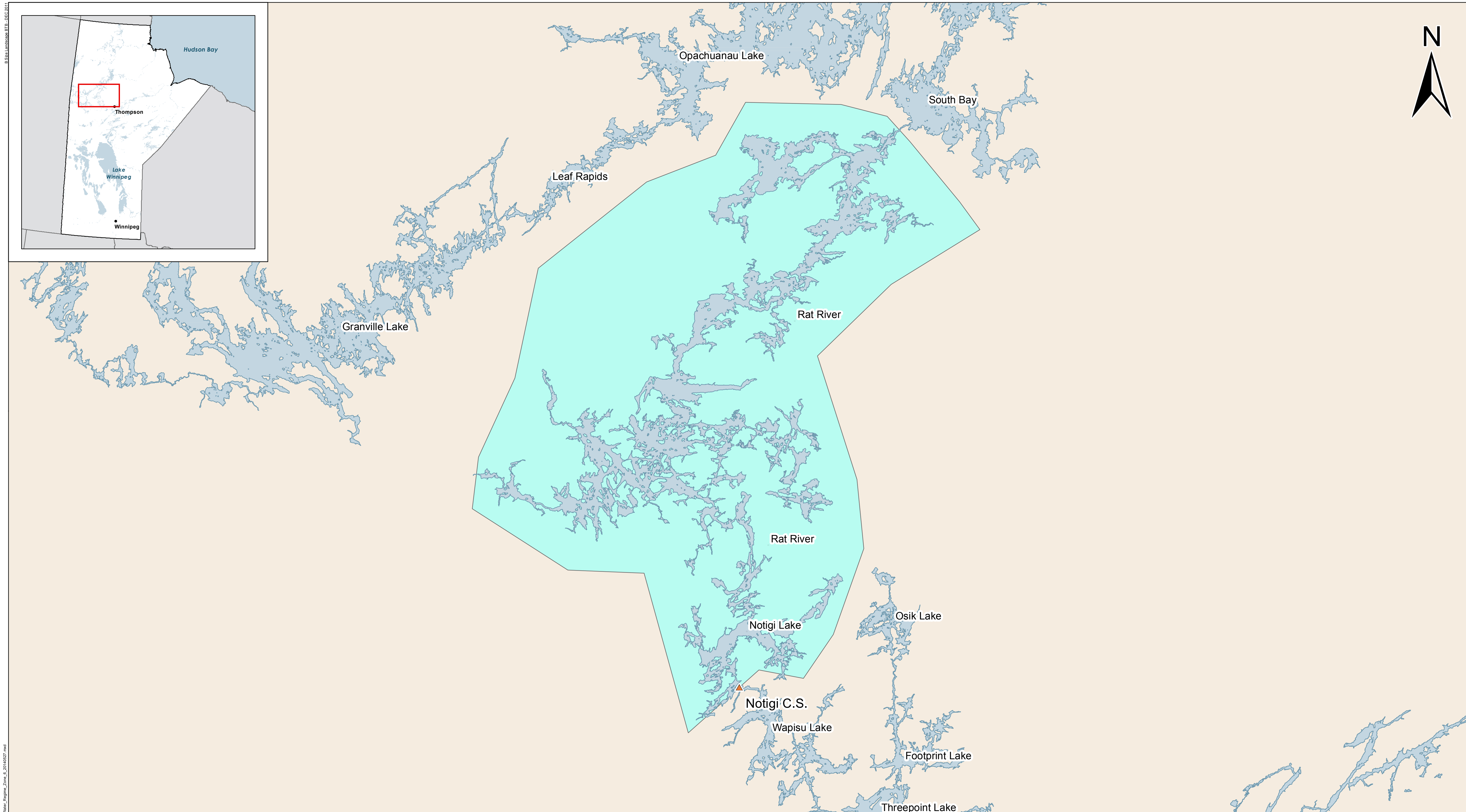
As part of the Keeyask Generation Project assessment, ECOSTEM Ltd. (2012a) studied peatland disintegration in portions of the Notigi reservoir. Peatland breakdown and land area losses over a 22 year period were documented, and potential physical and biological factors contributing to different rates of peatland breakdown and land area loss were evaluated.

4.3.7.3 SEDIMENTATION

Vitkin and Penner (1979) assessed the impact of the CRD projects on sedimentation along the waterway between South Bay and Notigi structures based on the suspended sediment data collected by Manitoba Department of Natural Resources. The effect of the CRD on water quality parameters including turbidity in the Churchill River at Granville Lake were investigated by comparing water chemistry data for pre-development (1972-1976) and post-development (1976-1984) by Playle and Williamson (1986). A Manitoba Hydro report (1982) summarized the results of 1981 (July to October) water sampling for suspended sediment concentration and chemical analysis collected in Notigi Lake. Bodaly *et al.* (1987) reported suspended sediment concentration collected in Granville, Notigi and East Mynarski lakes in the open water seasons of 1981 and 1982.

As part of the Wuskwatim GS aquatic environment studies, composition of bed materials in Notigi Lake was reported by Zrum and Neufeld (2003a) based on the sediment sampling conducted at four transects in 1999 and three transects in 2000.

Since 2008, Mynarski (Central basin), Rat, and Notigi (East and West basins) lakes have been sampled rotationally every three years for water quality parameters (including suspended sediment and turbidity) under CAMP (CAMP 2014b, CAMP *unpubl. data*).



Manitoba Hydro

DATA SOURCE:
Manitoba Hydro

CREATED BY:
Water Resources Engineering - Sediment & Ice Studies

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	23-MAY-14	27-MAY-14
0 6.5 13 Kilometres / 0 5.5 11 Miles	VERSION NO: 1.0	QA/QC: RDB / MRK

Legend

▲ Control Structures (C.S.)

RCEA
Erosion and Sedimentation Zone 6

4.3.8 ZONE 7 – NOTIGI CONTROL STRUCTURE TO EARLY MORNING RAPIDS

4.3.8.1 AREA OVERVIEW

This zone, shown in Map 4-21, covers the Rat/Burntwood River system from the Notigi CS to Early Morning Rapids. Major lakes in this zone include Wapisu Lake, just downstream from Notigi, and Threepoint Lake. Footprint Lake and Osik Lake are also in this zone along the Footprint River, which is a tributary to the Burntwood River.

4.3.8.2 EROSION

The LWCNRSB divided Zone 7 into lake areas and river reaches between lakes (Water Resources Branch 1974). Approximately 90% of the Wapisu Lake shoreline is bedrock-controlled. Most of these shorelines are low bedrock shorelines with shallow backshore overburden, with a smaller amount characterized as bedrock shorelines with an overburden beach. Clay shorelines and willow shorelines can be found in embayments. Low bedrock shorelines are common on Threepoint Lake, with most areas between bedrock shoreline segments characterized by clay shorelines of low height. Beaches are common on Threepoint Lake.

LWCNRSB (1975) predicted the erosional response of Zone 8 to the CRD and regulation at the Notigi CS. The impact on lakeshores underlain by bedrock was anticipated to involve erosion until bedrock was reached. Dead trees were expected to clutter these shorelines indefinitely, and embayments and other protected shorelines would remain congested with standing dead trees. Steep clay banks would continue to erode, but at an accelerated rate.

As part of the erosion monitoring program conducted by Manitoba Hydro along the CRD (Manitoba Hydro 1982a, 1983a, 1984, 1985a, 2001b), several sites within Zone 7 were monitored in 1981. However, the number of sites monitored in this area gradually decreased to one by 2001. This site is located on Threepoint Lake, and it has been surveyed in 1981 and then at least once each year from 1983 to 2001. In 1981, there were three sites near Nelson House, one just downstream of the Notigi CS and one near Gate Falls on the Burntwood River.

In May 1980, Manitoba Hydro retained MacLaren Engineers Inc. and Intergroup Consulting Engineers Ltd. to conduct an environmental overview of options for the development of power potential along the Rat-Burntwood diversion route. Most of the environmental work was conducted in 1980 and 1981, and the final report was released in 1984 (MacLaren/Intergroup 1984a). MacLaren/Intergroup (1984d) reported on the Wuskwatim reach, between the Notigi CS and Taskinigup Falls as it appeared in 1980, after three years of diversion flows. Some evidence was observed of locally significant erosion along river channels. The main areas of erosion identified were on Threepoint Lake within the Nelson House Reserve area, on the Rat River upstream and downstream of Wapisu Lake, and at Gods Rapids. Extensive erosion of lake shorelines had not taken place in this zone, although localized slumping was noted in coarse-grained and clay shorelines oriented towards the prevailing winds and exposed to long open water fetches.

Manitoba Hydro (1987) repeated the lake and river shoreline classification of the diversion route first presented in the Physical Impact Study (Water Resources Branch 1974). The classified reach extends from Notigi to Split Lake. The reclassification was based on 1:20,000 scale air photos flown in the summer of 1986.

Kellerhals Engineering Services Ltd. (1988) compared pre- and post-diversion lake surface areas and shoreline lengths in parts of Threepoint and Footprint lakes and along a river section between the two lakes. The evaluated lake areas increased by 36 to 53% post-diversion, while the river section between the lakes increased by 158%.

Kellerhals Engineering Services Ltd. (1988) also carried out feasibility studies to use historical air photos to map the distribution of three types of features that increased in abundance along the Rat-Burntwood system following the CRD: 1) inundated standing dead trees or accumulations of large floating debris, 2) unstable eroding materials, and 3) shallow water depths. The data from Footprint Lake indicated that prior to diversion, areas of shallow water depths or showing the presence of floating or submerged vegetation were limited to low gradient deltas near tributary streams. Cleared or eroding shorelines were similarly restricted to disturbed areas near Nelson House. Following diversion, extensive areas of former shoreline were flooded and this resulted in the generation of large amounts of dead standing trees, floating or submerged vegetation, and extensive areas with shallow water depths. The lengths of eroding shoreline increased from 4 km to 40 km, indicating the potential for widespread sediment production.

In addition to the feasibility studies described above, Kellerhals Engineering Services Ltd. (1988) also made estimates of the volume of material eroded at two sites within Zone 7. At Footprint Lake, a comparison of 1954 (1:61,000) and 1972 (1:24,000) air photos indicated no detectable change in shoreline position. Photography taken in 1985 (1:20,000) indicated generally much more turbid water conditions with localized sediment plumes extending off many of the west-facing shorelines and an average of 30 m of recession over a stretch of shoreline 300 m in length. The other site where volume estimates were made was in the reach that includes Gods, Caribou and Early Morning rapids. Five segments of river channel near the major rapids were selected for detailed study. The analysis indicated that approximately 50% of the total shoreline in the five segments were actively retreating.

Baracos and Galay (1973a) investigated shoreline stability, wave erosion and slope stability for the settlement of Nelson House. Flooding of the land, wave erosion and destabilization of marginally stable slopes were the main problems expected to arise from the CRD. Fourteen cross sections were surveyed with boreholes drilled at locations where bedrock outcrop was not evident.

Penner (1974) developed setback lines for the settlement of Nelson House based on the assumption that no protective works would be constructed. The setback line was developed based on a consideration of flooding, erosion and bank stability.

Manitoba Hydro (1982b) predicted short-term and long-term erosion at Nelson House in the areas not protected by riprap, and they defined areas to be protected in the future to prevent serious erosion. Work was carried out in 1977 and 1978 to protect six major road crossings and three cemeteries. Riprap work on three major reaches of shoreline and one cemetery was carried out in the winter of 1981-82. Erosion rates at Nelson House were established based on transects surveyed at twenty sites in 1980 and 1981, with rates of 0.3 to 2.7 m per year and an average of 1 m per year.

4.3.8.3 SEDIMENTATION

Water samples for determination of suspended sediment concentration and chemical analysis were collected on the Rat River downstream of Notigi and upstream of Threepoint Lake in summer-fall of 1969 to 1972 (Manitoba Hydro 1970, 1971, 1973).

Sedimentation processes in the area between the Notigi CS and Early Morning Rapids were discussed in the LWCNRSB report (1975a). In this study, sediment and water quality data collected by federal and provincial agencies prior to 1972 were analyzed along with the 1972-1974 sediment data reported by Morreli (1975) for the Footprint River at Threepoint Lake, and the Rat River at Threepoint Lake.

The effect of the CRD on sediment transport along the Rat-Burntwood rivers from Notigi downstream was assessed by Underwood McLellan & Associates (1973a). The pre-CRD assessment was based on limited suspended sediment data collected by Manitoba Hydro, Water Survey of Canada, or private consultants at various locations from Threepoint Lake to upstream of Spilt Lake between 1968 and 1972. Post-CRD sediment load was estimated with sediment contributions coming from the Churchill River, natural erosion processes (existing shoreline slumping, sheet erosion), eroding shorelines, and channel erosion.

Underwood McLellan & Associates (1973b) proposed a suspended sediment monitoring program in the pre-diversion period and several years following diversion. The proposed monitoring included suspended sediment and bed material sampling.

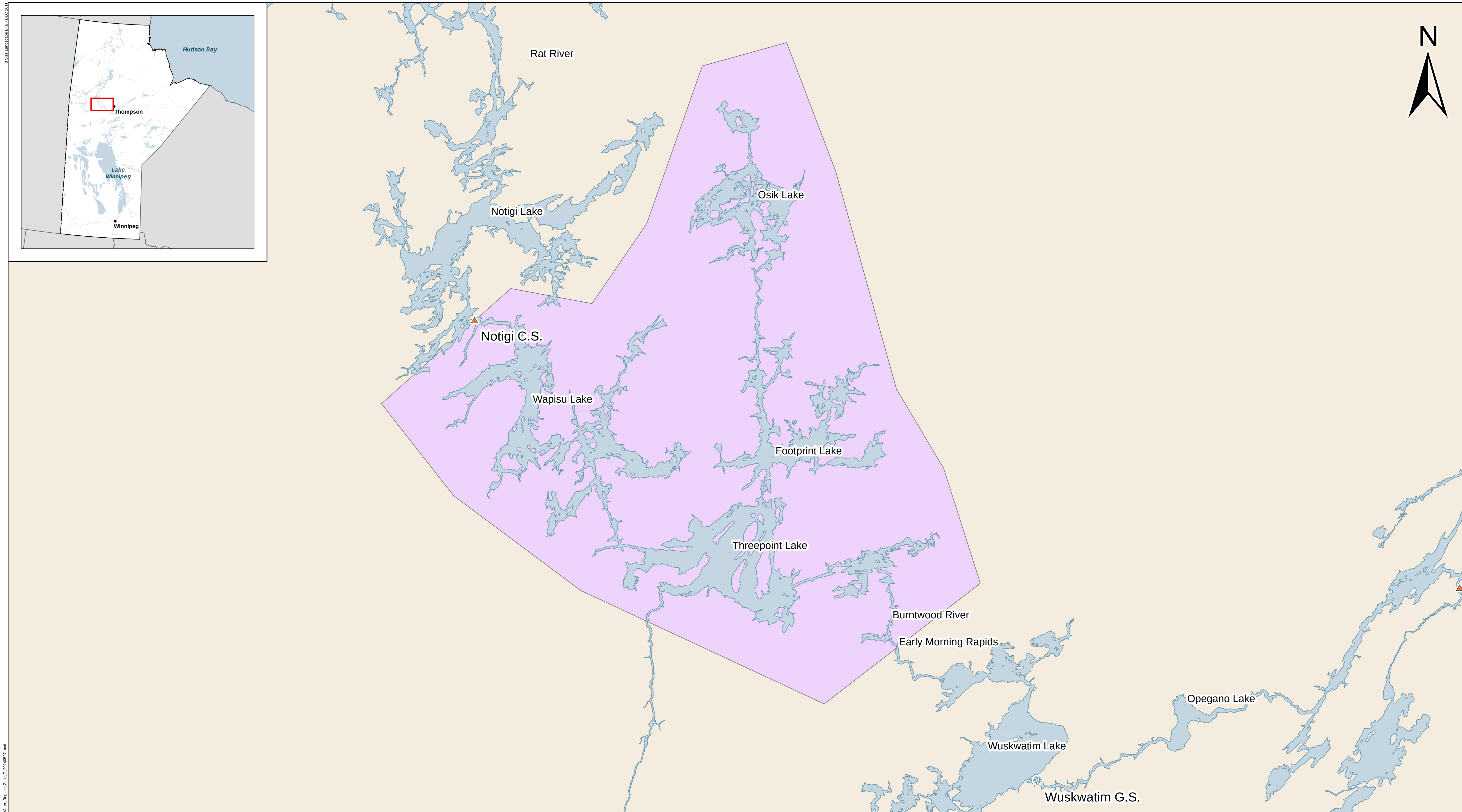
Vitkin and Penner (1979) assessed the impact of the CRD projects on sedimentation upstream of Threepoint Lake based on the suspended sediment data collected by the Manitoba Department of Natural Resources. Suspended sediment concentrations collected in Footprint Lake for the open water season of 1981 were reported by Bodaly *et al.* (1987). In 1981, Manitoba Hydro collected water samples for suspended sediment concentration and chemical analysis in Footprint River, Footprint Lake, Threepoint Lake, and Mystery Lake (Manitoba Hydro 1982).

As part of the Wuskwatim GS EIS studies, suspended sediment data was collected during summer of 1999, 2000, and 2001 in Kinosaskaw Lake located upstream of Early Morning Rapid (Wuskwatim EIS Vol. 5, 2003c).

As part of the Wuskwatim GS aquatic environment studies, bottom substrate samples were collected and analyzed for particle size composition from Threepoint Lake in 1998-2000 (Zrum and Neufeld 2003b; Zrum and Kroeker 1999a), Wapisu Lake in 1999-2000 (Zrum *et al.* 2003), and Footprint Lake in 1999-2001(Zrum and Neufeld 2003c).

Some sediment data has also been collected from Threepoint Lake, Rat River and backwater inlets upstream of Threepoint Lake and Leftrook Lake since 2007 as part of the Wuskwatim GS Aquatic Effects Monitoring Plan (AEMP). Collected data includes TSS, turbidity, substrate type, and sediment depositional rate (Wuskwatim GS AEMP 2007b). A summary of each year's AEMP monitoring activities are presented in the AEMP annual reports. Blanchard and Schneider-Vieira (2009) summarized the 2007 aquatic habitat baseline monitoring in the Wuskwatim GS area. As part of this program, six sediment traps were deployed in Threepoint Lake in May 2007 and removed in September 2007. Grain size distribution and total dry weight of sediment deposited in each of the traps were analyzed and presented.

As part of CAMP, Threepoint Lake has been monitored for water quality four times annually since 2009, and Footprint and Apussigamasi lakes and the Burntwood River below First Rapids have been monitored rotationally every three years (CAMP 2014b, CAMP *unpubl. data*).



Manitoba Hydro

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Legend

- Existing Generating Stations (G.S.)
- Control Structures (C.S.)

RCEA
Erosion and Sedimentation Zone 7

Map 4-21

4.3.9 ZONE 8 – EARLY MORNING RAPIDS TO WUSKWATIM GS

4.3.9.1 AREA OVERVIEW

This zone covers the portion of the Burntwood River between Early Morning Rapids and the Wuskwatim GS, which includes Wuskwatim Lake as shown in Map 4-22. The Wuskwatim GS was completed in 2012 and is owned by the Wuskwatim Power Limited Partnership (WPLP), a legal entity involving Nisichawayasihk Cree Nation and Manitoba Hydro.

4.3.9.2 EROSION

The LWCNRSB classified about one-half of the Wuskwatim Lake shoreline as bedrock-controlled, with the rest classified as low alluvial and marsh types (Water Resources Branch 1974). LWCNRSB (1975) predicted the erosional response of Zone 8 to the CRD and regulation at the Notigi CS. The impact on lakeshores underlain by bedrock was anticipated to involve erosion until bedrock was reached. Dead trees were expected to clutter these shorelines indefinitely, and embayments and other protected shorelines would remain congested with standing dead trees. Steep clay banks would continue to erode, but at an accelerated rate.

As part of the CRD erosion studies (Manitoba Hydro 1982a, 1983a, 1984, 1985a, 2001b), a few sites within Wuskwatim Lake had been monitored since 1981. However, the CRD monitoring program did not provide site-specific data to assess erosion impacts in the Wuskwatim development area. As a result, in order to assess shoreline erosion for the pre-Wuskwatim development condition, several new sites were established in 1989 with more added in 1993. The new monitoring program was referred to as the Physical Environment Monitoring Program (PEMP), and the three following paragraphs describe the results from three annual reports (Manitoba Hydro 2001a, 2008, 2012).

Manitoba Hydro (2001a) summarized the available CRD erosion monitoring data from 1989 through 2000. Data for each site includes a site plan, erosion transect survey profiles, photographs, field notes, and a textual description of the geology, erosional activity and a qualitative prediction of future erosion. Bank heights ranged from 2 to 10 m with erosion scarp heights of 0.5 to 5 m. Horizontal bank loss measurements were based on sequential measurements of the horizontal distance from a survey control point above the top of bank to the leading edge of the erosional scarp. This method was the same as that used by the Freshwater Institute on their erosion studies on Southern Indian Lake. Horizontal bank loss was as much as 11.6 m over the monitoring period.

Manitoba Hydro (2008) summarized erosion transect data collected in 2006 and 2007 at 27 lakeshore sites on Wuskwatim, Opegano and Birch Tree lakes and at eight sites on the Burntwood River downstream of the Wuskwatim GS. Top of bluff recession and cross sectional erosion were measured from erosion transects. Top of bluff recession measured from 2006 and 2007 transects was 52% higher than the historical average rates. The 52% increase was interpreted to be caused by high water levels during and preceding the 2006 and 2007 surveys.

Manitoba Hydro (2012) summarized erosion monitoring results obtained from profiles surveyed in 2006, 2007, 2008, 2009, and 2011 in this area. The 2011 survey represents the final survey prior to operation of the Wuskwatim GS. Average top of bluff recession rates for lakeshore sites surveyed between 2006 and 2011 was 1.0 m/y while historical rates measured between 1989 and 2000 were 0.59 m/y.

As part of ongoing studies to characterize the physical environment associated with the Wuskwatim Development Project, JDMA (2002) classified riverbanks and lake shorelines upstream and downstream of Wuskwatim Lake, and mapped changes in riverbank and lake shoreline position from 1985 to 1998 air photos. The upstream section extends from Early Morning Rapids to Cranberry Lake.

MacLaren/Intergroup (1984c) conducted an erosion study within the Wuskwatim reach, between the Notigi CS and Taskinigup Falls, after three years of diversion flows. Some evidence was observed of locally significant erosion along river channels. The main riverine areas of erosion identified in Zone 8 were downstream of Early Morning Rapids where the river makes a sharp 'S' bend. These eroding areas were generally characterized by steeply-banked overburden deposits of varying thickness. These materials were suggested to be extremely sensitive to changes in water level. Extensive erosion of the lake shorelines had not taken place in the lakes of the Wuskwatim reach, although a site along the south shore of Wuskwatim Lake was identified as an erosion hot spot.

Kellerhals Engineering Services Ltd. (1988) estimated erosion volumes at the southern shore of Wuskwatim Lake in order to test the feasibility of using air photos and topographic data to estimate sediment volumes produced by erosion. Comparative air photo studies were undertaken along an 8 km section of the southwest shore of Wuskwatim Lake. No detectable change was observed in shoreline position when comparing 1955 and 1972 photos. Photography taken in 1985 indicated extensive areas undergoing active erosion, with eroded trees littering the nearshore and highly turbid water conditions along the foreshore. Given the small scale of the 1972 photos (1:50,000), bank recession rates in the period up to 1985 were frequently smaller than what could be readily detected with the available equipment. Total bank retreat in the order of 10 to 15 m was indicated at some sites, indicating average recession rates of 2 m/y.

JDMA has conducted several erosion studies on Wuskwatim Lake (JDMA 1991, 1992a,b,c, 1993). JDMA (1992c) used air photos to measure shore recession at points on clay segments of shoreline around Wuskwatim Lake. Pre- and post-CRD shore erosion was estimated from comparison of 1950 and 1972, and 1978 and 1985 air photos, respectively. Several measurement accuracy problems were identified and solutions were discussed. Average annual shore erosion estimates were about 0.7 m/y in the 1950-1972 pre-diversion period and 1.9 m/y in the 1978-1985 post-diversion period. JDMA (1992a) presented the results of an office and field study to predict shore erosion around the proposed Wuskwatim reservoir. The primary objectives of the study involved gaining a better understanding of erosion processes and, based on this, developing a numerical shore erosion predictive model for permafrost-affected reservoirs. The model was then used to predict shore bank positions 25, 50, 100, and 300 years after reservoir impoundment. Terrain maps of the Wuskwatim study area were developed and correlated with ecological land classification maps. The terrain maps were used in the erosion prediction. JDMA (1998) conducted a comparative evaluation of anticipated shore erosion impacts for two possible scenarios of forebay development. The primary output parameter on which the assessment was based was the predicted sediment volume likely to be eroded from the shore zone under the two forebay elevations considered.

Volume 4 of the Wuskwatim EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003a) provides information on the physical environment. Section 6 presents information on erosion around Wuskwatim Lake, including the classification of the shoreline into four main types and the prediction of future erosion.

Manitoba Hydro (2008) summarized erosion transect data collected in 2006 and 2007 at 27 lakeshore sites on Wuskwatim, Opegano, and Birch Tree lakes and at eight sites on the Burntwood River downstream of the Wuskwatim GS. Bioremediation measures were implemented at several test sites in Wuskwatim Lake sometime after 2009 to test the effectiveness of these techniques for reducing shoreline erosion. However, no reports from this project have been made available at this time.

ECOSTEM Ltd. conducted several peatland disintegration and shoreline studies in the Wuskwatim Lake area, as a component of the Wuskwatim Generation Project environmental assessment (Manitoba Hydro and Nisichawayasihk Cree Nation 2003b) and post-project monitoring. For the environmental assessment studies, historical air photos were used to document historical peatland breakdown rates and land area losses over a 24 year period following implementation of the CRD. Different rates of peatland breakdown were related to physical factors. Factors controlling peatland disintegration processes in the Wuskwatim Lake area were further evaluated in ECOSTEM Ltd. (2012a) through comparisons with other locations on the Rat/Burntwood and Nelson rivers that have been affected by hydroelectric flooding and water regulation.

4.3.9.3 SEDIMENTATION

Water samples for determination of suspended sediment concentration and chemical analysis were collected from Wuskwatim Lake in summer-fall of 1969 to 1972 (Manitoba Hydro 1970, 1971, 1973).

The effect of the CRD on sediment transport along the Rat-Burntwood rivers downstream of Notigi was assessed by Underwood McLellan & Associates (1973a). The pre-CRD assessment was based on limited suspended sediment data collected by Manitoba Hydro, Water Survey of Canada, or private consultants at various locations from Threepoint Lake to upstream of Spilt Lake between 1968 and 1972. Post-CRD sediment load was estimated with sediment contributions coming from the Churchill River, natural erosion processes (existing shoreline slumping, sheet erosion), eroding shoreline, and channel erosion.

A suspended sediment monitoring program was proposed in the pre-diversion period and several years following diversion (Underwood McLellan & Associates 1973b). The proposed monitoring included suspended sediment and bed material sampling.

Manitoba Hydro (1982) collected water samples for suspended sediment concentrations and chemical analysis in Wuskwatim Lake from July to October 1981.

As part of the Wuskwatim GS aquatic environment studies, bottom sediment and water transparency samples were collected and analyzed for particle size composition in Wuskwatim Lake in 1998 (Zrum and Kroeker 1999b).

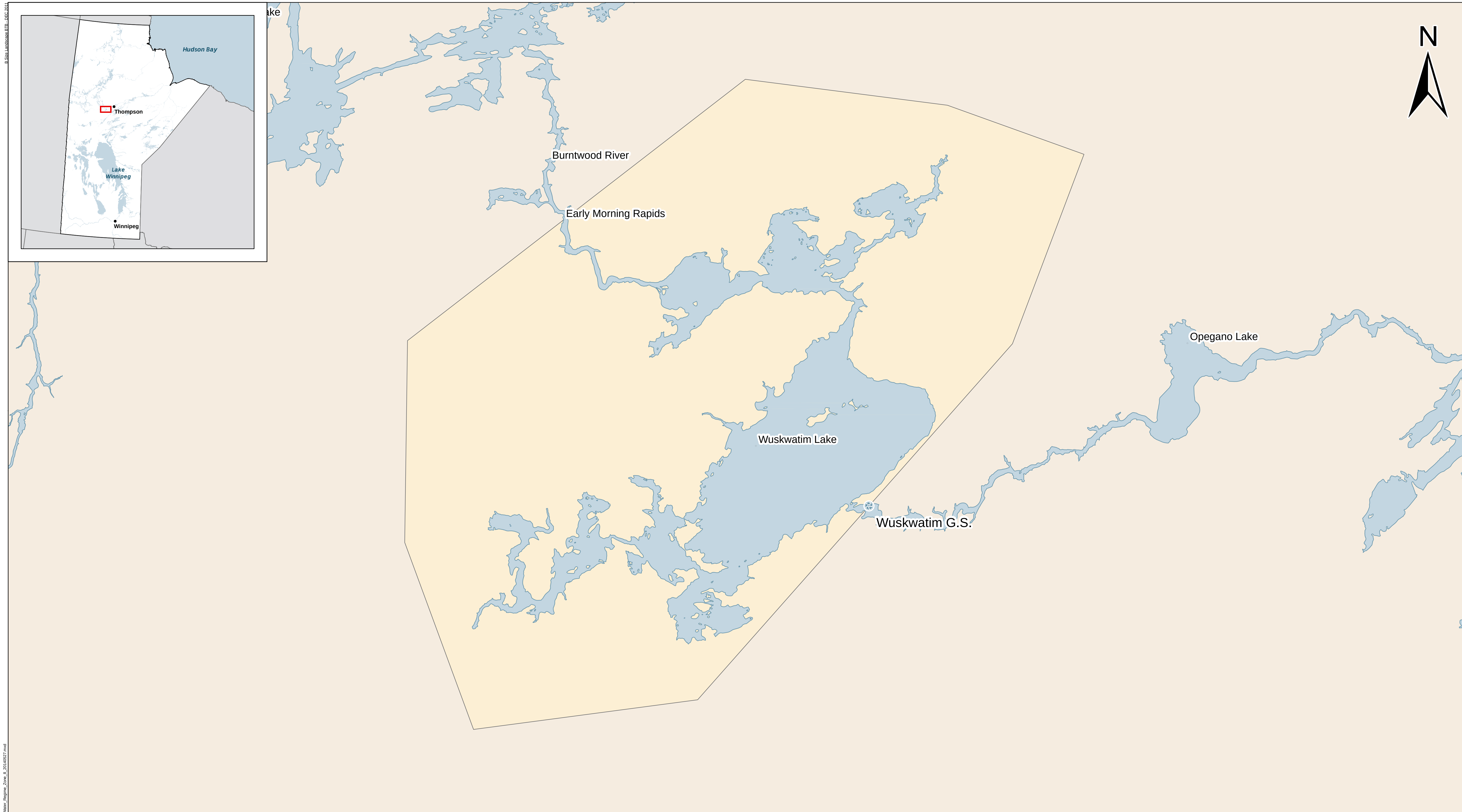
Sediment deposition rate in Wuskwatim Lake was investigated between 1999 and 2001 using sediment traps and coring (Bezte and Richardson 2004). Sediment traps were set up in summer of 1999 and 2000 at 10 locations. The collected sediment in the traps comprised of clay and silt. Sediment cores were taken from a 10 m deep area in Wuskwatim Lake in 2001. Radiochemical analyses were carried out on these samples.

The Wuskwatim GS EIS presented the pre-construction sediment load and sedimentation processes in the Wuskwatim GS Project area and evaluated the potential effects of the lake erosion changes associated with construction and operating of the Project on sedimentation in Wuskwatim Lake (Wuskwatim EIS Vol. 1, 2003a). A sediment budget model was created for Wuskwatim Lake using limited sediment data available at the time of the study (Wuskwatim EIS Vol. 4, 2003b). As part of the EIS studies, suspended sediment data was collected during summer of 1999, 2000, and 2001 on the Burntwood River downstream of Early Morning Rapids, downstream of Cranberry Lake, and downstream of Taskinigup Falls, on the Wuskwatim Brook, and in Sesep and Wuskwatim lakes (Wuskwatim EIS Vol. 5, 2003c).

KGS Acres (2009g) analyzed sediment data (including turbidity and TSS concentration) collected in 2003 in an area from Wuskwatim Lake to Spilt Lake. The report discussed the nature of TSS distribution in Wuskwatim Lake and its dependency on climate factors such as wind. It also presented a relationship between Tu and TSS.

The Wuskwatim Generation Project PEMP was initiated by Manitoba Hydro on behalf of the Wuskwatim Power Limited Partnership to document various physical environment parameters during the construction and operational phases of the Project (Wuskwatim Generation Project PEMP 2007a). As part of this monitoring program, sediment parameters including suspended sediment, bedload, bed material and turbidity data have been collected on the Burntwood River from Early Morning Rapids to Split Lake since 2005. The water quality and sedimentation data collected under this program are presented in several reports prepared by KGS Acres (2008a, 2010a, b, c, d, e, 2011) and HATCH (2011a, b, c, 2012, 2013a, b, c). A summary of each year's PEMP monitoring activities and collected sediment data are presented in the PEMP annual reports. The latest PEMP report presents sediment data collected in 2012 along with a summary of the sediment data collected since 2005 under this program (Wuskwatim Generation Project PEMP 2012/2013 Annual Report, 2013).

Some sediment data has also been collected in Wuskwatim Lake since 2007 as part of the Wuskwatim GS AEMP. Collected data includes TSS, Tu, substrate type, and sediment depositional rate (Wuskwatim GS AEMP 2007b). A summary of each year's AEMP monitoring activities are presented in the AEMP annual reports. Blanchard and Schneider-Vieira (2009) summarized the 2007 aquatic habitat baseline monitoring in Wuskwatim Lake. Some of the specific objectives of this program were to provide information on pre-impoundment conditions in the Wuskwatim GS study area for the substratum along transects off of eroding and non-eroding shorelines, and rates of sediment deposition as measured in sediment traps in the same area. Three transects were sampled in 2007 to determine the lake bed material type. Nine sediment traps were deployed in Wuskwatim Lake in May, 2007 and removed in September 2007. Grain size distribution and total dry weight of sediment deposited in each of the traps were analyzed and presented.



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Legend

Existing Generating Stations (G.S.)

RCEA
Erosion and Sedimentation Zone 8

Map 4-22

4.3.10 ZONE 9 – WUSKWATIM GS TO SPLIT LAKE INLET

4.3.10.1 AREA OVERVIEW

This zone covers the portion of the Burntwood River downstream of the Wuskwatim GS to the inlet of Split Lake as shown in Map 4-23. Major lakes in this zone include Opegano, Ospwagan, Birch Tree, Mystery, and Apussigamasi.

4.3.10.2 EROSION

The LWCNRSB divided Zone 9 into several reaches (Water Resources Branch 1974). The Burntwood River flows through glacial Lake Agassiz deposits in this area. The majority of the shorelines and backshore areas are represented by silts and clays overlying bedrock. In general, irregular and narrow channel sections contain bedrock shorelines while widenings in the channel and embayments contain clay banks. Opegano and Birch Tree lakes are situated in deep deposits of lacustrine material where shoreline instability is common. The Burntwood River between these lakes is generally bedrock-controlled. Apussigamasi Lake is largely bedrock-controlled, with heavy overburden in embayments. The river channel to Split Lake rests on bedrock, with thick lacustrine deposits present locally.

LWCNRSB (1975) predicted the erosional response of Zone 9 to the CRD and regulation at the Notigi CS. Lakeshores underlain by bedrock and those characterized by steep clay banks were predicted to respond similar to those described in Zone 7 and 8. Along river channel reaches, an increase in channel size was anticipated, both vertically and laterally, with little change occurring where the channel was bedrock-controlled but perhaps up to 20 m of retreat on either side of the channel where the channel width was controlled by clay shores. The main difference anticipated between rivers and lakeshores was the removal of flooded and fallen trees, with riverbanks not expected to contain the amount of dead standing trees expected along protected lakeshores.

As part of the CRD erosion studies (Manitoba Hydro 1982a, 1983a, 1984, 1985a, 2001b), nine sites within Zone 9 were monitored in 1981. Manitoba Hydro (2001b) compiled the available survey data since 1981 at nine erosion monitoring sites within Zone 9. Each site was also described in terms of the extent and types of erosion observed, and field photographs were provided for most sites. The monitoring locations in this zone include sites on Opegano and Birch Tree lakes, at the Thompson pumphouse, sewage plant and cemetery, and at First Rapids and Manasan Falls. Two of the three sites downstream of the Manasan Falls CS displayed considerable erosion, as they were located on the south shore of the Burntwood River in the direct path of flows that passed through the control structure.

Manitoba Hydro (2008) summarized erosion transect data collected in 2006 and 2007 at sites along the Burntwood River between the foot of Early Morning Rapids and Birch Tree Lake. Manitoba Hydro (2012) summarized erosion monitoring results obtained from profiles surveyed in 2006, 2007, 2008, 2009, and 2011 in this area. Erosion was observed on the south shore of the Burntwood River just downstream of the Wuskwatim GS due to a deviation in the construction sequence, which resulted in flow being directed at an unprotected bank.

As part of ongoing studies to characterize the physical environment associated with the Wuskwatim Development Project, JDMA (2002) classified riverbanks and lake shorelines upstream and downstream of Wuskwatim Lake, and mapped changes in riverbank and lake shoreline position from 1985 to 1998 air photos. The downstream section extends from Taskinigup Falls to First Rapids.

Volume 4 of the Wuskwatim EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003a) provides information on the physical environment. Section 7 presents a prediction of downstream riverbank erosion.

Kellerhals Engineering Services Ltd. (1988) estimated erosion volumes at First Rapids in order to test the feasibility of using air photos and topographic data to estimate sediment volumes produced by erosion. Prior to the CRD, First Rapids consisted of three bedrock-controlled sills. Bedrock was exposed on both channel banks, and the valley walls confined the river channel continuously. Following diversion, the width of the channel near First Rapids widened substantially and additional bedrock became exposed. An estimated 60,000 to 270,000 m^3 of sediment was removed from this area between 1970 and 1981.

MacLaren/Intergroup (1984c) provided some information on erosion within the Manasan Falls reach, extending between Taskinigup Falls and Manasan Falls. MacLaren/Intergroup (1984b) conducted an erosion study along the First Rapids reach, between Manasan Falls and Split Lake. Significant erosion was observed mainly at the major rapids and at a few exposed lakeshore sites.

Baracos and Galay (1973c) evaluated the regime of the Burntwood River near Thompson, the state of the riverbanks, and the extent of low-lying facilities, and then predicted the effect of the CRD. The report included a discussion of the stability of the banks of the Burntwood River near Thompson. Severe local instabilities of the bank have been caused by gullying where flows from drains have been routed to the top of the bank. Some evidence of localized shoreline erosion due to waves caused by either wind or boat traffic had been observed.

4.3.10.3 SEDIMENTATION

Pre-development water samples for determination of suspended sediment concentration and chemical analysis were collected on the Burntwood River (downstream of Birch Tree Lake and upstream of Thompson), Manasan, and Odei rivers in the summer-fall of 1969 to 1972 (Manitoba Hydro 1970, 1971, 1973). Also, turbidity, as a surrogate for suspended sediment, was collected as part of the water quality program in the Burntwood River at the Thompson and Birch Tree mine pumphouses from 1974 to 1976 (Manitoba Hydro 1976, 1977c).

Sedimentation processes in this zone were discussed in the LWCNRSB report (1975a). In this study, sediment and water quality data collected by federal and provincial agencies prior to 1972 were analyzed along with the 1972-1974 sediment data reported by Morreli (1975) for the Burntwood River at Thompson and Taylor River at Thompson (Pipe Lake).

The effect of the CRD on sediment transport in this zone was assessed by Underwood McLellan & Associates (1973a). The pre-CRD assessment was based on limited suspended sediment data collected by Manitoba Hydro, Water Survey of Canada, or private consultants at various locations from Threepoint Lake to upstream of Spilt Lake between 1968 and 1972.

A suspended sediment monitoring program was proposed in the pre-diversion period and several years following diversion (Underwood McLellan & Associates 1973b). The proposed monitoring included suspended sediment and bed material sampling.

Vitkin and Penner (1979) assessed the impact of the CRD projects on sediment regime in the Burntwood River (downstream of Wuskwatim Lake, downstream of First Rapids, and upstream of Split Lake) and at Manasan Falls based on the suspended sediment data collected by the Manitoba Department of Natural Resources. Guilbault *et al.* (1979) compared pre-CRD (1961-1976) and post-CRD (1976-1977) water quality parameters including turbidity in Burntwood River near Thompson.

Post-CRD water samples were collected for suspended sediment concentration and chemical analysis on the Burntwood River, Thompson pumphouse, Birch Tree Lake, Ospwagan Lake, Mystery Lake, and Odei River from July to October 1981 by Manitoba Hydro (Manitoba Hydro 1982). The effects of LWR and the CRD on water quality of the Burntwood at Thompson was also investigated by comparing water chemistry data for pre-development (from 1972 to 1976) and post-development (1976-1984) by Playle and Williamson (1986).

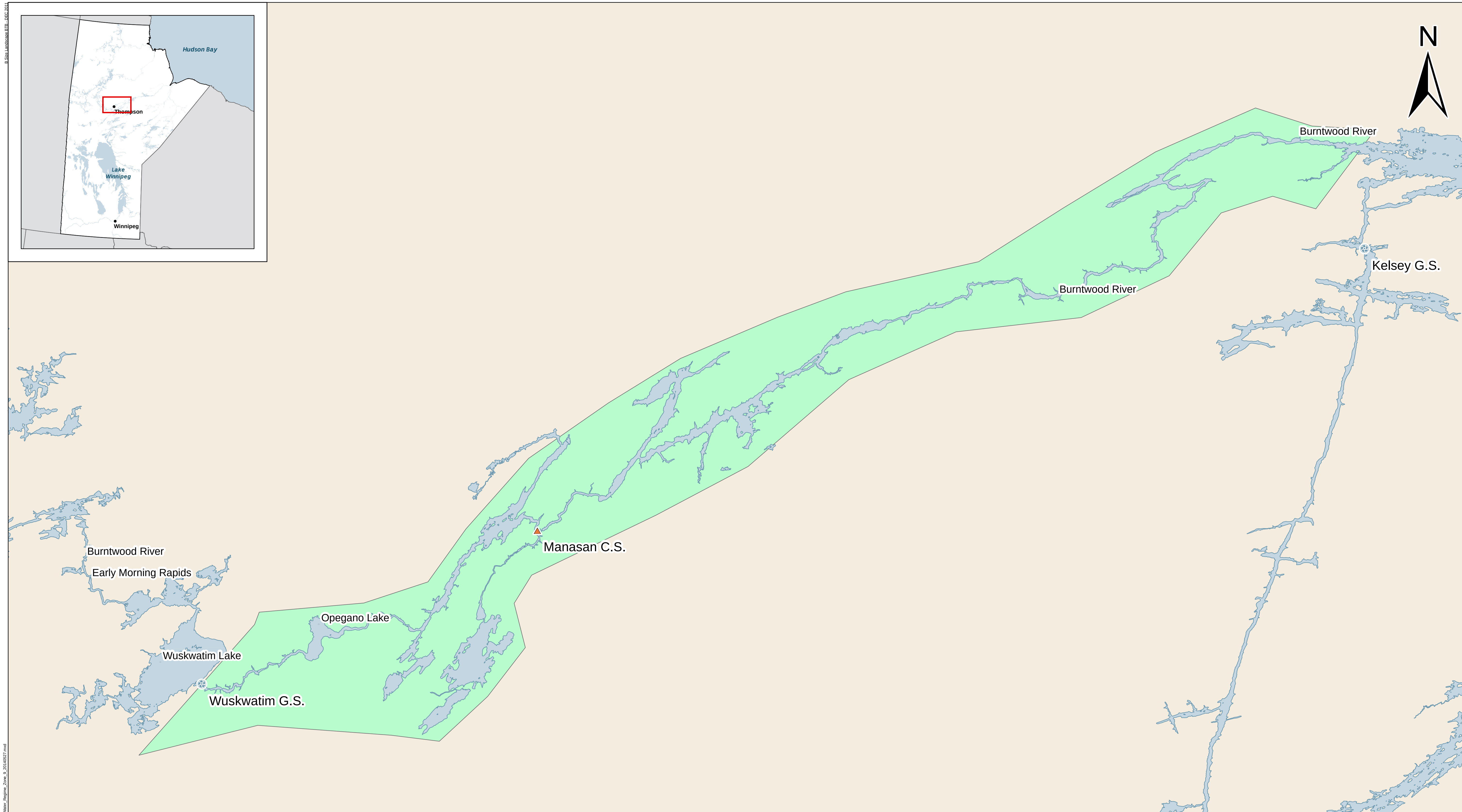
As part of the Wuskwatim GS aquatic studies, bottom substrate samples were collected and analyzed for particle size composition in Birch Tree Lake in 2000 and 2001 (Zurm and Neufeld 2003d) and in Opegano Lake and the Burntwood River (between Wuskwatim and Opeganao lakes) from 1998 to 2001 (Zrum and Juliano 2004).

KGS Acres (2009g) analyzed sediment data (including turbidity and TSS concentration) collected in 2003 along the Burntwood River from Wuskwatim Lake to Spilt Lake, and in Opegano and Birch Tree lakes. The report discussed the nature of TSS distribution and its dependency on climate factors such as wind in the Burntwood River, and Opegano and Birch Tree lakes. It also presented a relationship between Tu and TSS.

The Wuskwatim GS EIS presented the pre-construction sediment load and sedimentation processes in the Wuskwatim GS project area and evaluated the potential effects of the lake erosion changes associated with construction and operating of the project on sedimentation in the Burntwood River (Wuskwatim EIS Vol. 1, 2003a).

Wuskwatim Generation PEMP was initiated by Manitoba Hydro on behalf of the Wuskwatim Power Limited Partnership to document various physical environment parameters during the construction and operational phases of the Project (Wuskwatim Generation Project PEMP 2007a). As part of this monitoring program, sediment parameters including suspended sediment, bedload, bed material and turbidity data have been collected on the Burntwood River from Early Morning Rapids to Split Lake since 2005. The water quality and sedimentation data collected under this program are presented in several reports prepared by KGS Acres (2008a, 2010a, b, c, d, e, 2011) and HATCH (2011a, b, c, 2012, 2013a, b, c). A summary of each year's PEMP monitoring activities and collected sediment data is presented in the PEMP annual reports. The latest PEMP report presents sediment data collected in 2012 along with a summary of the sediment data collected since 2005 under this program (Wuskwatim Generation Project PEMP 2012/2013 Annual Report, 2013).

Some sediment data has also been collected on the Burntwood River between the Wuskwatim GS and Split Lake since 2007 as part of the Wuskwatim GS AEMP. Collected data includes TSS, turbidity, substrate type, and sediment depositional rate (Wuskwatim GS AEMP 2007b). A summary of each year's AEMP monitoring activities is presented in the AEMP annual reports. The turbidity data collected under this program are presented in several reports prepared by KGS Acres (2010b, 2011) and HATCH (2012, 2011c).



Manitoba Hydro

DATA SOURCE:
Manitoba Hydro

CREATED BY:
Water Resources Engineering - Sediment & Ice Studies

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
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Legend

- Existing Generating Stations (G.S.)
- Control Structures (C.S.)

RCEA
Erosion and Sedimentation Zone 9

Map 4-23

4.3.11 Zone 10 – Split Lake to Gull Rapids

4.3.11.1 Area Overview

This zone covers the lower Nelson River including Split Lake to just upstream of Stephens Lake as shown in Map 4-24. Major lakes in this zone include Split, Clark , and Gull lakes. There are currently no structures related to hydroelectric development in this zone although the proposed Keeyask GS would be located at the downstream end of this zone at Gull Rapids.

4.3.11.2 Erosion

The LWCNRSB divided Zone 10 into two main reaches (Water Resources Branch 1974). Split Lake formed the upper reach. About 98% of the Split Lake shoreline is bedrock-controlled, with a mix of shoreline types consisting of low bedrock-controlled shorelines (type 15), bedrock-controlled shorelines with an overburden beach (type 14), steep bedrock shorelines (type 11), and low bedrock shorelines with shallow backshore overburden (type 13). Low alluvial and low willow shorelines comprised the final 2% of the Split Lake shoreline. The lower reach extends from the outlet of Split Lake to the upper end of the Kettle forebay. About 80% of the lower reach consisted of low bedrock shorelines with shallow backshore overburden. About 10% consisted of bedrock-controlled shorelines with an overburden beach. The final 10% consisted of low willow shoreline.

LWCNRSB (1975) predicted the erosional response of Zone 10 to the CRD. Around Split Lake, the type 15 and 14 shorelines were anticipated to recede by about 3 to 6 m following the CRD. The steep bedrock shorelines were not expected to respond to impoundment. The low alluvial and low willow shorelines were anticipated to see the severest flooding due to their low relief. Minimal erosion was anticipated between the outlet of Split Lake and the upper end of the Kettle forebay.

As part of the CRD erosion studies (Manitoba Hydro 1982a, 1983a, 1984, 1985a, 2001b), one site within Zone 9 was monitored in 1981. However, it appears that this site has not been monitored since 1981. Four erosion monitoring transects are presently being monitored near the settlement of York Landing, but no results have been reported to date.

JDMA (2007) presents the results of an air photo, map and literature study describing the physical environment and shoreline classification around the community of Split Lake for defining suitable shore monitoring and repair guidelines. Shoreline recession was mapped from multiple sets of air photos. The south shore of the peninsula where the Split Lake community is located has been eroding at an average rate of 0.2 to 0.4 m/y between 1947 and 2003. In contrast, the north shore appeared relatively stable over this period. However, shoreline erosion has been observed recently along the north shore, where riprap has been placed for shore protection (J. Tutkaluk, *pers. comm.* 2014).

JDMA (2012a) discussed shore zone processes that result in erosion of mineral soil in the existing environment of the proposed Keeyask Generation Project. The report summarized data from stereoscopic air photos, published literature and reports, multi-season field observations and photographs, shore zone classification data, air photo terrain mapping, shore zone video, erosion transect data, nearshore cores, and Manitoba Hydro's ice reconnaissance reports and videos. Historical average post-CRD annual bank recession rates were below 0.25 m/y over the majority of the mineral shoreline length. Maximum bank recession rates rarely exceeded 1-2 m/y. These high rates were restricted to relatively localized shoreline areas where river flow was channelized against shore banks by ice dams that typically formed below Birthday and Gull rapids on an annual basis.

JDMA (2012b) presented results of analyses done to project future bank recession and sediment loads due to erosion of mineral soil shores without the Keeyask Project in place. Future bank recession rates were projected based on rates measured using air photos dated 1986 to 2006 and from erosion transects surveyed in the summers of 2006 and 2007.

ECOSTEM Ltd. conducted several peatland disintegration, shoreline characterization and land area loss studies for the Keeyask Generation Project physical and terrestrial environment assessments. Existing shoreline and peatland conditions in the reach from Clark Lake to the Long Spruce GS are described in Keeyask Hydropower Limited Partnership (2012a, b) and ECOSTEM Ltd. (2011; 2012a, b, c). Historical air photos, field transects and laboratory studies were used to document flooded land area, historical peatland breakdown, peat resurfacing rates and land area losses over a variety of periods at several locations on the Rat/Burntwood and lower Nelson rivers. Physical and biological factors controlling peatland disintegration processes and land area losses were evaluated through comparisons within and between multiple locations on the Rat/Burntwood and Nelson rivers affected by past hydroelectric flooding and water regulation. These studies also included predictions of future shoreline composition, resurfacing of flooded peat and the amount of organic material (peat) released into the aquatic system with and without the Keeyask GS. ECOSTEM Ltd. (2011a, b) report on physical properties of peat relevant for peatland disintegration processes and organic sedimentation.

4.3.11.3 SEDIMENTATION

Most of the studies conducted before and after the CRD were focused on Split Lake, with limited mention of Clark and Gull lakes. However, in the past decade sediment monitoring plans were initiated in this zone to facilitate the EIS of the proposed Keeyask GS. A brief account of the studies conducted in this region is given below.

Schlick (1968) reported turbidity in Split Lake measured in 1966, while comparing the productivity of the Nelson and Burntwood rivers. Manitoba Hydro (1970, 1971, 1973) presents results of water sampling for suspended sediment concentration conducted from 1969 to 1972, and published the results under the scope of CRD surveys. Hecky and Harper (1974) had also recorded TSS values in Split Lake while studying the primary productivity of the lower Churchill lakes. Cleugh (1974) surveyed the hydrography of lower Churchill lakes and reported TSS values in Split Lake. Both of these studies were commissioned by the LWCNR Study Board. The final LWCNRSB reports (1975a, b, c, d) contain turbidity values measured at different locations along the diversion route, including Split Lake. Penner *et al.* (1975) undertook a physical impact study to examine the effects of hydro developments on the lower Nelson River. This study focused towards assessing the sediment load and provided a prediction for post-development. Average TSS concentrations in Zone 10 were provided in this report.

Manitoba Hydro (1982) published turbidity and TSS concentrations for Split Lake obtained from water sampling that was conducted in the open water season of 1981. Manitoba Environment and Workplace

Safety & Health investigated the effects of LWR and the CRD on water quality by comparing pre-development (1972-1976) water chemistry data with the post-development (1976-1984) data. Split Lake was included in this study area. The findings of this comparison were published in Playle and Williamson (1986).

FEMP reports (Environment Canada and DFO 1987, 1988, 1989a, b, c, 1990) documented the sedimentation studies, observations, and assessments initiated under this program. The related activities included sediment budget analysis, morphological assessment, and sediment coring for quantitative assessment of sedimentation along the diversion route, including Split Lake. Some TSS and Secchi disk readings were also noted. Summaries of these reports were published in two technical documents and one summary report (Environment Canada and DFO 1992a, b, c).

The effects of hydroelectric generating stations on Split Lake were evaluated by Split Lake Cree – Manitoba Hydro joint studies. During this process, Lawrence (1996) reviewed previous studies and available data to identify the gaps. An environmental monitoring program was recommended and sediment monitoring was initiated in 1996. Turbidity and TSS concentrations in a reach from Split Lake to Stephens Lake have been recorded since 1996.

The turbidity and TSS concentrations in this zone are documented by North South Consultants in following studies: Lawrence and Fazakas (1997) and Fazakas and Zrum (1999) for the reach between Split and Clark lakes; Clarke and Lawrence (1998), Bezte and Lawrence (1999), Zrum and Kroeker (2003), and Schneider-Vieira and Hnatiuk (2009, 2010, 2011, 2013) for Split Lake; Zrum and Bezte (2003) for Gull Lake and the reach between Birthday and Gull rapids; Zrum and Neufeld (2001) and Cooley and Lawrence (2007) for the York Landing; Juliano and Neufeld (2004) and Badiou and Cooley (2005) for Split, Clark and Gull lakes; Neufeld (2007) for Clark and Gull lakes; and Badiou and Cooley (2004) for Split and Gull lakes.

Sedimentation monitoring has been performed at Split Lake as part of a program conducted by Manitoba Hydro to address concerns raised by Tataskweyak Cree Nation regarding the potential impact of Wuskwatim GS on suspended sediment in Split Lake. Sedimentation data collected includes bed material, TSS, and turbidity. Data has been collected since 2007 at selected sites located in this zone (Schneider-Vieira and Hnatiuk 2009, 2010, 2011, 2013).

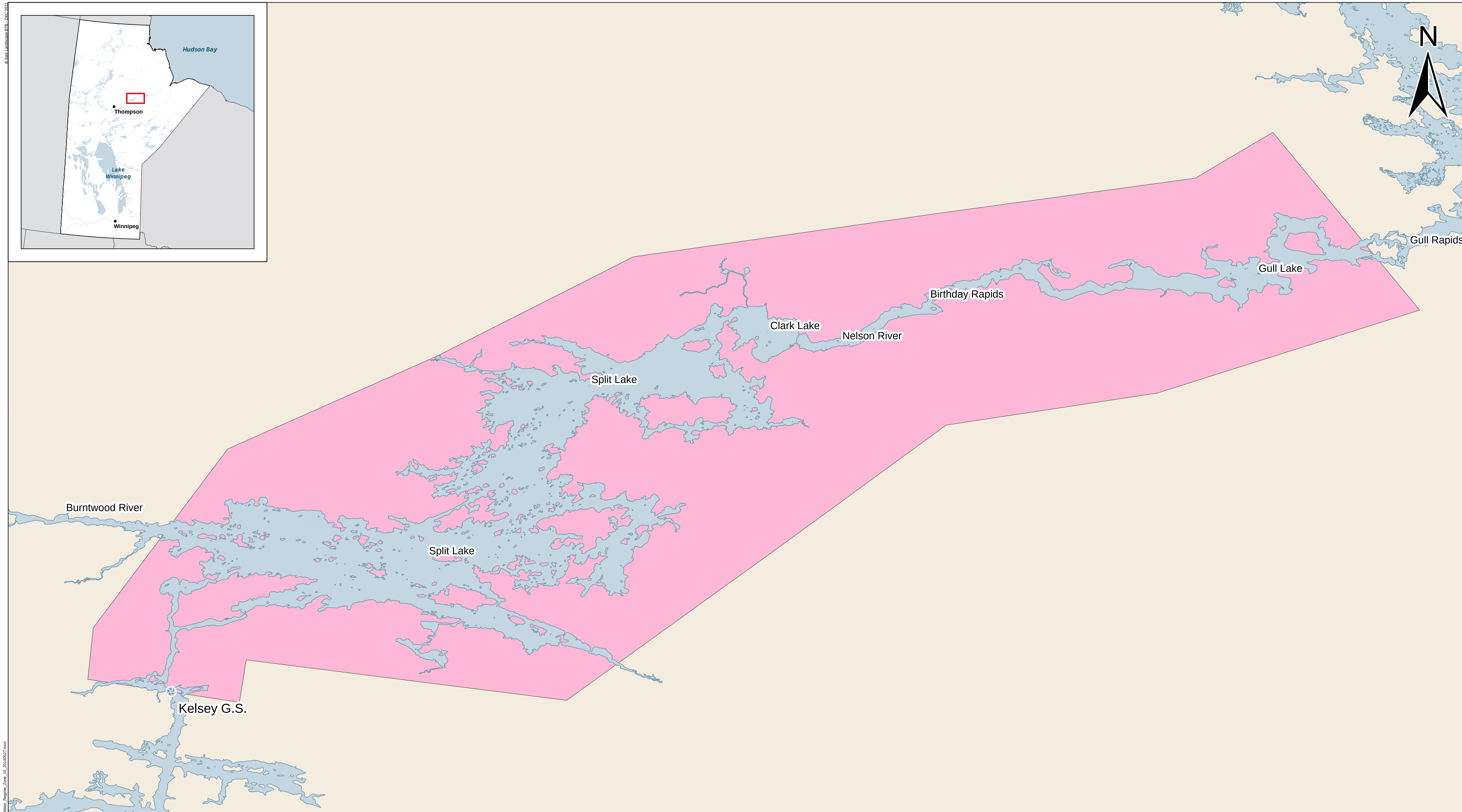
As part of the Keeyask Generating Station EIS studies, Manitoba Hydro initiated an extensive sediment data collection program to perform sedimentation studies in the reach spanning from Clark Lake to the location of proposed Keeyask GS. Given below is an account of the major sedimentation studies conducted by Manitoba Hydro and the consultants in the study area since 2004.

KGS Acres (2009g) analyzed sediment data (including turbidity, and TSS concentration) collected in 2003 in an area from Wuskwatim Lake to Spilt Lake. The report discussed the nature of TSS distribution in Wuskwatim Lake, its dependency on climate factors such as wind and its effect on TSS concentration in the downstream lakes including Split Lake. Acres Manitoba Ltd. (2004) performed a preliminary sediment budget analysis for the proposed Keeyask GS. In this study TSS, turbidity, and bed material samples collected by North South Consultants (in 2001-2003) and by Acres Manitoba (in 2004) from the river reach from Split Lake to Stephens Lake were used. Manitoba Hydro (2006) collected TSS and turbidity data at variable depths over several sections across the Nelson River from Clark Lake to the proposed location of Keeyask GS. Bed loads were measured at all TSS measurement locations.

Acres Manitoba (2009) provides an assessment of suspended and total sediment loads carried by the Nelson River using data collected since 2001. The study area spans from Clark Lake to Kettle GS. KGS Acres (2010e) provided Split Lake turbidity data collected in 2009. KGS Acres (2011) compiled the Split Lake turbidity data from 2007 to 2010, collected as a component of the Wuskwatim GS PEMP.

KGS Acres (2012a) provided an assessment of transport and deposition of mineral sediment for the during operation phase of the Keeyask GS in Stephens Lake. KGS Acres (2012b) also established a relationship between TSS and turbidity in the proposed Keeyask GS project area using data collected from 2006 to 2010.

HATCH (2011c, 2012) presented the continuous turbidity data measured during 2010 and 2011 in Split Lake. HATCH (2013d) summarized field data (TSS, turbidity, sediment composition) collected by Manitoba Hydro in 2009 and 2011 within the Trapline 13 area and on Split Lake at York Landing to establish baseline sedimentation data prior to the development of the proposed Keeyask Generation Project. Historic sedimentation data was included in this report in tabular form as a reference.



DATA SOURCE:
Manitoba Hydro

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Water Resources Engineering - Sediment & Ice Studies

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UTM NAD 1983 Z15N	23-MAY-14	27-MAY-14

0 2.5 5 Kilometres
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VERSION NO:	QA/QC:
1.0	RDB / MRK

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Existing Generating Stations (G.S.)

RCEA
Erosion and Sedimentation Zone 10

4.3.12 ZONE 11 – STEPHENS LAKE TO LIMESTONE GS

4.3.12.1 AREA OVERVIEW

Shown in Map 4-25, this zone covers Stephens Lake and the lower Nelson River downstream to the Limestone GS and includes Manitoba Hydro's three biggest generating stations. The Kettle GS is located at the downstream end of Stephens Lake near the town of Gillam and was completed in 1974. The Long Spruce GS is located 10 mi (16 km) downstream from Kettle GS and was completed in 1979. The Limestone GS is located 14 mi (23 km) downstream from Long Spruce GS and was completed in 1992.

4.3.12.2 EROSION

The LWCNRSB divided Zone 11 into two main reaches (Water Resources Branch 1974). The upper reach consists of Stephens Lake (*i.e.*, the Kettle GS forebay), which was flooded in two stages in the falls of 1970 and 1971, with the increase in water level varying from about 30 m at the dam to about 13 m at the base of Gull Rapids. The lower reach extends from the Kettle GS to the present location of the Limestone GS. The highest banks along the Nelson River were found in this reach. Ice-scoured till banks (type 21) formed about 80% of the reach. Portions of these banks were very steep with the winter trim line extending as much as about 15 m above the open water level. The vegetation below the trim line was limited to grasses and small stunted willows. Above the trim line, a closed forest of white and black spruce was found. Bedrock was frequently found at the open water shoreline. The remaining 20% of the banks were characterized as slumping overburden shorelines (type 25). The lower half of these banks was frequently steep and bare.

LWCNRSB (1975) predicted the erosional response of Zone 11 to the CRD. However, the subsequent flooding associated with the construction of the Long Spruce and Limestone generating stations was not considered in that study. The physical impact of these hydroelectric developments was forecasted by Penner *et al.* (1975) using a refined shoreline classification system tailored for the lower Nelson River.

As part of the Physical Impact Study (Water Resources Branch 1974), the impact of hydroelectric development was assessed at the Kettle forebay. The Kettle forebay was formed over two stages in the falls of 1970 and 1971. The increase in level varies from a maximum of 30 m at the dam to a minimum of 13 m at the base of Gull Rapids. The readjustment process involved undercutting due to wave action on high till banks, extensive thawing of permafrost throughout the reservoir resulting in widespread areas of instability and slumping, large areas of flooded vegetation with some floating peat islands, severe erosion of overburden banks and midstream islands. No impact was observed over about 5% of the shoreline where bedrock formed the shoreline. Severe impact was observed over the remaining 95% of the shoreline, with impacts consisting of flooded vegetation, erosion and permafrost thawing.

Manitoba Hydro (1992) presented erosion monitoring results from a fall 1991 survey at 12 sites along the Limestone forebay. Surveyed profiles from as early as 1986 were plotted with surveys from all subsequent years up to 1990 to provide a record of pre-development erosion. A second set of plots were presented with the fall 1991 surveys included, showing post-development erosion. Photographs were presented to illustrate post-development conditions.

Penner *et al.* (1975) evaluated the geomorphology and river processes present along the lower Nelson River, downstream of the Kettle GS. The present shoreline state was mapped and data on stratigraphy, permafrost characteristics, ice processes, sedimentation, and vegetation were collected and analyzed. Overall, the study dealt with three aspects of the river environment: the banks and shoreline, the vegetation, and the delta. The physical impact of the reservoirs planned for the lower Nelson River at four sites between the Kettle GS and Gillam Island was assessed. The effects of the reservoirs on the current delta forming processes were estimated. Timber clearing guidelines for the flooding banks along the lower Nelson River were proposed.

JDMA (2011l) calculated historical bank recession rates on Long Spruce and Limestone forebays by mapping and measuring the top-of-bank position on 1993 and 2006 air photos. This document provides a brief summary of the methods used and deliverables generated. This study utilized georeferenced air photos for the Limestone and Long Spruce forebays (JDMA 2011g, h).

JDMA (2011m) reports on sediment cores extracted from Long Spruce and Limestone forebays, which are regarded as proxy sites for the Conawapa project. The 2007 coring operations indicate that the deposition of finer-grained cohesive sediment was very limited and discontinuous within the Long Spruce and Limestone forebays during the post-flooding period. However, no offshore cores or cores taken from immediately upstream of the dams have been acquired. Subsequently, nearshore sediment cores were collected at the mouths of two creeks in the Long Spruce forebay and two creeks in the Limestone forebay to assess potential impacts on sedimentation in flooded creek mouths (JDMA 2011a). Twenty-four sediment cores were collected to determine whether the flooded mouths of tributary streams have served as sediment traps.

Erosion monitoring transects were established on Stephens Lake and on the Long Spruce forebay in 2006. However, no documents describing the results of these surveys have been found.

4.3.12.3 SEDIMENTATION

Sediment related studies in this zone before and after the CRD are rare. Most of the sedimentation related work has been done to support the of the proposed Keeyask GS and planned Conawapa GS EISs. Also, a few water quality studies contain discreet accounts of TSS and turbidity at selected locations. A brief account of the studies conducted in this region is given below.

Crowe (1973) documented the turbidity of Kettle reservoir while conducting a limnological investigation of Kettle reservoir and the Nelson River above Kelsey GS. Cleugh (1974) included Secchi disk depths measured in Stephens Lake. Hecky and Harper (1974) recorded the TSS values in the Kettle GS reservoirs main stem, while studying the primary productivity of the Nelson River reservoirs and lakes. Morelli (1975) provided turbidity and TSS concentrations for the Nelson River at Kettle Rapids. Jackson and Hecky (1980) recorded Secchi disk values for the Kettle Reservoir measured during 1972-74. Ramsey *et al.* (1989) measured TSS and turbidity values in Stephens Lake. Green (1990) also provided the TSS and turbidity values in Stephens Lake. Janusz (1990) provided the turbidity values measured in Stephens Lake. North/South Consultants Inc. and I.D. Systems Ltd. (1994) provided the TSS and turbidity values for Stephens Lake, Long Spruce, and Limestone reservoirs.

The effects of hydroelectric generating stations in Zone 11 were evaluated by Split Lake Cree-Manitoba Hydro joint studies. During this process, Lawrence (1996) cited the following additional water quality studies which included TSS and/or turbidity data: Didiuk (1975), Swanson (1986), Baker (1990, 1991, 1992), Horne and Baker (1993), Schneider and Baker (1993), Horne and MacDonell (1995), MacDonell and Horne (1994), Schneider-Vieira (1994, 1996), and Kroeker and Horne (1993).

Badiou and Cooley (2004) presented the TSS and turbidity values of Stephens Lake. Neufeld (2004) presented the results of sediment sampling, which contains the Stephens Lake sediment composition. Juliano and Neufeld (2005) sampled 31 sites in Stephens Lake and provided the sediment composition. Badiou and Cooley (2005) recorded the TSS and turbidity values of Stephens Lake.

Acres Manitoba (2004) performed a preliminary sediment budget analysis for the proposed Keeyask GS. In this study TSS, turbidity, and bed material samples collected by North South Consultants Inc. (in 2001-2003) and by Acres Manitoba (in 2004) from the river reach from Split Lake to Stephens Lake were used. Acres Manitoba (2009) contains an assessment of suspended and total sediment load flowing through the study area using data collected since 2001. The study area spans from Clark Lake to Kettle GS.

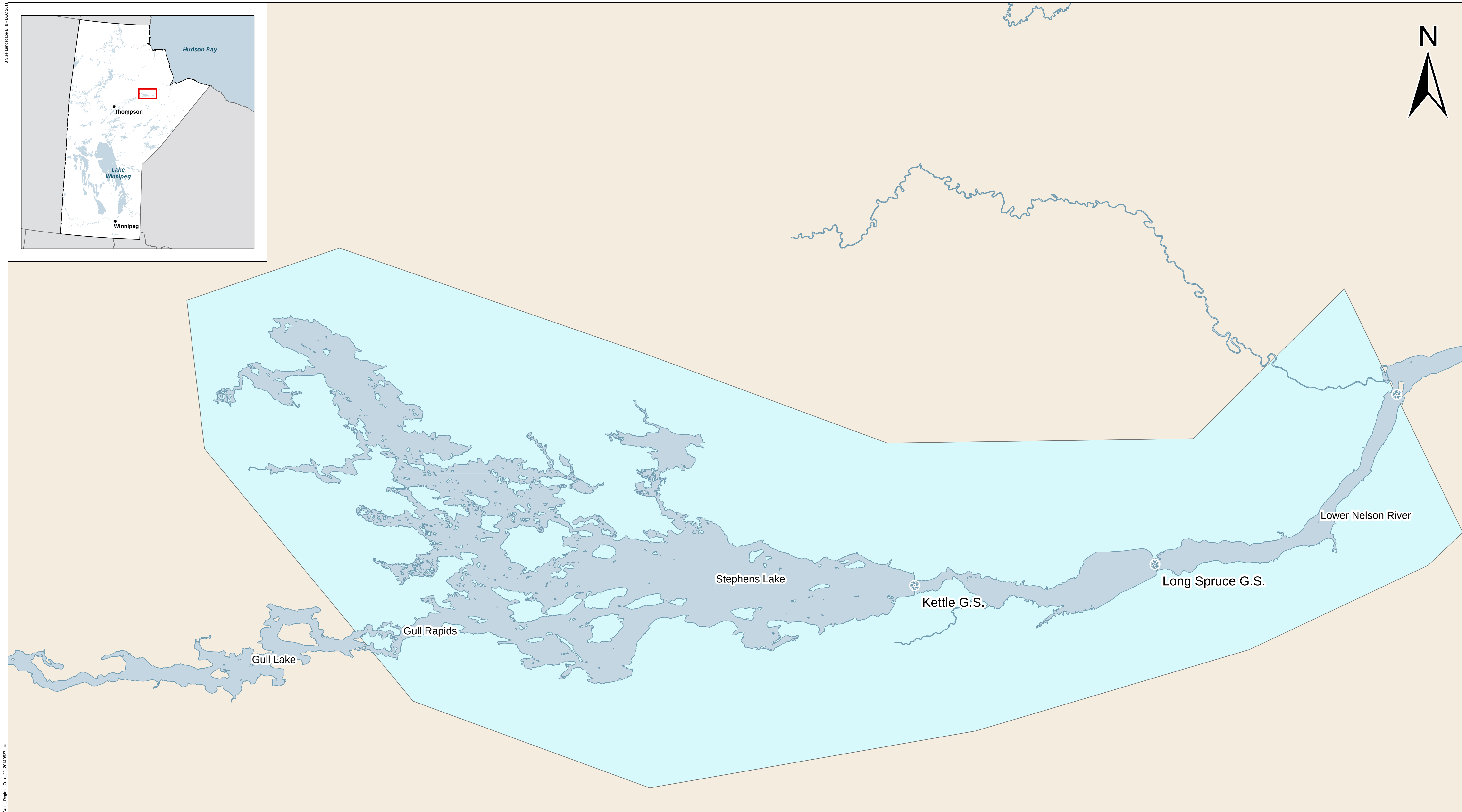
Savard and Cooley (2011) conducted a sediment sampling program and produced sediment sampling size distributions of the suspended particles in the Limestone forebay.

KGS Acres (2012a) provided an assessment of transport and deposition of mineral sediment for the during operation phase of the Keeyask GS. The assessments included quantification and spatial distribution of post-project TSS concentrations, and nearshore and offshore deposition. The study area spans from Clark Lake to the proposed location of the Keeyask GS. KGS Acres (2012b) also established a relationship between TSS and turbidity in the proposed Keeyask GS project area using data collected from 2006 to 2010.

North/South Consultants (2012) documented the AEMP of Limestone GS. As part of this program, water quality sampling, including TSS and turbidity, was performed along the Nelson River from Stephens Lake to Port Nelson during 1989-2003.

KGS Acres (2012c) discussed sediment regimes in the Lower Nelson River from Kettle GS at the exit of Stephens Lake to Gillam Island near the start of the Nelson River estuary. Temporal and spatial analysis of sedimentation data and contributing factors such as wind, precipitation and discharge on sediment load were presented in this report.

Water quality parameters including suspended sediment and turbidity in the north and south basins of Stephens Lake are monitored every three years as part of CAMP (CAMP 2014b, CAMP *unpubl. data*). Also, the Limestone forebay is sampled every winter (*i.e.*, when the riverine site is unsafe); the forebay is sampled during the open-water season every three years as part of CAMP (CAMP 2014b,CAMP *unpubl. data*).



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Existing Generating Stations (G.S.)

RCEA
Erosion and Sedimentation Zone 11

4.3.13 ZONE 12 – LIMESTONE GS TO GILLAM ISLAND

4.3.13.1 AREA OVERVIEW

This zone covers the lower Nelson River from the Limestone GS to Gillam Island as shown in Map 4-26. Gillam Island is the upstream extent of tidal influence from the Nelson River estuary. There are currently no hydroelectric structures located in this zone although the planned Conawapa GS would be located 18 mi (29 km) downstream from the Limestone GS.

4.3.13.2 EROSION

The LWCNRSB divided Zone 12 into two main reaches (Water Resources Branch 1974). The upper reach extends from the Limestone GS to Goose Creek. Here, the river has eroded itself into the Paleozoic bedrock so that 80% of the bed and bank material is limestone (type 12 shorelines). The height of the winter trim line exceeds that of the bedrock shorelines in this area by up to 10 m, which results in either slumping in the banks above or an ice-modified terrace above the bedrock shoreline. The remaining 20% of the upper reach consists of ice-scoured till banks (type 21) or shorelines in slumping overburden (type 25). The lower reach consists of roughly equal portions of ice-scoured till bank and shorelines in slumping overburden. These banks are similar to those in the upper reach, except that thaw-induced slumping is more widespread and the height of the winter trim line decreases with proximity to Hudson Bay.

LWCNRSB (1975) predicted the erosional response of Zone 12 to the CRD. The vertical bedrock shorelines (type 12), which formed 80% of the upper reach, were not expected to be influenced by raised open water levels. Higher winter water levels, however, were anticipated to increase the slumping of overburden that mantles the bedrock cliffs. It was anticipated that the altered water regime would have minor effects on the ice-scoured till banks (type 21), with only localized erosion and bank slumping near the shoreline. The shorelines in slumping overburden were expected to experience an increase in the rate of erosion and consequent slumping in the locations where banks were already actively eroding. However, the slumping overburden shorelines in Zone 12 were generally viewed as protected from erosion at normal water levels by a boulder or cobble layer along the shoreline, and it was mainly at higher water levels that these shorelines were expected to be vulnerable.

Conawapa-related research is ongoing and none of the reports mentioned below are finalized reports. The references in the reference list indicate whether the report status is in draft stage or if it has reached REV-0 status, meaning that it is still not final but signoff sheets have been completed.

JDMA (2011b) made an assessment of historical changes in geomorphology of the lower Nelson River using 1:250,000 scale topographic maps. The topographic maps used were developed based on air photos and field surveys from the 1950s. Features identified in these maps were compared with features identified in a 2006 orthoimage. From these comparisons, it appeared that there has been very little change in the overall morphology of the Nelson River since the 1950s.

JDMA (2011c) characterized the geomorphology of the planned Conawapa forebay and the materials along the banks. Landforms were mapped from air photos. Materials and stratigraphy were described based on field observations and grain-size analyses. This document described the methods and deliverables. JDMA (2011d) digitized a bedrock subcrop map produced by D.S. Matheson during low flow explorations in September 1986. JDMA (2011e) digitized the shoreline classification applied to the lower Nelson River by Penner *et al.* (1975).

JDMA (2011f, k) made preliminary estimates of minimum, maximum and mean erosion rates using 1993 georeferenced air photos (JDMA 2011i) and 2006 orthoimagery. These rates were used to provide a preliminary estimate of sediment delivery from bank erosion. The mass of eroded sediment was also estimated using transect surveys conducted in 2006, 2007, and 2008.

JDMA (2013a) represents a draft report on the erosional response of the shores of the Nelson River to the construction of the Limestone GS. Air photos acquired in 1985 were compared with 2006 imagery to search for downstream changes since the construction of the Limestone GS. The study also compared 1954 air photos with 2003 imagery at selected locations between the Angling River and Gillam Island. Historical ice observations indicated that the ice front progressed to the Limestone Cofferdam or further upstream prior to construction of the Limestone GS, and after that time the ice front generally advanced only as far as Lower Limestone Rapids or rarely to Sundance Rapids. Thus, since construction the 8 to 10 m of staging associated with the advancement of the ice front did not occur as frequently between Sundance Rapids and Lower Limestone Rapids, and it is not known to have occurred upstream of Sundance Rapids. High winter water levels are essential for causing erosion over much of this reach, because bedrock generally prevents erosion at the open water shoreline. The trim line has become vegetated upstream of Sundance Rapids since 1985, and this increase in vegetation was observed to diminish with distance downstream of Sundance Rapids. In summary, a reduction in the amount of erosion since the construction of the Limestone GS has been inferred in most locations upstream of Lower Limestone Rapids that would previously see erosion during the winter when water levels were raised up above the bedrock open water shoreline.

JDMA (2013b) assessed historical rates of erosion at five sites containing heritage values along the lower Nelson River. Four air photos from 1954 and one from 1971 were compared with the 2003 orthoimagery and the 2004 LiDAR digital elevation model. Detectable bank erosion was observed only in six locations within four of the five sites considered. These locations represented the zones where the greatest amount of erosion would have occurred historically. The amounts of recession measured ranged from 1 to 30 m.

JDMA (2013c) described and quantified the existing erosional conditions on the banks of fourteen tributaries within the hydraulic zone of influence of the planned Conawapa project. Erosion along these tributaries was too slight to be detected using air photos and therefore had to be estimated qualitatively. The Angling and Weir rivers were also considered. JDMA (2013d) provided an estimate of future bank erosion in the tributaries dealt with above. The eroded sediment volumes estimated were based on the projection of estimated historical rates of erosion.

JDMA (2013e) documented the nature of and controls on mass wasting landforms and processes in the existing environment of the planned Conawapa forebay. The document integrated data from several sources, including field observations, previous work, erosion transect data, borehole logs, LiDAR data, climate data, tree-ring analysis, and vertical and oblique aerial photos. Erosional activity and landforms were investigated at several sites. Field observations were made at the three Conawapa sites where the largest amount of erosion had been recorded in transect surveys. A distinct lack of erosion recorded on most transect sites was attributed in part to the presence of an erosion-resistant open water shoreline. A slope failure classification was developed for this part of the Nelson River consisting of four types: rotational slips, failures related to perched groundwater flow systems, earthflows, and surficial slides on burned forest slopes.

Van Zeyl *et al.* (2013) investigated a landslide that occurred in Horseshoe Bay in December 2008. The failure occurred between December 14 and 17, 2008, in the upper part of a 45 m-high, northwest facing bank of the Nelson River, within 1 km downstream of the planned Conawapa GS. The slope failure occurred at a spring site in a bay associated with a buried valley. The sediment input to the river from this event was roughly 20,000 to 25,000 m^3. The source zone consisted of a 25 m-thick zone of water-bearing sand and gravel confined between ice-rich silty clay at the top of the bank and laminated to rhythmically bedded silt and clay at the base of the section. The collapse was confined to the material above the basal silts and clays and was associated with a perched groundwater flow system. A strong argument for drainage cutoff by the advancement of seasonal frost has been demonstrated through the correlation of the bank collapse with the timing of a significant cold snap recorded at two nearby weather stations. The failure illustrates the importance of stratigraphy in controlling bank erosion in this area. Previously, fluvial erosion was seen as an important control on mass wasting in Horseshoe Bay. However, surface information suggested that no toe erosion except to remove the slide deposit had occurred at this site since 2004.

4.3.13.3 SEDIMENTATION

The earliest study on the lower Nelson River sediment regime was undertaken by Penner *et al.* (1975). This physical impact study was initiated to examine the effects of the proposed hydro development (including Long Spruce, Limestone, Gillam Island reservoirs) on bank erosion, sediment transport, permafrost, and on the ice regime along the lower Nelson River.

Environment Canada (1982) documented chemical, physical and biological parameters of surface water for the lower Nelson River upstream of the Weir River collected during 1980 and 1981.

Capar and Gill (2008a, b) presented information on benthic invertebrate and sediment samples collected from the lower Nelson River mainstem (between Limestone GS and Long Island) during open water season in September/October 2002 and September 2003.

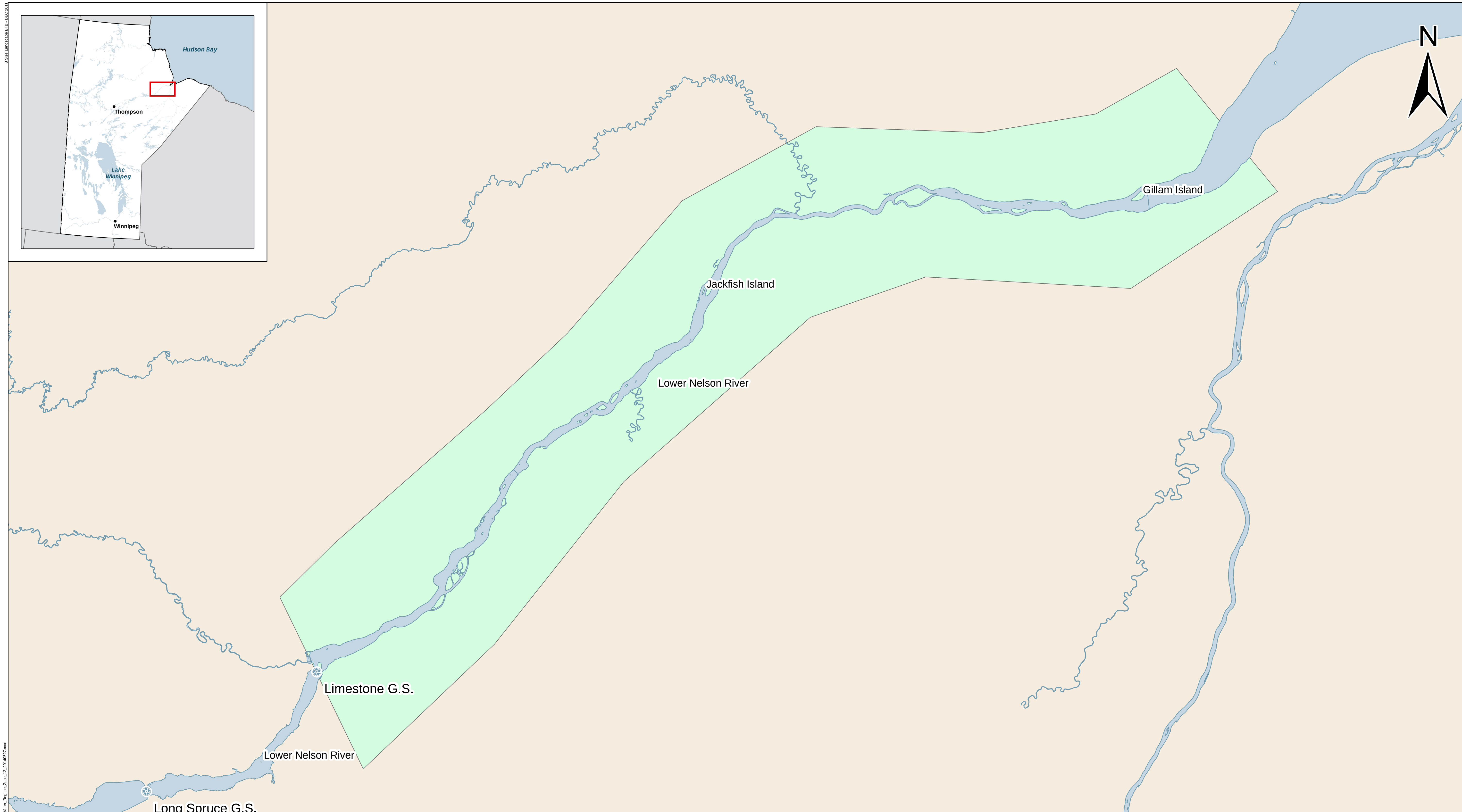
Savard and Cooley (2011) reported the 2010 sediment quality sampling program that was conducted at three sampling locations on the lower Nelson River from Limestone GS forebay to Deer Island. Results of this sampling program indicated that sediment particle size in suspension were coarser with increased distance from the Limestone GS. The turbidity data was also recorded and reported for this reach.

KGS Acres (2012b) discussed the sediment regime in the lower Nelson River from Kettle GS at the exit of Stephens Lake to Gillam Island near the start of the riverine portion of the Nelson River estuary. Temporal and spatial analysis of sedimentation data and contributing factors such as wind, precipitation and discharge on sediment load were presented in this report. Based on an extensive sedimentation data collection program in the open water seasons of 2005 to 2008 and the winters of 2007/2008 to

2009/2010, suspended load, bedload and total load carried by the Nelson River between Limestone GS forebay to upstream of Gillam Island were estimated (KGS Acres 2012c). Sediment parameters collected and analyzed in these studies included TSS measurements, particulate size, continuous turbidity, bed material samples, and bedload. A summary of field activities and sediment parameters collected each year are presented in several field reports (KGS Acres 2007, 2008b, c, 2009a, b, c, d, e, f, 2010f, g, h, i, j). A relationship was developed between TSS and turbidity using data collected in the period of 2006 to 2009 on the lower Nelson River (KGS Acres 2014).

Sediment transport under dynamic variation of ice condition (during ice formation, before break-up, and during the break-up period) was studied in an area downstream of planned Conawapa GS (Weiss *et al.* 2013; Zare *et al.* 2013; Moore *et al.* 2013).

Water quality parameters such as suspended sediment and turbidity in the lower Nelson River below the Limestone GS are sampled three times annually under CAMP (CAMP 2014b, CAMP *unpubl. data*).



DATA SOURCE:
Manitoba Hydro

CREATED BY:
Water Resources Engineering - Sediment & Ice Studies

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	23-MAY-14	27-MAY-14
0 4 8 Kilometres / 0 3.5 7 Miles	VERSION NO: 1.0	QA/QC: RDB / MRK

Legend

Existing Generating Stations (G.S.)

RCEA
Erosion and Sedimentation Zone 12

Map 4-26

4.3.14 SCIENTIFIC REFERENCES

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PART V: WATER AND LAND

Manitoba Hydro

REGIONAL CUMULATIVE EFFECTS ASSESSMENT

PART V

WATER AND LAND

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF MAPS

ACRONYMS, ABBREVIATIONS AND UNITS

Acronym/Abbreviation	**Term/Unit**
°	degrees
>	greater than
ATK	Aboriginal Traditional Knowledge
ATP	Adenosine triphosphate
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
c.	Circa
CAMP	Coordinated Aquatic Monitoring Program
CEC	Clean Environment Commission
CHC	Chlorinated Hydrocarbon Contaminant
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRD	Churchill River Diversion
CS	Control Structure
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DELT	Deformities, erosion, lesions or tumours
DFO	Fisheries and Oceans Canada (formerly known as Department of Fisheries and Oceans Canada)
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DP	Total dissolved phosphorus
DU	Designatable Unit
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPP	Environmental Protection Plan
e.g.	Example
et al.	and others
FEMP	Federal Ecological Monitoring Program

Acronym/Abbreviation	**Term/Unit**
FRI	Forest Resource Inventory
GHA	Game Hunting Area
GIS	Geographic information system
GPS	Global Positioning System
GS	Generating station
i.e.	That is
IUCN	International Union for Conservation of Nature and Natural Resources
km	kilometre
km^2	square kilometre
km^3	cubic kilometre
LCC	Landcover Classification of Canada
LCCEB	Landcover Classification of Canada, Enhanced for Bipole
LSSEP	Lake Sturgeon Stewardship and Enhancement Program
LWCNRSB	Lake Winnipeg, Churchill and Nelson Rivers Study Board
LWR	Lake Winnipeg Regulation
m	metre
MB	Manitoba
MCWS	Manitoba Conservation and Water Stewardship
MEMP	Manitoba Ecological Monitoring Program
mi	mile
MU	Management Unit
NAQUADATA	National Water Quality Data Bank
N	North
n.d.	No date
NFA	Northern Flood Agreement
No.	Number
NRSB	Nelson River Sturgeon Board
NTS	National Topographic System
PC	Particulate carbon
PCB	Polychlorinated biphenyl
PPER	Post Project Environmental Review

Acronym/Abbreviation	Term/Unit
ppm	parts per million
PR	Provincial Road
RMA	Resource Management Area
ROW	Right-of-way
RSC	Regional Study Component
RTL	Registered Trapline
Spp	Species
SSEA	Site Selection and Environmental Assessment
TCPM	Tris 4-Chlorophenyl Methanol
TDN	Total dissolved nitrogen
TDP	Total dissolved phosphorus
TDS	Total dissolved solids
TIC	Total inorganic carbon
TN	Total nitrogen
TOC	Total organic carbon
TP	Total phosphorus
TSS	Total suspended solids
Unpubl.	Unpublished
US	United States
VEC	Valued Environmental Component
WHB	Western Hudson Bay

5.0 WATER AND LAND

5.1 INTRODUCTION

The Water and Land sections document current understandings about effects of past hydroelectric developments to aquatic and terrestrial environments. Phase I is a comprehensive synthesis of available studies associated with hydro development in the Region of Interest. Phase II will include an assessment of the environmental effects of hydroelectric development based on all available existing information.

For this section, topics that reflect key ecological and social concerns, or are of key importance to the people living in the area, have been selected to focus the assessment and to represent the overall effects of hydro developments within the Region of Interest. The preliminary list of Regional Study Components (RSCs) is provided in Table 5-1 below, along with the rationale for their selection. The list will be reviewed following input received from the review of the Phase I report. Selection of RSCs was based on one or more of the following:

- Overall importance/value to people as identified by residents in the Region of Interest through various forums (*e.g.*, Clean Environment Commission [CEC] Hearings, Aboriginal Traditional Knowledge [ATK] reports from the First Nations, Northern Flood Agreement [NFA] Claims);
- Umbrella indicator for groups of species, selected ecosystem components, or ecosystems at one or more spatial scales;
- Importance/value to overall ecosystem function; and
- Known to be susceptible to the direct or indirect effects from hydroelectric developments.

Although the Region of Interest provides a boundary for defining which hydroelectric developments are considered in the assessment and the primary region of direct Project effects, the area of interest for each RSC, will be defined by what is ecologically meaningful for that component (*e.g.* population ranges for wildlife species), and will be presented with associated rationale in the Phase II report. Where required, the areas of interest will extend beyond the Region of Interest to provide context for a specific topic. The assessment areas selected will be large enough to capture the cumulative effects of hydro development, but not so large as to mask the effects on a given component (by making the effects appear unreasonably small as a percentage of the total area considered).

For the purposes of documenting and assessing changes to the Land and Water RSCs, the Region of Interest has been organized into the following four geographic areas:

- Area 1: Warren Landing to the inlet of Split Lake;
- Area 2: Split Lake to the Nelson River estuary;
- Area 3: Opachuanau Lake to Split Lake Inlet (including Southern Indian Lake); and
- Area 4: the Missi Falls Control Structure to the Churchill River estuary (see Map 5-1).

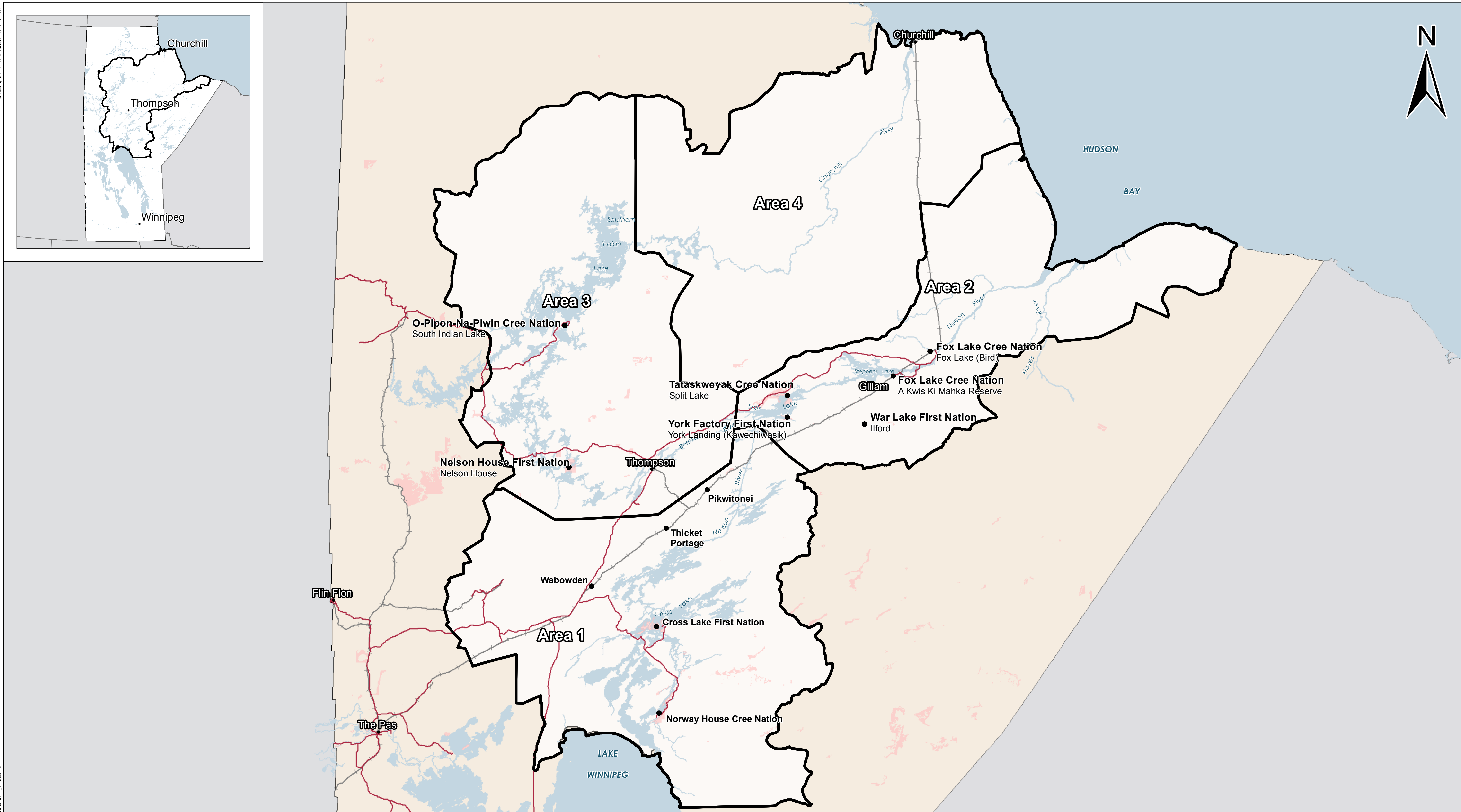
The inland portions of Areas 1 to 4 generally coincide with the boundaries for resource management areas (RMAs), Registered Trapline (RTL) Districts, ecodistricts and/or watersheds.

Table 5-1: List of Regional Study Components for Water and Land

Major Ecosystem	Regional Study Component	Rationale
Water	Water Quality	Water quality affects the ability of the aquatic environment to support aquatic life. It is also important to the people who live in the area as a source for drinking water, transportation, recreation, and aesthetics.
	Fish Community	The fish community was selected due to its ecological importance, as an indicator of aquatic habitat changes, and its importance to the commercial and domestic fisheries in northern communities.
	Lake Sturgeon	Lake Sturgeon was selected as they are culturally important to First Nation members, are a favoured domestic food item in many communities, are a species of conservation concern, and are particularly sensitive to many human activities including hydroelectric development.
	Fish Quality	Mercury in fish flesh was selected due to the importance of fish to the commercial and domestic fisheries in the impacted communities and the effect of mercury on the suitability of fish for consumption (due to the risk to human health).
	Marine Mammals	Marine mammals were selected due to their importance to a variety of stakeholders, including commercial tourism operators and all Manitobans. Polar bear and beluga are also species of conservation concern.
Land	Terrestrial Habitat	Terrestrial habitat was selected because some habitat types are especially important for social and ecological reasons and because human induced changes to terrestrial habitat are a key pathway for effects on the entire terrestrial ecosystem
	Intactness	Intactness was selected because it is often used as an overall indicator of cumulative effects on ecosystems at multiple spatial scales and on wildlife habitat in environmental assessment and monitoring.

Table 5-1: List of Regional Study Components for Water and Land

Major Ecosystem	Regional Study Component	Rationale
	Birds (waterfowl, colonial waterbirds, boreal forest birds)	Waterfowl: were selected due to their importance to resource harvesters, their link to the health of wetland habitats and lower food chain levels, and they can be substantially affected by hydroelectric development. Waterfowl are affected by hydroelectric developments in several ways with the flooding of habitat and water level fluctuations often being the primary pathways to the effects as well as the potential for line strikes. Colonial waterbirds: were selected for several reasons. Some species use some rare or uncommon environmental features for breeding. Colonial birds have been recognized as good indicators of aquatic ecosystem health. Some species are of conservation concern. Flooding and water level fluctuations can result in population and habitat effects. Some species may be particularly vulnerable to collisions with man-made structures (*e.g.*, line strikes). Forest Birds: were also selected for several reasons. Forest birds are culturally significant to local First Nations and Aboriginal peoples. Many species of boreal forest birds are undergoing long-term population declines throughout Canada. Some species are of conservation concern. Hydro developments can directly affect forest birds.
	Furbearers (aquatic and terrestrial)	Aquatic: Aquatic furbearers are important to the people who live in the area as a source of income and food. They are negatively affected by the water impacts of hydro development (*e.g.*, flooding and water level fluctuations). Terrestrial: Terrestrial furbearers were selected due to their economic importance to local people, they are at the top of the food chain and they can be affected by roads, transmission lines, borrow areas, and other land impacts associated with hydro development.
	Caribou	Caribou are an important symbol of Canadian wilderness and can be sensitive to disturbance of the landscape. Their specialized habitat needs may not be well captured by other land RSCs. They are a species of conservation concern.
	Moose	Moose were selected primarily because of their importance to First Nations peoples and sensitivity to habitat fragmentation and increased access for predators and hunters.



DATA SOURCE:
Manitoba Hydro; Government of Manitoba; Government of Canada

CREATED BY:
Manitoba Hydro - Hydro Power Planning - GIS & Special Studies

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	15-MAY-14	
0 30 60 Kilometres / 0 25 50 Miles	VERSION NO: 1.0	QA/QC: MT/RDB

Legend

- RCEA Region of Interest
- Rail
- Highways
- Aboriginal Lands

RCEA Region of Interest
Areas 1 to 4

Map 5-1

Areas 1 to 4 are similar to those used in two major study programs—namely, the Lake Winnipeg, Churchill and Nelson Rivers Study Board (1971-1975) and Manitoba and Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP; 2007 to present). The exception is Area 3, which combines Southern Indian Lake and the diversion route, which were dealt with separately in the aforementioned studies.

It should be noted that the Phase II analysis undertaken for RSCs may combine areas where appropriate (*e.g.*, for components like intactness) to provide a more complete analysis of the cumulative effects of hydroelectric developments over a broader geographic area.

There is an extensive body of information available for the Water and Land components; however, the utility of the information in quantifying the cumulative effects of hydro developments is limited for some RSCs by the following:

- There is often a lack of pre-development scientific data which precludes the ability to conduct a quantitative assessment of post-development changes for some RSCs. Comparisons of pre- and post-project data are also hindered by analytical or equipment changes that occur over time (*e.g.*, changes in soil or water quality detection limits);
- Differences in the "types" of studies conducted can make comparisons difficult (*e.g.*, resource management studies often target key fish species to monitor their abundance at specific locations over time while impact assessment studies set nets randomly to determine habitat use by the broader fish community); and
- There is often insufficient data to quantify effects on a number of RSCs, particularly RSCs that do not have a direct commercial value (*e.g.*, forest birds).

As a result, establishing a pre-development condition from which to evaluate cumulative effects is challenging and not always possible. The assessment of the cumulative effects of hydro development on some RSCs will also hampered by the following:

- The ability to quantify the effect of hydroelectric developments on some RSCs may be masked by the effects of other projects and activities (*e.g.*, the loss of land due to clearing for hydro developments in an area where large scale forestry operations are located). Similarly, some RSCs have a broad home range and may be affected more by developments outside rather than inside the Region of Interest (*e.g.*, many songbirds migrate from the Region of Interest to areas in Central and South America); and
- Quantifying the effects of hydro developments on RSCs that are harvested either commercially (*e.g.*, aquatic furbearers) or domestically or for sport (*e.g.*, moose) is difficult as populations will reflect the level of harvest and this is often linked to economics (*e.g.*, fur prices) or resource management decisions (*e.g.*, changes in harvest quotas).

Despite these limitations, which are common in assessments spanning a long timeframe, Manitoba Hydro and Manitoba will provide the best information available and will use the best contemporary methodologies for environmental assessments and post-project environmental reviews to meet the objectives of the Terms of Reference.

In particular, following the conclusion of the Phase I report, Manitoba will work to develop metrics, where feasible, of ecosystem health to enhance the assessment of information and data during Phase II. These metrics, where available, will be used as a basis for assessing the health of the current state of the environment.

5.2 WATER

5.2.1 WATER QUALITY

5.2.1.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

5.2.1.1.1 SUMMARY OF SCIENTIFIC INFORMATION

OUTLET LAKES

Water quality (temperature, pH, colour, turbidity, suspended matter, specific conductance, total dissolved solids [TDS], major ions, nitrate, alkalinity, hardness) was measured at Norway House in June 1953 and February 1954 (Thomas 1959) and in Playgreen, Kiskittogisu, and Kiskitto lakes and the Nelson River at Norway House in 1970-1974 (also including oxygen, nutrients, Secchi disk depth, and heavy metals; Schlick 1972; Stockner 1972; Koshinsky 1973; Lake Winnipeg, Churchill and Nelson Rivers Study Board 1975b; Morelli 1973, 1975; Grapentine *et al.* 1988). Conditions in the outlet lakes were measured sporadically thereafter.

Temporal changes in turbidity and suspended solids (TSS) were assessed in Playgreen Lake/Norway House and Kiskittogisu Lake for 1973-1977, 1972-1999, and 1987-1997 (Northwest Hydraulic Consultants Ltd. 1987). MacLaren Plansearch Inc. and Lavalin (1985a, b)and MacLaren Plansearch Inc. (1985) analysed existing provincial and federal water quality data, as well as additional data collected by the authors, to describe the water quality of Playgreen Lake pre- LWR (Lake Winnipeg Regulation) and post-LWR.

The Nelson River near Norway House has been monitored since 1972 for physical, chemical, and bacteriological parameters (currently monitored by Manitoba Conservation and Water Stewardship [MCWS]) and the Federal Ecological Monitoring Program included monitoring from 1987-1989 in the Nelson River below Sea River Falls and in the Jack River above Norway House (Environment Canada 1978, 1980; Ramsey 1991b, Environment Canada and Department of Fisheries and Oceans 1992).

Assessments of changes near Norway House resulting from hydroelectric development have also periodically been undertaken (Morelli 1975; Playle 1986; Playle and Williamson 1986; Duncan and Williamson 1988; Grapentine *et al.* 1988; Playle *et al.* 1988; Ralley and Williamson 1990; Baker and Davies 1991; Ramsey 1991b; Williamson and Ralley 1993; Jones and Armstrong 2001; Bourne *et al.* 2002).

Since 2009, Playgreen and Little Playgreen lakes have been monitored every three years under the Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP 2014, *unpubl. data*).

CROSS LAKE

Water quality sampling was conducted in Cross Lake prior to LWR as reported in Driver (1965), Driver and Doan (1972), Koshinsky (1973), Morelli (1973, 1975), and Cleugh (1974b). Post-LWR data sources include the Manitoba Ecological Monitoring Program conducted from 1985 to 1989 (Derksen 1987; Derksen *et al.* 1988; Ramsey *et al.* 1989; Green 1990), long-term water quality monitoring conducted by

MCWS near the community of Cross Lake, recent and ongoing water quality monitoring conducted by MCWS at the Jenpeg Generating Station (GS) (MCWS *unpubl. data*), studies conducted in association with the Cross Lake weir (Kroeker and Bernhardt 1993; Bernhardt and Schneider-Vieira 1994; Bernhardt 1995), and fisheries studies of Cross Lake (Gaboury and Patalas 1981, 1982). Other studies of the lake have been conducted but were generally more limited in duration, intensity, and/or number of parameters measured (Kozody 1979; Grapentine *et al.* 1988; Green 1991; Ramsey 1991b; Wiens and Rosenberg 1991).

No water quality data were located for Drunken Lake. Water quality data for Walker Lake are limited to results of a study conducted in 1981 (Gaboury and Patalas 1981, 1982) and data collected under CAMP (CAMP 2014, *unpubl. data*). Conductivity, TDS, pH, oxygen, temperature, nutrients, and major ions were measured in Pipestone Lake during fishery surveys conducted in 1980, 1981, 1986, 1993, and 1994 (Gaboury and Patalas 1981, 1982; Sopuck 1987; Bernhardt and Schneider-Vieira 1994; Bernhardt 1995).

Assessments of the effects of LWR on water quality in the area were conducted by Nelson River Group (1986b), Playle (1986), Playle and Williamson (1986), Williamson (1986), Duncan and Williamson (1988), Playle *et al.* (1988), Baker and Davies (1991), Ramsey *et al.* (1989), Ralley and Williamson (1990), Ramsey (1991b), and Williamson and Ralley (1993). Temporal changes in turbidity and suspended solids were assessed for the periods 1975-1984 and 1970-1999 (MacLaren Plansearch Inc. and Lavalin 1986; Northwest Hydraulic Consultants Ltd. 1987; MacLaren Plansearch Inc. 1989).

The historical water quality monitoring site on Cross Lake near the community continues to be monitored four times per year under CAMP (CAMP 2014, *unpubl. data*). Ongoing water quality monitoring is also conducted at the Jenpeg GS as a cooperative undertaking by Manitoba Hydro and MCWS.

SIPIWESK LAKE

Pre-LWR water quality conditions were studied in Sipiwesk Lake by the province of Manitoba in relation to developing commercial fishing limits (Schlick 1968) and the Lake Winnipeg, Churchill and Nelson Rivers Study Board (Morelli 1973, 1975; Cleugh 1974a, b). Post-LWR water quality studies include include long-term water quality monitoring conducted by MCWS in Sipiwesk Lake (MCWS *unpubl. data*), the Manitoba Ecological Monitoring Program conducted from 1986 to 1989 (Ramsey *et al.* 1989, Green 1990), and through studies examining mercury in the aquatic environment (Kozody 1979; Ramsey and Ramlal 1986; Williamson 1986). Various authors have statistically or qualitatively assessed the impacts of LWR on conditions in the lake (Playle 1986; Playle and Williamson 1986; Northwest Hydraulic Consultants Ltd. 1987; Playle *et al.* 1988; Ramsey *et al.* 1989; Ralley and Williamson 1990; Williamson and Ralley 1993).

The Nelson River downstream of Sipiwesk Lake was studied for a number of parameters on two occasions in 1953 (*i.e.*, prior to construction of Kelsey GS; Thomas 1959). Since that time, monitoring has generally been conducted in the Kelsey Forebay; pre-LWR data sources include studies conducted by the Lake Winnipeg, Churchill and Nelson Rivers Study Board (1972, 1973, and 1974: Morelli 1973, 1975; Cleugh 1974b), a study conducted by the Province of Manitoba in 1972 (Crowe 1973), a study examining primary productivity in hydroelectric reservoirs in 1974 (Jackson and Hecky 1980), and monitoring conducted by Environment Canada (National Water Quality Data Bank [NAQUADATA]; Environment Canada 1978, 1980, 1982). Post-LWR water quality studies in this area include the Federal Ecological Monitoring Program conducted from 1987 to 1989 (Ramsey 1991b), the Manitoba Ecological Monitoring Program conducted from 1985 to 1989 (Green 1990), the Keeyask Generation Project environmental studies program (2001-2004, 2009, and 2011: Badiou and Cooley 2004, 2005; Badiou *et al.* 2005, 2007; Jansen and Cooley 2012; Keeyask Hydropower Limited Partnership 2012), and monitoring conducted under CAMP (CAMP *unpubl. data*).

Sipiwesk Lake and the Nelson River upstream of Kelsey GS are each monitored every three years under CAMP (CAMP *unpubl. data*). The historical water quality monitoring site located near the outlet of Sipiwesk Lake continues to be monitored three times per year by MCWS (MCWS *unpubl. data*).

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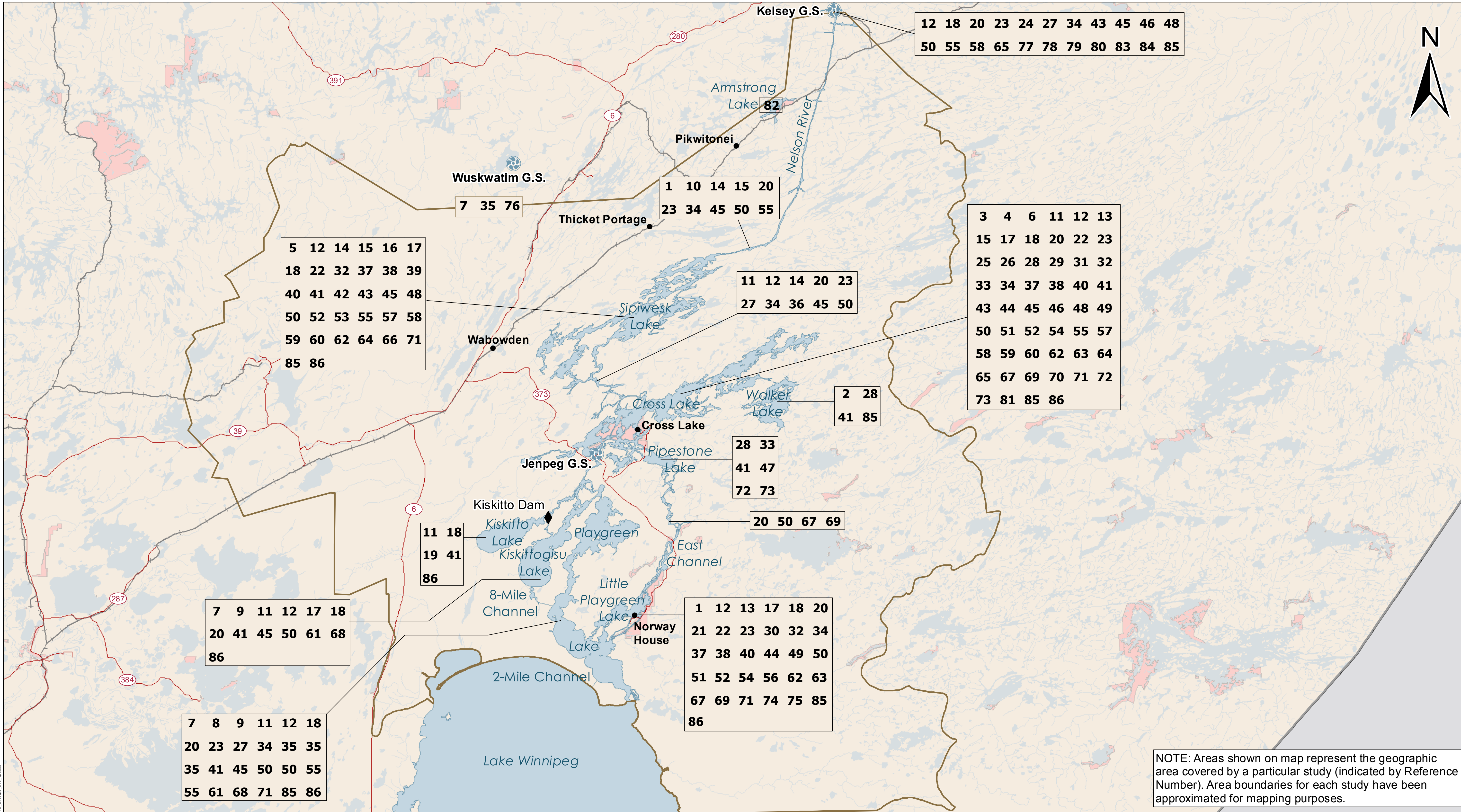

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
0 20 40 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Dam
- Generating Station (Existing)
- Highway
- Rail
- First Nation Reserve

Water Quality
Area 1

Map 5-2

5.2.1.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

5.2.1.2.1 SUMMARY OF SCIENTIFIC INFORMATION

SPLIT LAKE

Various water quality parameters were measured in the Grass River and associated lakes during the open-water periods of 1958-1962, 1964, 1967, 1969 to assess the impacts of the INCO (now Vale) mine in Thompson on the downstream environment (Beak 1962; Sunde 1962; Cober 1971, 1972; Crowe 1973a; Environment Canada 1978; Grapentine *et al.* 1988). The Grass River near the junction with the Nelson River was also studied in 1972 and 1973 for temperature, oxygen, Secchi disk depth, nutrients, conductivity, total dissolved solids (TDS), total suspended solids (TSS), and chlorophyll *a* to document background conditions prior to construction of the Churchill River Diversion(CRD) and the Long Spruce GS (Cleugh 1974a, b).

Early studies of water quality in Split Lake included measurements (temperature, pH, Secchi disk depth, TDS, and alkalinity) collected during the commercial fisheries assessment conducted in July 1966 (Schlick 1968). Subsequently, the Lake Winnipeg, Churchill and Nelson Rivers Study Board conducted studies of various areas in the lake as well as the Burntwood and Nelson rivers upstream of the lake in 1972-1974 for the aforementioned parameters as well as turbidity and nutrients, and presented predictions of the impacts of Churchill River Diversion on the area (Cleugh 1974a, b; Hecky and Harper 1974; Lake Winnipeg, Churchill and Nelson Rivers Study Board 1975; Grapentine *et al.* 1988). Aqueous mercury concentrations in the lake were documented in 1972, and TSS concentrations in the Burntwood River upstream of Split Lake were documented for 1969-1977 (Kozody 1979; Vitkin and Penner 1979).

Water quality of Split Lake has been monitored almost annually since 1975 as part of provincial monitoring, the Northern Flood Agreement, the Manitoba and Federal Ecological Monitoring Programs, or under studies related to potential future hydroelectric development (Kozody 1979; Playle 1986; Derksen 1987; Rannie and Punter 1987; Derksen *et al.* 1988; Grapentine *et al.* 1988; Playle *et al.* 1988; Green 1990; Cann 1991; Environment Canada and Department of Fisheries and Oceans 1992a, b, c; Lawrence and Fazakas 1997; Clarke and Lawrence 1998; Fazakas and Lawrence 1998a, b; Bezte *et al.* 1999; Fazakas 1999a, b; Fazakas and Zrum 1999; Zrum and Neufeld 2001; Badiou and Cooley 2004, 2005; Dunmall *et al.* 2004; Holm and Remnant 2004; Badiou *et al.* 2005, 2007; Juliano and Neufeld 2005; Savard *et al.* 2009a; Hnatiuk Stewart and Cooley 2010; Savard and Cooley 2011b; Keeyask Hydropower Limited Partnership 2012). Parameters measured have varied through time and across programs but generally included temperature, conductivity, pH, oxygen, Secchi disk depth; colour, nutrients, TSS, TDS, alkalinity, major ions, iron, arsenic, cadmium, copper, lead, mercury, and zinc. Assessments of the changes through time have also been conducted using various time periods (Playle and Williamson 1986; Northwest Hydraulic Consultants Ltd. 1987, 1988; Duncan and Williamson 1988; Ramsey *et al.* 1989; Ralley and Williamson 1990; Baker and Davies 1991; Williamson and Ralley 1993; Split Lake Cree 1996; Split Lake Cree-Manitoba Hydro Joint Studies 1996b; Savard *et al.* 2009b; Keeyask Hydropower Limited Partnership 2012). Analysis of the sedimentation regime in Split Lake was conducted on behalf of Manitoba Hydro or the Tataskweyak Environmental Monitoring Agency in 1981, 1997, 1998, 2008-2010, 2012 through the monitoring of continuous turbidity data and sediment deposition rates (Clarke and

Lawrence 1998; Bezte and Lawrence 1999; Schneider-Vieira and Hnatiuk 2009; Schneider-Vieira and Hnatiuk Stewart 2010, 2011, 2013).

Post-CRD studies of water quality (up to the full suite of parameters) slightly upstream of Split Lake (*i.e.*, in the Nelson and Burntwood rivers) and at the outlet of the lake have generally been conducted with the intent of analyzing temporal changes in the lake resulting from hydroelectric developments along the rivers (Grapentine *et al.* 1988; McKerness 1988, 1989a, 1990; Green 1990; Ramsey 1991a; Environment Canada and Department of Fisheries and Oceans 1992c; Badiou and Cooley 2004, 2005; Badiou *et al.* 2005, 2007; Cooley and Savard 2008; Savard *et al.* 2009a, b, 2010; Hnatiuk Stewart and Cooley 2010; Savard and Cooley 2011b; Keeyask Hydropower Limited Partnership 2012).

The Split Lake community uses the lake as a drinking water source; therefore, water quality near the community has been assessed since 1972, with parameters generally including turbidity, TSS, colour, nutrients, pH, conductivity, alkalinity, major ions, arsenic, cadmium, copper, iron, lead, mercury, zinc, and bacteria (Morelli 1973, 1975; Underwood and McLellan Ltd. 1983a, 1984a; Manitoba Conservation Water Stewardship [MCWS] *unpubl. data*). The site is currently monitored four times annually under the Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP 2014, *unpubl. data*).

Water quality was not measured in the Aiken River prior to CRD construction (*i.e.*, this is the drinking water source for the community of York Landing; Ramsey 1991a); monitoring commenced in 1975 and included the same parameters measured concurrently in Split Lake (Underwood and McLellan Ltd. 1983b, 1984b; Grapentine *et al.* 1988; McKerness 1988, 1989a, 1990; Williamson and Ralley 1993; G.A. Pratt & Associates Inc. 1994). The potential and observed impacts of CRD were discussed in several reports (Damas and Schmidt 1981; Baker and Davies 1991; Ramsey 1991a; Environment Canada and Department of Fisheries and Oceans 1992b, c). Water quality of the Aiken River and Split Lake near York Landing was also assessed in 2001-2004 and 2009 as part of the Keeyask Generation Project environmental studies (Badiou and Cooley 2004, 2005; Badiou *et al.* 2005, 2007; Savard *et al.* 2010; Keeyask Hydropower Limited Partnership 2012).

GULL LAKE TO STEPHENS LAKE

Limited water quality data are available for Gull and Stephens lakes prior to CRD. Water quality (temperature, conductivity, TDS, TSS, major ions, nutrients, and chlorophyll *a*) of Clark Lake was assessed in 1972-1973 (Cleugh 1974b). Data were collected in Stephens Lake (*i.e.*, the Kettle GS forebay) multiple times in 1972 during construction of the Kettle GS; conditions were compared to those in the existing Kelsey forebay (Crowe 1973b; Morelli 1973). Moose Nose Lake (which became the north arm of Stephens Lake after impoundment) was studied in 1972/1973 under Lake Winnipeg, Churchill and Nelson Rivers Study Board (generally parameters were as above) and studies were conducted in Stephens Lake (south) in 1972-1974 (as above plus colour, light profiles, Secchi disk depth, aluminum, and iron; Cleugh 1974b; Hecky and Harper 1974; Morelli 1975; Environment Canada 1978; Jackson and Hecky 1980).

Assessments of the impacts of hydroelectric development on TSS, primary production, and general limnological conditions were conducted in Stephens Lake shortly following construction of the Kettle GS and CRD (Jackson and Hecky 1980; Bodaly *et al.* 1984; Split Lake Cree 1996; Ramsey and Ramlal 1986;

Swanson 1986; Derksen 1987). This lake was also studied under the Canada-Manitoba Agreement on the Study and Monitoring of Mercury Program (MEMP) and the Manitoba and Federal Ecological Monitoring Program (FEMP) in 1986-1989 for temperature, pH, conductivity, Secchi disk depth, nutrients, chlorophyll *a*, major ions, iron, mercury, and methylmercury (Environment Canada 1978, 1980, 1982a; Derksen *et al.* 1988; Grapentine *et al.* 1988; Baker 1989; Ramsey *et al.* 1989; Green 1990; Janusz 1990a, b; McKerness 1990; Ramsey 1990; Green 1991; Ramsey 1991b; Environment Canada and Department of Fisheries and Oceans 1992b).

Numerous studies have been conducted in Gull (1999, 2001-2004, 2009) and Stephens (1990-1994, 1999, 2001-2006, 2009) lakes, as well as respective areas of the Nelson River, as part of the Conawapa and Keeyask Generation Projects environmental studies and the Limestone GS aquatic monitoring program (MacDonell and Horne 1994; Zrum and Bezte 2003; Badiou and Cooley 2004, 2005; Dunmall *et al.* 2004; Badiou *et al.* 2005; Juliano and Neufeld 2005; Badiou *et al.* 2007; Neufeld 2007; Savard and Cooley 2007b, c; Cooley and Savard 2008; Cooley *et al.* 2009; Demarty *et al.* 2009; Savard *et al.* 2010; Jansen and Cooley 2012; Keeyask Hydropower Limited Partnership 2012; North/South Consultants Inc. 2012). Studies have generally included pH, conductivity, alkalinity, nutrients, chlorophyll *a*, major ions, iron, silica, and TSS, although other parameters have also been measured periodically, including: profiles of temperature, turbidity, and oxygen; Secchi disk depth; light extinction; metals; radioactivity; hydrocarbons; coliforms; parasites, and *in situ* gas pressure. An assessment of changes in water quality in Stephens Lake between 1972 and 2006 was conducted as part of the Keeyask GS EIS (Keeyask Hydropower Limited Partnership 2012).

The north and south basins of Stephens Lake are monitored every three years as part of CAMP (CAMP 2014, *unpubl. data*).

LOWER NELSON RIVER

Technical surveys of the Lower Nelson River were limited prior to CRD. Single sampling events were conducted in 1958 and 1959 in the Nelson River near the Limestone River to document pH, colour, turbidity, conductivity, TDS, suspended matter, major ions, iron, nitrate, silica, and alkalinity (Thomas 1959). Studies coordinated through the Lake Winnipeg, Churchill and Nelson Rivers Study Board included assessments of water quality (as above plus nutrients and chlorophyll *a*) in the Nelson River near the Long Spruce GS and downstream of the GS in 1972-1974 (Cleugh 1974b; Hecky and Harper 1974; Morelli 1975; Northwest Hydraulic Consultants Ltd. 1987; Grapentine *et al.* 1988).

Studies along the lower Nelson River after 1974 were typically related to measuring baseline conditions in relation to potential future GS developments (*i.e.*, Limestone, Conawapa, or Keeyask GSs) or assessing impacts relating to GSs under construction or existing GSs (*i.e.*, Long Spruce or Limestone GSs). Water quality (generally including profiles of temperature, oxygen, conductivity, and turbidity; Secchi disk depth; TSS; alkalinity; nutrients; iron; silica, and chlorophyll *a* although light extinction, metals, radioactivity, hydrocarbons, coliforms, and parasites were periodically measured after 2002) of the Long Spruce and Limestone forebays and the Nelson River below the Limestone GS was measured in 1988-1994, 1996, 1999, 2002-2004, 2006, 2009; 2010; and 2011 (MacLaren Plansearch and InterGroup Consultants 1986; Baker 1989, 1990a, 1991, 1992, 1996; Horne and Baker 1993; Kroeker and Horne 1993; Schneider and Baker 1993; MacDonell and Horne 1994; Schneider-Vieira 1994, 1996; Horne and MacDonell 1995; Split

Lake Cree 1996; Horne 1997a; Zrum and Kennedy 2000; Badiou and Cooley 2005; Badiou *et al.* 2005, 2007; Burt and Neufeld 2007; Savard and Cooley 2007d, 2011a; Savard *et al.* 2010; Jansen and Cooley 2012; Keeyask Hydropower Limited Partnership 2012; North/South Consultants Inc. 2012; Juliano *et al.* 2013; Cooley et al. 2014). Studies relating to the impacts to fisheries in the Limestone River, tributaries to the Nelson River, and/or the Long Spruce and Limestone forebays were also conducted in 1975, 1979, 1985-1990, and 2003-2005 and included measurements of some or all of the following: temperature; pH; conductivity; TDS; alkalinity; major ions; filterable and non-filterable residues; turbidity; arsenic; cadmium; copper; iron; lead; nickel; and zinc (Gaboury 1978, 1980a; Swanson 1986; Swanson *et al.* 1988, 1990, 1991; Davies 1989; Baker *et al.* 1990; Kroeker 1991; Kroeker and MacDonell 2006; Keeyask Hydropower Limited Partnership 2009).

Environment Canada monitored water quality on the lower Nelson River upstream of the Weir River from 1979 through 1983 (parameters measured included pH, alkalinity, nutrients, metals, TSS, turbidity, conductivity, TDS, colour, and hardness; Environment Canada 1982b, 1984). In 2003-2007, concentrations of total and methyl mercury (dissolved and total forms), total phosphorus, total nitrogen, particulate and dissolved organic carbon, and chlorophyll *a* were measured upstream and downstream of the Limestone GS (Kirk and St. Louis 2009).

The major tributaries to the Nelson River below the Limestone GS (*i.e.*, the Limestone, Angling, and Weir rivers) were monitored in 2002-2004, 2006, and 2009, and greenhouse gas sampling for carbon dioxide and methane was conducted in each forebay in 2001-2004 (Cooley and Savard 2008). An early assessment of CRD in relation to the overall effects of development was also conducted (Bodaly *et al.* 1984).

The lower Nelson River below the Limestone GS is sampled three times annually under CAMP and the Limestone forebay is sampled every winter (*i.e.*, when the riverine site is unsafe); the forebay is also sampled during the open-water season every three years as part of CAMP (CAMP 2014, *unpubl. data*).

NELSON RIVER ESTUARY

Data collection in the Nelson River estuary is logistically difficult and expensive, resulting in a limited number of water quality studies available: the majority of studies have been conducted on behalf of Manitoba Hydro. Prior to 1975, data from the estuary were limited to measurements of sediment loads (Penner *et al.* 1975); temperature and salinity were also measured in 1979 during a fisheries survey (Gaboury 1980b). In 1988-1989, 1992, and 1995-1999, temperature, salinity, oxygen, and conductivity profiles and Secchi disk depth were measured *in situ*; surface and bottom (where stratified) samples were collected for analysis of pH, TSS, nutrients, silica, and chlorophyll *a;* and the impacts of hydroelectric development on the estuary were discussed (Baker 1989, 1990b, 1996; Lawrence *et al.* 1992; Schneider-Vieira *et al.* 1993; Horne 1997b; Horne and Bretecher 1998; Teklemariam 1999; Zrum 1999, 2000; Mundy and Sydor [c.2005]). Surface temperatures and salinities were again documented in August 2006 (Holm and Bernhardt 2011).

Between 2003 and 2007, an independent study was conducted to quantify the loads of mercury and nutrients entering Hudson Bay from the Nelson River (Kirk and St. Louis 2009). ArcticNet also coordinated studies in the Nelson River estuary and Hudson Bay, including characterization of the processes affecting turbidity and the distribution of TSS (Lorrain *et al.* 2008) and an assessment of the sources of dissolved organic matter (Guéguen *et al.* [c.2010], [c.2011a, b]).

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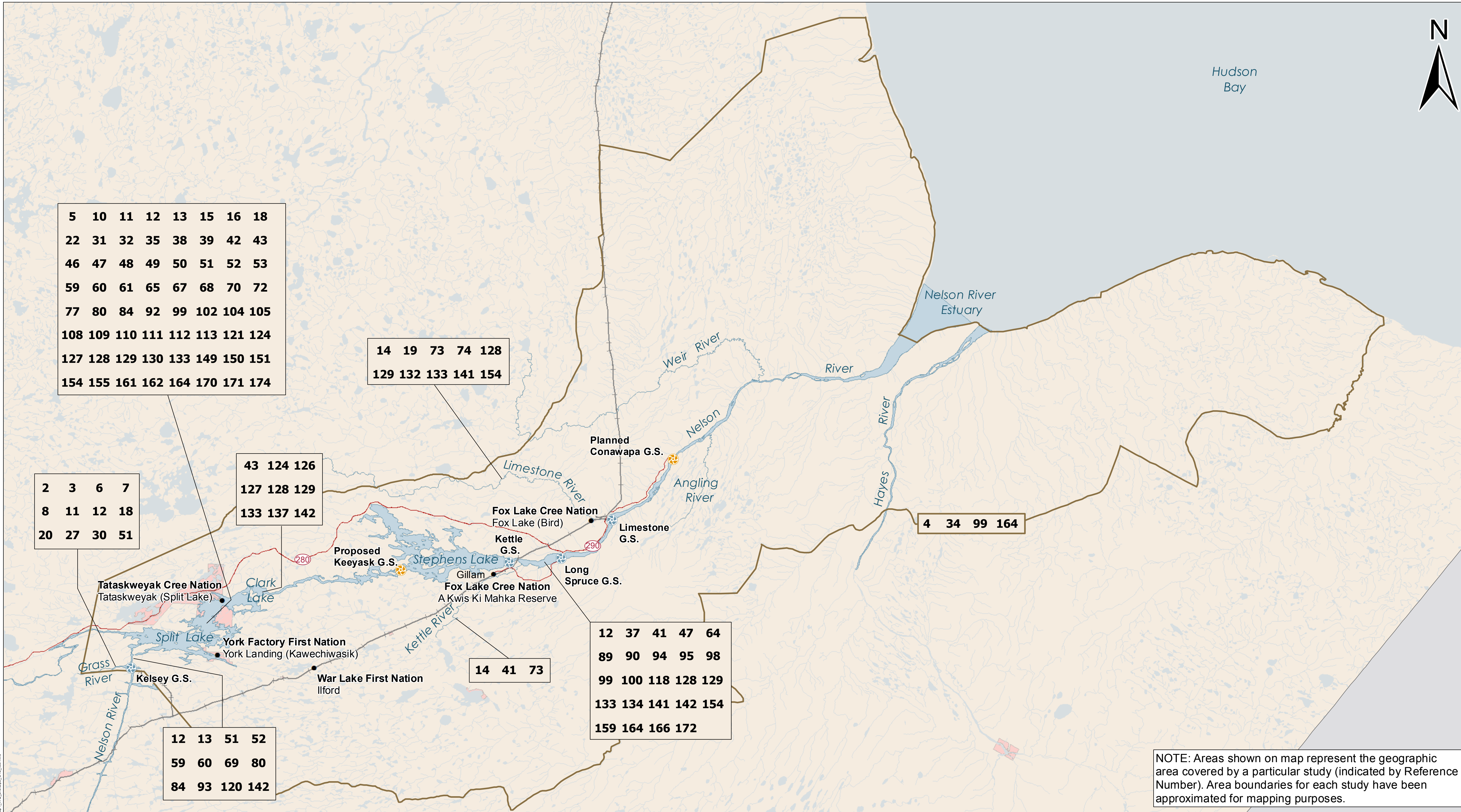


Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

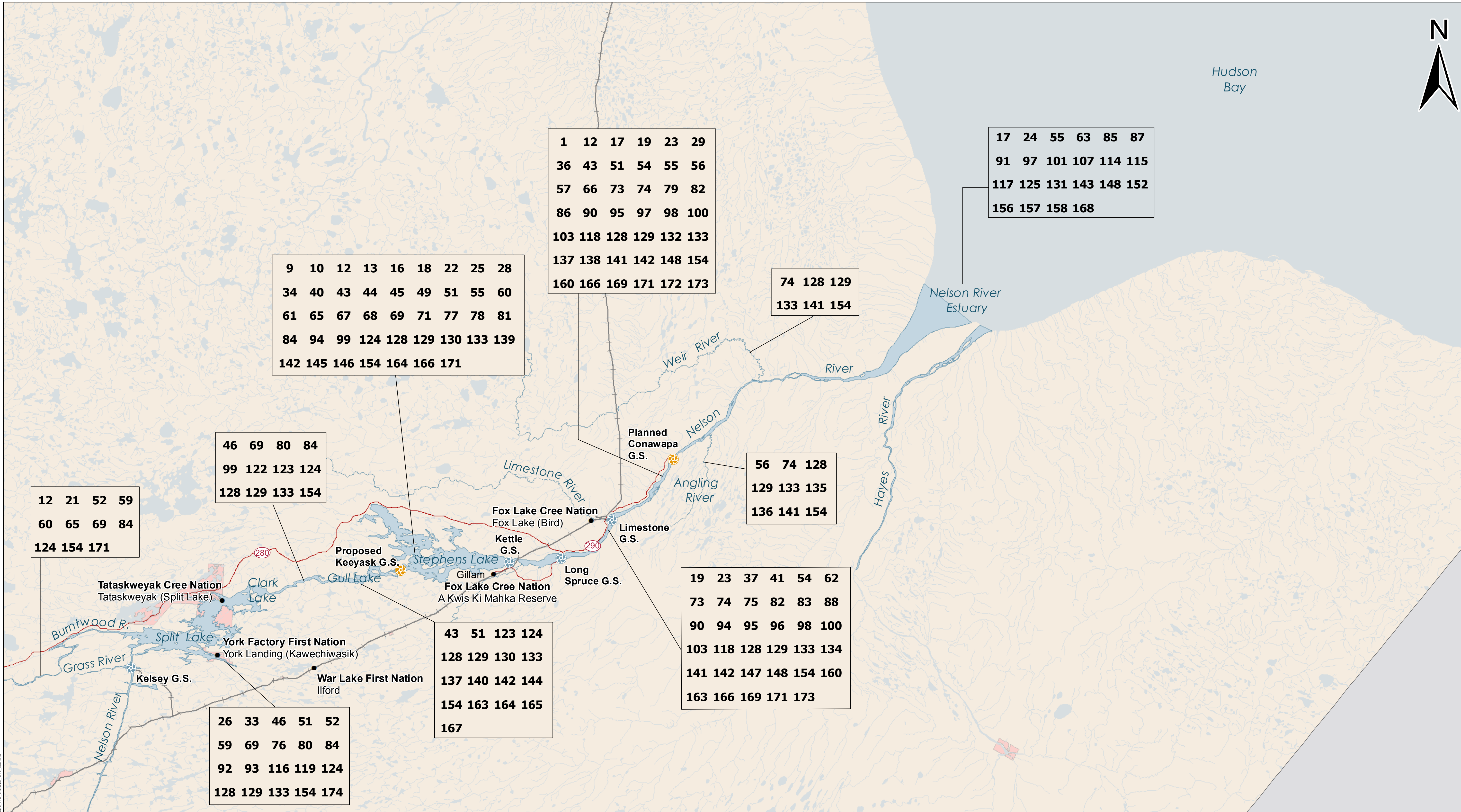
COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	27-MAY-14
0 10 20 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: LDB/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- First Nation Reserve

Water Quality
Area 2 - Map 1

Map 5-3A



Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
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Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- First Nation Reserve

Water Quality
Area 2 - Map 2

Map 5-3B

5.2.1.3 Area 3: Opachuanau Lake to Split Lake Inlet (including Southern Indian Lake)

5.2.1.3.1 Summary of Scientific Information

Southern Indian Lake

In 1952, an assessment of fishery conditions throughout Southern Indian Lake documented pH, temperature, oxygen, and turbidity of the surface and bottom waters, as well as Secchi disk depth, for over 35 sites (McTavish 1952).

The Lake Winnipeg, Churchill, and Nelson Rivers Study Board report initiated intensive studies of Southern Indian Lake in 1972 to document baseline conditions prior to the Churchill River Diversion (CRD). Water quality (colour, conductivity, total dissolved [TDS], nutrients, silicon, cations, and anions) of the tributaries to Southern Indian Lake was measured in August 1972 (Cleugh 1974a; Grapentine *et al.* 1988) and total suspended solids (TSS) of the Churchill River upstream of Southern Indian Lake was measured in 1972 and 1973 (Underwood McLellan and Associates Ltd. 1973a). Conditions in Southern Indian Lake, Missi Falls, Opachuanau Rapids, and Barrington River were also studied up to nine times in 1972; Opachuanau Rapids and Missi Falls were studied again multiple times in 1973 and 1973-1974, respectively (for the aforementioned parameters as well as pH, TSS, turbidity, chlorophyll *a*, Secchi disk depth, alkalinity, copper, lead, iron, manganese, mercury, zinc, bacteria, and profiles of temperature and oxygen at certain sites; Morelli 1973, 1975; Underwood McLellan and Associates Ltd. 1973b; Cleugh 1974a; Environment Canada 1979a; Playle 1986; Playle and Williamson 1986; Duncan and Williamson 1988; Grapentine *et al.* 1988; Playle *et al.* 1988). These data were summarized and used to assess influences on other components of the aquatic ecosystem in Southern Indian Lake (Cleugh 1974b; Hamilton 1974; Hecky and Ayles 1974a; Hecky *et al.* 1974; Hecky 1975; Lake Winnipeg, Churchill and Nelson Rivers Study Board 1975).

Construction and post-CRD monitoring for various parameters (any combination of temperature, specific conductance, pH, alkalinity, nutrients, TSS, turbidity, light penetration, colour, chlorophyll *a*, Secchi disk depth, coliforms, major ions, arsenic, cadmium, copper, iron, lead, mercury, silicon, and zinc) were conducted in 1974-1978 for Opachuanau Lake and up to 29 sites in Southern Indian Lake (Environment Canada 1978b, 1979b, 1980; Hecky *et al.* 1979; Playle 1986; Playle and Williamson 1986; Duncan and Williamson 1988; Grapentine *et al.* 1988; Playle *et al.* 1988). Phosphorus turnover was also examined in Southern Indian Lake in 1976 (Planas and Hecky 1984).

Studies of the effects of impoundment initially occurred between 1974 and 1978 and included assessment of changes in water quality and phytoplankton biomass and productivity (using aqueous adenosine triphosphate [ATP] concentrations; pH, conductivity, and light profiles; Secchi disk depth; nutrients; chlorophyll *a*; iron; and aluminum; Guildford 1977, 1978; Healey and Hendzel 1980; Jackson and Hecky 1980; Hecky *et al.* 1982; Hecky 1984; Hecky and Guildford 1984; Guildford 1985; Hecky *et al.* 1986). Temperature, Secchi disk depth, suspended solids, and chlorophyll *a* in the reservoir were used to assess changes in invertebrate populations (Patalas and Salki 1984; Wiens and Rosenberg 1984; Giberson 1991; Giberson *et al.* 1992). Additionally, changes in the sedimentation regime (*i.e.*, size of particles in suspension and TSS), temperature, conductivity, nutrients, Secchi disk depth, and chlorophyll *a* concentrations throughout the lake have been considered in relation to the ongoing concerns over the status of the whitefish populations in the lake (Hecky and Newbury 1977; J.F. MacLaren Ltd. 1978; Vitkin and Penner 1979; Fudge and Bodaly 1984; Hecky and McCullough 1984b, Hecky *et al.* 1985; Newbury and McCullough 1984; Northwest Hydraulic Consultants Ltd. 1987; McCullough 2012; Bodaly 2013a, b; Hesslein 2013; North/South Consultants Inc. 2013). Assessments of the fisheries in Southern Indian Lake are ongoing and periodically include measurement of temperature, pH, conductivity, oxygen, and turbidity (Graveline and Remnant 2005; Gurney and Remnant 2005).

Studies of mercury concentrations in water, sediment, plankton, and fish, and measurement of the specific rates of methylation and demethylation of mercury in Southern Indian Lake were initiated in 1977 under the umbrella of a number of different programs, including the Canada-Manitoba Agreement on the Study and Monitoring of Mercury and the Manitoba and Federal Ecological Monitoring Programs (MEMP and FEMP, respectively; Bodaly and Hecky 1979; Kozody 1979; Bodaly *et al.* 1984b, 1987a; Canada-Manitoba 1984, 1987; Ramlal *et al.* 1986; Ramsey and Ramlal 1986a; Williamson 1986; Hecky *et al.* 1987a, b, c, d, 1991; Jackson 1987, 1988, 1991; Ramsey 1987, 1988, 1989, 1990b, 1991a; Rannie and Punter 1987; Environment Canada and Department of Fisheries and Oceans 1992b). Supporting variables for the mercury studies included periodic measurements of temperature, pH, conductivity, oxygen, nutrients, chlorophyll *a*, TSS, light penetration, and major ions. Mesocosm experiments conducted in Southern Indian Lake also examined the influence of temperature, oxygen, pH, aqueous mercury, organic matter, and nutrients concentrations on mercury cycling in the reservoir (Canada and Manitoba 1987; Guildford *et al.* 1987; Hecky *et al.* 1987a, b; Ramlal *et al.* 1987). Examination of mercury in the Barrington River, Opachuanau Lake, and the Churchill River upstream of Southern Indian Lake were also conducted in 1974-1979 in support of the mercury studies in Southern Indian Lake (Bodaly and Hecky 1979; Kozody 1979; Williamson 1986; Rannie and Punter 1987; Grapentine *et al.* 1988).

Overall effects of CRD are summarized in a number of reports (Baxter and Glaude 1980; Hecky *et al.* 1981; Bodaly *et al.* 1984a; Hecky *et al.* 1984; Newbury *et al.* 1984; Lehman 1986; McKerness 1989c; Bodaly and Rosenberg 1990; Unies Ltd. 1990).

MEMP and FEMP were conducted in 1985-1989 and 1986-1990, respectively. These programs included measurement of an array of water quality parameters throughout Southern Indian Lake (temperature, conductivity, pH, turbidity, alkalinity, colour, nutrients, major ions, coliforms; and periodically TSS, TDS, copper, iron, lead, silica, zinc, chlorophyll *a*, and Secchi disk depth; McKerness 1988, 1989a, 1990; Environment Canada and Department of Fisheries and Oceans 1992b). Sampling dates for collection of TSS, turbidity, and/or limnological parameters were documented by McKerness (1989b) for most waterbodies in northern Manitoba; however, no data were provided. Subsequently, comparisons of pre-, during-, and post-CRD data were conducted to quantify the effects of diversion (Ralley and Williamson 1990; Williamson and Ralley 1993).

Salki *et al.* (1999) summarized limnological conditions (temperature, pH, conductivity, Secchi disk depth, nutrients, chlorophyll *a*, and major ions) measured at up to 43 stations throughout Southern Indian Lake between 1972 and 1998.

Manitoba Conservation and Water Stewardship (MCWS) has monitored water quality near the community of South Indian Lake since 1972; the site is currently monitored three times during the open-water season (Morelli 1973, 1975; Warrener 1975; MCWS *unpubl. data*). Since 2008, water quality has been sampled four times annually at Southern Indian Lake near Missi Falls under the Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP); Southern Indian Lake at South Bay and near the Churchill River inlet, and Opachuanau Lake have been studied rotationally every three years (CAMP 2014, *unpubl. data*).

RAT RIVER (TO NOTIGI CS)

As part of the Lake Winnipeg, Churchill, and Nelson Rivers Study Board studies, water quality conditions (temperature profiles, oxygen, pH, conductivity, TDS, Secchi disk depth, nutrients, chlorophyll *a*, major ions, iron, and carbon dioxide) were measured in Issett (subset of parameters), Karsakuwigamak, Pemichigamau, Mynarski (west basin), Rat, and Notigi lakes in 1972-1973 (Cleugh 1974b; Hecky and Ayles 1974b; Hecky and Harper 1974; Grapentine *et al*. 1988).

As in Southern Indian Lake, studies of the effects of impoundment of Notigi Lake included assessment of changes in water quality and phytoplankton biomass between 1974 and 1977 (via ATP concentrations; alkaline phosphatase activity; pH, conductivity, and light profiles; Secchi disk depth; nutrients; chlorophyll *a*; iron; and aluminum; Guildford 1977, 1978; Healey and Hendzel 1980; Jackson and Hecky 1980). Pre- and post-CRD concentrations of TSS in Notigi Lake were also measured and evaluated over the period of 1969-1977 (Vitkin and Penner 1979), and LANDSAT images from 1973-1986 over Issett, Pemichigamau, Karsakuwigamak, and Notigi lakes were evaluated for changes in inferred turbidity (Barber 1987; Northwest Hydraulic Consultants Ltd. 1988). The effects of CRD on temperature, Secchi disk depth, oxygen saturation, and total phosphorus concentrations in Notigi Lake were examined for the period 1972-1984 (Hecky *et al*. 1987d) and changes in temperature, oxygen, magnesium, and calcium in Karsakuwigamak, Mynarski (east, west, and central basins), Rat, and Notigi lakes were assessed for 1973-1979 (Grapentine *et al*. 1988). Predictions for and the overall effects of CRD were also summarized in various reports (Lake Winnipeg, Churchill, and Nelson Rivers Study Board 1975; Baxter and Glaude 1980; Bodaly *et al*. 1984a; McKerness 1989c; Environment Canada and Department of Fisheries and Oceans 1992b).

Assessments of mercury (and periodically methylmercury) were conducted in 1978 in Pemichigamau and Notigi lakes (Bodaly and Hecky 1979), and specific rates of methylation and demethylation were calculated for Issett, Mynarski (east, west, and central basins), and Notigi lakes in 1981 (Bodaly *et al.* 1987a; Ramlal *et al*. 1987). Mercury and supporting parameters (temperature, pH, conductivity, oxygen, nutrients, chlorophyll *a*, TSS, light penetration, and major ions) were also periodically measured in Issett, Mynarski, Rat, and Notigi lakes between 1981 and 1984 under the Canada-Manitoba Agreement on the Study and Monitoring of Mercury (Canada and Manitoba 1984, 1987; Ramsey and Ramlal 1986a; Bodaly *et al*. 1987b; Hecky *et al*. 1987c; Jackson 1987, 1988, 1991; Ramsey 1988, 1991a; Environment Canada and Department of Fisheries and Oceans 1992b; Grapentine *et al*. 1988). Both total and methyl mercury were studied in Notigi Lake again in 1987-1989 (McKerness 1990; Ramsey 1990b).

The Provincial monitoring program (MEMP) measured temperature profiles, pH, conductivity, TDS, colour, Secchi disk depth, nutrients, major ions, and metals in Notigi and Rat lakes in 1985-1989

(Derksen 1987; Derksen *et al.* 1988; McKerness 1988, 1989a; Ramsey *et al.* 1989; Green 1990; Janusz 1990 a, b; Cann 1991). Studies of post-CRD conditions in Notigi Lake (east and west basins) also included examination of phosphorus turnover in 1976 (Planas and Hecky 1984). Sampling dates for collection of TSS, turbidity, and/or limnological parameters were documented by McKerness (1989b) for most waterbodies in northern Manitoba; however, no data were provided.

Temperature, conductivity, TSS, Secchi disk depth, major ions, and mercury were measured in Notigi Lake in 1974-1978 and were used for an assessment of future projects along the Rat-Burntwood System (MacLaren Engineers Inc. and InterGroup Consulting Economists Ltd. 1984d). The baseline studies for the Wuskwatim GS started in 1999 and included measurement of oxygen, conductivity, pH, turbidity, TSS, Secchi disk depth, chlorophyll *a*, and nutrients in Rat Lake in 1999 and Notigi Lake in 1999-2001 (Bezte and Kroeker 2000; Zrum and Fazakas. 2000; Zrum and Neufeld. 2003a; Cooley and Badiou 2004a, b).

Since 2008, Mynarski (central basin), Rat, and Notigi (east and west basins) lakes have been studied rotationally every three years under CAMP (CAMP 2014, *unpubl. data*). No pre- or post-CRD water quality data were found for Macheewin Lake.

RAT/BURNTWOOD RIVER (DOWNSTREAM OF NOTIGI CS)

The Province conducted "pre-pollution surveys" of the lower Burntwood River in 1958-1960 prior to initiation of operation of INCO (now Vale), the nickel mine in Thompson; surface temperature, pH, oxygen, and Secchi disk depth were recorded (Sunde 1958, 1960; Beak 1962). Copper and/or zinc concentrations were also measured in 1959, 1960, and 1964, and colour, pH, turbidity, TSS, alkalinity, specific conductivity, and TDS were measured in 1967-1969 to quantify the effects of the mine on the ecosystem (Cober 1971; Chekay and Crowe 1972).

In 1972/1973, Lake Winnipeg, Churchill, and Nelson Rivers Study Board studies included the Rat, Burntwood, and Footprint rivers above Threepoint Lake; Wapisu, Footprint, Threepoint, and Wuskwatim lakes; and the Burntwood River upstream and downstream Thompson (Morelli 1973, 1975; Cleugh 1974 a, b; Hecky and Ayles 1974b; Hecky and Harper 1974; Environment Canada 1978b, 1979a, b; Kozody 1979; Playle 1986; Playle and Williamson 1986; Williamson 1986; Duncan and Williamson 1988; Grapentine *et al.* 1988). Water quality data (pH, colour, conductivity, TSS, turbidity, chlorophyll *a*, Secchi disk depth, nutrients, alkalinity, silicon, cations, anions, copper, lead, iron, manganese, mercury, zinc, and bacteria) were summarized and used in the assessment of potential effects of CRD (Underwood McLellan and Associates Ltd. 1973a, b; Lake Winnipeg, Churchill, and Nelson Rivers Study Board Report 1975). Post-CRD studies (1977-1979, 1981) and assessments of changes in TSS and mercury were conducted in many of these areas as part of the Northern Flood Agreement (Guilbault *et al.* 1979; Vitkin and Penner 1979; Environment Canada 1980; Canada-Manitoba 1984; Grapentine *et al.* 1988; Northwest Hydraulic Consultants Ltd. 1987, 1988). General assessments of changes resulting from CRD were also made with regards to water quality (Reynolds and Ujjainwalla 1981; Bodaly *et al.* 1984a). Additional water quality data (temperature, oxygen, conductivity, nutrients, and light penetration) were measured in Footprint Lake in 1981 (Bodaly *et al.* 1987a, b).

Threepoint Lake, the inlets to Threepoint Lake, the Burntwood River at Thompson, and the Burntwood River upstream of Split Lake were studied by Environment Canada and under MEMP and FEMP from 1984 to 1989 for temperature, pH, conductivity, Secchi disk depth, nutrients, TSS, TDS, and mercury and other metals (Canada-Manitoba 1984, 1987; Environment Canada 1986, 1988b; Derksen 1987; Derksen *et al.* 1988; McKerness 1988, 1989a, b, 1990; Ramsey *et al.* 1989; Green 1990, 1991; Janusz 1990a, b; Ramsey 1990b, 1991b; Cann 1991; Environment Canada and Department of Fisheries and Oceans 1992b, c). Conditions in the region were summarized in the FEMP Summary Report (Environment Canada and Department of Fisheries and Oceans 1992a).

Additional hydroelectric projects along the Burntwood River (*i.e.*, downstream of Notigi Reservoir) were considered in the early 1980s and assessments included a broad analysis of temperature, oxygen, TSS, anions, cations, and mercury concentrations in Threepoint, Wuskwatim, Apussigamasi, and Mystery lakes as well as the Burntwood River at First Rapids, at Thompson, and at the junctions with the Manasan and Odei rivers (MacLaren Engineers Inc. and InterGroup Consulting Economists Ltd. 1984a, b, c, d). Baseline studies conducted in 1999-2004 and 2008 for the Wuskwatim GS included assessments of pH, conductivity, oxygen, TSS, turbidity, Secchi disk depth, chlorophyll *a*, nutrients, metals, TDS, colour, polycyclic aromatic hydrocarbons, benzene, toluene, ethylbenzene and xylene (BTEX), bacteria, and protozoan parasites (Zrum and Kroeker 1999; Bezte and Kroeker 2000; Cooley *et al.* 2003; Manitoba Hydro and Nisichawayasihk Cree Nation 2003b; Cooley and Badiou 2004a, b; Cooley *et al.* 2006; Savard and Cooley 2006; Savard and Cooley 2007; Savard *et al.* 2009a, b; Hnatiuk Stewart and Cooley 2010). Waterbodies varied over the course of the baseline studies and included Wapisu, Footprint, Threepoint, Cranberry, Kinosaskaw, Wuskwatim, Opegano, and Birch Tree lakes and Wuskwatim Brook; additional interspersed riverine and lacustrine areas; and the Burntwood River upstream and downstream of Thompson. Temperature, conductivity, pH, turbidity, oxygen, or Secchi disk depth were also periodically measured during stream crossing assessments, gill-netting, invertebrate, and macrophyte sampling programs in the study area (Caskey *et al.* 2003; Fazakas and Remnant 2003; Zrum *et al.* 2003; Zrum and Neufeld 2003b, c, d; Dolce *et al.* 2004; Juliano and Neufeld 2004; Mota and Remnant 2006; Hudd 2009; Zrum and Wyn 2009; North/South Consultants Inc. 2010; Fazakas and Zrum 2011). Sedimentation rates were calculated using sediment trap, turbidity, and Secchi depth data collected from Wuskwatim Lake in 1999 (Bezte and Richardson 2004) and temperature and carbon dioxide and methane concentrations were measured in the Burntwood River downstream of Wuskwatim Lake in 2001-2004 (Cooley and Savard 2006).

Water quality monitoring was conducted during construction of the Wuskwatim GS over the period of 2008 through 2012 (Savard *et al.* 2009a; Hnatiuk Stewart and Cooley 2010; Szczepanski and Schneider-Vieira 2010; Savard and Cooley 2011; Savard 2012; Savard and Schneider-Vieira 2011, 2012, 2013).

Overall, water quality of Footprint Lake at Nelson House and the Burntwood River at Thompson have been monitored by MCWS/Environment Canada since 1972 and 1975, respectively, and analysis of change has been conducted over an array of time periods (Environment Canada 1975a, b, 1977, 1978a, b, 1979a, b, 1980, 1982, 1986, 1988a, 1989; Warrener 1975; Playle 1986; Playle and Williamson 1986; Williamson 1986; Duncan and Williamson 1988; Playle *et al.* 1988; Ralley and Williamson 1990; Williamson and Ralley 1993; Jones and Armstrong 2001; Bourne *et al.* 2002; Jones 2003; MCWS *unpubl. data*). Parameters generally included temperature, conductivity, pH, nutrients, alkalinity, bacteria, and metals. General conditions at each site have also been compiled at various points (MacLaren Plansearch Inc. 1989; Baker and Davies 1991; Ramsey 1991b; Environment Canada and Department of Fisheries and Oceans 1992a, b, c; Schneider-Vieira and Bernhardt 1997).

As part of CAMP, Threepoint Lake has been monitored four times annually since 2009, and Footprint and Apussigamasi lakes and the Burntwood River below First Rapids have been monitored rotationally every three years (CAMP 2014, *unpubl. data*).

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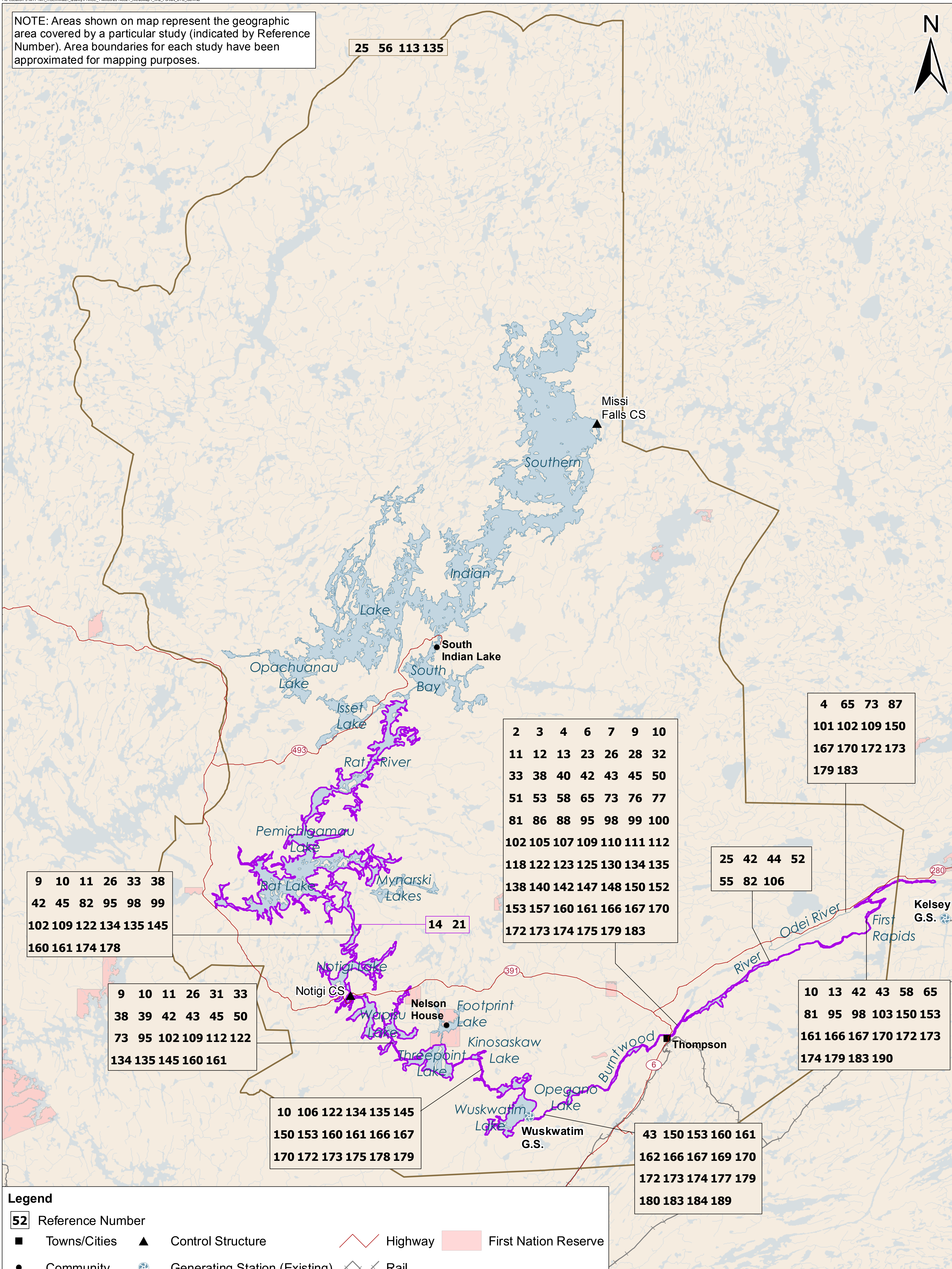

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

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UTM NAD 1983 Z14N	07-APR-14	28-MAY-14
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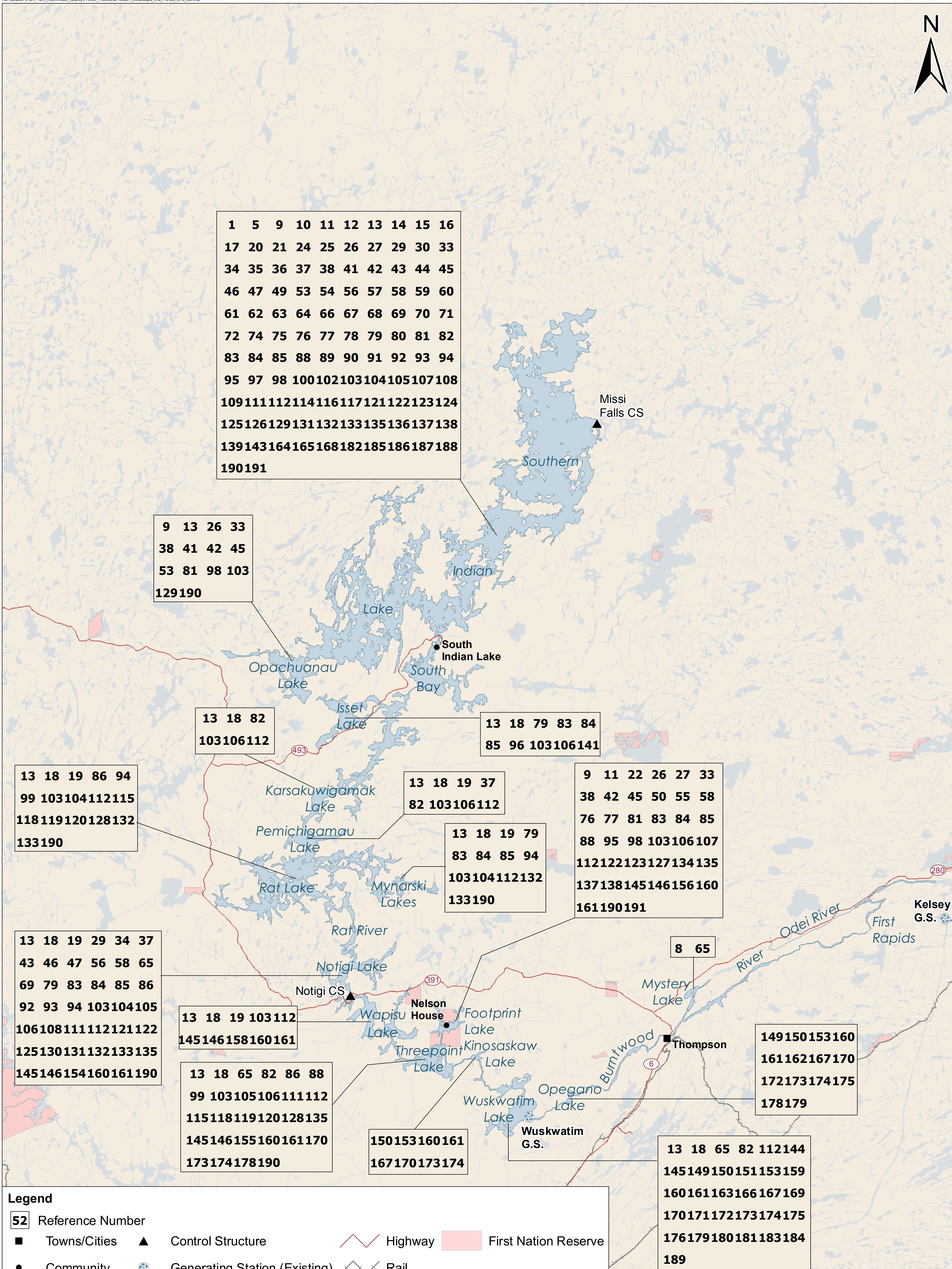
Manitoba Hydro

Water Quality
Area 3 - Map 1

Map 5-4A



Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
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Water Quality
Area 3 - Map 2

5.2.1.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.2.1.4.1 SUMMARY OF SCIENTIFIC INFORMATION

LOWER CHURCHILL RIVER AND LAKES

In response to high demand for information, the federal government initiated a survey of chemical conditions in major waterways in 1948 (Thomas 1964). The survey included sites along the Churchill River in Alberta, Saskatchewan, and Manitoba and the author reported general conditions and comparison to other waterbodies; however, the report did not clearly define the location or duration of sampling along the Manitoba portion of the Churchill River. An assessment of the commercial fishery potential in Northern Indian Lake also included measurements of total dissolved solids (TDS) in 1965 (Anthony 1971, 1972).

The Lake Winnipeg, Churchill and Nelson Rivers Study Board initiated baseline water quality studies of the lower Churchill River and associated lakes in 1972 and/or 1973 to make predictions regarding the impacts of the Churchill River Diversion (CRD) on the aquatic environment. Some data included in the Lake Winnipeg, Churchill and Nelson Rivers Study Board assessment were derived from the National Water Quality Data Bank (NAQUADATA; Environment Canada 1975). Water quality studies were also conducted in Partridge Breast, Northern Indian, and Fidler lakes, tributaries to the lower Churchill River including the Little Churchill River, and the Churchill River (at Missi Falls and below Fidler Lake); these studies generally included measurement of temperature, dissolved oxygen (DO), conductivity, TDS, total suspended solids (TSS), nutrients, chlorophyll *a*, Secchi disk depth, and major ions (Morelli 1973, 1975; Cleugh 1974a, b; Hecky and Ayles 1974; Hecky and Harper 1974; Grapentine *et al.* 1988). Similar parameters were measured infrequently during the construction phase of CRD at Partridge Breast Lake, the Churchill River (at Missi Falls and below Fidler Lake), and several tributaries (Morelli 1975; Guilbault *et al.* 1979; Grapentine *et al.* 1988). A summary of conditions and predicted impacts is provided in the Technical Report (Lake Winnipeg, Churchill and Nelson Rivers Study 1975). The Lake Winnipeg, Churchill and Nelson Rivers Study Board data were also later combined with other pre- and post-CRD data to assess statistical differences in water quality in the region as a result of the Project (Guilbault *et al.* 1979; Playle and Williamson 1986; Duncan and Williamson 1988; Playle *et al.* 1988; Ralley and Williamson 1990; Williamson and Ralley 1993). In addition to the sites listed above, Environment Canada monitored water quality on the lower Churchill River at Red Head Rapids from 1972 through 1996 (Environment Canada 1975, 1978, 1980, 1982a, b, 1984; Rannie and Punter 1987).

Between 1972 and 1977, water quality at the water intake for the Town of Churchill (temperature, colour, turbidity, alkalinity, pH, conductivity, total and fecal coliforms, TSS, total nitrogen (TN), total phosphorus (TP), total organic and inorganic carbon (TOC and TIC, respectively), major cations and anions, iron, fluoride, silica, copper, lead, zinc, mercury) was documented by the Lake Winnipeg, Churchill and Nelson Rivers Study Board (using NAQUADATA) to identify pollution sources and to form a baseline against which to evaluate the effects of CRD (Morelli 1973, 1975; Playle 1986; Grapentine *et al.* 1988). An assessment of the change in conditions was produced in two reports (Playle and Williamson 1986; Playle *et al.* 1988).

A study of the impacts of CRD on the benthic invertebrate communities of Partridge Breast, Northern Indian, and Fidler lakes also included temperature and oxygen readings for June 1973, 1977, and 1979, as well as 1981, 1983, and 1987 for the former two lakes (Wiens and Rosenberg 1994).

Concerns over the altered water regime in the lower Churchill River resulted in the initiation of the Lower Churchill River Water Level Enhancement Weir Study and construction of the Churchill River weir. Baseline water quality assessments were conducted in 1995 and 1996 to support the EIS for the Churchill River weir (Schneider-Vieira and Fazakas 1996; Manitoba Hydro and The Town of Churchill 1997; Schneider-Vieira and Sotiropoulos 1997). Construction and associated monitoring occurred in 1998 (Bernhardt 1999), and post-Project water quality monitoring was conducted in 1999, 2001, 2003, and 2005 (Bezte and Bernhardt 2000, 2002; Bezte and Bortoluzzi 2004; Bezte 2006). During all sampling years, water quality was generally evaluated along the mainstem of the lower Churchill River between the head of the estuary and Heppell Creek four times during the open-water season and periodically during winter; sampling was also conducted once in Goose and Herriot creeks. Parameters measured include pH, turbidity, conductivity, TSS, nutrients, and chlorophyll *a*. A synthesis of all components of the project was compiled by Bernhardt and Holm (2007) and an evaluation is provided in North/South Consultants Inc.(2010). In a separate study, temperature, conductivity, nitric and silicic acid, salinity, oxygen isotopes, total dissolved nitrogen (TDN), total dissolved phosphorus (TDP), dissolved organic carbon (DOC), reactive silica, and chlorophyll *a* concentrations were measured in the Churchill reservoir during the winter-spring of 2005 to assess the changes in hydrologic and physical conditions during the transition between seasons (Kuzyk *et al.* 2008).

Fish population and habitat use surveys conducted during the Churchill River Water Level Enhancement Weir Study included measurement of oxygen concentrations in the Churchill River (1996) and reservoir (2004), oxygen and temperature in the Goose Creek overwintering pool (1999-2001), and conductivity and colour in the Churchill River, Goose Creek, and Herriot Creek (1995) (Remnant and Kitch 1996; Bernhardt 1997, 2005; Remnant and Caskey 2000; Remnant *et al.* 2001).

Since 2008, Northern Indian Lake and the Churchill River above the confluence with the Little Churchill River have been monitored four times annually under the Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP), and Partridge Breast, Fidler, and Billard lakes and the lower Churchill River at Red Head Rapids have been monitored every three years; the Churchill Reservoir will be monitored in 2014/15 as part of the program (CAMP 2014, *unpubl. data*).

In 2003-2007, the mercury and nutrient loads of the Churchill River to Hudson Bay were measured and documented; this included analysis of total and methyl mercury, TP, TN, DOC, particulate carbon (PC), and chlorophyll *a* at the mouth of the river and at a site immediately downstream of Missi Falls (Kirk and St. Louis 2009). Stainton (2009) related air-water carbon dioxide exchange in relation to chemical and physical characteristics of the Churchill River and estuary.

General reviews of the impacts of reservoir formation on downstream environments occasionally summarize the aforementioned literature (Reynolds and Ujjainwalla 1981; Bodaly *et al.* 1984). Bodaly *et al.* (1989) also compiled suspended sediment, TDS, conductivity, pH, and dissolved nitrogen and phosphorus (TDN and TDP, respectively) concentrations for seven sites (including the Churchill River at Missi Falls) as part of a comparison of fisheries in the Mackenzie and Churchill river basins.

CHURCHILL RIVER ESTUARY

In 1948, the federal government initiated a survey of chemical conditions in major waterways including the Alberta, Saskatchewan, and Manitoba portions of the Churchill River; "mineral content" at Fort Churchill is mentioned in the report but the period of study and availability of additional parameters is unclear (Thomas 1964).

In 1983 and 1984, the University of Manitoba conducted a study of the composition and standing crop of aquatic or semi-aquatic plants in the estuary as well as environmental factors influencing those conditions; the program included one summer measurement of salinity, conductivity, and pH at each of four sites (Zbigniewicz 1985). Temperature, salinity, and turbidity were also frequently measured at a number of sites in the estuary in 1983, 1984, and 1986 to determine abiotic influences of beluga distribution (Hansen 1987).

The Water Level Enhancement Weir studies conducted near Churchill included an assessment of baseline, construction, and post-construction monitoring of water chemistry between the head and mouth of the estuary. Salinity and temperature were measured at more than 40 sites in the estuary in 1993 and a detailed assessment was conducted at four of those sites for conductivity; pH; suspended N, P, and C; TDN; TDP; TIC; DOC; silica; and chlorophyll *a* (North/South Consultants Inc. 1993; Schneider-Vieira *et al.* 1993; Baker *et al.* 1994). Deep-water salinity, temperature, and density were also measured at four sites in 1994 (during a survey of lower trophic levels; Lawrence and Baker 1995; Lawrence 1996), and TSS, pH, conductivity, nutrients, and chlorophyll *a* were measured at the head of the estuary four times during the open-water season and once in the ice-cover seasons of 1995 and 1996 (Schneider-Vieira and Fazakas 1996; Schneider-Vieira and Sotiropoulos 1997). Construction monitoring for the Churchill weir was conducted biweekly in 1998 and included assessment of sites along two transects downstream of the weir axis (TSS, total metals, extractable hydrocarbons, and dissolved aluminum); monitoring in 1999 was conducted along the same transects but only occurred once in each May and June and included the parameters sampled during baseline conditions (Bernhardt 1999; Bezte and Bernhardt 2000). Thereafter, the site at the head of the estuary was consistently sampled 3-4 times during the open-water season and once in winter for 1999, 2001, 2003, 2005 (Bezte and Bernhardt 2000, 2002; Bernhardt 2002a, b, 2005; Bezte and Bortoluzzi 2004; Bezte 2006).

Kuzyk *et al.* (2008) also studied conductivity, temperature, density, nitric and silicic acid salinity, oxygen isotopes, TDN, TDP, DOC, reactive silica, and chlorophyll *a* concentrations in 2005 to characterize the estuarine conditions during the transition from winter to spring (Kuzyk *et al.* 2008).

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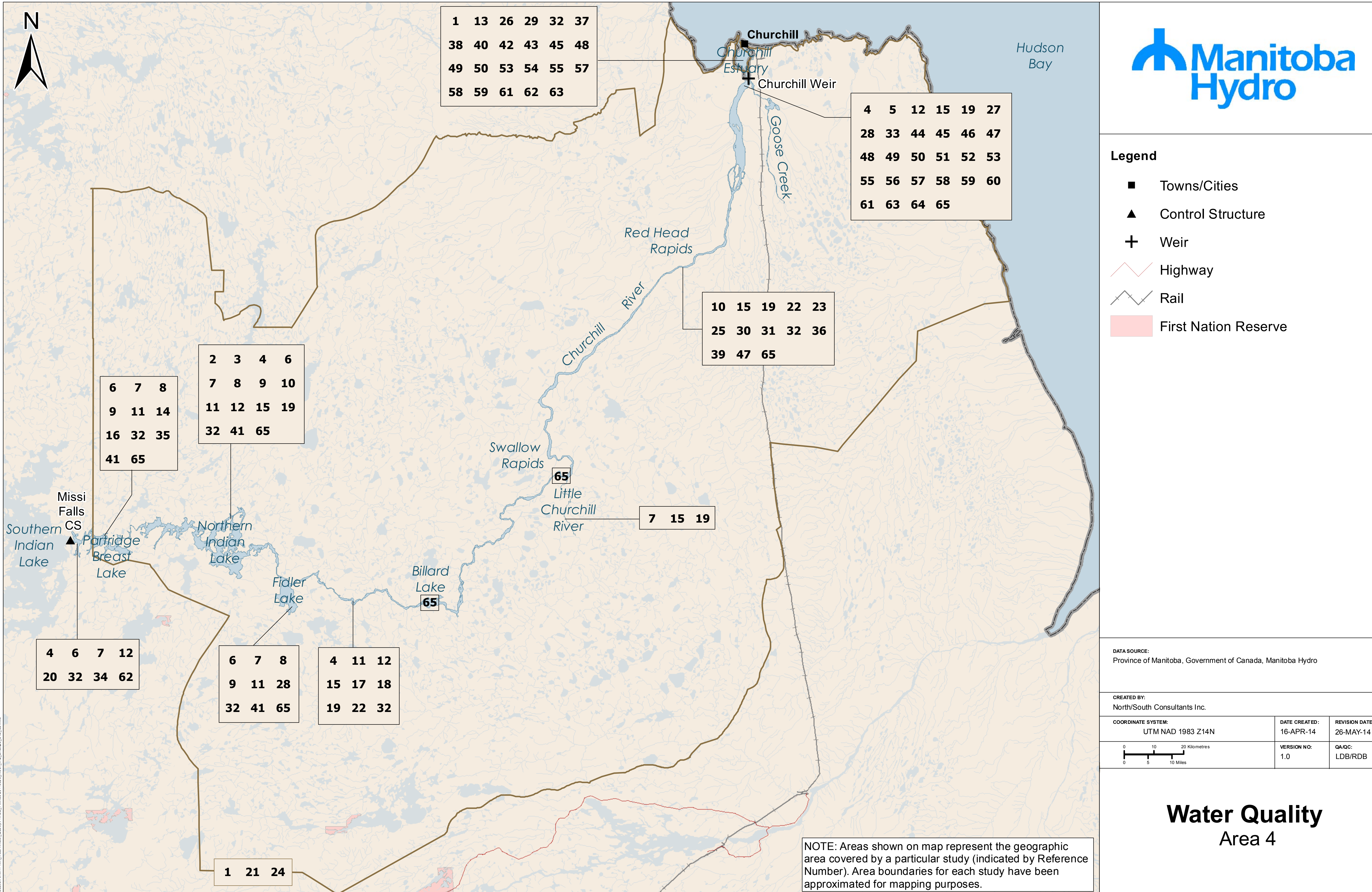
N
1 13 26 29 32 37
38 40 42 43 45 48
49 50 53 54 55 57
58 59 61 62 63
Churchill
Churchill Estuary
Churchill Weir
Hudson Bay
4 5 12 15 19 27
28 33 44 45 46 47
48 49 50 51 52 53
55 56 57 58 59 60
61 63 64 65
Goose Creek
Red Head Rapids
Churchill River
10 15 19 22 23
25 30 31 32 36
39 47 65
2 3 4 6
7 8 9 10
11 12 15 19
32 41 65
6 7 8
9 11 14
16 32 35
41 65
Swallow Rapids
65
Little Churchill River
7 15 19
Missi Falls CS
Southern Indian Lake
Partridge Breast Lake
Northern Indian Lake
Fidler Lake
Billard Lake
65
4 6 7 12
20 32 34 62
6 7 8
9 11 28
32 41 65
4 11 12
15 17 18
19 22 32
1 21 24
NOTE: Areas shown on map represent the geographic area covered by a particular study (indicated by Reference Number). Area boundaries for each study have been approximated for mapping purposes.
Manitoba Hydro
Legend
Towns/Cities
Control Structure
Weir
Highway
Rail
First Nation Reserve
DATA SOURCE:
Province of Manitoba, Government of Canada, Manitoba Hydro
CREATED BY:
North/South Consultants Inc.
COORDINATE SYSTEM:
UTM NAD 1983 Z14N
DATE CREATED:
16-APR-14
REVISION DATE:
26-MAY-14
0 10 20 Kilometres
0 5 10 Miles
VERSION NO:
1.0
QA/QC:
LDB/RDB
Water Quality
Area 4

Map 5-5

5.2.2 FISH COMMUNITY

5.2.2.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

The following provides a summary of information on fish populations in Area 1. Due to their importance to First Nations and that they were recommended to be listed as "endangered" under the *Species at Risk Act* (2006), information on Lake Sturgeon has been provided in a separate section.

5.2.2.1.1 SUMMARY OF SCIENTIFIC INFORMATION

OUTLET LAKES

Several studies provide pre-LWR data on fish populations in the outlet lakes. Population data for Playgreen Lake were derived from analysis of commercial catches (Sopuck 1978), as well as experimental gillnetting surveys (Stockner 1970, 1972; Schlick 1972; Koshinsky 1973; Ayles 1974). Koshinsky (1973) presents the results of gillnet sampling conducted in Kiskittogisu Lake in 1971 and 1972 and in Kiskitto Lake in 1972. Post-LWR fish population studies included analysis of commercial catch statistics (Sopuck 1978; MacLaren Plansearch Inc. and Beak Consultants Ltd. 1988, 1989) and experimental gillnetting surveys (O'Connor 1982; MacLaren Plansearch Inc. 1985; Cann 1993). While many of these studies report on the fish community as a whole, there is a focus on fisheries management sampling of Lake Whitefish as the most important fishery species historically. Fish populations on Playgreen Lake and Little Playgreen Lake are currently monitored under CAMP. The results of the CAMP pilot program (2008-2010) showed that the large-bodied fish assemblage in both lakes is currently dominated by White Sucker, Northern Pike, and Walleye (CAMP 2014). Post-LWR data on the fish communities in outlet lakes other than Playgreen Lake are limited.

Movements of Lake Whitefish between Playgreen Lake, Little Playgreen Lake, and Lake Winnipeg have been documented for both the pre- and post-LWR periods (Kennedy 1954; Pollard 1973; Koshinsky 1973; MacLaren Plansearch Inc. and Lavalin1985a, b; Davies *et al.* 1998). Manitoba Hydro commissioned a study in 1992 to determine potential effects of regulation on the whitefish fishery in Lake Winnipeg that included an assessment of potential effects of construction of 2-Mile channel on fish migration patterns (Lawler and Doan 1992).

CROSS LAKE

Investigations that examined Cross Lake fish populations prior to regulation include Driver (1965), Driver and Doan (1972), Koshinsky (1973), and Ayles *et al.* (1974). Fourteen fish species were reported from Cross Lake prior to LWR (Driver 1965; Driver and Doan 1972), including a high overall production of commercially important species (Ayles *et al.* 1974). Gaboury and Patalas (1981, 1982) conducted a study in 1980 and 1981 to assess post-LWR fish populations in Cross, Pipestones, and Walker lakes. The Manitoba Department of Natural Resources followed between 1985 and 1989 by undertaking the Manitoba Ecological Monitoring Program in response to NFA claim # 18 to investigate the impact of hydroelectric development on fish populations in six northern lakes, including Cross Lake. The results of annual experimental gillnetting surveys were presented in data reports (Mohr and Kirton 1986; Mohr 1987; Green 1988a, b, 1990) and progress reports (Derksen 1987; Derksen *et al.* 1988). In response to the completion of the Cross Lake weir (In Service Date of 1991), a co-operative project between Pimicikamak Cree Nation and Manitoba Hydro was implemented to monitor the fish population response. The monitoring program has established a fish population database for Cross and Pipestone lakes since 1992 and 1993, respectively (Kroeker and Bernhardt 1993; Bernhardt and Schneider-Vieira 1994; Bernhardt 1995, 1996; Kroeker and Bernhardt 1997; Kroeker and Graveline 1998, 1999; Barth *et al.* 2001; MacDonell and Graveline 2002; MacDonald and MacDonell 2003, 2004; Johnson *et al.* 2005; Neufeld *et al.* 2006; Richardson and MacDonell 2007; Gallagher and MacDonell 2008; Caskey and MacDonell 2010). The Cross Lake weir post-project monitoring program was concluded in 2008, but Cross Lake (west basin) continues to be monitored under CAMP, along with Walker Lake. The results of the CAMP pilot program showed that the large-bodied fish assemblage in both lakes is dominated by Northern Pike and White Sucker; Walleye are also common in Cross Lake and Cisco in Walker Lake (CAMP 2014).

SIPIWESK LAKE

Pre-Kelsey GS data on fish communities along the upper Nelson River were not located. Population studies were first conducted in Sipiwesk Lake to determine commercial fishing quotas in 1966 (Schlick 1968). At this time, White Sucker was reported to be the most abundant fish species. Ayles *et al.* (1974) provided similar information for Sipiwesk Lake based on a survey conducted in 1973 as part of the LWCNR Study Board study, as did Patalas (1984), based on information collected as part of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion. Post-LWR data was primarily collected for the Manitoba Ecological Monitoring Program (1985-1989; Mohr and Kirton 1986; Mohr 1987; Green 1988a, b, 1990). In 1996, Manitoba Hydro and the Split Lake Cree conducted a joint assessment of the effects of hydroelectric development in the Split Lake Resource Management Area, which includes a portion of the upper Nelson River downstream of Sipiwesk Lake (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996). Remnant *et al.* (1997) reported that Rainbow Smelt were found in the stomachs of Northern Pike from Sipiwesk Lake in 1994. These individuals were the first reported specimens captured downstream of Lake Winnipeg. More recently (2011), fish communities in Sipiwesk Lake and the upper Nelson River are being monitored on a rotational basis under CAMP (CAMP *unpubl. data*).

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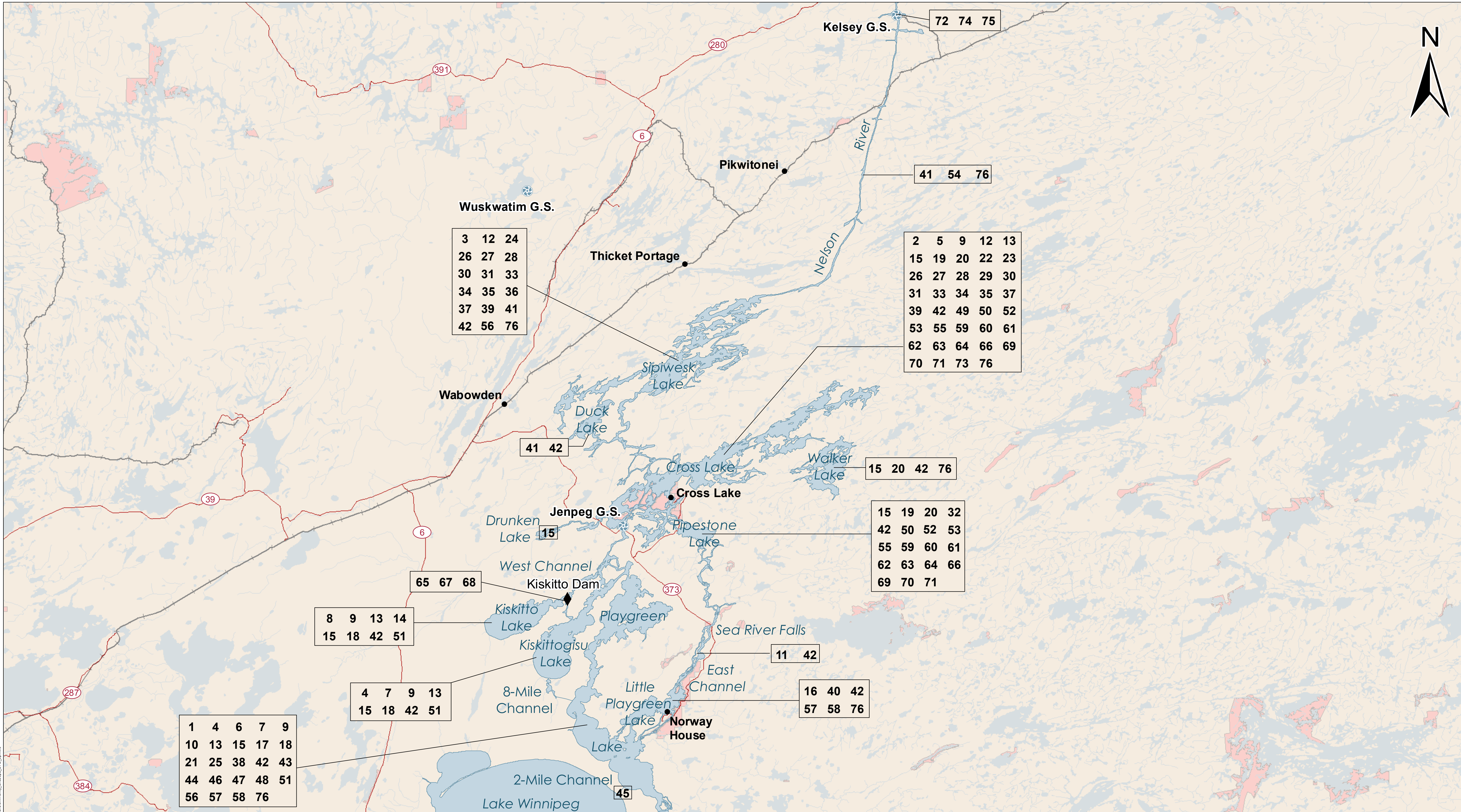

DATA SOURCE: Government of Manitoba; Government of Canada; Manitoba Hydro			
CREATED BY: North/South Consultants Inc.			
COORDINATE SYSTEM: UTM NAD 1983 Z14N	DATE CREATED: 07-APR-14	REVISION DATE: 27-MAY-14	
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Legend

- 52 Reference Number
- • Community
- ♦ Dam
- Generating Station (Existing)
- First Nation Reserve
- Highway
- Rail

Fish Community
Area 1

Map 5-6

5.2.2.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

The following provides a summary of information on fish populations in Area 2. Due to their importance to First Nations and that they were recommended to be listed as "endangered" under the *Species at Risk Act* (2006), information on Lake Sturgeon has been provided in a separate section.

5.2.2.2.1 SUMMARY OF SCIENTIFIC INFORMATION

SPLIT LAKE

Early fish population studies in Split Lake were conducted by the province in the 1950s and 1960s (Schlick 1968). At this time, 19 species were reported; of which White Sucker was the dominant species in the catch and Lake Whitefish was the most abundant commercial species. Ayles *et al.* (1974) documented 11 additional species during gillnetting surveys in Split Lake in 1973 as part of LWCNR Study Board studies. Post-CRD/LWR studies were conducted in Split Lake during the 1980s under the Manitoba Ecological Monitoring Program (Patalas 1984; Kirton 1986; Hagenson 1987a, b, 1988, 1989, 1990; Derksen *et al.* 1988). In 1989, an environmental evaluation was conducted on the effects of the augmented flow program on numerous components, including fish, along the diversion route, up to and including Split Lake (Miles *et al.* 1989).

A large number of studies were conducted in Split Lake and its major tributaries during the 1990s and 2000s, first as part of Split Lake Post Project Environmental Review studies (Fazakas and Lawrence 1998; Fazakas 1999; Kroeker 1999; Lawrence *et al.* 1999; Mota and MacDonell 2000; Split Lake Cree-Manitoba Hydro Joint Studies Group 1996) and then in support of the potential Keeyask GS (Dunmall *et al.* 2004; Holm and Remnant 2004; Mochnacz *et al.* 2004; Remnant *et al.* 2004a; Holm 2005; Johnson 2005; Maclean and Holm 2005; Maclean and Pisiak 2005a, b; Johnson and Maclean 2007a, b; Keeyask Hydropower Limited Partnership 2012). Split Lake is currently monitored annually as part of Manitoba/Manitoba Hydro's CAMP. The results of the pilot program (2008-2010) showed that the large-bodied fish assemblage is dominated by White Sucker, Walleye, and Northern Pike (CAMP 2014).

GULL AND STEPHENS LAKES

Historical information on fish communities in the Nelson River is not available prior to the construction of the Kettle GS. Population studies on Stephens Lake (*i.e.*, the Kettle reservoir) were initiated in the early 1970s for the LWCNR Study Board (Crowe 1973; Ayles *et al.* 1974). Following the implementation of LWR/CRD, the Province undertook studies in Stephens Lake from 1983 to 1989 as part of the Manitoba Ecological Monitoring Program (Patalas 1984; Kirton 1986; Hagenson 1987b, 1988, 1989, 1990; Derksen *et al.* 1988).

Manitoba Hydro has conducted numerous fish community studies in the Nelson River downstream of Clark Lake and in Stephens Lake and its tributaries since 1999 as part of environmental assessment studies for the Keeyask GS (Remnant and Barth 2003; Barth *et al.* 2003a, b, 2004; Hartman and Bretecher 2004; Pisiak *et al.* 2004; Remnant *et al.* 2004b; Holm *et al.* 2005; Johnson and Parks 2005; Kroeker and Jansen 2005; Murray *et al.* 2005; Pisiak 2005a, b; Pisiak and Hartman 2005; Richardson and Holm 2005; Holm 2006, 2007a, b, c, 2009, 2010a, b, 2011, 2013; Bretecher *et al.* 2007; Johnson 2007; MacDonald 2007; Murray and Barth 2007; Cassin and Remnant 2008; Michaluk *et al.* 2011; Keeyask Hydropower

Limited Partnership 2012) and supporting infrastructure (Mazur and Savard 2008; Keeyask Hydropower Limited Partnership 2009; Koga 2013). The fish community on Stephens Lake continues to be monitored on a rotational basis under Manitoba/ Manitoba Hydro's CAMP. The results of the pilot program (2008-2010) showed that the dominant large-bodied fish species in both the north and south basins are Walleye and Northern Pike (CAMP 2014).

LOWER NELSON RIVER

Historical descriptions of the fisheries resources of the lower Nelson River date back to the early 1900s (Comeau 1915; Skaptason 1926; Bickle 1995). Studies conducted in the late 1940s and early 1950s by the province focused largely on Brook Trout and provide data on the ecology and distribution of the species in the area (Doan 1948; Kooyman 1951). Around the time construction began on the Limestone GS, the provincial fisheries branch described the basic biology and life history requirements of Brook Trout in the lower Nelson River from 1975 through 1980 (Gaboury 1978, 1980a, b; Gaboury and Spence 1981). When major construction re-started on the Limestone GS, the Manitoba Fisheries Branch undertook aquatic monitoring studies during the period of 1985 to 1989 (Swanson 1986; Swanson and Kansas 1987; Swanson *et al.* 1988, 1990, 1991). The scope of the Limestone aquatic monitoring studies on the lower Nelson River area was expanded in 1988 in anticipation of the construction of the Conawapa GS.

More than 75 fisheries reports have been produced for Manitoba Hydro since 1990 as part of the Limestone/Conawapa programs. These studies can be delineated into five general workstreams:

- Limestone and Long Spruce forebay monitoring (Baker 1990a, 1991a, 1992; Baker *et al.* 1990; Horne and Baker 1993a; Kroeker and Horne 1993; MacDonell and Horne 1994; Horne and MacDonell 1995; Horne 1996; Bretecher and Horne 1997; Bretecher and MacDonell 1998a, 1999a, 2000a; Johnson *et al.* 2004; Pisiak and Barth 2006; Murray *et al.* 2007; Koga and MacDonell 2009; Pisiak 2009);

- Brook Trout populations (Kroeker 1991, 1993; MacDonell 1991a; Bernhardt and MacDonell 1992, 1993; Schneider and Remnant 1993; Schneider-Vieira 1994; MacDonell and Bretecher 1995; Horne and MacDonell 1996; MacDonell and Kitch 1997a; Bretecher and MacDonell 1998b, 1999b, 2000b; Johnson *et al.* 2005; Kroeker and MacDonell 2006, Lavergne and MacDonell 2008, 2010, 2012; Lavergne *et al.* 2008; Lavergne 2012a, b);

- tributary use (Baker 1991b; MacDonell 1991b, c, 1992, 1993, 1995, 1996; Kroeker and Bernhardt 1992; MacDonell *et al.* 1992; Horne and Baker 1993b; Horne and MacDonell 1993; MacDonell and McRae 1994; MacDonell and Kitch 1997b; Bretecher 1999; Neufeld 2010; Lavergne 2011); and

- mainstem use, with a focus on coregonine populations (Bernhardt *et al.* 1992; Bretecher and MacDonell 1998c; Remnant and Baker 1993; Johnson and MacDonell 2004; MacDonald *et al.* 2006; Mandzy *et al.* 2007, 2008, 2009, 2010, 2011; Milot *et al.* 2007; Nelson and MacDonell 2007; Caskey and MacDonell 2009; MacDonald *et al.* 2009; Coté *et al.* 2011; Hertam and MacDonell 2013).

These data have been summarized in several synthesis reports (MacDonell and Bretecher 1992; North/South Consultants Inc. 2012).

Fish populations in the Limestone forebay and the lower Nelson River are currently monitored under CAMP on a rotational basis. The results of the pilot program (2008-2010) showed that the large-bodied fish assemblage in these waterbodies is dominated by Walleye, Northern Pike, and Longnose Sucker (CAMP 2014).

NELSON RIVER ESTUARY

Historical information on the fish resources of the Nelson River estuary consists of an exploratory expedition to Hudson Bay during 1914 (Comeau 1915). Post-CRD studies in the Nelson River estuary began in the late-1980s with a focus on Brook Trout and Lake Sturgeon. Between 1979 and 1989, Manitoba Department of Natural Resources conducted several studies in the lower Nelson River, including the Nelson River estuary, in response to existing and proposed hydroelectric developments on the river (Gaboury 1980a; Swanson 1986; Swanson and Kansas 1987; Swanson *et al.* 1988, 1990). Biological surveys conducted throughout the estuary and coastal creek mouths between 1988 and 1992, as part of the environmental assessment of the planned Conawapa GS, documented 35 fish species, representing 14 families, 28 of which were freshwater species (Baker 1989, 1990b; Baker *et al.* 1993; North/South Consultants Inc. 2012). Fish (primarily larval Capelin and American Sand Lance) were also captured during zooplankton studies conducted between 1995 and 1996 as part of the Nelson River estuary monitoring program (Baker 1996; Horne 1997; Horne and Bretecher 1998; Zrum 1999, 2000). Schneider-Vieira *et al.* (1993) characterized the estuarine environments in Hudson Bay, including the fish communities. The authors reported that the brackish waters of estuaries were used extensively as feeding and nursery areas by diadromous fish, principally Cisco and Lake Whitefish, and that there was a potential for these species to move between estuaries. Stewart and Lockhart (2005) compiled an overview of the Hudson Bay marine ecosystem for Fisheries and Oceans Canada, including information on the fish community of the Nelson River estuary. More recently, information on fish use of the Nelson River estuary was collected from 2005-2009 as part of the Conawapa studies program (Caskey and MacDonell 2007; Holm and Bernhardt 2011; Bernhardt *et al.* 2012). The most commonly captured species varied by season, and included Ninespine Stickleback and juvenile Longnose Sucker, Lake Whitefish, and Cisco. Of note, Rainbow Smelt, which were not captured in the estuary in the 1980s, were frequently observed in catches in the estuary in later studies.

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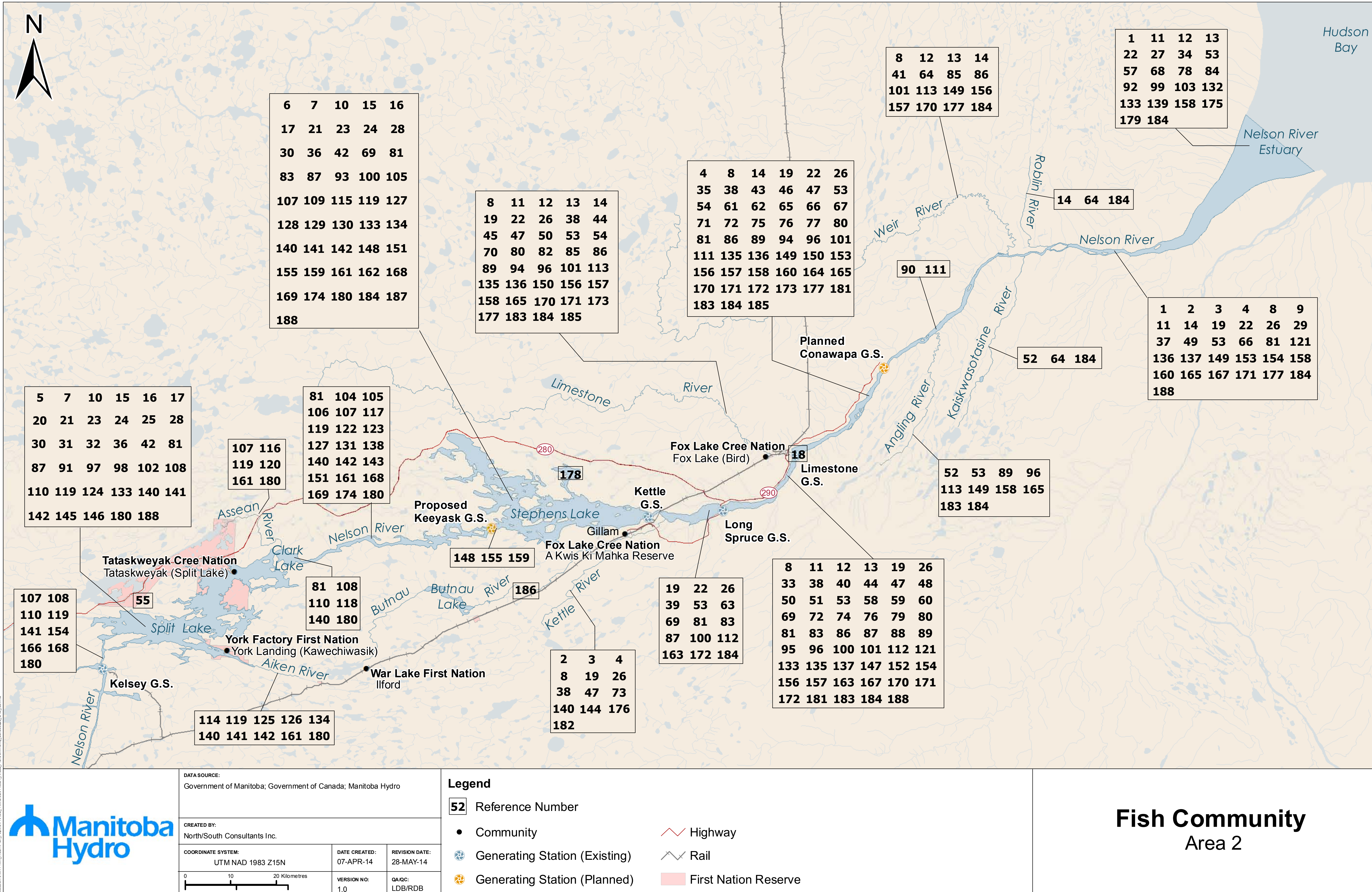
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Hudson Bay
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Limestone River
Kaiskwasotasine River
Angling River
Assean River
Clark Lake
Split Lake
Nelson River
Butnau Lake
Butnau River
Kettle River
Aiken River
Stephens Lake
Planned Conawapa G.S.
Fox Lake Cree Nation
Fox Lake (Bird)
Limestone G.S.
Kettle G.S.
Long Spruce G.S.
Gillam
Fox Lake Cree Nation
A Kwis Ki Mahka Reserve
Proposed Keeyask G.S.
Tataskweyak Cree Nation
Tataskweyak (Split Lake)
York Factory First Nation
York Landing (Kawechiwasik)
War Lake First Nation
Ilford
Kelsey G.S.
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Manitoba Hydro
DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
CREATED BY:
North/South Consultants Inc.
COORDINATE SYSTEM:
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DATE CREATED:
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VERSION NO:
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0 10 20 Kilometres
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First Nation Reserve
Fish Community
Area 2

Map 5-7

5.2.2.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

The following provides a summary of information on fish populations in Area 3. Due to their importance to First Nations and that they were recommended to be listed as "endangered" under the *Species at Risk Act* (2006), information on Lake Sturgeon has been provided in a separate section.

5.2.2.3.1 SUMMARY OF SCIENTIFIC INFORMATION

SOUTHERN INDIAN LAKE

Prior to CRD, the fish community of Southern Indian Lake was first described by McTavish (1952) and then as part of pre-project studies for the LWCNR Study Board (Ayles 1973; Weagle and Baxter 1973; Ayles and Koshinsky 1974). These studies revealed a diverse fish fauna of at least 19 species. Ayles (1976) reported on the spawning and population characteristics of Lake Whitefish in Southern Indian Lake prior to impoundment. Fisheries and Oceans Canada presented experimental gillnet data collected on Southern Indian Lake from 1972 and other years leading up to the construction and operation of CRD until 1982 to determine Lake Whitefish catch-per-unit-effort independent of sampling the commercial fishery (Bodaly *et al.* 1980, 1983, 1984). Since diversion, two studies have assessed potential impacts of the augmented flow program on various resources, including fish, in Southern Indian Lake (Shawinigan Consultants Inc. *et al.* 1987; Miles *et al.* 1989).

A number of studies have examined spawning success of fish species since CRD. Fudge and Bodaly (1984) presented information on the potential effect of increased erosion and sedimentation on Lake Whitefish spawning success. Bodaly and Lesack (1984) documented the short-term effect of flooding of a bay in Southern Indian Lake on Northern Pike reproduction and recruitment. Strange *et al.* (1991), under the Federal Ecological Monitoring Program, expanded on this work and presented a longer time series on Northern Pike reproductive success within the same bay following CRD. More recent work funded by the South Indian Lake Steering Committee has focused on the identification of Lake Whitefish spawning habitat through the collection of eggs and larvae between 2003 and 2009 (Johnson and Remnant 2004; Graveline and Remnant 2005; Caskey and Remnant 2006, 2008, 2009; North/South Consultants Inc. 2010a).

The movements of fish within and out of Southern Indian Lake have also been a focus of study. Bodaly (1980) reported on pre- and post-spawning movements of Walleye in two tributaries to Southern Indian Lake from 1975 to 1978. Graveline and Remnant (1999, 2004) reported on movements of Lake Whitefish and other species tagged in Southern Indian Lake during the fall of 1998. Gurney and Remnant (2005) reported on movements of spawning Walleye and other species in four streams flowing into Southern Indian Lake during spring 2004. Mota and Remnant (2006) documented the use of Sandhill Stream and Waddie River by spawning fish during early spring 2005. Manitoba Hydro funded studies to monitor the movements of fish through the Missi Control Structure (CS) between 2007 and 2010 (North/South Consultants Inc. and Biosonics Inc. 2008, 2009, 2010, 2011).

In 2013, the Southern Indian Lake Commercial Fishermen's Association commissioned a study to determine the possible cause(s) for the collapse of the whitefish fishery and make recommendations for its recovery (Bodaly 2013a, b; Hesselein 2013). Three distinct areas of Southern Indian Lake are currently monitored as part of Manitoba/Manitoba Hydro's CAMP (CAMP 2014).

RAT RIVER (TO NOTIGI CS)

Pre-CRD studies of the Rat River system above the proposed Notigi CS (including Issett, Pemichigamau, Karsakuwigamak, Rat, and the Mynarski lakes) were first conducted as part of the LWCNR Study Board studies (Ayles *et al.* 1974; Hecky and Ayles 1974). The authors reported that Lake Whitefish, Walleye, and Northern Pike were the commercial fish species present, with Walleye predominating in number more often than whitefish.

Following CRD, the Province conducted several experimental gillnetting investigations in Notigi, Rat, Karsakuwigamak, Pemichigamau, and the Mynarski lakes between 1983 and1984 as part of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion and from 1985-1989 as part of the Manitoba Ecological Monitoring Program (Patalas 1984; Kirton 1985; Green 1987a, b, 1989; Hagenson 1987; Derksen *et al.* 1988). In 1989, a study for Manitoba Hydro and the Northern Flood Committee Inc. assessed the impacts of the augmented flow program in conjunction with the effects of the existing CRD on numerous environmental components, including to fish, along the Churchill diversion route (Miles *et al.* 1989). Since 1999, experimental gillnetting studies have been conducted in Notigi Lake as part of the licensing process for the Wuskwatim GS (Mota and Fazakas 2000; Caskey and Mota 2003a; Manitoba Hydro and Nisichawayasihk Cree Nation 2003). As well, the movements of selected species (Walleye, Cisco, Lake Whitefish, and Northern Pike) tagged in the Rat/Burntwood system, including Notigi Lake, have been studied during the 1999-2002 period (Fazakas 2000a; Eddy and Fazakas 2001; Jansen *et al.* 2005).

Notigi and Rat lakes continued to be monitored under CAMP. The results of the pilot program (2008-2010) showed that the large-bodied fish assemblage in both lakes is dominated by White Sucker; Cisco is also common in Rat Lake (CAMP 2014). Starting in 2011, the fish community in West and Central Mynarski lakes is also being monitored on a rotational basis (CAMP *unpubl. data*).

RAT/BURNTWOOD RIVER (DOWNSTREAM NOTIGI CS)

The earliest published study of fish populations in the Burntwood River was by Sunde (1958, 1960, 1961), who reported on the composition, size, and frequency of fish caught at stations set 16.1 km (10 mi) apart from a point 8 km (5 mi) upstream of Thompson to the mouth of the Burntwood River. Prior to CRD, Ayles *et al.* (1974) conducted fish population studies in Wapisu, Threepoint, and Wuskwatim lakes for the LWCNR Study Board. The authors reported that Walleye were the most common commercial fish species in these lakes. Following CRD, the province conducted several experimental gillnetting investigations in Wapisu, Threepoint, Footprint, Wuskwatim, Osik, Macheewin, and Apussigamasi lakes between 1983-1984 as part of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion and from 1985-1989 under the Manitoba Ecological Monitoring Program (Patalas 1984; Kirton 1987; Green 1987a, b; Kirton 1987; Kirton and Mohr 1987; Derksen *et al.* 1988).

Manitoba Hydro and the Northern Flood Committee Inc. assessed the impacts of the augmented flow program in conjunction with the effects of the existing CRD on numerous environmental components, including fish, along the Churchill diversion route (Miles *et al.* 1989). In 1996, Manitoba Hydro and the Split Lake Cree conducted a joint assessment of the effects of hydroelectric development in the Split Lake Resource Management Area, which includes a portion of the Burntwood River downstream of Apussigamasi Lake (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996).

Prior to development of the Wuskwatim GS, Manitoba Hydro assessed effects of potential hydroelectric development options for a reach of the Burntwood River between Notigi and Split lakes on factors including the fisheries resource (MacLaren/InterGroup 1984). Since 1998, a number of experimental gillnetting studies have been conducted in Wuskwatim Lake and adjoining waterbodies (Wapisu, Threepoint, Footprint, Osik, Opegano, and Birch Tree lakes, and portions of the Burntwood River) as part of the licensing process for the Wuskwatim GS (Fazakas 2000b; Bernhardt and Mota 2003; Caskey and Mota 2003b, c, d, e; Caskey *et al.* 2003; Holm and Mota 2003a, b; Kroeker and Holm 2003; Kroeker *et al.* 2003a, b, c; Kroeker and Mota 2003; Mota 2003a, b, c, 2005a, b; Mota and Heuring 2003; Mota and Jansen 2003; Manitoba Hydro and Nisichawayasihk Cree Nation 2003). Spawning investigation were also conducted in these waterbodies (Mota *et al.* 2000; Mota 2005c), as well as movements studies of selected species (Walleye, Cisco, Lake Whitefish, and Northern Pike) during the 1999-2002 period (Fazakas and Mota 2000; Eddy and Fazakas 2001; Mota and Remnant 2003; Jansen *et al.* 2005). Aquatic effects monitoring, including fish as a component, has been conducted since the start of construction of the generating station (Mota 2009a, b, c, e, f, 2010a, b) and of supporting infrastructure (Fazakas and Remnant 2003; Hudd 2009; North/South Consultants Inc. 2010b).

Threepoint, Apussigamasi, and Footprint lakes are currently monitored under CAMP. The results of the pilot program (2008-2010) showed that the large-bodied fish assemblage in these lakes is dominated by white sucker and walleye; sauger is also common in Apussigamasi Lake (CAMP 2014).

Further downstream, fish use of the Burntwood River in the vicinity of First Rapids was assessed in 2001 and 2002 as part of environmental assessment studies for the Keeyask GS (Dunmall *et al.* 2004; Holm and Remnant 2004; Keeyask Hydropower Limited Partnership 2012).

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Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
0 4.5 9 Kilometres / 0 2.5 5 Miles	VERSION NO: 1.0	QA/QC: LDB/RDB

Fish Community
Area 3

Map 5-8

5.2.2.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

The following provides a summary of information on fish populations in Area 4. Due to their importance to First Nations and that they were recommended to be listed as "endangered" under the *Species at Risk Act* (2006), information on Lake Sturgeon has been provided in a separate section.

5.2.2.4.1 SUMMARY OF SCIENTIFIC INFORMATION

LOWER CHURCHILL RIVER AND LAKES

Prior to CRD, studies were conducted by the LWCNR Study Board on the lower Churchill River lakes, including Partridge Breast, Northern Indian, and Fidler. These studies indicated that Lake Whitefish, Northern Pike, and sucker were the most common large-bodied fish species (Ayles *et al.* 1974; Hecky and Ayles 1974). No pre-CRD data are available for the Churchill River mainstem downstream of Fidler Lake.

Following diversion, Barnes (1990) and Barnes and Bodaly (1994) assessed the number and origin of Lake Whitefish observed congregating immediately downstream of the Missi Falls CS under the Federal Ecological Monitoring Program. Mark/recapture studies were conducted on fish sampled in 1986 and 1987, comparisons of morphological characteristics were made among populations, and fish were examined for signs of physiological stress.

In 1996, Manitoba Hydro and the Split Lake Cree conducted a joint assessment of the effects of hydroelectric development in the Split Lake Resource Management Area, which includes a portion of the Churchill River downstream of Partridge Breast Lake (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996).

A large amount of data has been collected on abundance, species composition, and movements between the Deer River and the estuary as part of the environmental impact assessment and post-project monitoring for the Churchill River weir, which had an In Service Date of 1999 (Manitoba Hydro and the Town of Churchill 1997). A total of 17 species were reported from the lower Churchill River upstream of Mosquito Point. More than 35 fisheries reports have been produced for Manitoba Hydro since 1993 in support of the water level enhancement weir project. These studies have examined fish use of tributaries (Remnant and Bernhardt 1994; Bernhardt 1995, 1996, 1997a; Remnant and Kitch 1996a; Fazakas and Bernhardt 1997); fish populations in the vicinity of the weir (Remnant 1995; Remnant and Kitch 1996b; Bernhardt 1997b; Fazakas and Remnant 1997; Bernhardt 2000, 2001a, 2002a, b, 2005a; Bernhardt and Holm 2003; Bernhardt and Pisiak 2006; Bernhardt and Caskey 2009); fish passage at the weir (Peake and Remnant 2000; Peake 2001, 2003, 2004; Peake and Bernhardt 2002; Bernhardt 2003a; Murray *et al.* 2010); and fish use of Goose Creek habitat enhancement reach (Remnant and Bernhardt 1997; Remnant and Caskey 2000; Remnant *et al.* 2001; Caskey and Remnant 2002; MacDonald and Remnant 2003; MacDonald *et al.* 2004; Bernhardt and Holm 2005; Bernhardt 2011; Bernhardt and Pisiak 2011). Several synthesis reports have compared fish population responses to the project to predictions in the EIS (Bernhardt 2003b; Bernhardt and Holm 2007; North/South Consultants Inc. 2010).

Northern Indian, Partridge Breast, and Billard lakes, as well as the Churchill River at its confluence with the Little Churchill River are currently monitored under CAMP (CAMP 2014). Fish populations on Fidler Lake were also monitored in 2011 (CAMP *unpubl. data*). In 2014, a rotational CAMP site will be established at the Churchill River weir reservoir.

CHURCHILL RIVER ESTUARY

The earliest fish studies from the Churchill River estuary date to the 1930s and 1950s, and provide only species presence and general abundance. Walker (1931) and Keleher (1953) documented at least 13 fish species in the Churchill River estuary and the lower 10 km (6.2 mi) of the Churchill River. Catches of Cisco, Lake Whitefish, and Northern Pike were reported in both studies; other species included herring, trout, sculpin, Black Cod, Arctic Charr, Capelin, Longnose Sucker, and Ninespine Stickleback.

Manitoba Hydro conducted an interdisciplinary study to describe the biological characteristics of the estuary, including a description of the fish fauna, in 1993 and 1994 (Baker *et al.* 1994; Lawrence and Baker 1995). The predominant species observed in the estuary during the summer were larval American Sandlance and Capelin. Subsequently, Manitoba Hydro and the Town of Churchill (1997) compiled published data from a variety of sources and described the fish community in the Churchill River estuary as part of the EIS for the Churchill weir. The authors provided a general description of fish habitat in the estuary and documented a total of 23 fish species, representing 12 families both in the estuary and in Hudson Bay near the mouth of the Churchill River. A Floy-tagging study was conducted in summer 1995 to assess fish movement pattern in the estuary (Remnant and Kitch 1996b). Stewart and Lockhart (2005) compiled an overview of the Hudson Bay marine ecosystem for Fisheries and Oceans Canada, including published information on the fish community of the Churchill River estuary.

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Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	28-MAY-14
0 10 20 Kilometres / 0 9 18 Miles	VERSION NO: 1.0	QA/QC: LDB/RDB

Legend

- 52 Reference Number
- Towns/Cities
- Control Structure
- Weir
- Rail
- First Nation Reserve

Fish Community
Area 4

Map 5-9

5.2.3 LAKE STURGEON (*ACIPENSER FULVESCENS*)

5.2.3.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

5.2.3.1.1 SUMMARY OF SCIENTIFIC INFORMATION

Lake Sturgeon research in the Lake Winnipeg Outlet to Split Lake Inlet reaches has been driven by concerns over commercial and subsistence harvest, hydroelectric development, and long-term sustainability of the species. Stewart (2009) summarized commercial harvest data reported from 1876 to 2009 (discussed also in Skaptason 1926; Kooyman 1955; Sunde 1959; Harkness 1980), but Nelson River location specifics are often unknown, which complicates area specific interpretation. MacDonell (1997) collected historical, local, and Traditional Knowledge on Lake Sturgeon in the upper Nelson River from long-term residents of Thicket Portage, Pikwitonei, and Wabowden, and discussed historical harvest trends. The Nelson River Lake Sturgeon population has been assessed by the Status of Endangered Wildlife in Canada (Committee on the Status of Endangered Wildlife in Canada [COSEWIC] 2006) as endangered and is under consideration for listing under Schedule 1 of Canada's *Species at Risk Act*. Both Cleator *et al.* (2010) and Manitoba Conservation and Water Stewardship Fisheries Branch (2012) broke the Nelson River up into smaller management units, summarizing historical perspective and providing some additional information related to contemporary status and population trajectory. For consistency with these reports, the Lake Sturgeon section is structured based on the same management units. Manitoba Hydro (2014a) documented the current understanding of Lake Sturgeon populations in Area 1, and Manitoba Hydro (2014b, c) summarized initiatives undertaken by the Lake Sturgeon Stewardship & Enhancement Program in Area 1 between 2008 and 2012, and in 2013, respectively. Since 2008, Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP 2014) conducted fish populations surveys in several waterbodies within Area 1 (see Section 5.2.2.1, Area 1 fish community); methods are not specifically designed to capture Lake Sturgeon, however incidental captures are reported.

MU1: PLAYGREEN LAKE TO WHITEMUD FALLS

Since Skaptason (1926) alluded to extensive Lake Sturgeon harvest in the Outlet Lakes (Playgreen, Little Playgreen, Kiskittogisu, Kiskitto) few works have referred explicitly to this area. In part, this seems to be because populations within this reach were depleted prior to the 1950s (Manitoba Conservation and Water Stewardship 2012). Studies that have been conducted in this area have focused on historical exploitation and impacts of hydroelectric development. MacDonell (1997) summarized "pre-commercial" harvest of Lake Sturgeon from this area as a source of isinglass and described the progression of the commercial fishery down the Nelson River during the early 1900s as stocks were depleted. Macdonald (1998) discussed Lake Sturgeon in the outlet lakes in the context of LWR. The importance of Lake Sturgeon to the early historical subsistence economy of the area has also been reported (Petch 1992; Northern Lights Heritage Services 1994). Hannibal-Paci (2000) reported historical community harvest locations. As described in Section 5.2.2.1 (Area 1 fish community), many fish community studies have been conducted in this area since 1968, and the general absence of Lake Sturgeon is noteworthy and in agreement with the conclusions of Manitoba Conservation and Water Stewardship (2012). In response to extirpation and/or presumed remnant status of populations, the Nelson River Sturgeon Board (NRSB) stocked Landing River progeny into Little Playgreen Lake, Sea Falls and Pipestone Lake between 1994 and 2013 (Manitoba Conservation and Water Stewardship Fisheries Branch 2012). With collaborative funding from the NRSB and Manitoba Hydro's Lake Sturgeon Stewardship and Enhancement Program (LSSEP), recent studies have evaluated the interim success of stocking programs in this reach (McDougall and Pisiak 2012, 2014).

Lake Sturgeon stocks in Cross Lake were apparently heavily impacted during the early years of the Nelson River commercial sturgeon fishery (Skaptason 1926; Manitoba Conservation and Water Stewardship Fisheries Branch 2012). Consequently, Lake Sturgeon stocks in Cross Lake have received little scientific attention. In response to claims for domestic and commercial sturgeon fishing losses by the Cross Lake Band of Indians, a Manitoba Hydro funded study (McCart 1992) addressed maximum sustainable yield in Cross Lake following construction of Jenpeg. Usher and Tough (1999) and Tough (1999) question the validity of Cross Lake populations being depleted prior to the construction of the Jenpeg GS. Cleator *et al.* (2010) summarized what little previous data exists, while Manitoba Conservation and Water Stewardship Fisheries Branch (2012) supplemented the former with anecdotal reports of contemporary sightings and subsistence harvest.

MU2: Whitemud Falls to Kelsey GS (Sipiwesk Lake)

Sipiwesk Lake has received a considerable amount of scientific attention directed towards Lake Sturgeon. Kooyman (1955) and Sunde (1959) analyzed 1950s (pre-Kelsey GS) commercial harvest data from the Sipiwesk Lake area and presented harvest recommendations. Sunde (1961) described biological characteristics of the population. MacDonell (1997) provided a historical description of the commercial and domestic fishery in the reach from the perspective of residents of Wabowden, Thicket Portage and Pikwitonei.

Post-Kelsey GS sturgeon information was provided by Sopuck (1987), Patalas (1988) and McCart (1992). Gillnetting surveys were conducted to form the basis of mark-recapture estimates, and fishing mortality was quantified. Biological attributes were compared to pre-Kelsey data, and age-frequency distributions from 1987-1988 were compared to those from the 1950s (Sunde 1961). McCart (1992) addressed maximum sustainable yield in Sipiwesk Lake. MacDonell (1997) describes post-Kelsey domestic and commercial harvesting activity in the reach. Macdonald (1998) summarized Lake Sturgeon data from 1993-1997 collected as a part of the NRSB monitoring program, discussing possible effects of LWR on the Lake Sturgeon population. InterGroup Consultants (2005) prepared a 10-year review document for the Nelson River Sturgeon Board.

Both Cleator *et al.* (2010) and Manitoba Conservation and Water Stewardship (2012) present contemporary information relating to important spawning runs, and the population status and trajectory in Sipiwesk Lake. Recent population monitoring has primarily been conducted by the NRSB (*unpubl. data* in Manitoba Conservation and Water Stewardship 2012), or by the NRSB in collaboration with Manitoba Hydro's LSSEP (Groening *et al.* 2014). Côté *et al.* (2011) examined Nelson River Lake Sturgeon population structuring, partially relevant to this area.

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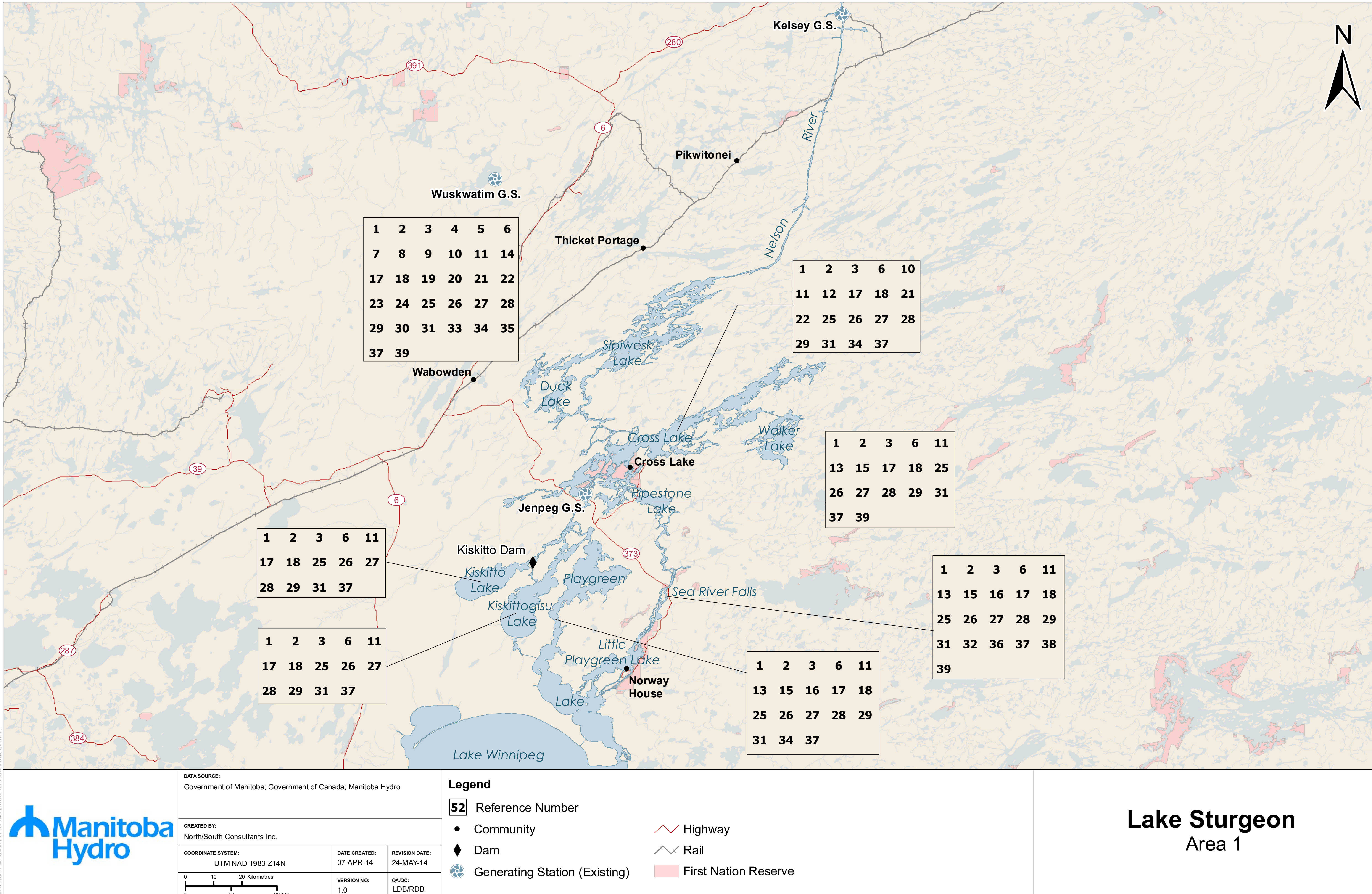

Kelsey G.S.
N
280
391
6
Pikwitonei
River
Nelson
Wuskwatim G.S.
Thicket Portage
1 2 3 4 5 6
7 8 9 10 11 14
17 18 19 20 21 22
23 24 25 26 27 28
29 30 31 33 34 35
37 39
1 2 3 6 10
11 12 17 18 21
22 25 26 27 28
29 31 34 37
Sipiwesk Lake
Wabowden
Duck Lake
Cross Lake
Walker Lake
Cross Lake
1 2 3 6 11
13 15 17 18 25
26 27 28 29 31
37 39
39
6
Pipestone Lake
Jenpeg G.S.
1 2 3 6 11
17 18 25 26 27
28 29 31 37
Kiskitto Dam
Kiskitto Lake
373
Playgreen
Sea River Falls
1 2 3 6 11
13 15 16 17 18
25 26 27 28 29
31 32 36 37 38
39
Kiskittogisu Lake
1 2 3 6 11
17 18 25 26 27
28 29 31 37
287
Little Playgreen Lake
Norway House
1 2 3 6 11
13 15 16 17 18
25 26 27 28 29
31 34 37
Lake
384
Lake Winnipeg
Manitoba Hydro
DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
CREATED BY:
North/South Consultants Inc.
COORDINATE SYSTEM:
UTM NAD 1983 Z14N
DATE CREATED:
07-APR-14
REVISION DATE:
24-MAY-14
0 10 20 Kilometres
0 10 20 Miles
VERSION NO:
1.0
QA/QC:
LDB/RDB
Legend
52 Reference Number
Community
Dam
Generating Station (Existing)
Highway
Rail
First Nation Reserve
Lake Sturgeon
Area 1

Map 5-10

5.2.3.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

5.2.3.2.1 SUMMARY OF SCIENTIFIC INFORMATION

Comeau (1915) and Skaptason (1926) provided descriptions of the fisheries resources of the lower Nelson River in the early 1900s and specifically reported on the presence of Lake Sturgeon.

The history of the commercial harvest of Lake Sturgeon in the Nelson River throughout the 1900s has been documented by several authors, including Sunde (1961), Sopuck (1981), Patalas (1988), and MacDonell (1997a). Due to the importance of the commercial fishery, several studies were initiated to set harvest quotas to manage the species, however, these studies were more focused on areas upstream of the Kelsey GS and were published for the fishery as a whole rather than providing site specific information relevant to Lake Sturgeon in the Nelson River between the Kelsey GS and the Nelson River estuary (Kooyman 1955; Sunde 1959, 1961; Harkness 1980; Sopuck 1981; Patalas 1988).

Despite the commercial value of Lake Sturgeon and their apparent abundance in the Nelson River downstream of the Kelsey GS, the species was subject to very little scientific study prior to 1985 (Swanson 1986). Didiuk (1975) only mentions Lake Sturgeon in an interim impact assessment study of the lower Nelson River. MacDonell (1997a) summarized the history of the Lake Sturgeon fishery on the lower Nelson River from the perspective of the communities of Pikwitonei, Thicket Portage, and Wabowden and makes several references to Area 2.

Several studies have been conducted in the lower Nelson River between the Kelsey GS and the Nelson River estuary commencing in the early 1970s that did not focus on Lake Sturgeon but reported on incidental captures. These include studies by the Lake Winnipeg Churchill and Nelson River Study Board in the 1970s, the post-CRD/LWR studies that were conducted under the Manitoba Ecological Monitoring Program in the 1980s, Manitoba Fisheries Branch studies in relation to the construction of the Limestone GS in the 1980s, Post Project Environmental Review (PPER) studies during the 1990s, Limestone GS monitoring studies in the 1990s, baseline studies in support of the proposed Keeyask GS and planned Conawapa GS Environmental Impact Statements in the 1990s and 2000s, and Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP 2014) that is referenced in Section 5.2.2.2 (Area 2 fish community).

In the Department of Fisheries and Oceans Recovery Potential Assessment for the entire Nelson River (Designatable Unit 3), Cleator *et al.* (2010) divided the Nelson River into 6 management units (MU) including: MU1: Playgreen Lake to Whitemud Falls; MU2: Whitemud Falls to Kelsey GS; MU3: Kelsey GS to Kettle GS; MU4: Kettle GS to Long Spruce GS; MU5: Long Spruce GS – Limestone GS; MU6: Limestone GS to the Nelson River estuary. Studies that specifically focus on Lake Sturgeon conducted since 1985 will be presented by MU beginning with MU3.

Manitoba Hydro (2014a) documented the current understanding of Lake Sturgeon populations in Area 2, and Manitoba Hydro (2014b, c) summarized initiatives undertaken by the Lake Sturgeon Stewardship & Enhancement Program in Area 2 between 2008 and 2012, and in 2013, respectively.

MU3: Nelson River - Kelsey GS to Kettle GS

Macdonald (1998) reported on a 5-year (1992–1997) field program conducted by the Nelson River Sturgeon Co-Management Board near the Landing River in MU2 that also included biological data collected from Lake Sturgeon in Gull Lake in 1995.

From 2001 to 2013, a considerable number of studies were conducted on Lake Sturgeon populations and habitat in MU3 to provide baseline data in support of the Environmental Impact Statement for the proposed Keeyask GS. Multiple years of catch and biological metric data were collected from three specific areas within MU3 to identify spawning locations, derive adult population estimates and develop a better understanding of condition, growth, habitat availability and use, and movements of adult and sub-adult Lake Sturgeon (Barth and Mochnacz 2004; Barth 2005; Barth and Murray 2005; Holm *et al.* 2005; Barth and Ambrose 2006; Holm 2006, 2007a, b, c, 2009, 2010, 2011, 2012, 2013; Barth and MacDonald 2008; MacDonald 2008, 2009; Michaluk and MacDonald 2010; MacDonald and Barth 2011; Henderson *et al.* 2011a, b, 2013; Hrenchuk and McDougall 2012; Henderson and Pisiak 2012; Keeyask Hydropower Limited Partnership 2012; Nelson and Barth 2012; Hrenchuk 2013; McDougall *et al.* 2013a, b; Groening *et al.* 2014).

MU4: Nelson River – Kettle GS to Long Spruce GS

Fisheries investigations conducted between 1985 and 2011 have suggested that only small numbers of Lake Sturgeon inhabit MU4 (Swanson 1986; Baker 1990, 1991, 1992; Baker *et al.* 1990; Kroeker and Horne 1993; Bretecher and Horne 1997; Bretecher and MacDonell 2000; Johnson *et al.* 2004; Holm *et al.* 2006; Ambrose *et al.* 2008, 2009). In DFO's recovery potential assessment, Cleator *et al.* (2010) assessed the MU4 population status as critical with an unknown trajectory.

More recently, studies have been undertaken by Manitoba Hydro's Lake Sturgeon Stewardship and Enhancement Program to inform stakeholders of the potential for re-establishment of a Lake Sturgeon population in MU4. In 2012, studies focussing on adult and juvenile Lake Sturgeon were conducted (Lavergne 2012; Lavergne and Barth 2012).

MU5: Nelson River – Long Spruce GS to Limestone GS

Several Lake Sturgeon investigations were conducted in MU5 following the In Service Date of the Long Spruce GS in 1979 and prior to the In Service Date of the Limestone GS in 1992. Swanson and Kansas (1987) surveyed the fish community of the Long Spruce Reservoir (MU5) in 1986 and also reported on a Lake Sturgeon population survey conducted in the Nelson River between the Long Spruce GS and the Weir River. Similarly, Swanson *et al.* (1988, 1990, 1991) reported on Lake Sturgeon populations in the lower Nelson River from 1987 to 1989 as part of monitoring impacts and investigating mitigation measures in relation to construction of Limestone GS that included information on Lake Sturgeon in MU5. MacDonell and Bernhardt (1992) provided a synthesis of studies conducted on the lower Nelson River from 1915 to 1992 which included life history information relevant to Lake Sturgeon in MU5.

Several studies relevant to Lake Sturgeon were conducted in MU5 following construction of the Limestone GS. Horne and Baker (1993), MacDonell and Horne (1994), Horne and MacDonell (1995), Horne (1996); Bretecher and MacDonell (2000), Johnson *et al.* (2004), Holm *et al.* (2006), Pisiak (2009) described fish community investigations conducted in MU5, which included incidental captures of Lake Sturgeon. A synthesis of aquatic studies conducted in the lower Nelson River from 1985 to 2003 reviews changes to the Lake Sturgeon community between the Long Spruce and Limestone generating stations over 14 years following construction of Limestone GS (North/South Consultants Inc. 2012). More recently, a juvenile Lake Sturgeon sampling program was conducted in the Limestone GS forebay during summer/fall of 2007 (Ambrose *et al.* 2009). Also in 2007, 16 sub-adult Lake Sturgeon captured in the lower Nelson River were tagged with acoustic-transmitters and transferred into MU5. Movements of these fish are documented in Ambrose *et al.* 2009, 2010a, b.

MU6: Nelson River – Limestone GS to the Nelson River Estuary

From 1985 to 1989, as part of an environmental assessment of the Limestone GS, Manitoba Department of Natural Resources conducted several fish community studies, some focusing on Lake Sturgeon, in the lower Nelson River, including the Nelson River estuary (Swanson 1986; Swanson and Kansas 1987; Swanson *et al.* 1988, 1990, 1991; MacDonell 1992b).

Following completion of the Limestone GS, several fish community studies that included Lake Sturgeon were undertaken in MU6 and associated tributaries as part of a long-term post-project monitoring program for the Limestone GS (MacDonell 1991, 1992a, 1993, 1995, 1996, 1997a, 1998; Bernhardt *et al.* 1992; MacDonell and Bernhardt 1992; MacDonell *et al.* 1992; Remnant and Baker 1993; Horne and Baker 1993; MacDonell and Horne 1994; MacDonell and McRae 1994; Horne and MacDonell 1995; MacDonell and Kitch 1997; Bretecher and MacDonell 1998b, 2000; Bretecher 1999; Barth and MacDonell 1999). More recently, Lake Sturgeon studies have been conducted annually in support of the Environmental Impact Statement for the planned Conawapa GS (Holm *et al.* 2006; Ambrose *et al.* 2007, 2008, 2009, 2010a, b; Pisiak *et al.* 2011).

Holm and Bernhardt (2011) documented use of the Nelson River estuary by Lake Sturgeon. The potential for movement of Lake Sturgeon between the Nelson and Hayes River systems was examined by Ambrose *et al.* (2009, 2010a), and Klassen (2012).

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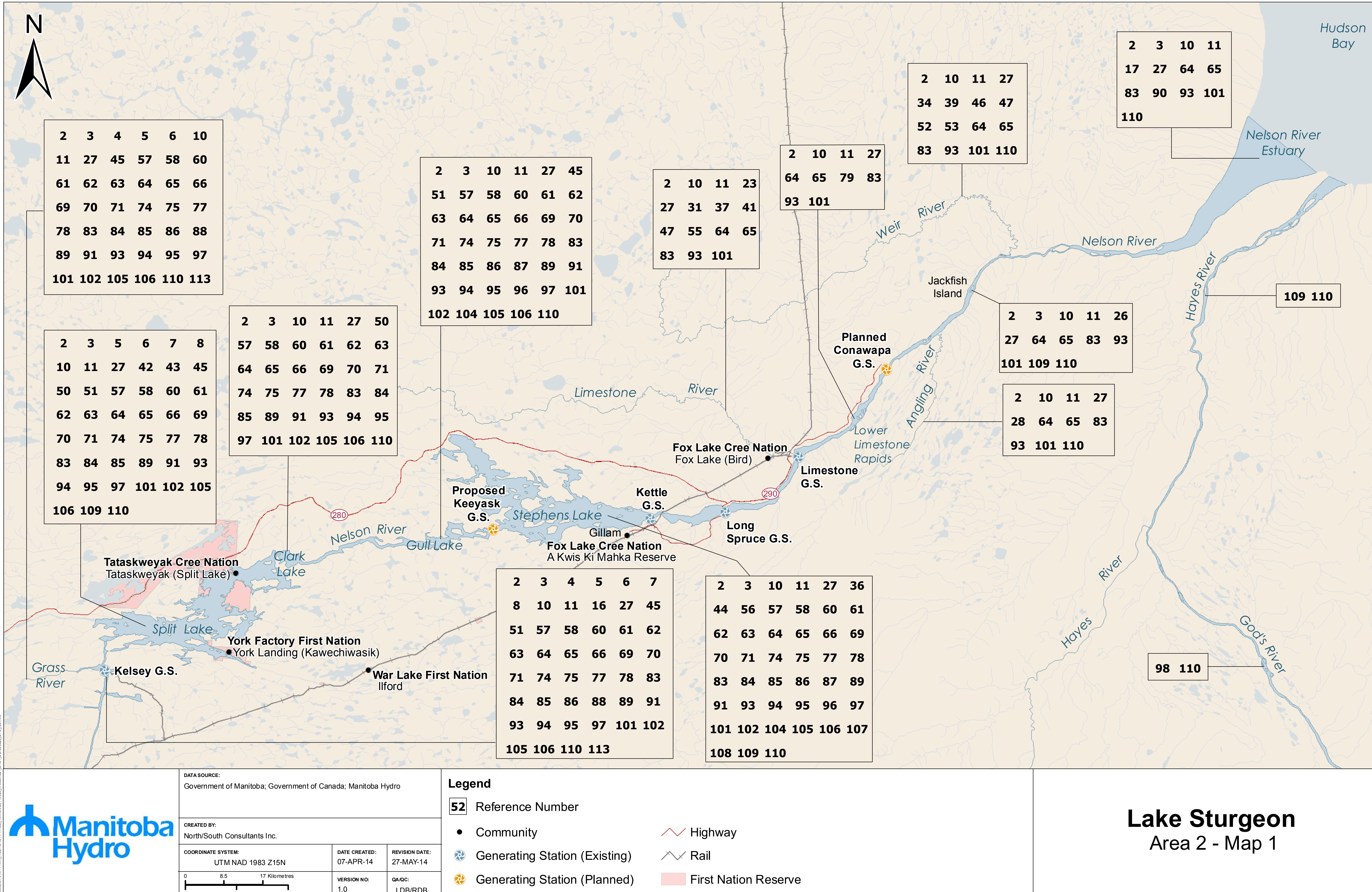
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Nelson River
Weir River
Hayes River
Jackfish Island
Planned Conawapa G.S.
Angling River
Lower Limestone Rapids
Limestone G.S.
Limestone River
Fox Lake Cree Nation
Fox Lake (Bird)
Kettle G.S.
Long Spruce G.S.
Proposed Keeyask G.S.
Stephens Lake
Gillam
Fox Lake Cree Nation
A Kwis Ki Mahka Reserve
Nelson River
Gull Lake
Clark Lake
Tataskweyak Cree Nation
Tataskweyak (Split Lake)
Split Lake
York Factory First Nation
York Landing (Kawechiwasik)
War Lake First Nation
Ilford
Kelsey G.S.
Grass River
God's River
280
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Government of Manitoba; Government of Canada; Manitoba Hydro
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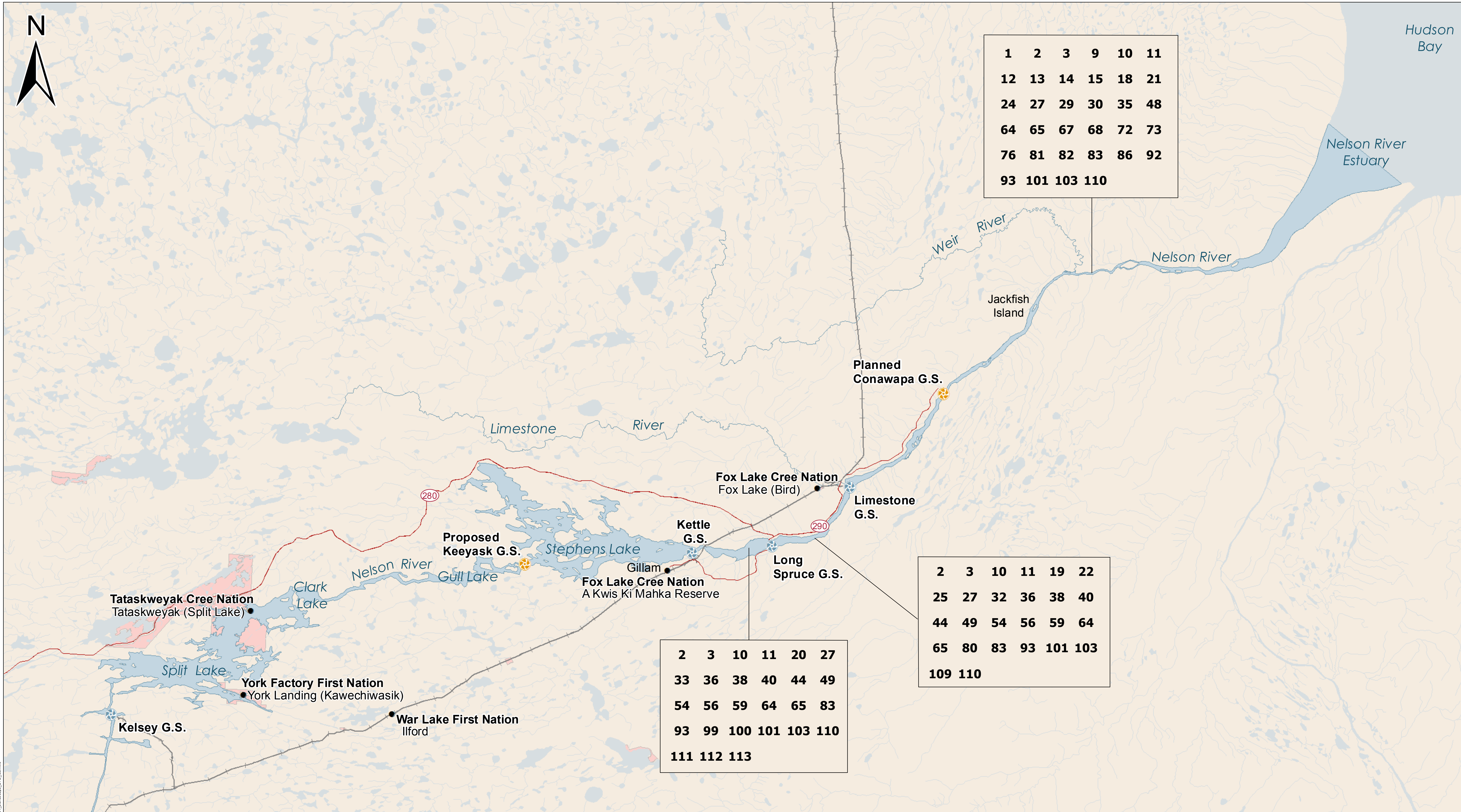
Lake Sturgeon
Area 2 - Map 1

Map 5-11A



Manitoba Hydro

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Government of Manitoba; Government of Canada; Manitoba Hydro

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Legend

52 Reference Number
Community
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Generating Station (Planned)
Highway
Rail
First Nation Reserve

Lake Sturgeon
Area 2 - Map 2

Map 5-11B

5.2.3.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

5.2.3.3.1 SUMMARY OF SCIENTIFIC INFORMATION

The Churchill River Lake Sturgeon population was assessed as "endangered" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2006) and is currently being considered for listing under Schedule 1 of the federal *Species at Risk Act*. The Churchill River system, beginning at Kettle Falls in Saskatchewan to its end at Hudson Bay, has been identified as Designatable Unit 1 (DU1), and has been further broken down into smaller management units (MUs) (Cleator *et al.* 2010a; Manitoba Conservation and Water Stewardship Fisheries Branch 2012); Lake Sturgeon in Southern Indian Lake fall into MU2. The Rat River and on-system lakes (*e.g.*, Notigi and Threepoint), including the Burntwood River as far as First Rapids, are not part of a designated unit. However, as part of the Environmental Impact Statement for the proposed Keeyask GS, the Burntwood River downstream of First Rapids has been included in MU3 of the Nelson River (*i.e.*, DU3). The Lake Sturgeon population within MU3 was also assessed as "endangered" by COSEWIC and is currently being considered for listing under Schedule 1 of the *Species at Risk Act* (Cleator *et al.* 2010b). Manitoba Hydro (2014) documented the current understanding of Lake Sturgeon populations in Area 3. Since 2008, Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP 2014) conducted fish populations surveys in several waterbodies within Area 3 (see Section 5.2.2.3, Area 3 fish community); methods are not specifically designed to capture Lake Sturgeon, however incidental captures are reported.

SOUTHERN INDIAN LAKE

In 1926, Skaptason wrote that Lake Sturgeon of the Indian lakes were "larger and more plentiful" than the Duck and Pukatawagan lakes located further upstream; however, a more detailed description of Lake Sturgeon in this area was never reported. In the 1950s and again during the 1970s, the fish community of Southern Indian Lake was described by the Lake Winnipeg Churchill and Nelson Rivers Study Board. An assessment of Southern Indian Lake conducted in 1952 provides anecdotal evidence of Lake Sturgeon captures (McTavish 1952), and despite periodic fish community assessments from 1972 to present (see Section 5.2.2.3), Lake Sturgeon have been absent from research gillnet catches.

RAT RIVER (TO NOTIGI CS)

Fish community studies along the Rat River, as far as the Notigi CS, were conducted pre-CRD as part of the Lake Winnipeg, Churchill and Nelson Rivers Study Board (LWCNRSB) and post-CRD as part of the Manitoba Ecological Monitoring Program. Additional fish community studies were conducted periodically between the 1980s and early 2000s (see Section 5.2.2.3).

RAT/BURNTWOOD RIVER (DOWNSTREAM OF NOTIGI CS)

Similar to the Rat River reach, fish population studies were conducted between the Notigi CS and the mouth of the Burntwood River pre-CRD and post-CRD (see Section 5.2.2.3). Lake Sturgeon captures were not recorded in any of these studies; however, Manitoba Conservation and Water Stewardship Fisheries Branch (2012) documented anecdotal accounts of sturgeon catches in the Burntwood River near Thompson, two of which occurred in the late 1990s. Anecdotal mention of Lake Sturgeon habitat and population alterations within the Burntwood River downstream of First Rapids were documented in the post-project effects of hydroelectric development in the Split Lake Resource Management Area (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996). In 2001, Lake Sturgeon investigations in the vicinity of First Rapids were conducted as part of environmental assessment studies for the proposed Keeyask GS (Barth and Mochnacz 2004). Since then, numerous adult and juvenile assessments have been conducted between First Rapids and Split Lake (Barth 2005; Barth and Murray 2005; Barth and MacDonald 2008; MacDonald 2008, 2009; Michaluk and MacDonald 2010, Henderson and Pisiak 2012; Hrenchuk and MacDougall 2012; Keeyask Hydropower Limited Partnership 2012a, b; Nelson and Barth 2012; Henderson *et al.* 2013; Hrenchuk 2013).

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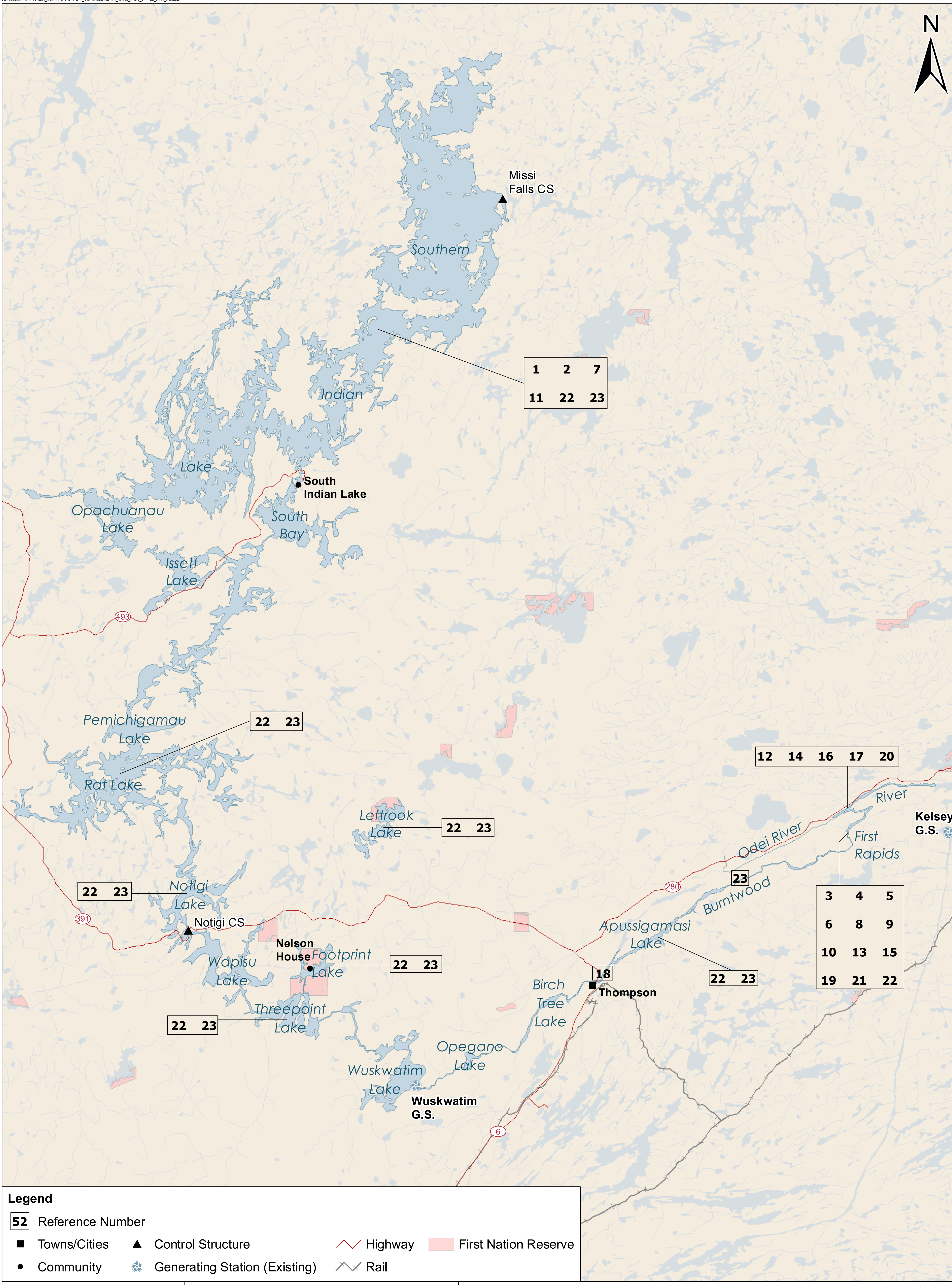

Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro

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North/South Consultants Inc.

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Lake Sturgeon
Area 3

5.2.3.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.2.3.4.1 SUMMARY OF SCIENTIFIC INFORMATION

Research conducted in Area 4 has been conducted due to concerns of over-exploitation, habitat degradation/loss due hydroelectric development, and long term sustainability of the species. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2006) has listed Lake Sturgeon from the Churchill River as "endangered" and the species is currently under consideration for listing under the *Species at Risk Act*. As mentioned in Section 5.2.3.3 (Area 3 Lake Sturgeon), the Churchill River (*i.e.*, DU1) has been broken into smaller management units, of which MU3 encompasses Lake Sturgeon populations from Missi Falls to the estuary (Cleator *et al.* 2010; Manitoba Conservation and Water Stewardship Fisheries Branch 2012). Manitoba Hydro (2014a) documented the current understanding of Lake Sturgeon populations in Area 4, and Manitoba Hydro (2014b, c) summarized initiatives undertaken by the Lake Sturgeon Stewardship & Enhancement Program in Area 4 between 2008 and 2012, and in 2013, respectively.

MISSI FALLS CS TO REDHEAD RAPIDS

The earliest Lake Sturgeon references for this area (Skaptason 1926; Kooyman 1955) relate to commercial harvest. In the 1970s, pre-CRD fish community studies were conducted in Partridge Breast, Northern Indian, and Fidler lakes (see Section 5.2.2.4, Area 4 fish community); although Lake Sturgeon are not referred to in the catches. After a period of closure, commercial Lake Sturgeon fishing was reopened at the Little Churchill River confluence in the 1980s and then permanently closed in 1992. In 1996, a summary of the overall post-project effects (*e.g.*, commercial and domestic fishing) of hydroelectric development in the Split Lake Resource Management Area, including a reach of the lower Churchill River that incorporated the Little Churchill River confluence, was reported (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996). Maclean and Nelson (2005) conducted a Lake Sturgeon population estimate for the Little Churchill River confluence area in spring 2003. Since 2008, Partridge Breast, Northern Indian, Billard, and Fidler lakes, in addition to the Little Churchill River confluence area, have been monitored under Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP 2014), although methods are not specifically designed to capture Lake Sturgeon. In 2010, habitat and flow conditions at the Little Churchill River confluence were assessed by the Tataskweyak Cree Nation after domestic resource harvesters observed low water levels during spring. The following year, two additional studies were conducted at the Little Churchill River confluence to assess recruitment via larval drift, and obtain a more detailed assessment of habitat. The results of these studies were not in the public domain at the time of writing. Recent Lake Sturgeon Stewardship and Enhancement Program studies have specifically examined Lake Sturgeon abundance in areas apart from the Little Churchill River confluence (North/South Consultants Inc. 2011; Blanchard *et al.* 2014).

REDHEAD RAPIDS TO CHURCHILL RIVER ESTUARY

Information was collected from resource users in Churchill in 1993 indicating capture locations of various fish species, including Lake Sturgeon, from the lower Churchill River (Remnant and Bernhardt 1994). Several years of index gillnetting were conducted by Manitoba Hydro in the lower Churchill River near Churchill in support of the Environmental Impact Assessment for the Lower Churchill River Water Level Enhancement Weir Project and subsequent post-Project monitoring. Incidental captures of juvenile and/or adult Lake Sturgeon were reported in several of these studies (Remnant 1995; Remnant and Kitch 1996; Manitoba Hydro and the Town of Churchill 1997; Bernhardt 2000, 2001, 2002; Bernhardt and Caskey 2009). No studies specifically targeting collection of Lake Sturgeon in the Churchill River estuary have been conducted and there are no documented records of the species in this location.

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Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
0 10 20 Kilometres / 0 9 18 Miles	VERSION NO: 1.0	QA/QC: LDB/RDB

Legend

- 52 Reference Number
- Towns/Cities
- Control Structure
- Weir
- Highway
- Rail
- First Nation Reserve

Lake Sturgeon
Area 4

5.2.4 FISH QUALITY

5.2.4.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

5.2.4.1.1 MERCURY

SUMMARY OF SCIENTIFIC INFORMATION

Mercury concentrations in several fish species sampled from commercial catches from upper Nelson River lakes between 1970-1971 were first compiled as part of federal-provincial studies (Bligh 1970, 1971; Tam and Armstrong 1972; Derksen 1978a, b, 1979).

Available mercury data for fish sampled commercially from upper Nelson River lakes through to 1985 was compiled as part of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion (Department of Fisheries and Oceans 1987; Rannie and Punter 1987). As part of the Agreement, fish from survey samples (*i.e.*, experimentally sampled rather than from commercial catches) from Sipiwesk Lake in 1983 were tested for mercury levels (Green 1986; Derksen and Green 1987). The monitoring of muscle mercury levels in fish sampled from Cross and Sipiwesk lakes continued between 1985 and 1989 under the Manitoba Ecological Monitoring Program in response to NFA Claim #18 (Green 1990; Ramsey 1991a; Environment Canada and Department of Fisheries and Oceans 1992). Information on fish mercury levels in lakes harvested by NFA communities was compiled as part of the Federal Ecological Monitoring Program by Baker and Davies (1991).

Samples for mercury analysis were collected from Cross Lake in 1992, 1994, and 1996 in conjunction with the Program for Monitoring Mercury Concentrations in Fish in Northern Manitoba Reservoirs, which was based on a joint agreement between Fisheries and Oceans Canada, Manitoba Hydro, Manitoba Department of Natural Resources, and Hydro Québec (Strange 1993, 1995; Strange and Bodaly 1997). The results for 1992 and 1994 were also used for the post-project monitoring of the Cross Lake weir (Kroeker and Bernhardt 1993; Bernhardt and Schneider-Vieira 1994; Bernhardt 1995). Fish mercury data from Cross Lake collected in 2007 were reported by Jansen (2010) together with the time series of available mercury data that included previously unpublished data dating back to 1971.

Fish mercury concentrations continue to be monitored in Sipiwesk, west Cross, Playgreen, and Little Playgreen lakes on a three-year rotational basis in conjunction with fish community studies under Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program and have been published for the 2010 collection year (CAMP 2014).

A few studies have been undertaken to assess possible impacts of hydroelectric development on fish harvested by communities located along the upper Nelson River. As part of post-project environmental review on effects to the town of Wabowden, MacKay *et al.* (1990) reported on historic mercury concentrations in fish from Sipiwesk Lake and Duck Lake. The report includes a discussion of possible causes of high mercury levels. In response to NFA Claim #110, mercury concentrations in fish species targeted by the Norway House domestic fishery were measured from several waterbodies, including Playgreen and Little Playgreen lakes, in 1993 and 1994 (Davies *et al.* 1998).

Fish mercury data from Sipiwesk Lake was used to test predictive models relating reservoir flooding to fish mercury concentrations (Johnston *et al.*1991) and as part of an analysis of post-impoundment trends in fish mercury concentrations in boreal Manitoba reservoirs (Bodaly *et al.* 2007).

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13 Rannie, W.F., and Punter, E. 1987. Survey of existing data on levels and sources of mercury within the region covered by the Canada-Manitoba mercury agreement. Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion, Technical Appendix 2, Volume 1. 172 pp.

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5.2.4.1.2 *TRIAENOPHORUS CRASSUS* CYSTS

SUMMARY OF SCIENTIFIC INFORMATION

Information on the rate of *T. crassus* infection in lakes along the upper Nelson River is limited to reports on whitefish cyst inspections of commercially fished waterbodies in the 1960s, including Kiskitto and Playgreen lakes (Sunde 1964a, b, 1965; Driver 1965; Driver and Doan 1972; Schlick 1967, 1968). Schlick (1967) compared pre-LWR cyst counts in Sipiwesk Lake to historical information (1945 and 1947). As part of the LWCNR Study Board, Koshinsky (1973) reported the Freshwater Fish Marketing Corporation's classification of Playgreen, Cross, Pipestone, Kiskittogisu, Kiskitto, Walker and Drunken lakes based on *T. crassus* infection and other considerations. The temporal pattern in the rate of *T. crassus* infection for Cisco, Lake Whitefish, and Northern Pike from 35 commercially fished lakes in Manitoba, including Sipiwesk, Walker, and Playgreen lakes, was studied from 1973-1983 (Sowe 1986).

A few studies have been undertaken to assess possible impacts of hydroelectric development on fish harvested by communities located along the upper Nelson River. Lake Whitefish from east Cross Lake were examined for *T. crassus* in 1981 as part of a study to assess adverse effects to commercial fishing caused by water level changes under regulation (Gaboury and Patalas 1981). As part of an impact assessment on effects to the town of Wabowden, MacKay *et al.* (1990) reported on *T. crassus* cysts counts for Lake Whitefish from Cauchon and Sipiwesk lakes. Information on *T. crassus* infections in lakes harvested by NFA communities was compiled as part of the Federal Ecological Monitoring Program by Baker and Davies (1991). In 1996, Manitoba Hydro and the Split Lake Cree conducted a joint assessment of the effects of hydroelectric development in the Split Lake Resource Management Area, which includes a portion of the upper Nelson River downstream of Sipiwesk Lake (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996). Published cyst counts from years after the start of regulation were not located for the outlet lakes.

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5.2.4.1.3 INDICATORS OF FISH HEALTH

SUMMARY OF SCIENTIFIC INFORMATION

The incidence of deformities, erosion, lesions, and tumours (DELTs) are monitored in Playgreen, Little Playgreen, west Cross, and Walker lakes under Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP 2014). The incidence of DELTs on fish in Sipiwesk Lake and the Nelson River between Sipiwesk Lake and the Kelsey GS was monitored in 2011 (CAMP *unpubl. data*).

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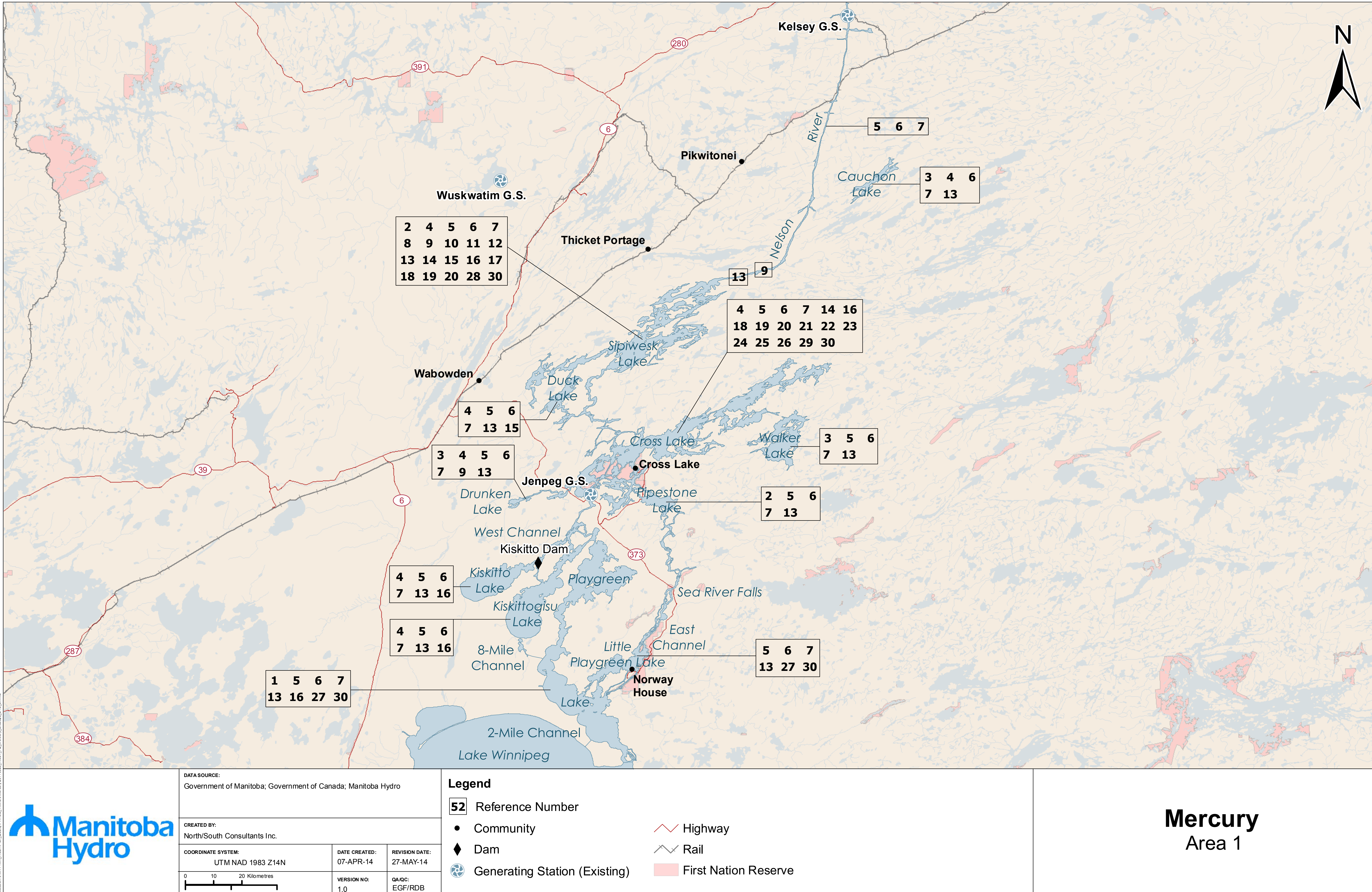
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Kelsey G.S.
280
391
6
Pikwitonei
River
5 6 7
Cauchon Lake
3 4 6 7 13
Wuskwatim G.S.
2 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 28 30
Thicket Portage
Nelson
13
9
4 5 6 7 14 16 18 19 20 21 22 23 24 25 26 29 30
Sipiwesk Lake
Duck Lake
Wabowden
4 5 6 7 13 15
Cross Lake
Walker Lake
3 5 6 7 13
3 4 5 6 7 9 13
Cross Lake
Jenpeg G.S.
39
Drunken Lake
Pipestone Lake
2 5 6 7 13
West Channel
Kiskitto Dam
373
4 5 6 7 13 16
Kiskitto Lake
Playgreen
Sea River Falls
Kiskittogisu Lake
4 5 6 7 13 16
East Channel
8-Mile Channel
Little Playgreen Lake
5 6 7 13 27 30
287
1 5 6 7 13 16 27 30
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Lake
2-Mile Channel
Lake Winnipeg
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Manitoba Hydro
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Government of Manitoba; Government of Canada; Manitoba Hydro
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North/South Consultants Inc.
COORDINATE SYSTEM:
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07-APR-14
REVISION DATE:
27-MAY-14
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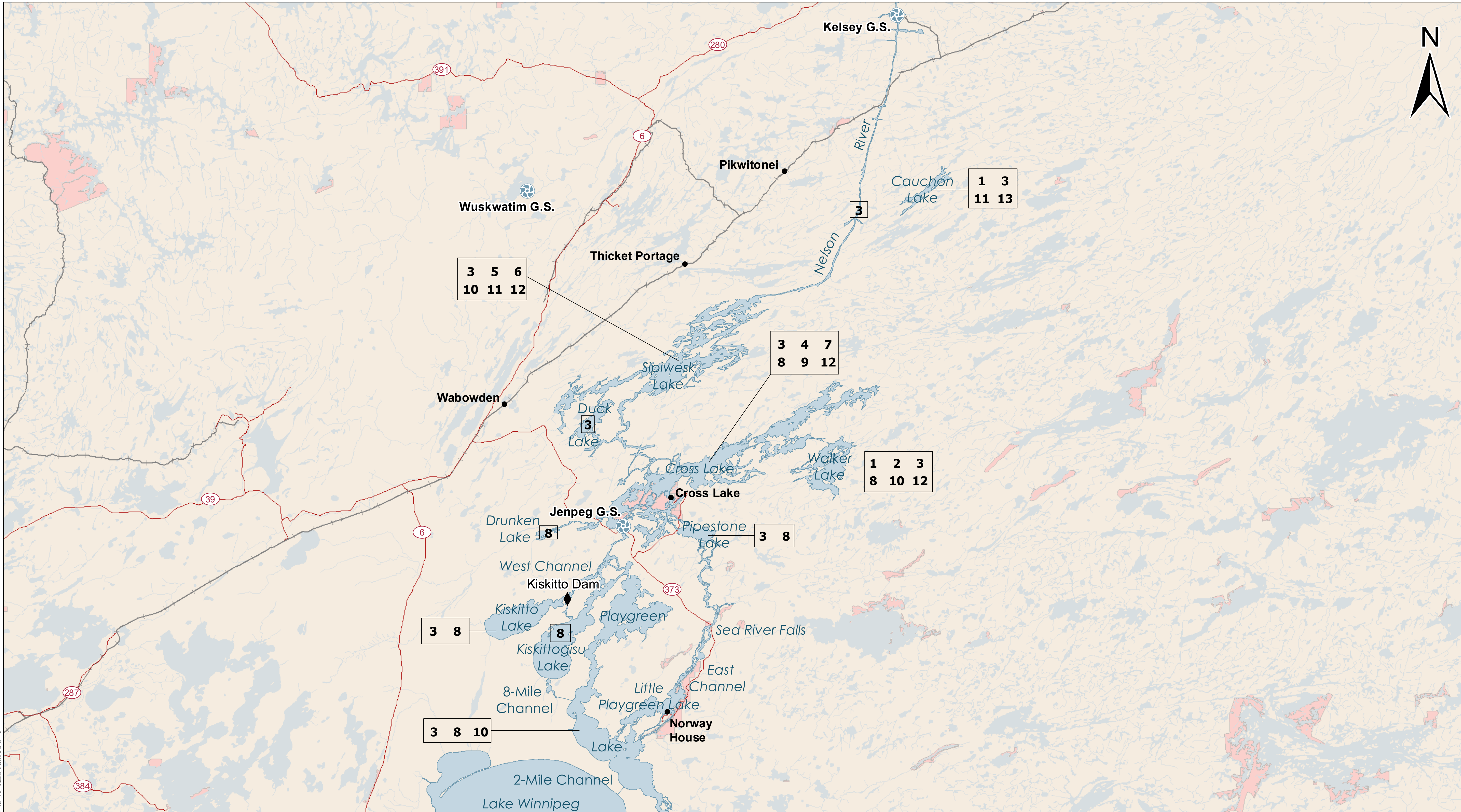
VERSION NO:
1.0
QA/QC:
EGF/RDB
Legend
52 Reference Number
Community
Dam
Generating Station (Existing)
Highway
Rail
First Nation Reserve
Mercury
Area 1

Map 5-14



DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

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Legend

- 52 Reference Number
- Community
- Dam
- Generating Station (Existing)
- Highway
- Rail
- First Nation Reserve

***Triaenophorus crassus* Cysts**
Area 1

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	23-MAY-14
0 10 20 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: EGF/RDB

Legend

- 52 Reference Number
- Community
- Dam
- Generating Station (Existing)
- Highway
- Rail
- First Nation Reserve

Indicators of Fish Health
Area 1

Map 5-16

5.2.4.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

5.2.4.2.1 MERCURY

SUMMARY OF SCIENTIFIC INFORMATION

Mercury concentrations in several fish species sampled from commercial catches from Split Lake between 1970 and 1979 were first compiled as part of federal-provincial studies (Bligh 1971; Derksen 1978a, b, 1979; Environment Canada 1979; McGregor 1980). Available mercury data for commercially sampled fish from Split and Stephens lakes and the Aiken River through to 1985 were compiled as part of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion (Department of Fisheries and Oceans 1987; Rannie and Punter 1987). As part of the Agreement, fish experimentally sampled from both lakes in 1983 and 1984 were tested for mercury (Green 1986; Derksen and Green 1987). The monitoring of muscle mercury levels in fish sampled from Split and Stephens lakes continued between 1985 and 1989 under the Manitoba Ecological Monitoring program in response to NFA Claim #18 (Green 1990; Ramsey 1991a; Environment Canada and Department of Fisheries and Oceans 1992). Information on fish mercury levels in lakes harvested by NFA communities was compiled as part of the Federal Ecological Monitoring Program by Baker and Davies (1991).

The monitoring of mercury concentrations in fish from the lower Nelson River forebays (Stephens Lake, Limestone, Long Spruce) as part of the Limestone Environmental Studies was initiated in 1985 (summary in North/South Consultants Inc. 2012). Preliminary reports documented mercury concentrations in fish collected from the Long Spruce forebay in 1985 and 1986 by the Manitoba Fisheries Branch (Swanson 1986; Swanson and Kansas 1987). Manitoba Hydro continued to monitor mercury concentrations in fish from the forebays starting in 1989 until the completion of the program in 2003 (Baker 1990a, 1991, 1992; Baker *et al.* 1990; Horne and Baker 1993; Kroeker and Horne 1993; MacDonell and Horne 1994; Horne and MacDonell 1995a; Bretecher and Horne 1997; Bretecher and MacDonell 1999, 2000; Johnson *et al.* 2004). On occasion, subsamples of fish captured from the Nelson River mainstem downstream of the Limestone GS (Johnson and MacDonell 2004), its tributaries (MacDonell 1991, 1992; Horne and MacDonell 1995b), and the estuary (Baker 1990b) were also analyzed for mercury.

Between 1992 and 1996, fish in lower Nelson River waterbodies (Split Lake, Stephens Lake, Limestone forebay) were measured for mercury concentrations as part of the Program for Monitoring Mercury Concentrations in Fish in Northern Manitoba Reservoirs, a joint agreement between Fisheries and Oceans Canada, Manitoba Hydro, Manitoba Department of Natural Resources, and Hydro Québec (Strange 1993, 1995; Strange and Bodaly 1997). Fish mercury monitoring as part of this program was extended from 1998 to 2005 under a three party agreement (Strange and Bodaly 1999; Jansen and Strange 2007a).

Fish mercury concentrations were monitored from 1999 to 2006 in the reach of the Nelson River between the Kelsey and Kettle GSs as part of the environmental assessment for the Keeyask GS. Waterbodies sampled included Gull Lake, Split Lake, Clark Lake, Stephens Lake, and the Aiken River (Remnant and Barth 2003; Mochnacz *et al.* 2004; Maclean and Pisiak 2005; Holm *et al.* 2007; Jansen and

Strange 2007b, 2009; Jansen 2010a; Keeyask Hydropower Limited Partnership 2012). Supplemental information was collected from Split and Stephens lakes in 2007 (Jansen 2010a), as well as Gull Lake and Aiken River in 2009 and 2012 (Jansen 2010b, 2013). In addition to fish species important to the domestic and commercial fisheries, forage species, particularly Rainbow Smelt, were sampled to provide information on mercury in the food chain. In 2009, trace elements, including mercury, were measured in the muscle tissue of fish captured in the lower Nelson River mainstem below the Limestone GS as part of baseline studies for the planned Conawapa GS (Johnson 2010).

Fish mercury concentrations continue to be monitored in Split and Stephens lakes, the Limestone forebay, and downstream in the lower Nelson River under Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program and have been published for 2009 and 2010 (CAMP 2014).

Several studies have been undertaken to assess possible impacts of hydroelectric development on fish harvested by communities located along the lower Nelson River. Available information on mercury concentrations in fish tissue was assembled by MacLaren and Beak (1988) in response to NFA Claim #97. In 1989, an environmental evaluation was conducted on the effects of increasing CRD flows (referred to as augmented flows) on numerous components, including mercury contamination in fish, along the diversion route, up to and including Split Lake (Rempel *et al.* 1989). Manitoba Hydro and the Split Lake Cree conducted a joint assessment of the effects of hydroelectric development on parameters including mercury levels in fish in the Split Lake Resource Management Area (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996). Fish mercury levels was one of the parameters assessed as potential impacts resulting from a change in operation of the Kettle GS in response to modifications made to the dam in 1996 (Manitoba Hydro 1998).

Fish mercury data from Split and Stephens lakes were used to test predictive models relating reservoir flooding to fish mercury concentrations(Johnston *et al.* 1991) and, along with Long Spruce forebay, as part of an analysis of post-impoundment trends in fish mercury concentrations in boreal Manitoba reservoirs (Bodaly *et al.* 2007).

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5.2.4.2.2 *TRIAENOPHORUS CRASSUS* CYSTS

SUMMARY OF SCIENTIFIC INFORMATION

Historic information on the rate of *T. crassus* infection in the lower Nelson River area is limited to reports of whitefish cyst inspections of commercial catches from Split Lake in the 1960s (Sunde 1965, 1967, 1968). Available information on *T. crassus* infection rates was assembled by MacLaren and Beak (1988) in response to NFA Claim #97 and whitefish cysts were considered in Manitoba Hydro and the Split Lake Cree joint assessment of the effects of hydroelectric development in the Split Lake Resource Management Area (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996). More recently, the cyst counts in Lake Whitefish captured in Split, Gull, and Stephens lakes were analyzed from 2003 to 2006 as part of the environmental assessment for the Keeyask GS and compared to data collected by the Freshwater Fish Marking Corporation (Jansen 2008; Keeyask Hydropower Limited Partnership 2012).

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5.2.4.2.3 INDICATORS OF FISH HEALTH

SUMMARY OF SCIENTIFIC INFORMATION

Historic information is limited to a few incidental reports of ectoparasites in Brook Trout sampled from the lower Nelson River in the 1950s (Kooyman 1951) and 1970s (Gaboury 1978, 1980), and intestinal parasites in fish captured in 1989 in the Nelson River estuary (Baker 1989) and downstream of the Long Spruce GS (Swanson *et al.* 1991). A DELT anomaly index was first used to evaluate the prevalence of external deformities, fin erosion, lesions, and/or tumours in fish captured in the lower Nelson River as part of the environmental assessment for the Keeyask GS. Fish captured during standard gang index gillnetting surveys in Split, Clark, Gull, and Stephens lakes were examined for external deformities and parasites from 2001 to 2004 and, again, in 2009 (Dunmall *et al.* 2004; Holm and Remnant 2004; Pisiak *et al.* 2004; Remnant *et al.* 2004; Johnson and Parks 2005; Holm 2005; Pisiak 2005; Holm 2010; Keeyask Hydropower Limited Partnership 2012). The incidence of DELTs has also been reported for fish captured during a 2003 index gillnetting survey of the lower Nelson River mainstem (Johnson and MacDonell 2004) and coregonines captured in hoop nets set in the Limestone River in 2008 (Mandzy *et al.* 2010). Walleye captured in Stephens Lake in 2003 underwent histopathological and bacteriological analysis to investigate if their health was being affected by an increase in the abundance of Rainbow Smelt in their diet (Cooley and Johnson 2008). Information on DELTs continues to be collected in Split Lake, Stephens Lake, the Limestone forebay, and downstream in the lower Nelson River under Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP 2014).

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Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	23-MAY-14
0 8.5 17 Kilometres / 0 7 14 Miles	VERSION NO: 1.0	QA/QC: LDB/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- First Nation Reserve

Mercury
Area 2

DATA SOURCE:	Government of Manitoba; Government of Canada; Manitoba Hydro	
CREATED BY:	North/South Consultants Inc.	
COORDINATE SYSTEM: UTM NAD 1983 Z15N	DATE CREATED: 07-APR-14	REVISION DATE: 27-MAY-14
0 8.5 17 Kilometres / 0 7 14 Miles	VERSION NO: 1.0	QA/QC: EGF/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- First Nation Reserve

***Triaenophorus crassus* Cysts**
Area 2

Map 5-18

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	23-MAY-14
0 8.5 17 Kilometres / 0 7 14 Miles	VERSION NO: 1.0	QA/QC: EGF/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- First Nation Reserve

Indicators of Fish Health
Area 2

Map 5-19

5.2.4.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

5.2.4.3.1 MERCURY

SUMMARY OF SCIENTIFIC INFORMATION

Mercury concentrations in several fish species sampled from commercial catches from Southern Indian and Opachuanau lakes and several lakes along the Rat-Burntwood river systems between 1970 and 1979 were first compiled as part of federal-provincial studies (Tam and Armstrong 1972; Derksen 1978a, b, 1979; Bodaly and Hecky 1979; Environment Canada 1979; McGregor 1980). Bodaly and Hecky (1979) also reported on mercury concentrations of Lake Whitefish from survey samples (*i.e.*, scientifically sampled rather than from commercial catches) at Southern Indian and Issett lakes in 1975 and 1978.

In response to the elevated (>0.5 ppm) fish mercury concentrations that were frequently documented for the 1970s samples, a number of projects were conducted under the 1983 Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion. These included investigations on mercury bioaccumulation and the monitoring of fish mercury levels. Results from the studies on Southern Indian Lake and diversion route lakes and the ongoing, parallel sampling of commercial fisheries in northern Manitoba through to 1985 were published in a journal article (Bodaly *et al.* 1984) and several reports (Strange 1985; Green 1986; Bodaly and Strange 1987; Derksen and Green 1987; Department of Fisheries and Oceans 1987; Hecky *et al.* 1987; Rannie and Punter 1987). In addition to the large-bodied species normally analyzed for mercury, Bodaly *et al.* (1987a, b) reported on mercury concentrations in two forage fish species (Spottail Shiner and Yellow Perch) sampled from several lakes (Southern Indian, Issett, Granville, Notigi, Mynarski, and Footprint) in 1981 and 1982. Similarly, mercury levels were measured in Yellow Perch stocked in limnocorrals installed on Southern Indian Lake as part of a series of experiments conducted from 1981-1984 to investigate pathways and dynamics of mercury bioaccumulation into fish (Hecky *et al.* 1987a, b).

The monitoring of muscle mercury in fish sampled from Rat and Threepoint lakes continued between 1985 and1989 under the Manitoba Ecological Monitoring program in response to NFA Claim #18 (Green 1990; Ramsey 1991a). Fish mercury concentrations from Southern Indian and Issett lakes were monitored in 1987 and 1988 under the auspices of the Federal Ecological Monitoring Program (Ramsey 1991b; Strange *et al.* 1991; Environment Canada and Department of Fisheries and Oceans 1992), and temporal trends in concentrations from Southern Indian Lake were compared to those along the diversion route and the Nelson River (Ramsey 1991b). Mercury concentrations in Yellow Perch captured in Granville Lake and transferred to holding pens in Methyl Bay (Southern Indian Lake) in 1989 were monitored to measure methylation rates in flooded zones of Southern Indian Lake (Ramsey 1990). Under FEMP, available information on fish mercury levels in lakes harvested by NFA communities was compiled by Baker and Davies (1991).

Johnston *et al.* (1991) developed and tested predictive models relating reservoir flooding to fish mercury concentrations using data from Southern Indian Lake and several of the diversion route lakes. Jackson

(1991) examined possible causes for inter-specific differences in the accumulation of mercury among fish species (Walleye, Northern Pike, Lake Whitefish, and Spottail Shiner) in areas affected by CRD.

Between 1992 and 1996, fish sampled from Southern Indian Lake as well as several diversion route lakes (Issett, Wuskwatim, Rat, and Threepoint) were tested for mercury as part of the Program for Monitoring Mercury Concentrations in Fish in Northern Manitoba Reservoirs, a joint agreement between Fisheries and Oceans Canada, Manitoba Hydro, Manitoba Department of Natural Resources, and Hydro Québec (Strange 1993, 1995; Strange and Bodaly 1997). Mercury monitoring as part of this program was extended from 1998 to 2005 under a three party agreement (Strange and Bodaly 1999; Jansen and Strange 2007).

Several waterbodies on the diversion route within the Nelson House RMA (Rat, Notigi, Wapisu, Footprint, Wuskwatim, Opegano, Birch Tree, Threepoint, and Osik lakes and the Burntwood River mainstem) were sampled for fish mercury between 1999 and 2007 as part of the environmental assessment for the Wuskwatim GS (Jansen and Barth 2003; Manitoba Hydro and Nisichawayasihk Cree Nation 2003; Jansen 2005, 2009; Jansen and Strange 2009).

Mercury concentrations in fish from Southern Indian, Issett, Rat, Threepoint, Wuskwatim, and Notigi lakes were subsequently measured in 2007 and 2008 as part of Manitoba Hydro's studies related to future developments (Jansen 2010). The report by Jansen (2010) includes the entire time series of available mercury data for Southern Indian, Issett, and Notigi lakes.

Fish mercury concentrations continue to be monitored in Southern Indian, Rat, and Threepoint lakes under Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program. CAMP results up to 2010 have been published in CAMP (2014).

Several studies have been undertaken to assess possible impacts of hydroelectric development on fish harvested by communities located along the diversion route. An impact assessment was conducted by Shawinigan Consultants Inc. *et al.* (1987) of the effects of the augmented flow program on Southern Indian Lake, which including mercury concentrations in fish. In response to NFA Claim #103, which had a geographic focus from Karsakuwigamik Lake to Wuskwatim Lake, available information on mercury concentrations in fish tissue was assembled and adverse effects of the program were evaluated by MacLaren Plansearch Inc. and Beak Consultants Ltd. (1988). In 1989, an environmental evaluation was conducted on the effects of CRD augmented flow on numerous components, including mercury contamination in fish, along the diversion route (Rempel *et al.* 1989). Manitoba Hydro and the Split Lake Cree conducted a joint assessment of the effects of hydroelectric development on parameters including mercury levels in fish in the Split Lake Resource Management Area, which includes a portion of the Burntwood River downstream of Apussigamasi Lake (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996).

Fisheries and Oceans Canada scientists have compiled fish mercury data from Southern Indian Lake and several diversion route lakes since the early 1970s and described post-impoundment trends in fish mercury concentrations in boreal reservoirs (Bodaly *et al.* 1984, 1988, 2007). Several review papers have discussed conditions at Southern Indian Lake and diversion route lakes to illustrate mercury bioaccumulation in fish in newly formed reservoirs (Bodaly *et al.* 1984, 1997, 2007; Hecky *et al.* 1991; Rosenberg *et al.* 1995).

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5.2.4.3.2 *TRIAENOPHORUS CRASSUS* CYSTS

SUMMARY OF SCIENTIFIC INFORMATION

Southern Indian Lake

Historic information on the rate of *T. crassus* infection of fish from Southern Indian Lake is limited to reports of cyst counts in Lake Whitefish in 1952 as part of a biological survey of the lake (McTavish 1952) and from inspections of commercial catches from Southern Indian Lake and Opachuanau Lake in the 1960s (Sunde 1963, 1964, 1965). A study of the parasites, including *T. crassus*, of Lake Whitefish, Cisco, and Northern Pike in Southern Indian Lake was conducted in 1975 and 1976 to establish baseline conditions prior to CRD and predict changes in parasite abundance in response to impoundment (Watson 1977; Watson and Dick 1979, 1980). In a 1978 report to Manitoba Hydro addressing the possible causes of changes in the quality of the Southern Indian Lake whitefish fishery, J.F. MacLaren

Ltd. (1978) noted that light coloured Lake Whitefish were characterized by having fewer *T. crassus* cysts than dark coloured fish and summarized cysts counts for the period 1971-1973 (pre-impoundment) and 1976-1977 (post-impoundment). Johnston (1984) examined regional differences in cyst counts in Lake Whitefish from Southern Indian Lake as well as the relationship between the rate of *T. crassus* infection and the external coloration (*i.e.*, light or dark) of Lake Whitefish. In response to declining market quality of the commercial whitefish fishery in Southern Indian Lake following Diversion, Fisheries and Oceans Canada compiled information on *T. crassus* cyst counts in Lake Whitefish from 1971-1982 and compared pre-impoundment rates of infestation to post-impoundment rates (Bodaly *et al.* 1980, 1983a, b, c, 1984). The temporal pattern of *T. crassus* cyst counts in Cisco, Lake Whitefish, and Northern Pike from 35 commercially fished lakes in Manitoba, including Southern Indian Lake and Opachuanau Lake, was studied from 1973-1983 (Sowe 1986). Cyst counts in Lake Whitefish were reported from commercial catches in 1987 and 1988 as part of a biological assessment of the post-impoundment commercial fishery under the Federal Ecological Monitoring Program (Peristy 1989). More recently, *T. crassus* infection rates were reported for Lake Whitefish captured in Southern Indian Lake in 2011 and 2012 as part of experimental gillnetting studies conducted to collect biological information on the status of whitefish stocks (Michaluk and Remnant 2012; Aiken and Remnant 2013).

Rat-Burntwood River System

Historic information on the rate of *T. crassus* infection is limited to reports of whitefish cyst inspections of commercial catches from several commercially fished lakes along the Rat-Burntwood River system (Karsakuwigamak, Mynarski, Pemichigamau, Wapisu, Notigi, Wuskwatim) in the 1960s (Sunde 1964, 1965; Schlick 1966). The temporal pattern of *T. crassus* cyst counts in Cisco, Lake Whitefish, and Northern Pike from 35 commercially fished lakes in Manitoba, including Wuskwatim lakes, was studied from 1973-1983 (Sowe 1986). Available information on *T. crassus* infection rates was assembled by MacLaren Plansearch Inc. and Beak Consultants Ltd. (1988) in response to NFA Claim #103 and as part of the Federal Ecological Monitoring Program by Baker and Davies (1991). More recently, the infection rates of *T. crassus* in Lake Whitefish captured in Wuskwatim Lake were analyzed in 2001 and 2002 as part of baseline studies in support of the Wuskwatim generation project and compared to data collected by the Freshwater Fish Marking Corporation collected in 1998 and 1999 (Manitoba Hydro and Nisichawayasihk Cree Nation. 2003; Jansen 2005).

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5.2.4.3.3 INDICATORS OF FISH HEALTH

SUMMARY OF SCIENTIFIC INFORMATION

Southern Indian Lake

The parasites of Lake Whitefish, Cisco, and Northern Pike collected from Southern Indian Lake in 1975 and 1976 were described to establish baseline conditions prior to CRD and predict changes in the abundance and composition of parasites in response to impoundment (Watson 1977; Watson and Dick 1979, 1980). A DELT anomaly index was first used to evaluate the prevalence of external deformities, fin erosion, lesions, and/or tumours in fish captured in Southern Indian Lake in 2011 and 2012 as part of experimental gillnetting studies conducted to collect biological information on the status of whitefish stocks (Michaluk and Remnant 2012; Aiken and Remnant 2013). Data on DELTs are collected in Areas

1, 4, and 6 of Southern Indian Lake under Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP 2014). The incidence of DELTs on fish in Opachuanau Lake was monitored in 2011 (CAMP *unpubl. data*).

Rat-Burntwood River System

Fish captured during standard gang index gillnetting surveys in several waterbodies between Notigi Lake and Birch Tree Lake were examined for external deformities using a DELT anomaly index from 2000 to 2002, and, again, in 2004 and 2007 as part of baseline studies in support of the Wuskwatim generation project (Mota 2001, 2005, 2009a; Mota and Heuring 2001; Caskey and Mota 2003a, b, c, d, e; Holm and Mota 2003a, b; Kroeker and Holm 2003; Kroeker *et al.* 2003a, b, c, d; Kroeker and Mota 2003; Mota and Jansen 2003). The use of sentinel species to monitor effects in the Wuskwatim project area was evaluated in 2005 and 2007 (Mota 2007). As part of this program, White Sucker were examined for external DELTs and an internal necropsy was conducted on each specimen. In order to monitor for effects of short-term increase in turbidity during the first year of instream construction of the GS in 2008, fish captured in the Burntwood River were examined for DELTs and were subjected to an internal health examination (Mota 2009c). Data on DELTs are collected in Rat, Notigi, Threepoint, Footprint, and Apussigamasi lakes under Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (CAMP 2014). The incidence of DELTs on fish in West/Central Mynarski Lake and the Burntwood River below First Rapids was monitored in 2011 (CAMP *unpubl. data*).

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Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	23-MAY-14
0 3 6 9 Kilometres / 0 3 6 Miles	VERSION NO: 1.0	QA/QC: LDB/RDB

Mercury
Area 3

Map 5-20

File Location: J:\MYP\MH_RCEA\Fish_Quality\PHASE_1\MXDs\T_Crassus\20140523_Area3_FQ_TCrassus_Portrait_BTB_ef.mxd

Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
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Triaenophorus crassus Cysts
Area 3

Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro

CREATED BY:
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COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
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0 3 6 9 Kilometres / 0 3 6 Miles	VERSION NO: 1.0	QA/QC: EGF/RDB

Indicators of Fish Health
Area 3

Map 5-22

5.2.4.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.2.4.4.1 MERCURY

SUMMARY OF SCIENTIFIC INFORMATION

Mercury concentrations in several fish species sampled from commercial catches from waterbodies in the lower Churchill River system between 1970-1979 were first compiled as part of federal-provincial studies (Derksen 1978a, b, 1979; Environment Canada 1979; McGregor 1980). Commercial samples from Northern Indian and Partridge Breast lakes continued to be monitored for mercury through to 1983 as part of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion (Rannie and Punter 1987). As part of the Agreement, mercury levels were also measured in fish sampled from 1978-1983 as part of surveys of selected lakes (*i.e.*, sampled with scientific sampling gill nets rather than from commercial catches), including Northern Indian and Partridge Breast. Fish mercury data from Northern Indian and Partridge Breast lakes were used to test predictive models relating reservoir flooding to fish mercury concentrations (Johnston *et al.* 1991).

Muscle mercury concentrations in fish were collected as part of the environmental assessment for the Churchill River weir (Manitoba Hydro and the Town of Churchill 1997). To address concerns associated with a potential for small increases in mercury levels in fish tissues in response to re-watering and flooding of terrestrial habitat resulting from the project, baseline mercury data was collected annually from 1993 to 1996 (Remnant and Bernhardt 1994; Remnant 1995; Remnant and Kitch 1996; Fazakas and Remnant 1997), and compared to post-project data collected from 1999 to 2013 (Bernhardt 2000, 2001, 2002, 2003; Bernhardt and Holm 2003, 2007; Bernhardt and Pisiak 2006; Bernhardt and Caskey 2009; Hertam *et al.* 2014).

Mercury levels continue to be monitored in Northern Indian Lake and the Churchill River at its confluence with the Little Churchill River and upstream of the weir under Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program. Results for the 2010 sampling at Northern Indian Lake and the Churchill River/Little Churchill River have been published (CAMP 2014) and monitoring at the Churchill River weir site will be first conducted as part of the 2017 CAMP sampling.

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5.2.4.4.2 *TRIAENOPHORUS CRASSUS* CYSTS

SUMMARY OF SCIENTIFIC INFORMATION

Information on the rate of *T. crassus* infection is limited to a taxonomic study of Cisco in the Churchill River estuary in 1953 (Keleher 1953), and several reports of whitefish cyst inspections of commercially fished waterbodies (Fidler Lake, Northern Indian Lake) in the 1960s (Sunde 1965; Anthony 1966a, b, 1971, 1972). The temporal pattern of *T. crassus* cyst counts in Cisco, Lake Whitefish, and Northern Pike from 35 commercially fished lakes in Manitoba, including Northern Indian Lake, was studied from 1973-1983 (Sowe 1986).

Scientific References

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5.2.4.4.3 Indicators of Fish Health

Summary of Scientific Information

The incidence of deformities, erosion, lesions, and tumours (DELTs) are monitored in Partridge Breast, Northern Indian, and Billard lakes and the Churchill River at the confluence with the Little Churchill River under Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Program (2014). The incidence of DELTs on fish in Fidler Lake was monitored in 2011 (CAMP *unpubl. data*). In 2014, a rotational CAMP site will be established at the Churchill River weir reservoir and DELTs will be monitored there.

Scientific References

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DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

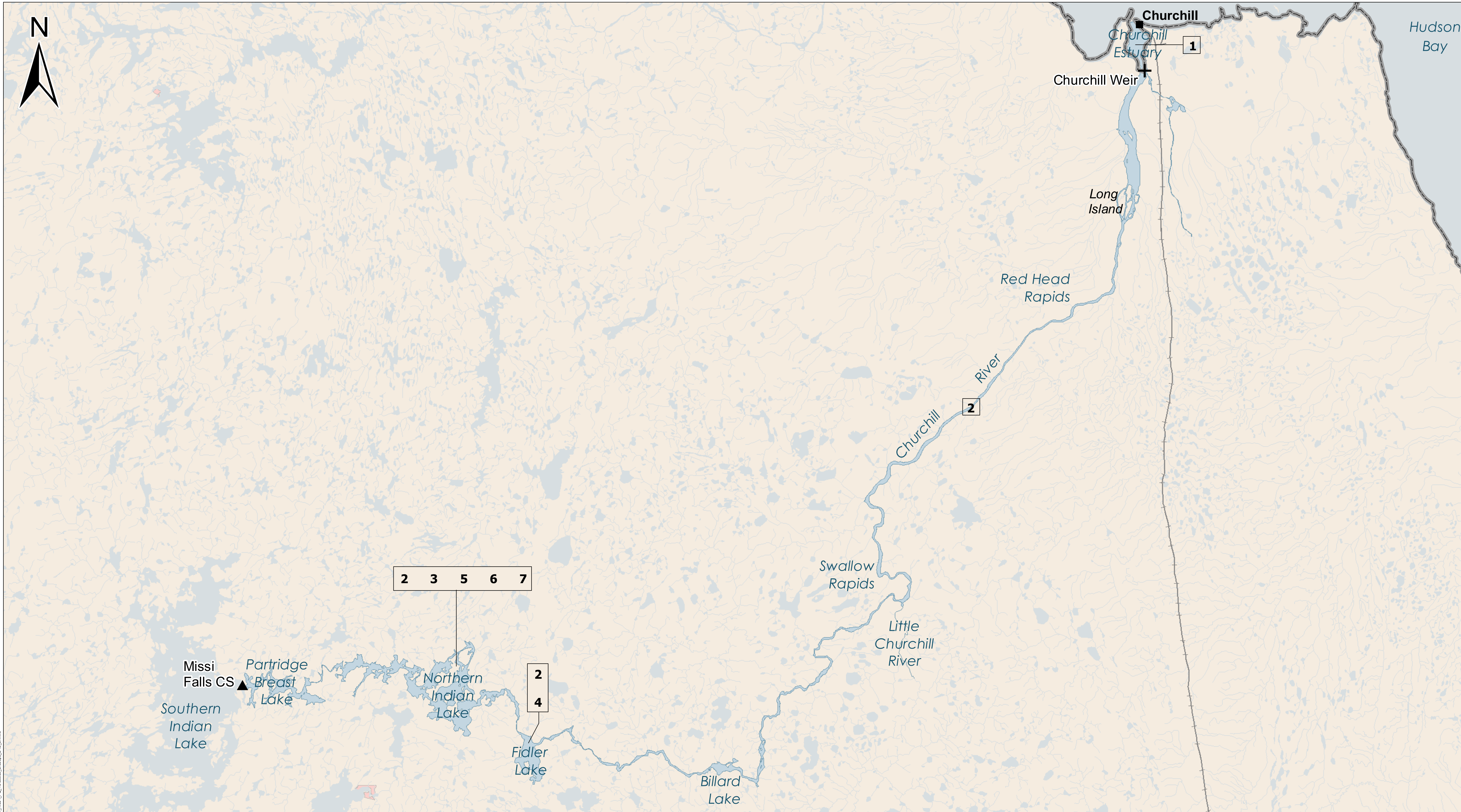
CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	26-MAY-14
0 10 20 Kilometres / 0 9 18 Miles	VERSION NO: 1.0	QA/QC: EGF/RDB

Legend

- 52 Reference Number
- ■ Towns/Cities
- ▲ Control Structure
- + Weir
- Rail
- First Nation Reserve

Mercury
Area 4



DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	26-MAY-14
0 10 20 Kilometres / 0 9 18 Miles	VERSION NO: 1.0	QA/QC: EGF/RDB

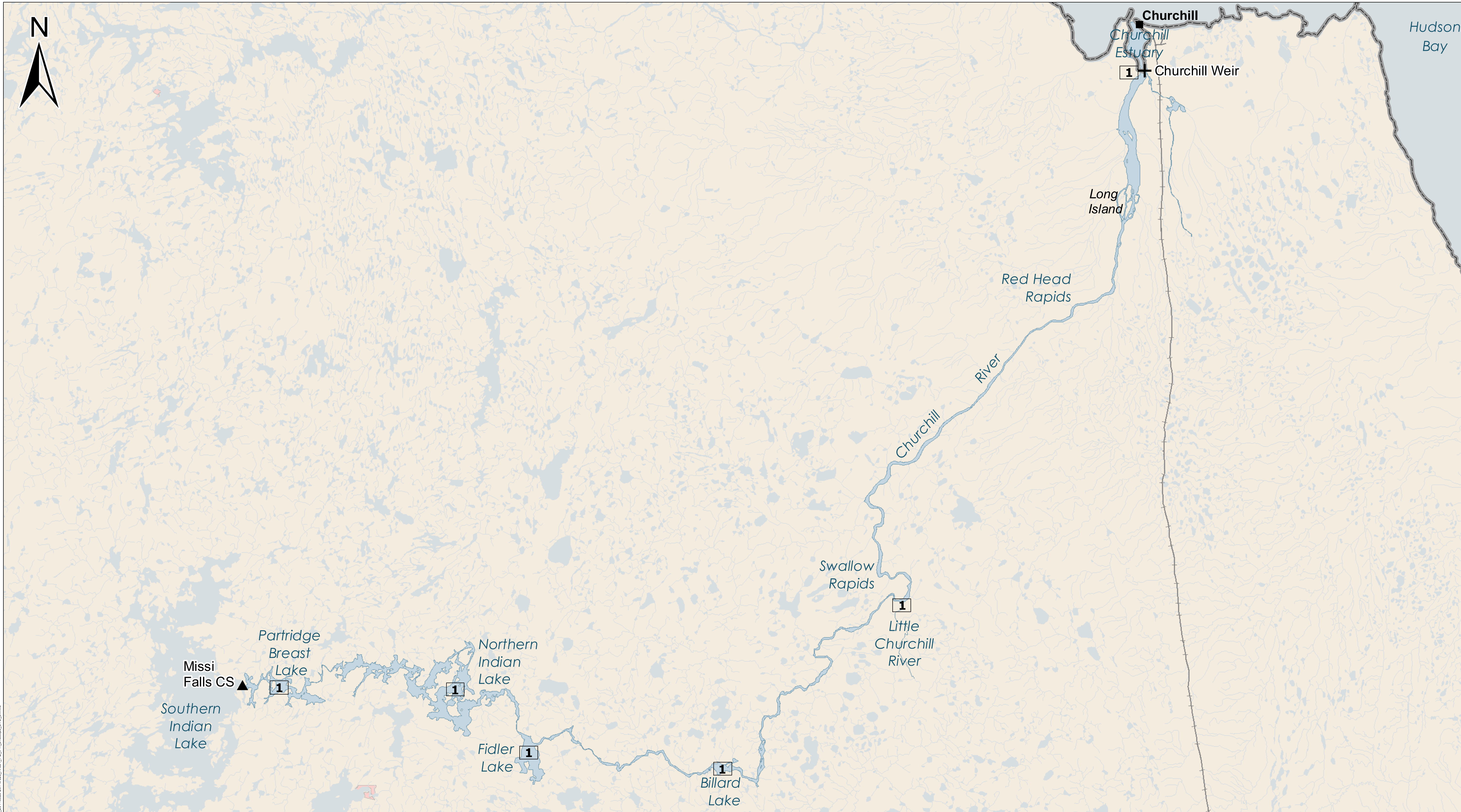
Legend

- 52 Reference Number
- Towns/Cities
- Control Structure
- Weir
- Rail
- First Nation Reserve

Manitoba Hydro

Triaenophorus crassus Cysts

Area 4



DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	23-MAY-14
0 10 20 Kilometres / 0 8.5 17 Miles	VERSION NO: 1.0	QA/QC: EGF/RDB

Legend

52 Reference Number
■ Towns/Cities
▲ Control Structure
+ Weir
Rail
First Nation Reserve

Indicators of Fish Health

Area 4

Map 5-25

5.2.5 Marine Mammals

5.2.5.1 Area 2: Split Lake Inlet to Nelson River Estuary

5.2.5.1.1 Polar Bears (*Ursus maritimus*)

Summary of Scientific Information

Polar bears from the Western Hudson Bay (WHB) population have been studied in the Nelson River region since the late 1960s following the establishment of the Federal-Provincial-Territorial Polar Bear Administrative Committee in 1969 and the Polar Bear Technical Committee in 1970. Data are primarily derived from multi-year mark-recapture programs conducted by, or in partnership with, the Canadian Wildlife Service. Monitoring programs in the WHB typically encompass both the lower Nelson and Churchill River regions and, consequently, many studies include data from both areas.

Historical population estimates for the WHB population using aerial survey data collected between 1971 and 1996 were presented by Stirling *et al.* (2004) and Atkinson *et al.* (2012) for data collected in 2011. Estimates based on mark-recapture data were published in Taylor and Lee (1995) as part of a circumpolar investigation and by Regehr *et al.* (2007) using multi-year (1984-2004) data specific to the WHB. Population data specific to the lower Nelson River region are limited to recent environmental monitoring studies (2005-2007) conducted by Manitoba Hydro as part of the Conawapa Generating Station Environmental Studies (Ambrose and Berger 2012a, b; Ambrose *et al.* 2013). The most recent population estimates of the WHB population were published by Stapleton *et al.* (2014).

Habitat utilization and movement studies were conducted primarily during the ice-free season using mark-recapture data (Lunn *et al.* 1997; Clark and Stirling 1998; Towns *et al.* 2009, 2010), a combination of mark-recapture and radio (Derocher and Stirling 1990a, b) or satellite (Stirling *et al.* 1999) telemetry, or aerial surveys (Stirling *et al.* 2004). Due to accessibility issues, studies related to sea ice utilization by polar bears within the Nelson River estuary and throughout the WHB are limited. Stirling *et al.* (2004) used sea ice information and polar bear survey data from 1971-1996 to examine the influence of ice breakup on bear distribution and movements along the coast. Stirling *et al.* (1999) examined polar bear body condition in relation to ice breakup in WHB using capture, radio collar and ice cover data from 1991-1998. Parks *et al.* (2006) used satellite-tracked collars to monitor the movement rates and distances of adult female polar bears on the Hudson Bay ice in relation to reproductive status between 1991 and 2004.

Physiological investigations have been conducted by several authors, the majority of which pertain to polar bear responses to immobilization (Cattett *et al.* 1997b) and transportation (Cattet *et al.* 1999) techniques. Cattet *et al.* (1997a) examined the relationships between age, sex, and morphometry (*e.g.*, total body mass, length, and girth) in polar bears from the WHB and other Canadian populations. Thiemann *et al.* (2006) used adipose tissue biopsies collected between 2001 and 2004 to assess overall body condition, lipid content and fatty acid composition in adult polar bears.

Reproductive biology and ecology was examined by several authors using long-term (1966-1994) mark-recapture data (Ramsay and Stirling 1986, 1988; Derocher and Stirling 1992, 1994, 1995; Derocher *et al.* 1992; Arnould and Ramsay 1994; Atkinson 1996; Stirling and Lunn 1997). Derocher and Stirling (1996) examined cub and yearling survival throughout the Churchill/Nelson River region. Derocher and Stirling (1998) used body length and head size to compare growth patterns of polar bears from the WHB and other regions of the Arctic. Denning habitat and den characteristics on the WHB Lowlands were examined by Clark *et al.* (1997). Denning behaviour and habitat in the lower Nelson River area was investigated by Jonkel *et al.* (1972) using 1969-1971 mark-recapture data and den examination, Ramsay and Stirling (1990) using 1980-1984 mark-recapture data, Clark *et al.* (1997) using mark-recapture methods and examination of dens in 1992 and 1993, Scott and Stirling (2002) using tree growth anomalies around and above den sites in 1993-1996, Lunn *et al.* (2004) using satellite radio collars in 1996 and 1997, Richardson *et al.* (2007) using 2001 and 2003 data describing the effects of forest fires on maternity denning habitat, and Richardson *et al.* (2005) using 2002-2005 aerial and ground surveys. A summary of information related to polar bear denning (site selection, physiology, disturbance responses) in WHB polar bears is presented in Linnel *et al.* (2000) as part of an Arctic-wide polar bear study. Although publications focusing on fat deposition and physiology are limited, Ramsay *et al.* (1992) analyzed biopsied adipose tissue from polar bears in northern Manitoba to compare seasonal differences between sexes.

Foraging information is limited to a small number of studies conducted during the ice-free period. Hobson and Stirling (1997) investigated the importance of supplemental food to polar bears using stable carbon isotope analysis of serum and cellular fractions of blood collected in 1988-1991. Iverson *et al.* (2006) estimated diet composition in WHB polar bears by analyzing the fatty acid signatures sampled in the 1980s and 1990s. Thiemann *et al.* (2008) expanded the study to include samples collected between 1972 and 2004. Derocher *et al.* (1993) investigated the foraging habits of polar bears on land during the ice-free periods of 1986-1992 through visual examination of captured bears and scat. Gormezano and Rockwell (2013) incorporated recent (2006-2008) scat data to compare current and historical diets.

Few polar bear contaminant studies have been conducted in the lower Nelson River area; however, McKinney *et al.* (2009) examined chlorinated and brominated contaminant concentrations in WHB polar bears in relation to changes in feeding ecology. Genetic studies are limited to Paetkau *et al.* (1995, 1999) who examined genetic isolation in polar bear populations using tissue samples obtained from past (1986-1993) monitoring programs.

Several authors have published partial or comprehensive reviews of polar bear biology, ecology and management using research conducted in the lower Nelson River and Churchill River regions (*e.g.*, International Union for Conservation of Nature and Natural Resources [IUCN] 1970, 1972, 1976, 1980, 1984, 1985, 1986, 1991, 1995, 1998, 2002, 2006, 2010; Stirling *et al.* 1977, 1980; Stirling and Ramsay 1986; COSEWIC 2008; Atkinson *et al.* 2013). Additionally, there are a growing number of publications concerning the impacts of climate change (*e.g.*, Stirling and Derocher 1993; Stirling 1997; Derocher *et al.* 2004; Stirling and Parkinson 2006; Cook *et al.* 2007; Laidre *et al.* 2008; Thiemann *et al.* 2008; Richardson 2009; Peacock *et al.* 2010; Molnár *et al.* 2010, 2011) and anthropogenic activities (*e.g.*, Derocher *et al.* 1997) on polar bear populations of the WHB and other locations. Stewart and Lockhart (2005) drafted a comprehensive review of the Hudson Bay marine ecosystem in the context of current and potential stressors (*e.g.*, climate change and hydroelectric development). Potential impacts of the Churchill River Diversion and other hydroelectric developments on Hudson Bay polar bears also were discussed in Schroeder-Lanz (1994).

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5.2.5.1.2 SEALS

SUMMARY OF SCIENTIFIC INFORMATION

Although some observations were reported in the 1970s (Didiuk 1975), few seal studies have been conducted in the Nelson River and its estuary. The majority of information was obtained through environmental assessment studies and monitoring programs related to the Limestone GS and planned Conawapa GS. Baker (1989) conducted aerial and water-based surveys in 1988 to identify seal species and estimate relative abundance in the Nelson River estuary prior to completion of the Limestone GS. Observations of bearded seals were also reported during fisheries surveys conducted in the Nelson River estuary in 1989 (Baker 1990). Results were summarized in North/South Consultants Inc. (2012) in its synthesis of aquatic monitoring results for the Limestone GS. Additional data were collected in 2005, 2006, 2007, and 2009 during aerial and water-based surveys conducted as part of the environmental assessment studies for the planned Conawapa GS (Ambrose and Berger 2012a, b; Bernhardt 2014).

Lunn *et al.* (1997) used aerial survey data collected in the Nelson River estuary and adjacent areas to estimate ringed and bearded seal densities in western Hudson Bay (WHB) and determine seal distribution and abundance in relation to winter and spring polar bear hunting. Bajzak *et al.* (2012) examined the movements, habitat preferences, and distribution of harbour seals in WHB using satellite telemetry in 2001 and 2002.

Current research focuses on assessments of known seal biology and ecology in the context of climate change (Stirling 1997; Stewart and Lockhart 2005; Laidre *et al.* 2008).

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5.2.5.1.3 BELUGA (*DELPHINAPTERUS LEUCAS*)

SUMMARY OF SCIENTIFIC INFORMATION

Beluga aerial survey data collected in the Nelson River region in the 1960s (Sergeant 1966, 1973; Didiuk 1975) and early 2000s (Richard 2005) contributed to population estimates for the western Hudson Bay (WHB) stock. Beluga research specific to the Nelson River and its estuary is primarily limited to multi-year studies conducted by Manitoba Hydro in support of Environmental Impact Statements and or monitoring programs for the Limestone and planned Conawapa generating stations.

Manitoba Hydro studies associated with the Limestone GS included aerial (1988 only) and boat-based (1988, 1989) surveys to determine beluga distribution and relative abundance in the Nelson River and estuary (Baker 1989; 1990). As part of aquatic monitoring programs for the Limestone GS and planned Conawapa GS, aerial surveys were conducted again in 2003 (Bernhardt 2004) and 2005 (Bernhardt 2014) to estimate beluga density, examine movement patterns and distribution, and to evaluate the potential effects of altered freshwater flow. A synthesis of monitoring results was presented by North/South Consultants Inc. (2012).

Smith (2007) investigated beluga use of the Nelson River estuary using radio-tracking and aerial survey data collected between 2002 and 2005. In that study, beluga distribution in relation to physical estuarine conditions (*e.g.*, temperature, depth, currents, and tidal cycle), age and sex were examined.

Additional information sources include partial or comprehensive reviews of WHB and other stocks in the Canadian Arctic in relation to status and management (North/South Consultants Inc. 1990; Richard 1993; COSEWIC 2004), subsistence and commercial harvests (Reeves and Mitchell 1989; Baker *et al.* 1992), hydroelectric development (Lawrence *et al.* 1992; Schroeder-Lanz 1994) and/or climate change (Stewart and Lockhart 2005; Laidre *et al.* 2008). Lawrence *et al.* (1992) examined the potential effects of hydroelectric development on Nelson River beluga. The report provides a review of the Nelson River and estuary, including physical and oceanographic conditions, beluga utilization and hydroelectric development, as well as a summary of the discussions and conclusions reached during a workshop held in November 1990 by Manitoba Hydro and Fisheries and Oceans Canada. Richard (1993) published a comprehensive review of beluga biology and ecology which included a discussion of anthropogenic activities and other factors affecting the WHB beluga population and recommendations for determining stock status.

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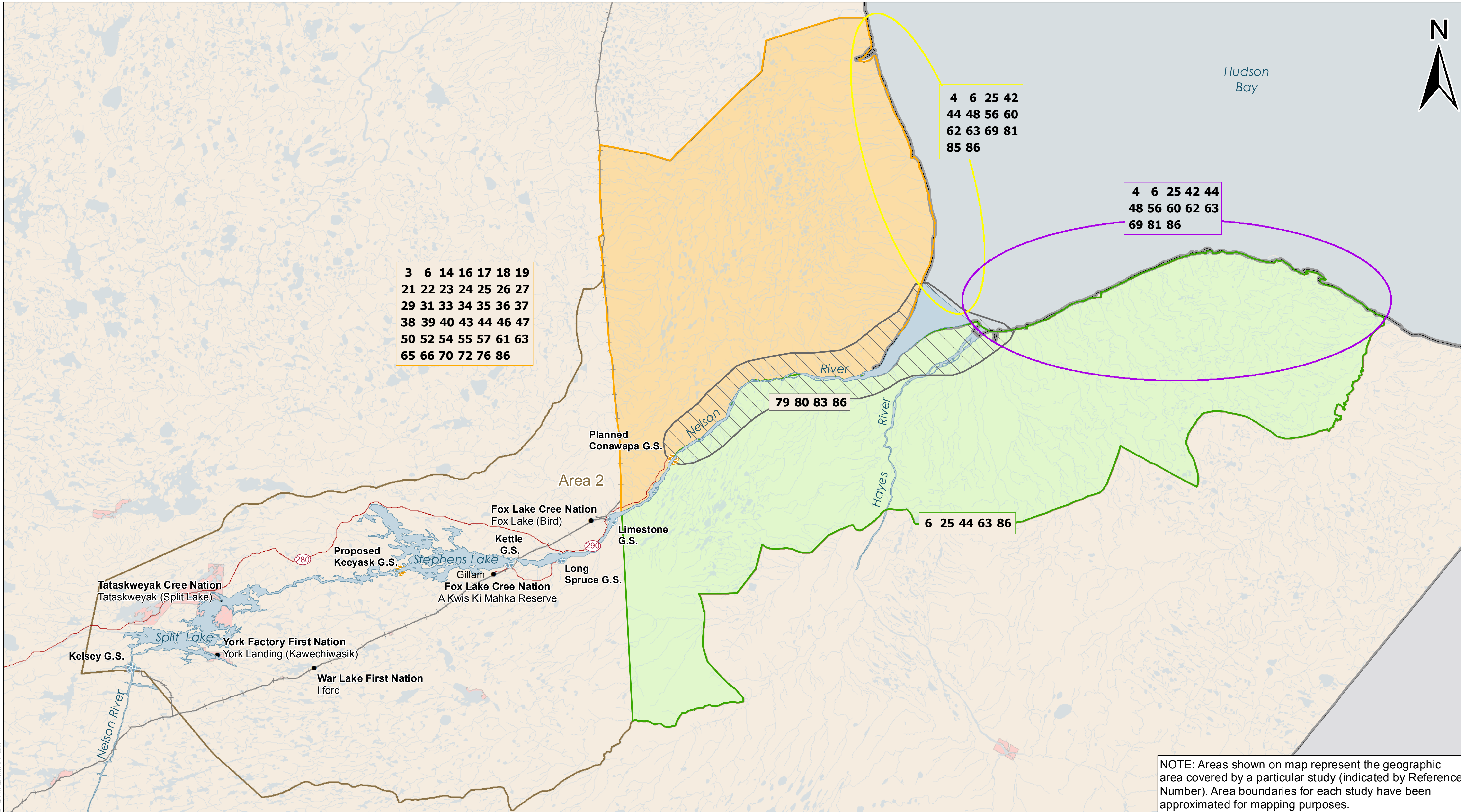

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
North/South Consultants

CREATED BY:
North/South Consultants Inc.

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Legend

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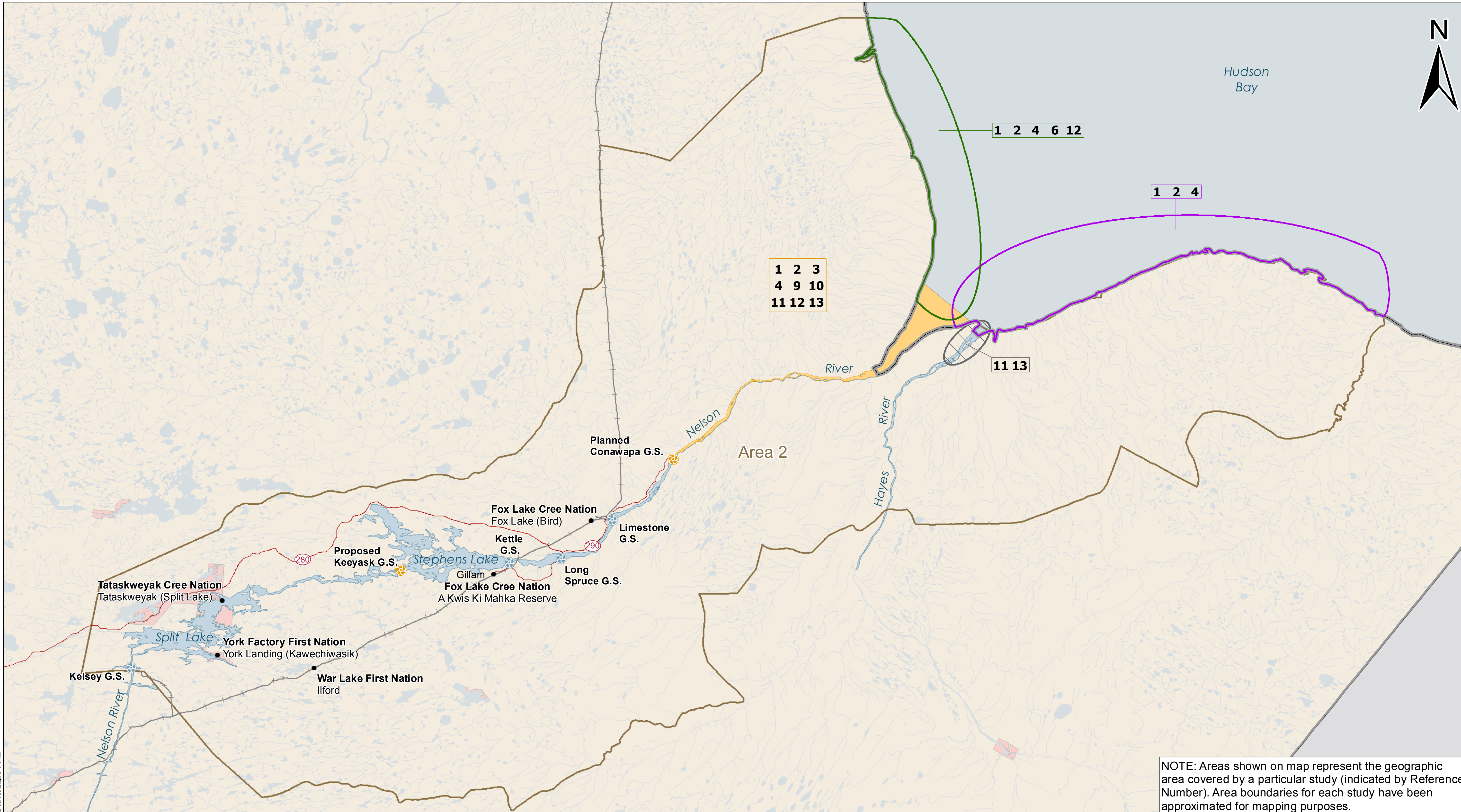
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- First Nation Reserve

Polar Bears
Area 2



Manitoba Hydro

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Government of Manitoba; Government of Canada; Manitoba Hydro

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- Community
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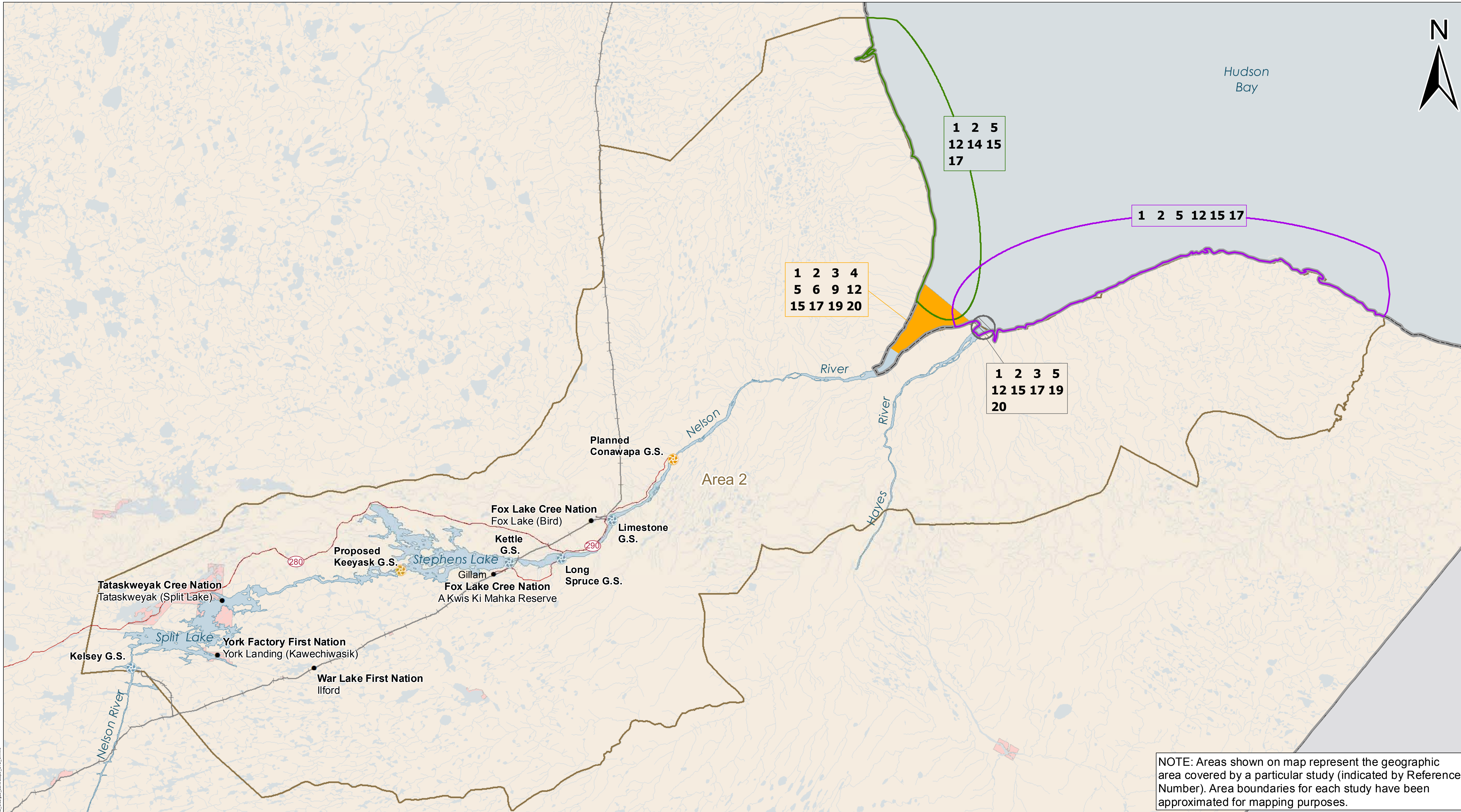
- Highway
- Rail
- First Nation Reserve

Seals
Area 2



Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	27-MAY-14
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Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- First Nation Reserve

Beluga
Area 2

Map 5-28

5.2.5.2 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.2.5.2.1 POLAR BEARS (*URSUS MARITIMUS*)

SUMMARY OF SCIENTIFIC INFORMATION

Polar bear studies in the Churchill River region began in the late 1960s following the establishment of the Federal-Provincial-Territorial Polar Bear Administrative Committee in 1969 and the Polar Bear Technical Committee in 1970. Data are primarily derived from multiple year mark-recapture programs conducted by, or in partnership with, the Canadian Wildlife Service. Monitoring programs in the western Hudson Bay (WHB) typically encompass both the Churchill River and lower Nelson River regions and, consequently, many studies include data from both areas.

Population estimates for the WHB population using aerial survey data collected between 1971 and 1996 were presented by Stirling *et al.* (2004) and in Atkinson *et al.* (2012) for data collected in 2011. Estimates based on mark-recapture data have been published in Taylor and Lee (1995) as part of a circumpolar investigation and by Regehr *et al.* (2007) using multi-year (1984-2004) data specific to the WHB. Habitat utilization and movement studies were conducted primarily during the ice-free season, using aerial surveys (Stirling *et al.* 2004), mark-recapture data (Lunn *et al.* 1997; Clark and Stirling 1998; Towns *et al.* 2009, 2010), or a combination of mark-recapture and radio (Jonkel 1969; Derocher and Stirling 1990a, b) or satellite (Stirling *et al.* 1999; Parks *et al.* 2006) telemetry. The most recent population estimates for the WHB were published by Stapleton *et al.* (2014).

Due to accessibility issues, studies related to sea ice utilization by polar bears within the Churchill River estuary and throughout the WHB are limited. Stirling *et al.* (2004) used sea ice information and polar bear survey data from 1971-1996 to examine the influence of ice breakup on bear distribution and movements along the coast. Stirling *et al.* (1999) examined polar bear body condition in relation to sea ice breakup in the WHB using capture, radio collar, and ice cover data from 1991-1998. Parks *et al.* (2006) used satellite-tracked collars deployed between 1991 and 2004 to monitor the rates and distances of movements by adult female polar bears on the Hudson Bay ice in relation to reproductive status.

Experimental investigations of polar bears in the Churchill River region were conducted throughout the 1970s, 1980s, and 1990s. Øritsland *et al.* (1977) measured changes in the heart rate and body temperature of active bears, while Hurst *et al.* (1982) examined body temperature and oxygen consumption during exercise. Best (1982) investigated the thermoregulatory effects of exercise in polar bears that were captured near Churchill. Cushing *et al.* (1988) examined the response of Churchill area polar bears to marine mammal (*e.g.*, seals, killer whales [*Orcinus orca*], and other polar bears) vocalizations in a laboratory setting. Additional studies have investigated the physiological responses of polar bears to immobilization (Cattett *et al.* 1997b; Cattet *et al.* 1999a; Caulkett *et al.* 1999) and transportation (Cattet *et al.* 1999a) techniques. Cattet *et al.* (1997a) examined the relationships between age, sex, and morphometry (*e.g.*, total body mass, length, and girth) in polar bears from the WHB and other Canadian populations.

Reproductive biology and ecology was examined by several authors using long-term (1966-1994) mark-recapture data (Ramsay and Stirling 1986, 1988; Derocher 1990; Derocher and Stirling 1992, 1994, 1995, 1996; Derocher *et al.* 1992; Arnould and Ramsay 1994; Atkinson 1996; Stirling and Lunn 1997). Derocher and Stirling (1996) examined cub and yearling survival throughout the Churchill/Nelson River region based on data collected between 1966 and 1992. Denning habitat and den characteristics on the WHB Lowlands were examined by Clark *et al.* (1997). Derocher and Stirling (1998) used body length and head size to compare growth patterns of polar bears from the WHB (1966-1991 data) and other regions of the Arctic. The reproductive biology of male bears was examined by Howell-Skalla *et al.* (2002) by comparing serum testosterone concentrations in breeding versus non-breeding bears in 1995 and 1996. Atkinson *et al.* (1996) reported a case of offspring adoption by a female polar bear near Cape Churchill in 1994.

Denning behaviour and habitat in the Churchill River area was investigated by several authors, including Jonkel *et al.* (1972) using 1969-1971 mark-recapture data and den examination, Watts and Hansen (1987) using data from natural and simulated denning habitat, Ramsay and Stirling (1990) using 1980-1984 mark-recapture data, Watts (1990) using simulated denning habitat in a laboratory setting, Clark *et al.* (1997) using mark-recapture methods and examination of known polar bear dens, Scott and Stirling (2002) using tree growth anomalies around and above den sites (1993-1996 data), Lunn *et al.* (2004) using satellite radio collars in 1996 and 1997, and Richardson *et al.* (2005) using 2002-2005 aerial and ground surveys. Richardson *et al.* (2007) described the effects of forest fires on maternity denning habitat using data collected in 2001 and 2003. A summary of information related to polar bear denning (site selection, physiology, and disturbance responses) is presented in Linnel *et al.* (2000) as part of an Arctic-wide polar bear study. Publications focusing on fat deposition and physiology are limited. One investigation authored by Ramsay *et al.* (1992) analyzed biopsied adipose tissue from polar bears in northern Manitoba to compare seasonal differences between sexes.

Foraging information is limited to a small number of studies conducted during the ice-free period. Lunn and Stirling (1985) investigated the importance of supplemental food to polar bears in 1982 and 1983 by measuring urea and creatinine levels in the blood. Hobson and Stirling (1997) conducted a similar study using stable carbon isotope analysis of serum and cellular fractions of blood collected from 1988-1991. Iverson *et al.* (2006) estimated diet composition of WHB polar bears by analyzing the fatty acid signatures of bears sampled in the 1980s and 1990s. Thiemann *et al.* (2008b) expanded the study to include samples collected between 1972 and 2004. Derocher *et al.* (1993) investigated the terrestrial foraging habits of polar bears between 1986 and 1992 through visual examination of captured bears and scat. Scat was also used by Russell (1971, 1975) to examine terrestrial foraging in Churchill area polar bears in 1968 and 1969. Rockwell and Gormezano (2009) examined variations in terrestrial foraging behaviour of polar bears along the Cape Churchill Peninsula in the context of climate change. Gormezano and Rockwell (2013) incorporated recent (2006-2008) scat data to compare current and historical diets.

Some contaminant studies have been conducted in the Churchill River region. Øritsland *et al.* (1981) examined the physiological effects of crude oil on Churchill area polar bears. Jarman *et al.* (1992) analyzed tissue concentrations of dichlorodiphenyltrichloroethane (DDT), polychlorinated biphenyls (PCBs), tris 4-Chlorophenyl Methanol (TCPM), and dieldrin in previously sampled WHB polar bears as part of a larger-scale study investigating birds and mammals worldwide. Letcher *et al.* (1996) measured chlorinated hydrocarbon contaminant (CHC) concentrations in polar bear livers and their effects on hepatic function. Norstrom (1995) and Norstrom *et al.* (1998) compared concentrations of dieldrin, 4,4'-dichlorodiphenyldichloroethylene (DDE), PCBs, and CHLs in the adipose tissue of bears sampled between 1989 and 1993 in WHB to those in other populations. McKinney *et al.* (2009) investigated chlorinated and brominated contaminant concentrations in WHB polar bears in relation to changes in feeding ecology. Genetic studies are limited to Paetkau *et al.* (1995, 1999) who examined genetic isolation in polar bear populations using tissue samples obtained from past (1986-1993) monitoring programs.

The majority of research related to polar bear social behaviour was conducted in the Churchill region in bears awaiting Hudson Bay ice. Latour (1981a, b) observed polar bear interactions at Cape Churchill in 1978 and discussed these behaviours in relation to play, conflict, and density. Lunn (1986) investigated aggression in polar bears around the Churchill garbage dump in the fall of 1983 and Eckhardt *et al.* (2003) conducted a similar study between 2001 and 2002. Ramsay and Stirling (1984) described observations of interactions between wolves and polar bears in the polar bear maternity denning area southeast of Churchill.

Several authors have published partial or comprehensive reviews of polar bear biology, ecology, and management using research conducted in the Churchill River area (IUCN 1970, 1972, 1976, 1980, 1984, 1985, 1986, 1991, 1995, 1998, 2002, 2006, 2010; Jonkel 1970a, b; Macpherson and Jonkel 1970; Stirling *et al.* 1977; Stirling and Smith 1980; Stirling *et al.* 1984; Calvert *et al.* 1986, 1991, 1995; Stirling and Ramsay 1986; Lunn *et al.* 1998, 2002, 2006, 2010; COSEWIC 2008; Atkinson *et al.* 2013). There are a growing number of publications concerning the impacts of climate change (Stirling and Derocher 1993; Stirling 1997; Derocher *et al.* 2004; Stirling and Parkinson 2006; Cook *et al.* 2007; Laidre *et al.* 2008; Thiemann *et al.* 2008a; Richardson 2009; Molnár *et al.* 2010, 2011; Peacock *et al.* 2010; Rockwell *et al.* 2011) and anthropogenic activities (Jonkel 1970a; Jonkel *et al.* 1976; Miller 1983, 1987; Stenhouse and Cattet 1984; Compuheat Services Canada Inc. 1986; Derocher and Miller 1986; Clarkson 1987; Derocher *et al.* 1997; Dyck 2001; Dyck and Baydack 2004; Eckhardt 2005; Clark *et al.* 2012) on the WHB and other polar bear populations. Potential impacts of the CRD on polar bears was discussed by the LWCNR Study Board (1974; 1975a, b) and Schroeder-Lanz (1994). Stewart and Lockhart (2005) drafted a comprehensive review of the Hudson Bay marine ecosystem in the context of current and potential stressors (*e.g.*, climate change and hydroelectric development).

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5.2.5.2.2 SEALS

SUMMARY OF SCIENTIFIC INFORMATION

Few seal studies have been conducted in the Churchill River and its estuary. In 1954, McLaren (1958a) examined the stomach contents of ringed seals in the Churchill area as part of a larger-scale study comparing the diets of seal populations throughout the eastern Canadian Arctic. McLaren (1958b) used catch statistics to estimate the number of bearded seals within Hudson Bay, Hudson Strait/Ungava Bay, Foxe Basin, and eastern and northern Baffin Island. The majority of information specific to the Churchill region is derived from surveys conducted by Fisheries and Oceans Canada and Manitoba Hydro.

Lunn *et al.* (1997) used aerial survey data collected in the Churchill River estuary and adjacent areas in 1994 and 1995 to estimate ringed and bearded seal densities for each area and determine distribution and abundance in western Hudson Bay (WHB) in relation to winter and spring polar bear hunting. Seal distribution, abundance and habitat utilization along the lower Churchill River and estuary was investigated during the Churchill River Water Level Enhancement Weir Project monitoring studies conducted by Manitoba Hydro between 1996 and 2005 (Remnant 1997; Bernhardt 1999, 2000, 2001, 2003, 2006). The monitoring program was designed to investigate the location and utilization of haul-out sites, seal use of the fishways and reservoir during the open water season, disturbance of seals at haul out sites during construction activities, and hunting pressure. The program incorporated boat, aerial, and land-based survey data as well as opportunistic observations and anecdotal information by local resource users (Bernhardt and Holm 2007).

Bajzak *et al.* (2012) examined the movements, habitat preferences, and distribution of harbour seals captured and released in the Churchill River estuary using satellite telemetry in 2001 and 2002. The authors also examined the potential for harbour seals to replace ringed seals as the primary food source for polar bears as a result of a warming climate. Vincent-Chambellant (2010) combined aerial data collected by Environment Canada between 1995 and 2000 with that collected by Fisheries and Oceans Canada in 2007 and 2008 to estimate ringed and bearded seal density and abundance in WHB, assess potential inter-annual variations in seal density in relation to the sea-ice regime, and assess trends in ringed seal density in the context of climate warming. The 2007-2008 data were also summarized in Chambellant and Ferguson (2009). Additional survey data were collected by Fisheries and Oceans Canada in 2009 and 2010 (Ferguson and Young 2011). A summary of seal population data for WHB was presented in Fisheries and Oceans Canada (2011).

Current research focuses on assessments of known seal biology and ecology in the context of climate change (Stirling 1997; Stewart and Lockhart 2005; Laidre *et al.* 2008; Chambellant 2010).

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5.2.5.2.3 BELUGA (*DELPHINAPTERUS LEUCAS*)

SUMMARY OF SCIENTIFIC INFORMATION

The earliest beluga studies from the Churchill River area were conducted by the Fisheries Research Board of Canada in the late 1940s, 1950s, and 1960s. Between 1948 and 1968, aerial surveys (1948, 1950, 1955, 1965, 1966), sample collections (1948-1950, 1955, 1956) and experimental marking studies (1949-1950) were conducted to collect baseline data regarding biology, seasonal abundance, behaviour (foraging and migration) and habitat utilization prior to a potential re-opening of the commercial whaling industry (Douglas 1950, 1951; Doan and Douglas 1953; Dunbar 1955; Sergeant 1966; Sergeant and Brodie 1969a, b; Sergeant and Brodie 1975). Morphological measurements and necropsy results collected in 1955 and 1956 were pooled and used as a representative sample of the western Hudson Bay (WHB) stock for comparison to other Canadian Arctic stocks (Sergeant and Brodie 1969a). Sergeant and Brodie (1975) summarized results of the 1950s and 1960s data collections, including aerial surveys (abundance, population structure, and movement patterns), necropsy data (diet, age and sex, reproduction, and growth), and tagging program.

Parasitological studies are rare. Kenyon and Kenyon (1977) and Kenyon *et al.* (1999) examined *Pharurus pallasii* (Nematoda) infections, pathology and mode of transmission in beluga taken during subsistence harvests from the Churchill River estuary in the 1970s.

Research in the 1980s and early 1990s focused primarily on seasonal movements and behaviour in relation to environmental factors such as water temperature, salinity, turbidity, depth, and tidal cycle. These relationships were investigated by Hansen (1987) and Hansen *et al.* (1988) using aerial survey and water chemistry data collected in 1983, 1984, and 1986, and by Idle *et al.* (1988) and Idle (1989) using land-based observations (1982-1986). The importance of freshwater inputs to beluga in the Churchill River estuary also was examined by Watts and Draper (1988) and Watts *et al.* (1991) using aerial survey data and land-based observations, respectively. Additional behavioural studies involving Churchill River beluga include Watts and Draper (1986) who investigated foraging behaviour in response to avoidance by prey (capelin [*Mallotus villosus*]), and Martin *et al.* (2001) who used satellite-linked data loggers to examine diving behaviour. In 2004, Fisheries and Oceans Canada conducted aerial visual line-transect and photographic surveys in the Churchill-Seal River and Nelson River areas to estimate population size of the WHB stock and compare to data obtained in 1987 (Richard 2005).

A multi-year monitoring study associated with Manitoba Hydro's Churchill River Water Level Enhancement Weir Project provided additional data regarding beluga use of the Churchill River and its estuary and response to hydroelectric development. In 1998, land- and boat-based surveys documented beluga movements and assessed their responses to construction-related activities (*e.g.*, blasting and rock dumping) (Bernhardt 1999). Post-project monitoring studies included interviews with whale-watching operators in 1999 (Bernhardt 2000) and additional aerial surveys in 2000 (Bernhardt 2002). Bernhardt (2002) compared current (2000) and past (Hansen 1987) aerial survey data with physical parameters (*e.g.*, water temperature and freshwater discharge) to investigate potential changes in beluga use of the upper Churchill River estuary as a result of the Project. Results were summarized Bernhardt (2003) and Bernhardt and Holm (2007).

Few genetic studies involving Churchill area beluga are available. Brennin *et al.* (1997) examined the genetic structure of North American beluga populations using variations in mitochondrial DNA (mtDNA). Samples collected by Fisheries and Oceans Canada in the Churchill River area during subsistence hunts were representative of the WHB population. Turgeon *et al.* (2009) conducted a similar study using mtDNA from beluga collected in the Hudson Bay/Hudson Strait/Baffin Island geographical complex between 1984 and 2004.

Beluga vocalization studies conducted in the Churchill River and its estuary are limited to Chmelnitsky (2010) and Chmelnitsky and Ferguson (2012), who examined recorded vocalizations in the context of behaviour in 2006-2008. A single study examined contaminants in Churchill River beluga. Letcher *et al.* (2000) measured concentrations of PCBs, DDEs, and $MeSO_2$-metabolites in the tissues of whales biopsied during a catch-and-release program conducted in conjunction with the Inuit subsistence hunt.

Some experimental studies have been conducted in the Churchill River and estuary. In the mid-late 1980s, St. Aubin and Geraci (1989, 1992) investigated metabolic change in response to captivity by analyzing hematologic parameters in the blood of beluga captured and held temporarily. In 1987, Orr and Hiatt-Saif (1992) experimentally banded beluga in the Churchill River to determine the size and shape most compatible for long-term mark-recapture programs. Numerous aquaria-based experimental studies involving captive beluga from the Churchill area also have been published (Ridgway *et al.* 1984; Cornell *et al.* 1988; De Guise *et al.* 1997; Lockyer *et al.* 2007; Vergara and Barrett-Lennard 2008; Vergara 2011).

Comprehensive or partial reviews of beluga biology, ecology, and/or history (*e.g.*, commercial exploitation) in the Churchill River area are presented in Sergeant (1962), Sergeant and Brodie (1975), Reeves and Mitchell (1989), North/South Consultants Inc. (1990), and Richard (1993). Although discussions related to hydroelectric development are limited, Sergeant and Brodie (1975) reviewed beluga distribution and abundance in both the Churchill and Nelson River areas in the context of anthropogenic activities and future hydroelectric development. Potential impacts of the CRD and other hydroelectric developments to beluga also were discussed in Schroeder-Lanz (1994). Subsistence and commercial harvests within the WHB were reviewed by Baker *et al.* (1992). Recent reviews focus on stock status (COSEWIC 2004) and issues related to climate change (Stewart and Lockhart 2005; Laidre *et al.* 2008) and tourism (Malcolm and Penner 2011).

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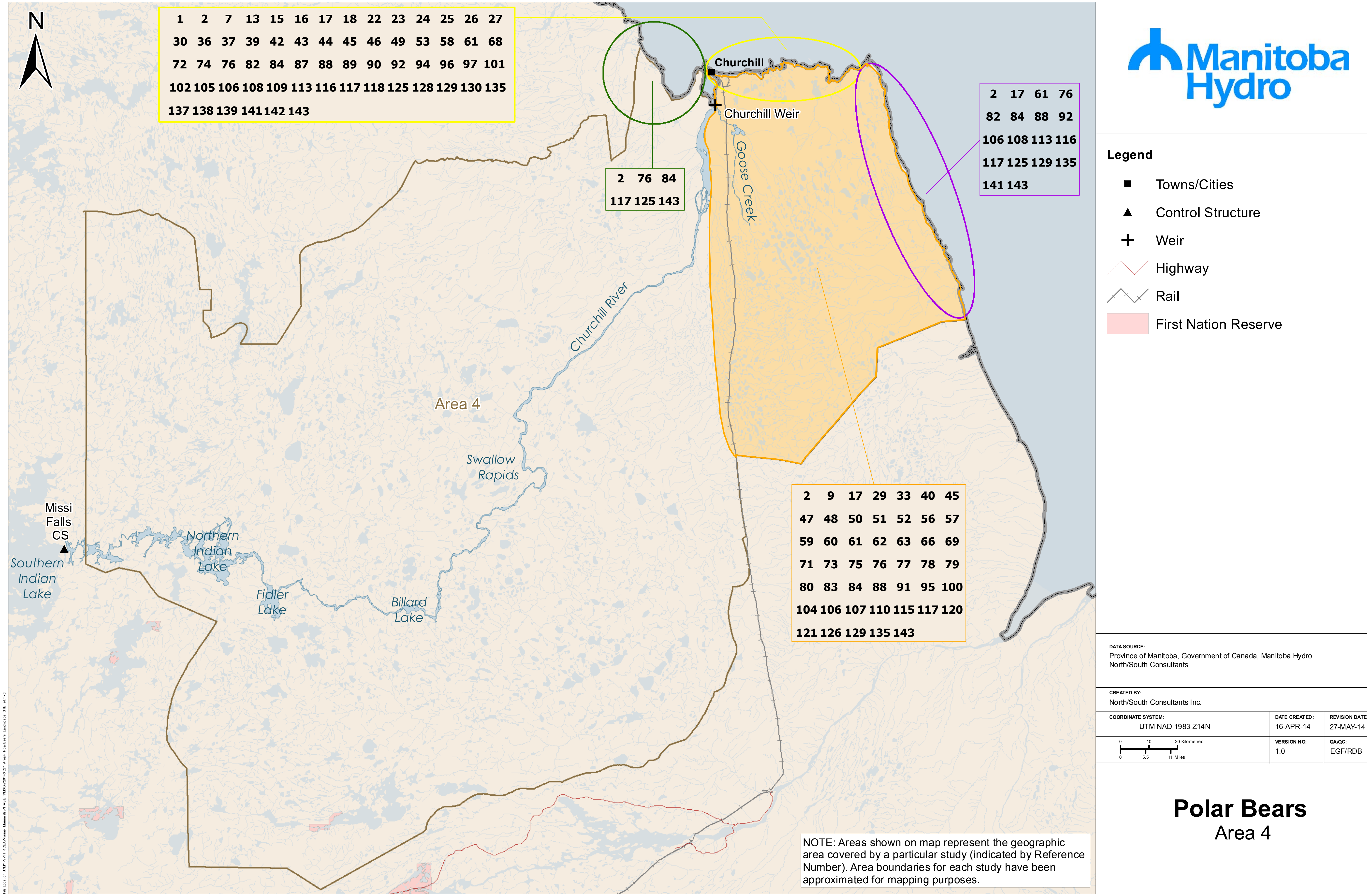
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2 76 84
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Churchill
Churchill Weir
Goose Creek
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117 125 129 135
141 143
Churchill River
Area 4
Swallow Rapids
Missi Falls CS
Northern Indian Lake
Southern Indian Lake
Fidler Lake
Billard Lake
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NOTE: Areas shown on map represent the geographic area covered by a particular study (indicated by Reference Number). Area boundaries for each study have been approximated for mapping purposes.
Manitoba Hydro
Legend
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Control Structure
Weir
Highway
Rail
First Nation Reserve
DATA SOURCE:
Province of Manitoba, Government of Canada, Manitoba Hydro
North/South Consultants
CREATED BY:
North/South Consultants Inc.
COORDINATE SYSTEM:
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DATE CREATED:
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VERSION NO:
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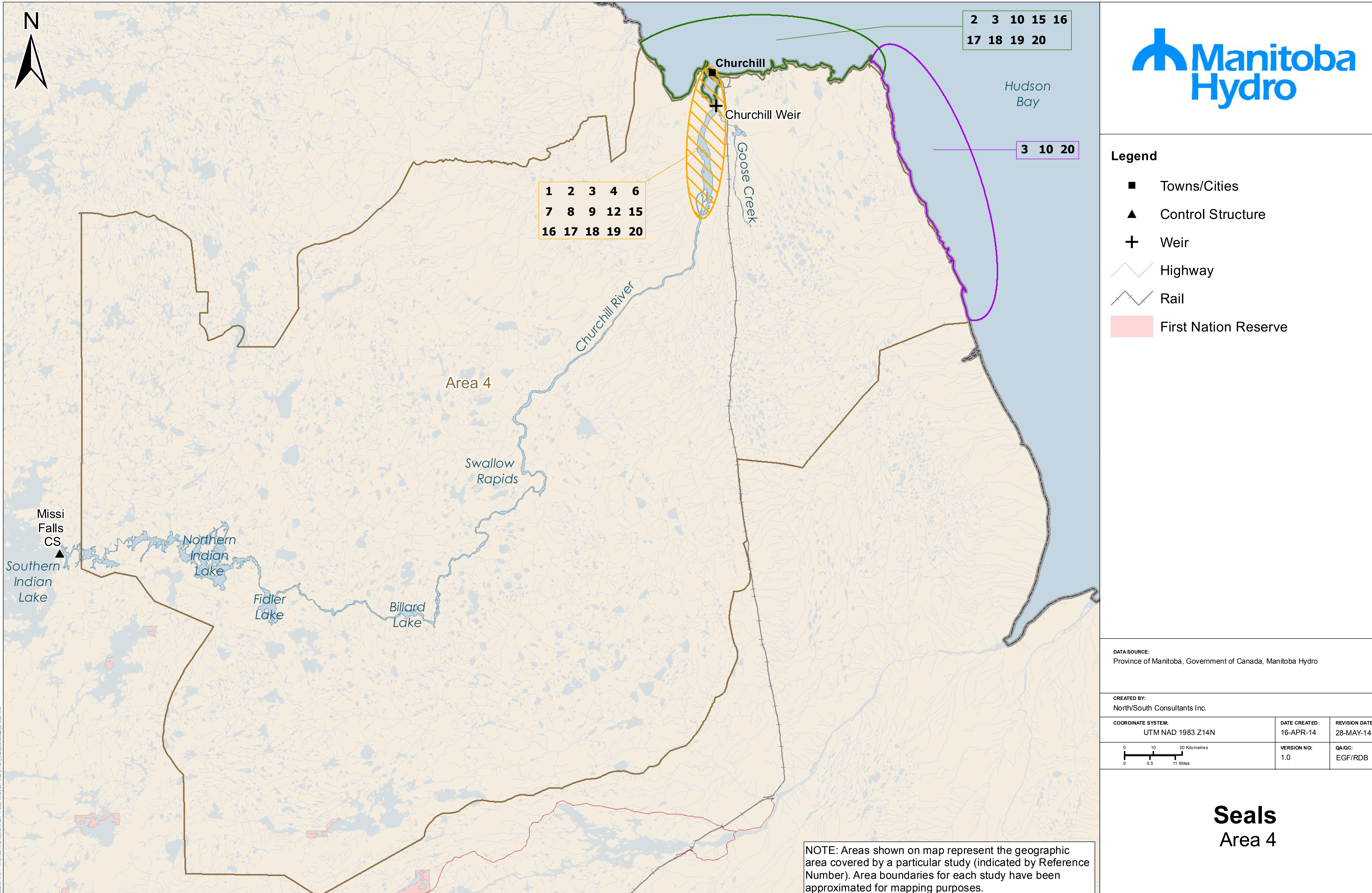
Polar Bears
Area 4

Map 5-29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Towns/Cities
Control Structure
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Rail
First Nation Reserve
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Province of Manitoba, Government of Canada, Manitoba Hydro
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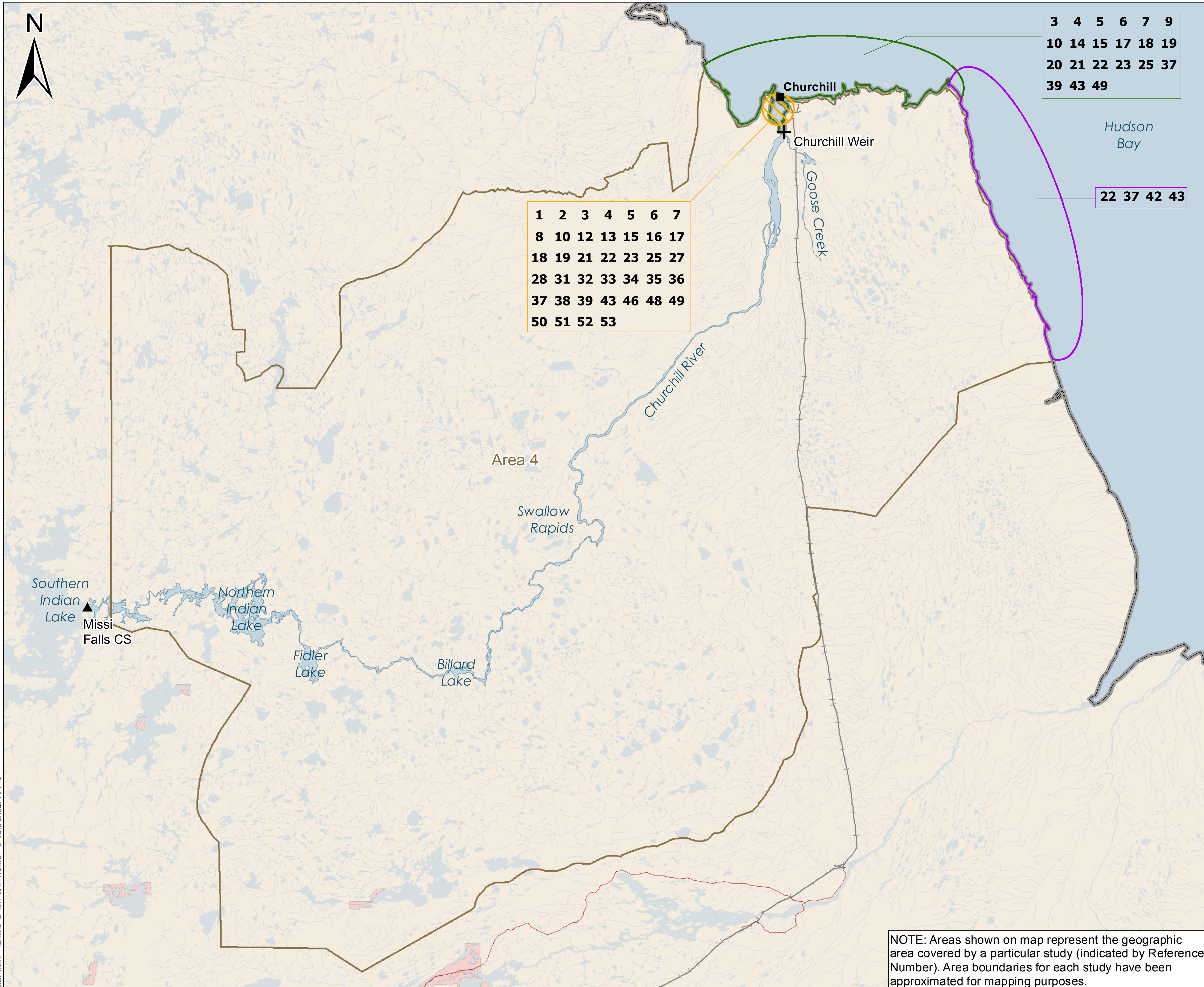
NOTE: Areas shown on map represent the geographic area covered by a particular study (indicated by Reference Number). Area boundaries for each study have been approximated for mapping purposes.
Seals
Area 4

Map 5-30



Manitoba Hydro

Legend

- Towns/Cities
- Control Structure
- Weir
- Highway
- Rail
- First Nation Reserve

DATA SOURCE:
Province of Manitoba, Government of Canada, Manitoba Hydro
North/South Consultants

CREATED BY:
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Beluga
Area 4

5.3 LAND

5.3.1 TERRESTRIAL HABITAT

5.3.1.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

5.3.1.1.1 SUMMARY OF SCIENTIFIC INFORMATION

Terrestrial habitat refers to the vegetation, soils and site conditions occurring at a given location. The following provides a summary of terrestrial habitat information available for Area 1.

LITERATURE

While numerous studies provide scientific information for Area 1, the predominant geographic focus of these studies was on the Nelson River and the immediate surrounding area. Additionally, the majority of these studies focused on aquatic environments, water quality and fisheries. These studies rarely described Nelson River shore zone or inland terrestrial habitats beyond some general qualitative descriptions. For example, in a fisheries survey of Cross Lake, Driver and Doan (1972) included a basic qualitative discussion of the surrounding area, and mentioned the presence of scarce aquatic vegetation, including emergents (*Phragmites* spp.) and submergents (*Myriophyllum exalbescens* and *Potamogeton americanus*), but gave no indication of amounts or locations.

The most extensive terrestrial habitat information for the pre-hydroelectric development period was provided in the Lake Winnipeg, Churchill and Nelson Rivers Study Board reports published from 1971 to 1975. A comprehensive shoreline mapping study was produced for the entire Nelson River shoreline in Area 1 (Manitoba Department of Mines, Resources and Environmental Management 1973). The shoreline was mapped using aerial photography, providing a complete, general overview of the shoreline in the area prior to LWR and CRD commencement. Each shore segment was classified into one of 14 shore zone types based on bank materials, morphology and vegetation. The report included diagrams of typical vegetation zones and plant species for each shore zone type.

The LWCNRSB reports also included forest inventories in areas to be cleared for channel construction and in the future reservoir areas (Duncan 1973; Lamont and Kaye 1973); however, this information was focused on commercial tree species. A description of shoreline bank materials and the percentage of marsh in the lower Nelson Reaches between Lake Winnipeg and the Kelsey reservoir were also included in these reports (Webb 1973).

For Nelson River shore zone habitat, the Split Lake Cree Post Project Environmental Review (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996) provided some general qualitative information applicable to pre- and post-hydroelectric development wetlands between Sipiwesk and Split lakes. However, there was no specific information on shore zone wetland distribution and abundance.

Other post-hydroelectric development studies describing inland and Nelson River shore zone habitats were limited in terms of their terrestrial focus. The Federal Ecological Monitoring Program, which was a five-year program to study the ecological effects of hydroelectric development on the Churchill-Nelson River system, was primarily aquatic-focused.

Studies regarding the effects of generating station construction and water regulation on terrestrial habitat in Area 1 are rare. Several studies provided broad overviews of the effects of hydroelectric development in the Churchill-Nelson River system, including effects on wetlands, but did not go into specific impacts by area (Dickson 1975; Rosenberg *et al.* 1987, 1997).

Several studies provide pre-hydroelectric development terrestrial habitat information for selected inland areas. The LWCNR Study Board reports included a general biophysical land classification for the outlet lakes area (Beke *et al.* 1973). Veldhuis *et al.* (1979) produced a biophysical land classification for the Sipiwesk Lake area. Habitat, topography, and soils mapping is also available from the Wuskwatim Transmission Project EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003). The Wuskwatim Transmission Project Environmental Protection Plan (E. Hicks & Associates Ltd. *et al.* 2008) provides sensitive site mapping along the proposed transmission line route. The Bipole III EIS included a description of vegetation, habitat and soils within a 4.8 km (3 mi) wide corridor along the planned right-of-way (Szwaluk Environmental Consulting Ltd. *et al.* 2011; Stantec Inc. 2011), which passed through the area to the west of the Nelson River. As part of the Bipole III Site Selection and Environmental Assessment (SSEA) terrestrial component, a spatial ecological geographic information system (GIS) layer termed the Landcover Classification of Canada, Enhanced for Bipole (LCCEB) was developed by Joro Consultants Inc. (2011) for the Bipole III study area, with an expansion to include boreal caribou ranges in the Wabowden area, based upon the Landcover Classification for Canada (LCC) developed by the Canadian Forest Services (Wulder and Nelson 2003). Several studies analysed woodland caribou habitat using Forest Resource Inventory (FRI) mapping for a study area that overlaps the western extent of the area (Brown 2001; Metsaranta *et al.* 2003; Dyke 2009).

Construction of the Hudson Bay Railway in the area, which began around 1918 (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996), was the first human impact unrelated to hydroelectric development in Area 1. A soil survey adjacent to the Hudson Bay Railway (Ehrlich *et al.* 1959) provided limited information for the soils component of terrestrial habitat. Thie (1974) studied permafrost distribution and thawing in an area to the east of Playgreen Lake using 1967 and earlier aerial photography.

Studies regarding the effects of transmission projects on terrestrial habitat in the area are available. MacLellan (1982) described the variation of vegetation communities and their habitat in the areas within and immediately surrounding the Bipole I and II transmission line rights-of-way. Another study by Magnusson and Stewart (1987) studied the effects of disturbances on vegetation communities and habitat within Bipole I and II transmission line rights-of-way.

Other studies for broad regions that happened to overlap Area 1 provide some relevant information. Rosenberg *et al.* (2005) provided an historical to current overview description of the entire Nelson and Churchill rivers basins, including general geomorphology and vegetation descriptions. Scoggan's Flora of Manitoba (1957) included plants found in the region of interest prior to hydroelectric development, but specific locations were usually not provided. Several studies from the discontinuous permafrost zone in northern Manitoba characterized permafrost dynamics in peatlands (Camill and Clark 1998; Camill 1999, 2000, 2005; Beilman *et al.* 2001). A study by Parisian *et al.* (2006) analysed the spatial patterns of forest fires for the boreal forest of Canada between 1980 and 1999. General wetland descriptions provided by Zoltai *et al.* (1988) and Halsey *et al.* (1997) for boreal Canada are applicable to, but not specific to Area 1.

Wulder *et al.* (2003) described a small-scale (1:250,000) land cover mapping program using Landsat data. This is one of many land cover mapping products available for various years starting in the 1980s. Unfortunately, most of the existing land cover maps produced from satellite imagery are of limited use for documenting historical hydroelectric development impacts due to the timing of their data acquisition relative to when impacts occurred, their coarse spatial resolution and/or the low number of land cover classes included in the mapping.

DATA

Data sources that may provide useful information in addition to that already provided by the abovementioned studies include provincial forest resource inventories, 1:50,000 National Topographic System (NTS) maps, aerial photography and satellite imagery.

Provincial forest resource inventories provide detailed vegetation mapping from large scale aerial photography. A limitation of the forest resource inventory mapping for this project is the fairly generalized classification of non-forested areas because the inventory was focused on commercial forest resources.

Available historical aerial photography, which dates back to 1946, is of variable quality and scale (Barber 1987; Manitoba Conservation air photo library). Photography of sufficient scale to photo-interpret the aerial extent of marsh, for example, is available starting in 1946 for most of the outlet lakes area, and for all of the Nelson River shore zone in Area 1 beginning in the 1960s. Much of this photography was the same as that used to produce the provincial forest resource inventories.

While there is a considerable variety of satellite imagery data from various years starting in 1972, most of this imagery was collected at spatial resolutions and wavelength ranges (*i.e.*, bands) that would not support detailed terrestrial habitat mapping. This is less true for the more recent satellite sensors which provide higher resolution imagery and, in some cases, more bands.

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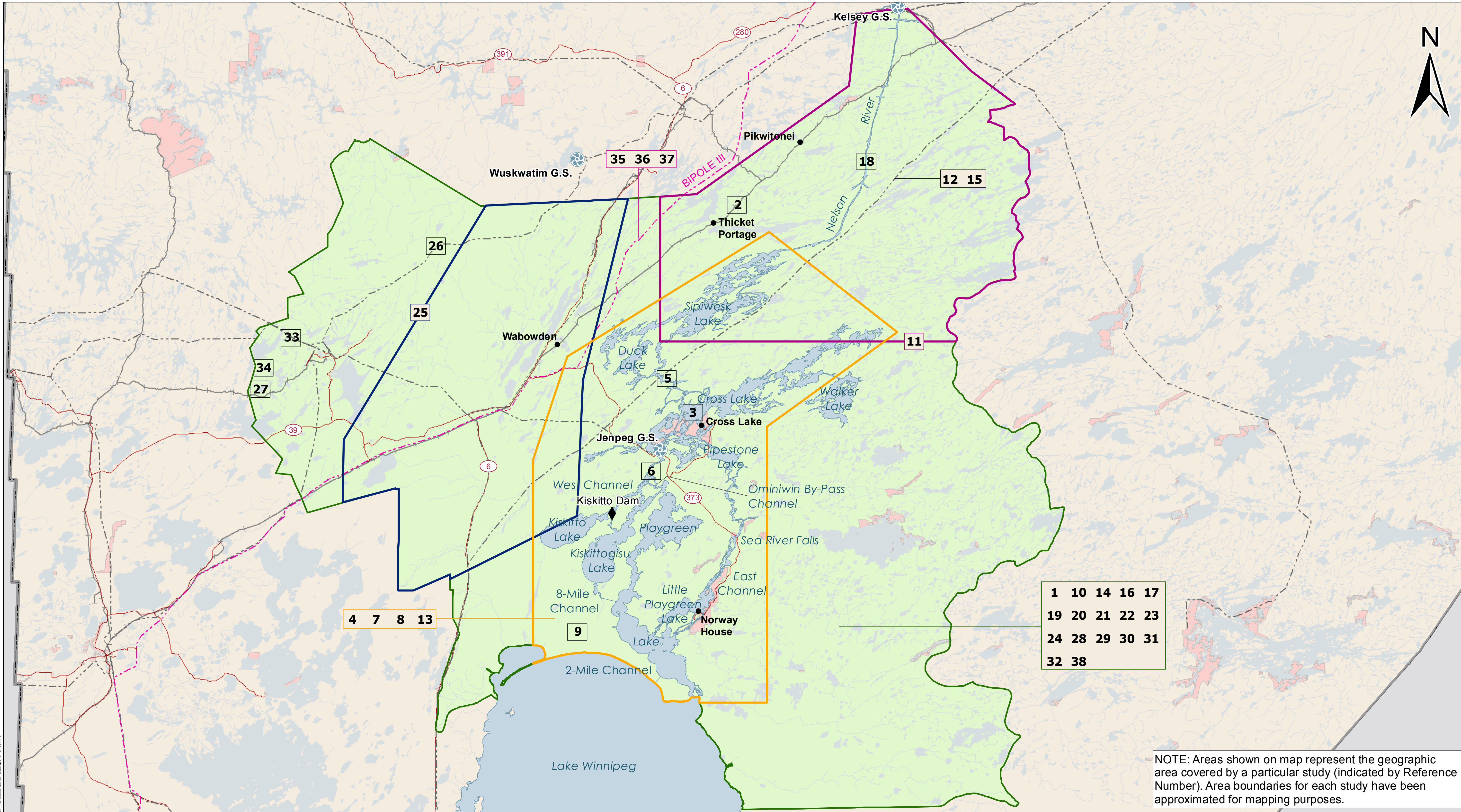

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro; Ecostem; North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
0 10 20 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Dam
- Generating Station (Existing)
- Highway
- Rail
- Transmission (Future)
- Transmission (Existing)
- First Nation Reserve

Terrestrial Habitat
Area 1

Map 5-32

5.3.1.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

5.3.1.2.1 SUMMARY OF SCIENTIFIC INFORMATION

Terrestrial habitat refers to the vegetation, soils and site conditions occurring at a given location. The following provides a summary of terrestrial habitat information available for Area 2.

LITERATURE

While numerous studies provide scientific information for Area 2, the predominant geographic focus of these studies was on the Nelson River and the immediate surrounding area. Additionally, the majority of pre- hydroelectric development studies were focused on aquatic environments, water quality and fisheries. These studies rarely described terrestrial or Nelson River shore zone habitats beyond some general qualitative descriptions.

The most extensive and detailed terrestrial habitat information for the pre- and post-hydroelectric development periods, for both the Nelson River shore zone and inland areas, is provided by studies conducted in support of the cumulative effects assessments of the Keeyask Generation Project, the Keeyask Infrastructure Project, and the Keeyask Transmission Project. Associated documents (ECOSTEM Ltd. 2011; 2012a, b; 2013) detailed current and historical terrestrial habitat for the Nelson River shore zone in the Kelsey GS reservoir and from the Clark Lake outlet to the Long Spruce GS, and for an approximately 12,400 km^2 (4,788 mi^2) surrounding region. These documents detailed current habitat distribution and abundance, provided habitat descriptions and included detailed information regarding vegetation and soil relationships. These documents also evaluated the effects of past and current developments on terrestrial habitat and ecosystems from a technical perspective. Pre-development habitat composition within existing human footprints was estimated from regional proportions for some areas and photo-interpreted from large-scale historical air photos for other areas. Total terrestrial habitat loss was also provided for a region extending eastward past the site of the planned Conawapa Generation Project (Keeyask Hydropower Limited Partnership 2013).

The Lake Winnipeg, Churchill and Nelson Rivers Study Board reports published from 1971 to 1975 (Manitoba Department of Mines, Resources and Environmental Management 1973) included a comprehensive shoreline mapping study for the entire length of the Nelson River in Area 2 and the outlet of the Burntwood River into Split Lake. This project used aerial photography to map the shoreline, providing a complete, general overview of the shoreline in the area prior to LWR and CRD commencement. Each shore segment was classified into one of 14 shore zone types based on bank materials, morphology and vegetation. The report included diagrams of typical shoreline vegetation zones and species for each class. The mapping applied was for either the pre- or the post-development period, depending on the river reach, since areas extending from the Kelsey reservoir and downstream were already affected by the Kelsey GS and Kettle GS by this time. Additionally, this study included small inland areas already affected by the Kelsey to Thompson and Kelsey to Radisson transmission projects, and by the Hudson Bay Railway.

The Split Lake Cree Post Project Environmental Review (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996) included much of the lower Nelson River reach. While this study provided some general, qualitative information on changes to Nelson River shore zone wetlands in Split Lake and downstream reaches, there was no specific information on pre- or post-LWR shore zone wetland distribution. This study also provided detailed quantitative information on the land areas lost to hydroelectric development. A study by Eaton (2012) compiled traditional ecological knowledge from Shamattawa First Nation, including some information on plants harvested and qualitative environmental observations. While much of the observations relate to locations outside of the region of interest, they may be applicable to Area 2 for pre-hydroelectric development conditions.

Studies regarding the effects of generating station construction and water regulation on terrestrial habitat in Area 2 are rare. Several studies provided broad overviews of the impacts of hydroelectric development in the Churchill-Nelson River system, including impacts on wetlands, but do not go into specific impacts by area (Dickson 1975; Rosenberg *et al.* 1987, 1997).

Studies focused on the Nelson River shore zone are limited to Newbury (1968), Simpson (1972), and Briscoe (1975). Newbury (1968) studied ice-regime processes on the lower Nelson River, including observations of ice-scouring effects on shore zone vegetation at selected locations, and summarized some historical observations from 1812. Simpson (1972) characterized the development of the Beacon and Marsh Point peninsula prior to CRD. This study included detailed habitat and topographic information, including inland and Nelson River shore zone vegetation, soils and habitats, as well as Nelson River estuary processes and their effect on vegetation cover. Briscoe (1975) described 1974 waterfowl habitat in the Nelson River estuary downstream of Port Nelson. Detailed shore zone vegetation and habitat descriptions were based on transect sampling.

Other post-hydroelectric development studies describing inland and Nelson River shore zone habitats were limited in terms of their terrestrial focus. In 1986 the Federal Ecological Monitoring Program, in partial response to the Northern Flood Agreement, established a five-year ecological monitoring program to study the effects of hydroelectric development on the Churchill-Nelson river system. The monitoring reports were primarily aquatic-focused.

Several studies provide pre-hydroelectric development terrestrial habitat information for selected inland areas. J.D. Mollard and Associates (1965) described the pre-development physiographic and hydrological features of the areas surrounding the Nelson River between Split Lake and Gillam Island using aerial photography mosaics. Pre-development terrestrial habitat was characterized in the vicinity of a number of transmission projects. The environmental assessment for the North Central Project, which was a transmission line connecting the Kelsey GS and Oxford House, produced several relevant reports. A biophysical land classification included generalized habitat, soils and topography mapping along a 10 km (6.2 mi) corridor centred on the proposed right-of-way route prior to its development (Terrain Analysis Services Ltd. 1992). Epstein Associates Inc. (1993) provided more detailed habitat descriptions, including plant species lists and some rare plant locations along the proposed route.

The Gillam to Churchill transmission line EIS (I.D. Systems Ltd. 1984) described pre-development terrestrial habitat, vegetation cover, soils and topography in the areas traversed by the potential right-of-way corridors. The Split Lake Transmission Line Project EIS (Manitoba Hydro 1992) described vegetation, soils and topography along and adjacent to the proposed Split Lake transmission line right-of-way, which runs between the Kelsey GS and the community of Split Lake. Finally, the Bipole III EIS included a description of vegetation, habitat and soils within a 4.8 km (3 mi) wide corridor along the planned right-of-way (Szwaluk Environmental Consulting Ltd. *et al.* 2011; Stantec Inc. 2011), which passed through the area to the north of the Nelson River and predominantly to the north of Provincial Road (PR) 280. As part of the Bipole III SSEA terrestrial component, a spatial ecological GIS layer termed the Landcover Classification of Canada, Enhanced for Bipole (LCCEB) was developed by Joro Consultants Inc. (2011) for the Bipole III study area, based upon the Landcover Classification for Canada (LCC) developed by the Canadian Forest Services (Wulder and Nelson 2003). I.D. Systems Ltd. (1989) described pre-development topography, soils and vegetation along the route of the proposed Conawapa all-weather road, and along the proposed construction power transmission line (I.D. Systems Ltd. 1990).

Various studies regarding how transmission projects affect terrestrial habitat have been conducted. For the North Central Project, Kroupa and Krindle (2000a, b, c) included general descriptions of landforms, as well as more detailed vegetation and habitat descriptions of the areas within and immediately adjacent to the right-of-ways, and descriptions of the vegetation in riparian areas at stream crossings. MacLellan (1982) described the variation of vegetation communities and their habitat in the areas within and immediately surrounding the Bipole I and II transmission line rights-of-way. Magnusson and Stewart (1987) studied the effects of disturbances on vegetation communities and habitat within Bipole I and II transmission line rights-of-way.

Several other studies provide pre-hydroelectric development terrestrial habitat information for inland areas. Veldhuis *et al.* (1979) produced a biophysical land classification for the Split Lake area, and Harper and Bukowsky (1975) analyzed small-scale land form and vegetation mapping in the northeast quarter of the area in support of studies for potential road corridors. Brook (2001) characterized landscape to community level vegetation dynamics in Wapusk National Park and the Cape Churchill Wildlife Management Area. Piercey-Normore (2005) studied the distribution of lichens in Wapusk National Park. Sladen *et al.* (2009) characterized permafrost distribution in the vicinity of the York Factory Historic Site. Studies related to polar bear habitat in Wapusk National Park often provide relevant inland terrestrial habitat information. Richardson *et al.* (2005) described sites and vegetation communities associated with bear dens, while another study of forest fire impacts on denning habitat by Richardson *et al.* (2007) provided annual burn area for the period of 1998 to 2003 in the Wapusk area.

Studies for broad regions that happened to overlap Area 2 provide some relevant information. Rosenberg *et al.* (2005) provided a historical to current overview description of the entire Nelson and Churchill River basins, including general geomorphology and vegetation descriptions. Scoggan's Flora of Manitoba (1957) included plants found in the region of interest, but specific locations were usually not provided. Several studies from the discontinuous permafrost zone in northern Manitoba characterized permafrost dynamics in peatlands (Camill and Clark 1998; Camill 1999, 2000, 2005; Beilman *et al.* 2001). A study by Parisian *et al.* (2006) analysed the spatial patterns of forest fires for the boreal forest of Canada between 1980 and 1999. General wetland descriptions provided by Zoltai *et al.* (1988) and Halsey *et al.* (1997) for boreal Canada are applicable to, but not specific to Area 2.

Wulder *et al.* (2003) described a small-scale (1:250,000) land cover mapping program using Landsat data. This is one of many land cover mapping products available for various years starting in the 1980s. Most of the existing land cover maps produced from satellite imagery are of limited use for documenting historical hydroelectric development impacts due to the timing of their data acquisition relative to when impacts occurred, their coarse spatial resolution and/or the low number of land cover classes included in the mapping.

DATA

Data sources that may provide useful information in addition to that already provided by the abovementioned studies include provincial forest resource inventories, 1:50,000 NTS maps, aerial photography and satellite imagery, and Conawapa Generation Project EIS habitat mapping that is currently in development.

Provincial forest resource inventories, which are available for the southwestern portions of Area 2, provide detailed vegetation mapping from large scale aerial photography. A limitation of the forest resource inventory mapping for this project is the fairly generalized classification of non-forested areas because the inventory was focused on commercial forest resources.

Available historical aerial photography, which dates back to 1946, is of variable quality and scale (Barber 1987; Manitoba Conservation air photo library). Photography of sufficient scale and quality to photo-interpret the aerial extent of marsh, for example, was generally only available starting in 1962.

While there is a considerable variety of satellite imagery from various years starting in 1972, most of this imagery was collected at spatial resolutions and wavelength ranges (*i.e.*, bands) that would not support detailed terrestrial habitat mapping. This is less true for the more recent satellite sensors which provide higher resolution imagery and, in some cases, more bands.

An historical video, "Seaport of the Prairies" (Manitoba Archives 1925), provides some documentation of conditions along the route of the Hudson Bay Railway during its construction. This video includes glimpses of the Nelson River banks between Kettle Rapids and Port Nelson.

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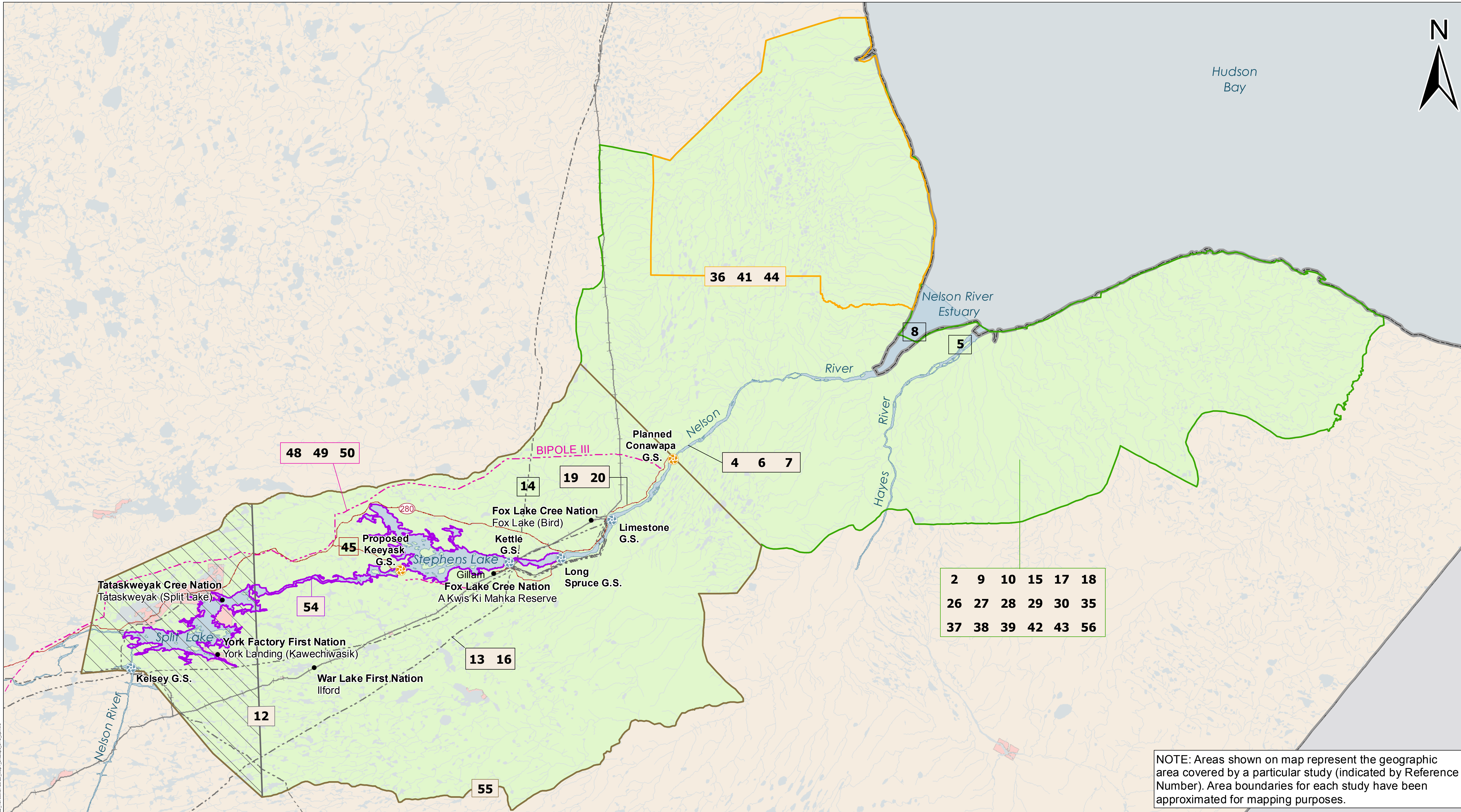


Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro North/South Consultants

CREATED BY:
North/South Consultants Inc.

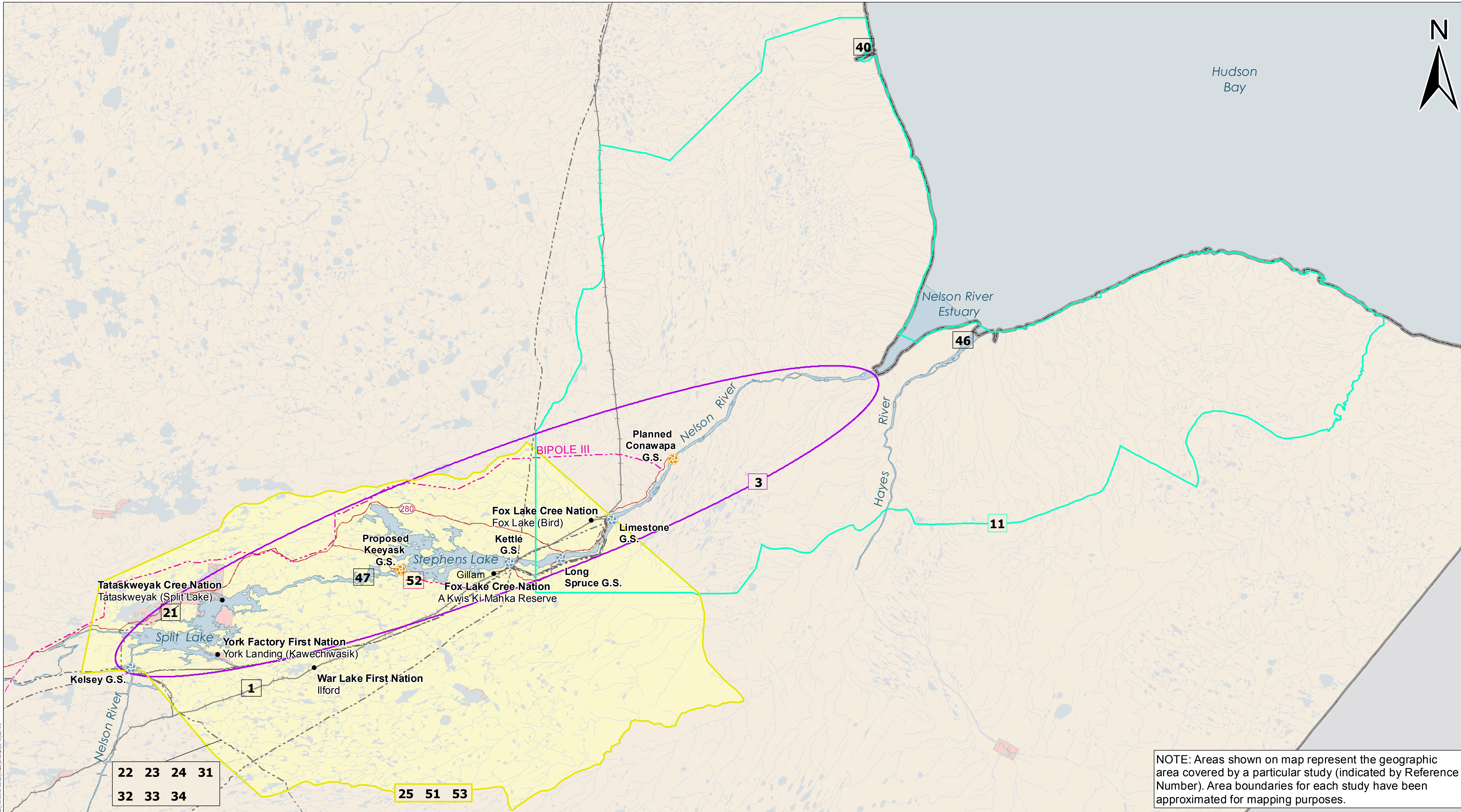
COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	27-MAY-14
0 10 20 30 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

Terrestrial Habitat
Area 2 - Map 1

Map 5-33A



DATA SOURCE:
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CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM: UTM NAD 1983 Z15N

DATE CREATED: 07-APR-14

REVISION DATE: 24-MAY-14

VERSION NO: 1.0

QA/QC: CMP/RDB

0 10 20 30 Kilometres
0 10 20 Miles

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

Manitoba Hydro

Terrestrial Habitat
Area 2 - Map 2

Map 5-33B

5.3.1.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

5.3.1.3.1 SUMMARY OF SCIENTIFIC INFORMATION

Terrestrial habitat refers to the vegetation, soils and site conditions occurring at a given location. The following provides a summary of terrestrial habitat information available for Area 3.

LITERATURE

While a number of studies provide scientific information for Area 3, the predominant geographic focus of these studies was on the CRD route and the immediate surrounding area. The majority of studies conducted in Southern Indian Lake and the Rat and Burntwood rivers area were focused on aquatic environments, water quality and fisheries. These studies rarely described shore zone or inland terrestrial habitats beyond some general qualitative descriptions.

The most detailed and extensive information for pre- and post-CRD terrestrial habitat was produced for the Wuskwatim Generating Station EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003a). This report included detailed shore zone habitat mapping for Wuskwatim Lake and terrestrial habitat for the 24,790 km^2 (9,571 mi^2) surrounding region. ECOSTEM Ltd. (2011) also produced large-scale pre-CRD ecosite mapping for major portions of the Notigi reservoir flooded area from 1969 photography as part of a Keeyask Generation Project peatland disintegration study.

The Lake Winnipeg, Churchill and Nelson Rivers Study Board reports published from 1971 to 1975 included a comprehensive shoreline mapping study which extends along the entire CRD route prior to hydroelectric development in the shore zone (Manitoba Department of Mines, Resources and Environmental Management 1973). This study used aerial photography to map the entire shoreline, providing a complete, general overview of the shoreline in the area prior to LWR and CRD. Maps show each shore segment classified into one of 14 shore zone types based on bank materials, morphology and vegetation. The report included diagrams of typical shoreline vegetation zones and plant species for each class. Other Lake Winnipeg, Churchill and Nelson River Study Board reports included forest resource inventories for the area to be flooded along the Rat-Burntwood rivers diversion route, and the area between Southern Indian Lake and the 850-foot elevation contour (Flanders *et al.* 1973; Whidden *et al.* 1973; Whidden and Lamont 1974). Webb and Foster (1974) described shoreline bank materials, as well as the percentage of marsh habitat along the pre-CRD shorelines in Area 3.

Other post-hydroelectric development studies describing inland and Churchill/Burntwood rivers shore zone habitats were limited in terms of their terrestrial focus. In 1986 the Federal Ecological Monitoring Program, in partial response the NFA, established a five-year ecological monitoring program to study the effects of hydroelectric development on the Churchill-Nelson river system. The monitoring reports were primarily aquatic-focused. Some studies provided general, qualitative description of the habitat surrounding segments of the river, and some discussion of wetland loss, without providing details on quantity or location (MacLaren Engineers Inc. and InterGroup Consulting Economists Ltd. 1984; MacLaren Plansearch Inc. 1986, 1989).

Studies regarding the effects of generating station construction and water regulation on terrestrial habitat in Area 3 are rare. Several studies provided broad overviews of the impacts of hydroelectric development in the Churchill-Nelson river system, including impacts on wetlands, but do not go into specific impacts by area (Dickson 1975; Rosenberg *et al.* 1987, 1997).

Several studies provide pre-hydroelectric development terrestrial habitat information for selected inland areas. Detailed inland habitat mapping covering a 2 km (1.2 mi) wide corridor surrounding Highway 280 between Thompson and the Area 2 boundary, was produced for the Keeyask Generation Project EIS (ECOSTEM Ltd. 2012a). This included detailed habitat, vegetation and soils mapping and analysis. Pre-development habitat composition within existing human footprints was estimated from regional proportions for some areas and photo-interpreted from large-scale historical air photos for other areas. Ritchie (1956) characterized vegetation in different forest types around MacBride Lake, which is just to the west of Southern Indian Lake. This study also described plant species composition and relationships to site conditions. The Lake Winnipeg, Churchill and Nelson River Study Board reports also included a more general biophysical land classification of the Rat-Burntwood rivers and Southern Indian Lake areas (Beke *et al.* 1973), and the geology of the Ospwagon Lake area (Stephenson 1973). Several recent studies were conducted in the boreal forest near Thompson, focused on carbon and nitrogen processes (Harden *et al.* 1997; Potter *et al.* 2001; Peng *et al.* 2002; Bond-Lamberty and Gower 2008), but these studies were limited to small sites.

Pre-development terrestrial habitat was characterized in the vicinity of a number of transmission projects. Detailed habitat, topography and soils mapping, including vegetation, is also available as part of the Wuskwatim Transmission Project EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003b) and Environmental Protection Plan (E. Hicks & Associates Ltd. and MMM Group 2006) along the proposed transmission line route. Pre-development terrestrial habitat was characterized in the vicinity for the planned Bipole III transmission line right-of-way. The Bipole III EIS included a description of vegetation, habitat and soils within a 4.8 km (3 mi) wide corridor along the planned right-of-way (Szwaluk Environmental Consulting Ltd. *et al.* 2011; Stantec Inc. 2011). As part of the Bipole III SSEA terrestrial component, a spatial ecological GIS layer termed the Landcover Classification of Canada, Enhanced for Bipole was developed by Joro Consultants Inc. (2011) for the Bipole III study area, based upon the Landcover Classification for Canada developed by the Canadian Forest Services (Wulder and Nelson 2003).

Other relevant studies were for broad regions that happen to overlap Area 3. Rosenberg *et al.* (2005) provided an historical to current overview description of the entire Nelson and Churchill rivers basins, including general geomorphology and vegetation descriptions. Several studies from the discontinuous permafrost zone in northern Manitoba characterized permafrost dynamics in peatlands (Camill and Clark 1998; Camill 1999, 2000, 2005; Beilman *et al.* 2001). One study by Parisian *et al.* (2006) analysed the spatial patterns of forest fires for the boreal forest of Canada between 1980 and 1999. General wetland descriptions are provided by Zoltai *et al.* (1988) and Halsey *et al.* (1997) for boreal Canada, and are applicable to, but not specific to, Area 3.

Wulder *et al.* (2003) described a small-scale (1:250,000) land cover mapping program using Landsat data. This is one of many land cover mapping products available for various years starting in the 1980s. Most of the existing land cover maps produced from satellite imagery are of limited use for documenting historical hydroelectric development impacts due to the timing of their data acquisition relative to when impacts occurred, their coarse spatial resolution and/or the low number of land cover classes included in the mapping.

DATA

Data sources that may provide useful information in addition to that already provided by the abovementioned studies include provincial forest resource inventories, 1:50,000 NTS maps, aerial photography and satellite imagery.

Provincial forest resource inventories provide detailed terrestrial habitat mapping from large-scale aerial photography. A limitation of the forest resource inventory mapping for this RCEA is the fairly generalized classification of non-forested areas because the inventory was focused on commercial forest resources.

Available historical aerial photography, which dates back to 1946, is of variable quality and scale (Barber 1987; Manitoba Conservation air photo library). Photography of sufficient scale and quality to interpret marsh habitat, for example, is non-existent prior to hydroelectric development.

While there is a considerable variety of satellite imagery from various years starting in 1972, most of this imagery was collected at spatial resolutions and wavelength ranges (*i.e.*, bands) that would not support detailed terrestrial habitat mapping. This is less true for the more recent satellite sensors which provide higher resolution imagery and, in some cases, more bands.

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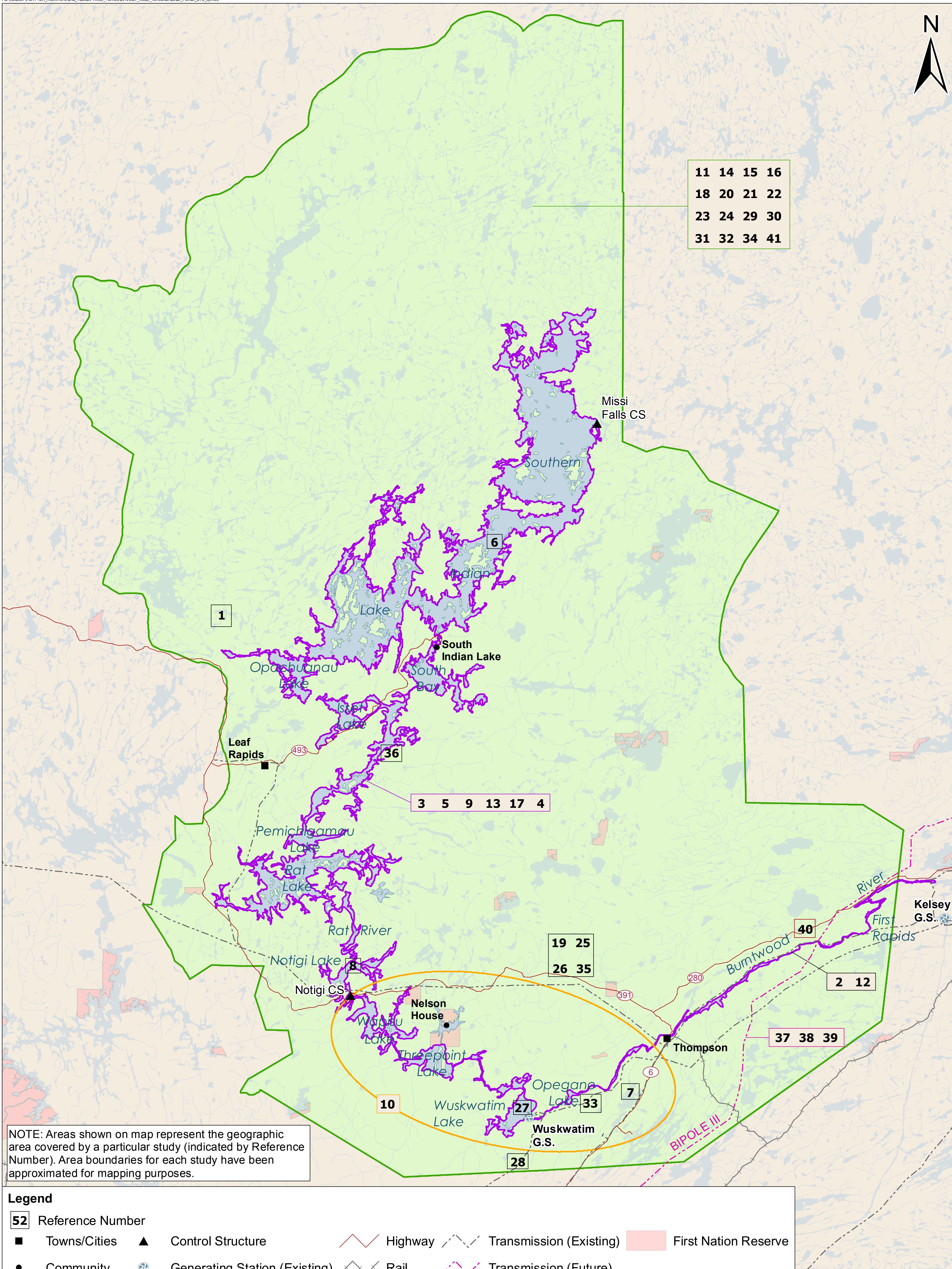

Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro; North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	28-MAY-14
0 4 8 Kilometres / 0 3 6 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Terrestrial Habitat
Area 3

5.3.1.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.3.1.4.1 SUMMARY OF SCIENTIFIC INFORMATION

Terrestrial habitat refers to the vegetation, soils and site conditions occurring at a given location. The following provides a summary of terrestrial habitat information available for Area 4.

LITERATURE

The predominant geographic focus of studies conducted in Area 4 was the lower Churchill River and the immediate surrounding area. Additionally, aquatic environments, water quality and fisheries were the focus topics for the majority of pre-hydroelectric development studies. These studies rarely described terrestrial or Churchill River shore zone habitats beyond some general qualitative descriptions.

The most extensive terrestrial habitat information available was provided in the Lake Winnipeg, Churchill and Nelson Rivers Study Board reports published from 1971 to 1975. A comprehensive shoreline mapping study was conducted which extends along the entire lower Churchill River system (Manitoba Department of Mines, Resources and Environmental Management 1973). This project used aerial photography to map the entire shoreline, providing a complete, general overview of the shoreline in the area prior to the Churchill River Diversion. Each shore segment was classified into one of 14 shore zone classes based on bank materials, morphology and vegetation. The report included diagrams of typical shoreline vegetation zones and species for each class. Other studies in the Study Board reports were predominantly focused on the aquatic environment. The most relevant of these for terrestrial habitat was Webb and Foster (1974), who described shoreline bank materials, as well as the percentage of marsh habitat along the lower Churchill River shorelines to the estuary.

The Split Lake Cree Post Project Environmental Review (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996) included portions of the lower Churchill River reach. While this study provided some general, qualitative information on the historical Churchill River shoreline and changes following CRD, there was no specific information on pre- or post-CRD shore zone wetlands distribution.

Other studies focused on the pre-development Churchill River shore zone are limited to Ritchie (1957), which described the sequence of vegetation extending inland from the river flats of the Churchill River estuary.

More recent studies describing inland and shore zone habitats in Area 4 were limited in terrestrial focus and geographic extent. Jacques (1986) used LANDSAT imagery to analyze post-CRD changes in shore zone vegetation along a small portion of the Churchill River between Northern Indian Lake and Fidler Lake. In 1986, the Federal Ecological Monitoring Program, in partial response the Northern Flood Agreement, established a five-year ecological monitoring program to study the effects of hydroelectric development on the Churchill-Nelson river system. The monitoring reports were primarily aquatic-focused. A study by Zbigniewicz (1985) described shore zone plant communities and site relationships in the Churchill River estuary. Another study by Chang *et al.* (2000) produced a seed flora database for coastal habitats from a bay at the north end of Wapusk National Park.

Studies regarding the effects of generating station construction and water regulation on terrestrial habitat in Area 4 are rare. Several studies provided broad overviews of the impacts of hydroelectric development in the Churchill-Nelson river system, including impacts on wetlands, but do not go into specific impacts by area (Dickson 1975; Rosenberg *et al.* 1987, 1997).

Several studies provide pre-hydroelectric development terrestrial habitat information for selected inland areas. The most relevant information includes detailed current and historical inland habitat mapping and analysis that was produced for the Keeyask Generation Project EIS (ECOSTEM 2012). The information is relevant for southern portions of the Area 4. This includes studies on existing habitat, vegetation and soils, as well as predicted effects of the Keeyask project on terrestrial habitat and ecosystems. Pre-development habitat composition within existing human footprints was estimated from regional proportions for some areas and photo-interpreted from large-scale historical air photos for other areas.

Other studies relevant for inland terrestrial habitat information are available but not extensive, and/or focused on areas near Churchill or along transmission line rights-of-way. The Gillam to Churchill transmission line EIS (I.D. Systems Ltd. 1984) described habitats, vegetation cover, soils and topography along the potential right-of-way corridors between the Nelson River and Churchill. Harper and Bukowsky (1975) analyzed small-scale land form and vegetation mapping in the eastern portions of the area in support of studies for potential road corridors. Brook (2001) studied landscape to community level vegetation dynamics in Wapusk National Park and the Cape Churchill Wildlife Management Area. Piercey-Normore (2005) studied the distribution of lichens in Wapusk National Park. Monson (2003) characterized the fire history and vegetation succession in the forest-tundra zone near Churchill. A study by Macrae *et al.* (2010) looked at past and future climatic conditions in the Churchill area, and the implications for the area's shallow waterbodies.

Several studies focused on wildlife habitat preferences potentially provide relevant habitat information. Studies related to polar bear habitat in Wapusk National Park often provide relevant inland terrestrial habitat information. Richardson *et al.* (2005) described sites and vegetation communities associated with bear dens, while another study of forest fire impacts on denning habitat by Richardson *et al.* (2007) provided annual burn area for the period 1998 to 2003 in the Wapusk area. Ballantyne and Nol (2011) described the vegetation composition of several inland whimbrel nesting sites.

Other relevant studies were for broad regions that happen to overlap Area 4. Rosenberg *et al.* (2005) provided a historical to current overview description of the entire Nelson and Churchill rivers basins, including general geomorphology and vegetation descriptions. Several studies from the discontinuous permafrost zone in northern Manitoba characterized permafrost dynamics in peatlands (Camill and Clark 1998; Camill 1999, 2000, 2005; Beilman *et al.* 2001). A study by Parisian *et al.* (2006) analysed the spatial patterns of forest fires for the boreal forest of Canada between 1980 and 1999. General wetland descriptions provided by Zoltai *et al.* (1988) and Halsey *et al.* (1997) for boreal Canada are applicable to, but not specific to, Area 4.

Wulder *et al.* (2003) described a small-scale (1:250,000) land cover mapping program using Landsat data. This is one of many land cover mapping products available for various years starting in the 1980s. Most of the existing land cover maps produced from satellite imagery are of limited use for documenting historical hydroelectric development impacts due to the timing of their data acquisition relative to when impacts occurred, their coarse spatial resolution and/or the low number of land cover classes included in the mapping.

DATA

Data sources that may provide useful information in addition to that already provided by the abovementioned studies include provincial forest resource inventories, 1:50,000 NTS maps, aerial photography, satellite imagery and Conawapa Generation Project EIS habitat mapping that is currently in development.

Provincial forest resource inventories provide detailed vegetation mapping from large-scale aerial photography. A limitation of the forest resource inventory mapping for this project is the fairly generalized classification of non-forested areas because the inventory was focused on commercial forest resources. Available forest resource inventory covers only a small portion of Area 4 along the western boundary.

Available historical aerial photography, which dates back to 1946, is of variable quality and scale (Barber 1987; Manitoba Conservation air photo library). Photography of sufficient scale to photo-interpret the aerial extent of marsh, for example, is not available until the 1980s for the lower Churchill River.

While there is a considerable variety of satellite imagery from various years starting in 1972, most of this imagery was collected at spatial resolutions and wavelength ranges (*i.e.*, bands) that would not support detailed terrestrial habitat mapping. This is less true for the more recent satellite sensors which provide higher resolution imagery and, in some cases, more bands.

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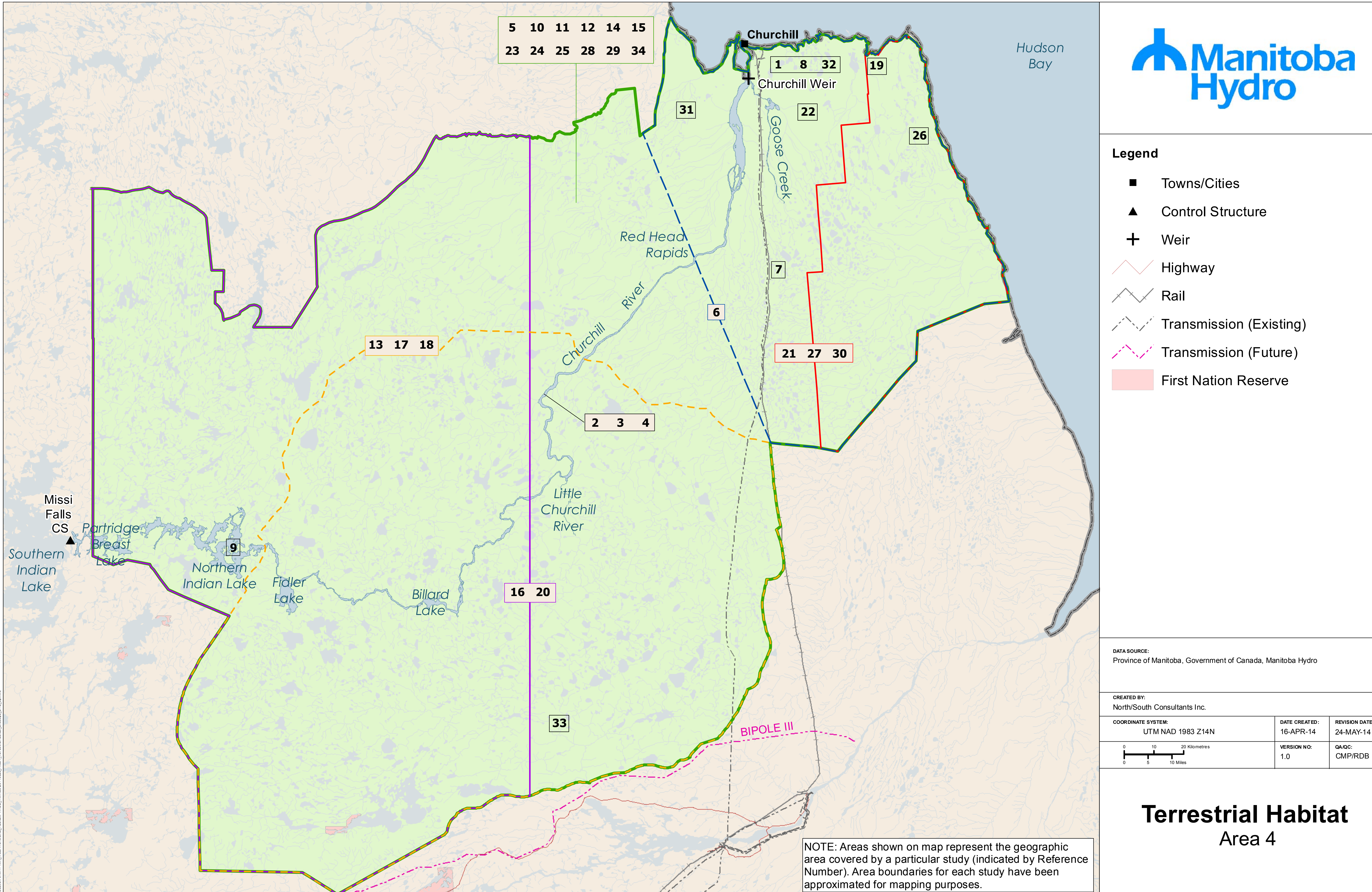
Manitoba Hydro
Legend
Towns/Cities
Control Structure
Weir
Highway
Rail
Transmission (Existing)
Transmission (Future)
First Nation Reserve
DATA SOURCE:
Province of Manitoba, Government of Canada, Manitoba Hydro
CREATED BY:
North/South Consultants Inc.
COORDINATE SYSTEM:
UTM NAD 1983 Z14N
DATE CREATED:
16-APR-14
REVISION DATE:
24-MAY-14
VERSION NO:
1.0
QA/QC:
CMP/RDB
0 10 20 Kilometres
0 5 10 Miles
Terrestrial Habitat
Area 4
NOTE: Areas shown on map represent the geographic area covered by a particular study (indicated by Reference Number). Area boundaries for each study have been approximated for mapping purposes.
Hudson Bay
Churchill
Churchill Weir
Goose Creek
Red Head Rapids
Churchill River
Little Churchill River
Missi Falls CS
Partridge Breast Lake
Southern Indian Lake
Northern Indian Lake
Fidler Lake
Billard Lake
BIPOLE III
5 10 11 12 14 15
23 24 25 28 29 34
1 8 32
19
31
22
26
7
6
21 27 30
13 17 18
2 3 4
9
16 20
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Map 5-35

5.3.2 INTACTNESS

5.3.2.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

5.3.2.1.1 SUMMARY OF SCIENTIFIC INFORMATION

The following provides a summary of terrestrial intactness information available for Area 1. Intactness essentially refers to the degree to which an ecosystem remains undisturbed by human development and activities that remove habitat, increase fragmentation and alter ecological flows. Human effects on intactness are typically inferred from the sizes and locations of human footprints and the density of human linear features (*e.g.*, lineal kilometres of human features per square kilometre of land area).

LITERATURE

While numerous studies provide scientific information for Area 1, the predominant geographic focus of these reports was on the Nelson River and the immediately surrounding area. The majority of pre-hydroelectric development studies conducted focused on aquatic environments, water quality and fisheries, or inland areas of limited geographic extent. In general, early environmental impact assessments did not study terrestrial intactness other than with reference to wildlife habitat.

The most detailed and extensive information related to intactness with respect to both hydroelectric and non-hydroelectric features is provided as part of several recent hydroelectric project Environmental Impact Assessments (EIAs) conducted in the area, including the Wuskwatim Transmission Project Environmental Impact Statement (EIS) (Manitoba Hydro and Nisichawayasihk Cree Nation 2003a). The Wuskwatim Transmission Project EIS includes detailed human features mapping from forest resource inventory data, a description of the proposed transmission line route, and predicted impacts on wildlife related to clearing and increased access. There is also discussion of other non-hydroelectric activities planned in the area, such as timber harvesting and mining. Information on linear feature density, including detailed human feature mapping in a 23,000 km² (8,880 mi²) area surrounding Wuskwatim Lake was produced as part of the Wuskwatim Generation Project EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003a). This area overlaps a portion of Area 1 in the north. Some discussion of access and disturbance-related effects on wildlife was included in the EIS.

Habitat fragmentation was studied in a 4.8 km (3 mi) wide corridor extending through the southwest portions of Area 1 as part of the Bipole III Transmission Project EIS (Joro Consultants Inc. 2011). The Bipole III EIS (Manitoba Hydro 2011; MMM Group Ltd. 2011) also described the project components and their dimensions in detail.

The Split Lake Cree Post Project Environmental Review (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996) also included part of the upper Nelson River reach. While the study provided detailed information on historical development of hydroelectric infrastructure, including transmission line corridors in portions of Area 1, along with construction dates, areas impacted were provided only for the Split Lake Cree study area. Some general qualitative information regarding how transmission lines affect wildlife behavior, as well non-hydroelectric development was also provided, but it is likely not adequate for quantitative analysis of intactness. A post project assessment study by MacKay *et al.* (1990) examined the impacts of the Kelsey Generating Station and Lake Winnipeg regulation on the community of Wabowden and area. This report also included historical and non-hydroelectric development information, along with some construction dates.

The first impacts from non-hydroelectric developments started in 1917 with the construction of the Hudson Bay Railway in the area. The most extensive information available for non-hydroelectric features that affected intactness was provided in the Lake Winnipeg, Churchill and Nelson Rivers Study Board reports published from 1971 to 1975. This collection of reports included a description and maps of transportation corridors in the outlet lakes area as of 1973 (Rosin *et al.* 1973), extending from the north shore of Lake Winnipeg to the Kelsey reservoir. The LWCNR Study Board reports also included descriptions and maps of the LWR-related infrastructure, such as channel construction and access roads, the related vegetation clearing, and the predicted level of impact (Lamont and Kaye 1973), giving a general picture of the degree of impact in areas supporting hydroelectric infrastructure.

A few independent studies examined, in a general way, the impacts of the LWR and CRD projects during and after implementation. Several studies provided an overview description of the project, and discussed the related ecological impacts (Dickson 1975; Rosenberg *et al.* 2005). The Cross Lake environmental impact study (Nelson River Group 1986) provided a description of the LWR components and a discussion of the impacts on ungulates, including predictions related to increased access.

Another important information source for documenting impacts on intactness is the historical highway maps archived by Manitoba Infrastructure and Transportation, which include Area 1 coverage dating back to 1961.

Several studies regarding the effects of transmission projects on intactness, including vegetation recovery within transmission rights-of-way in Area 1, are available. MacLellan (1982) described the variation of vegetation communities and their habitat, including weedy invasive species, within the Bipole I and II transmission line rights-of-way. Another study by Magnusson and Stewart (1987) studied the ongoing effects of vegetation management within the Bipole I and II transmission line right-of-way. Ehnes and ECOSTEM Ltd. (2006) reported on the width of right-of-way edge effects on overstorey vegetation and ecosite type for selected transmission projects ranging in age from approximately 20 to 48 years.

Other studies for broad regions that happened to overlap Area 1 provide some relevant information. Wulder *et al.* (2003) outlined a small-scale (1:250,000) land cover mapping program using Landsat data, which could possibly be used to map human features developed after 1967. This is one of many land cover mapping products available for various years starting in the 1980s. Most of the existing land cover maps produced from satellite imagery are of limited use for documenting historical hydroelectric development impacts due to the timing of their data acquisition relative to when impacts occurred and their coarse spatial resolution. A broad study by Rosenberg *et al.* (1997) on hydroelectric development, which included the Churchill-Nelson rivers system as an example, provided some general discussion of impacts related to increased access due to hydroelectric-related infrastructure.

DATA

Manitoba Hydro has footprint information for all of its developments in the RCEA region of interest. This information exists in paper form for older developments and as GIS data for some of the older and all of the more recent developments.

Data sources that may provide useful information in addition to that already provided by the abovementioned studies include provincial forest resource inventories, 1:50,000 NTS maps, aerial photography and satellite imagery. Provincial forest resource inventories include large-scale mapping of selected types of human footprints. Limitations of these inventories for this project are that the georeferencing of the older inventories is less accurate than modern datasets and some inventories only exist in paper format.

Satellite imagery provides the most extensive data for human footprints for various years starting in 1972. A limitation of these datasets is that narrow linear features and small footprints were not captured due to the low spatial resolution relative to the size of these footprints. This limitation is not applicable to the high resolution imagery that has become available in recent years.

Available historical aerial photography, which dates back to 1946, is of variable quality and scale (Barber 1987; Manitoba Conservation Air Photo Library). Typically, linear features and permanent infrastructure can be detected in smaller-scale photography, so the only limitation to this data source is availability and area coverage.

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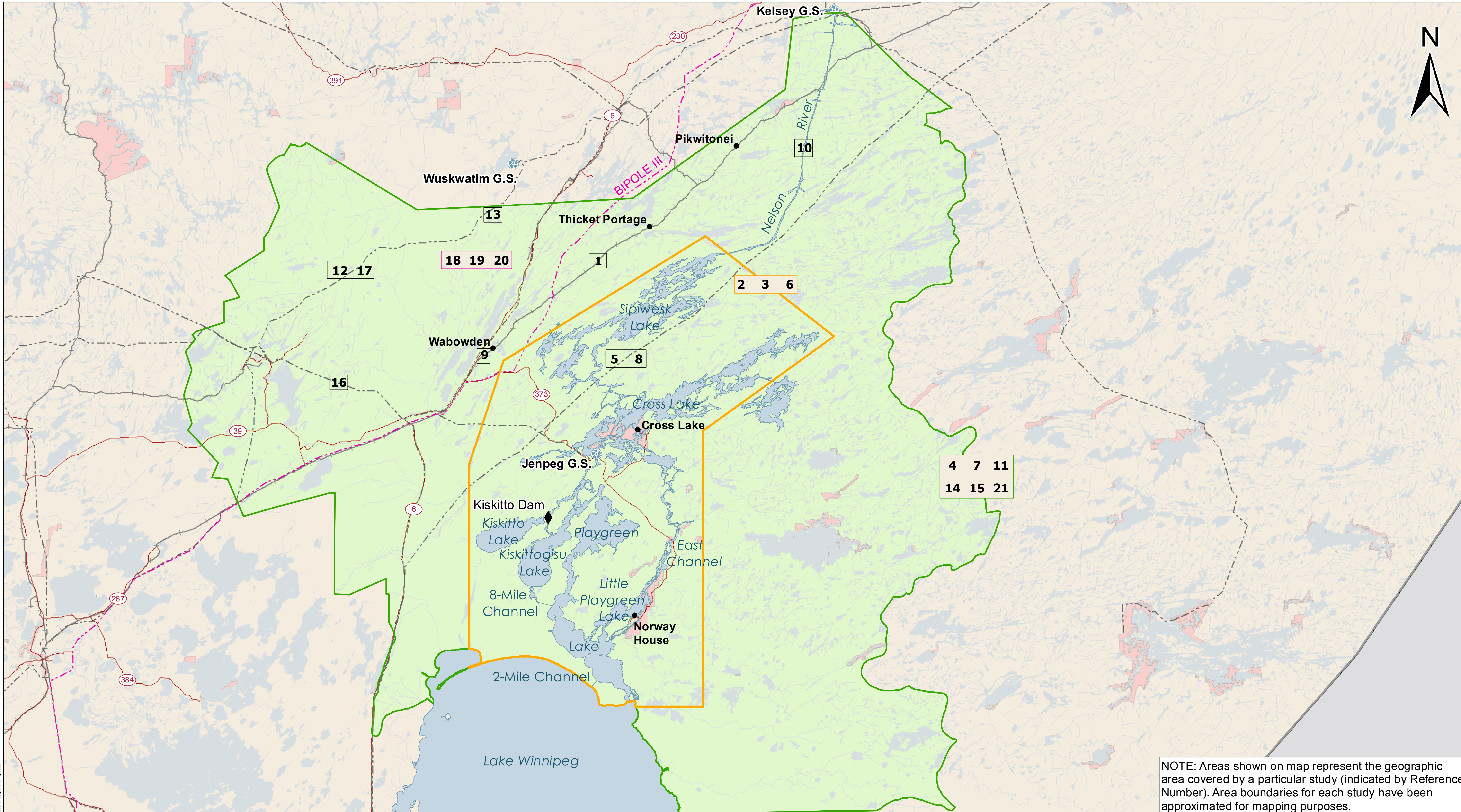

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	28-MAY-14
0 20 40 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Dam
- Generating Station (Existing)
- Highway
- Rail
- Transmission (Future)
- Transmission (Existing)
- First Nation Reserve

Intactness
Area 1

5.3.2.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

5.3.2.2.1 SUMMARY OF SCIENTIFIC INFORMATION

The following provides a summary of terrestrial intactness information available for Area 2. Intactness essentially refers to the degree to which an ecosystem remains undisturbed by human development and activities that remove habitat, increase fragmentation and alter ecological flows. Human effects on intactness are typically inferred from the sizes and locations of human footprints and the density of human linear features (*e.g.*, lineal kilometres of human features per square kilometre of land area).

LITERATURE

While numerous studies provide scientific information for Area 2, with a few exceptions, the predominant geographic focus of these reports was on the Nelson River and the immediately surrounding area. The majority of pre-hydroelectric development studies conducted in this area focused on aquatic environments, water quality and fisheries, or inland areas of limited geographic extent. In general, early environmental impact assessments did not study terrestrial intactness other than with reference to wildlife habitat.

The first impacts unrelated to hydroelectric development started around 1913 with construction of Port Nelson. The most extensive and detailed intactness information for the pre- and post-development periods was provided by studies conducted in support of the cumulative effects assessments of the Keeyask Generation Project, Keeyask Infrastructure Project, and the Keeyask Transmission Project. Associated documents (Keeyask Hydropower Limited Partnership 2009, 2012; ECOSTEM Ltd. 2012) detailed current linear feature densities and core habitat areas in an approximately 12,400 km² (4,788 mi²) region surrounding the Nelson and Burntwood rivers between Thompson and the Long Spruce generating station. These documents included detailed linear feature and human infrastructure maps for the areas, as well as evaluations regarding the effects of past and current developments on intactness. Similar information was provided for a region extending eastward past the site of the planned Conawapa Generation Project (Keeyask Hydropower Limited Partnership 2013).

Another important information source for documenting impacts on intactness is the historical highway maps archived by Manitoba Infrastructure and Transportation, which include Area 2 coverage dating back to 1961.

Another important source of post-hydroelectric development intactness information is the Split Lake Cree Post Project Environmental Review (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996). This was a joint study with Manitoba Hydro on the impacts of hydroelectric development in the Split Lake Cree Study Area, which included much of the lower Nelson River reach and surrounding land. The study provided detailed information on the hydroelectric development within Area 2, including land areas impacted by transmission lines and supporting infrastructure. Some general qualitative information regarding how transmission lines affect wildlife behaviour, as well non-hydroelectric development were also provided. Another study by Hill (1993) compiled a history of hydroelectric and non-hydroelectric development in the area from the perspective of Fox Lake Cree Nation.

Information regarding project effects on intactness in Area 2 was produced by a number of transmission projects. The environmental assessment for the North Central Project, which was a transmission line connecting the Kelsey GS and Oxford House, produced several relevant reports. Epstein Associates Inc. (1993) and Manitoba Hydro (1993) provided detailed descriptions and maps of the proposed route prior to development, and the nature of anticipated effects along the right-of-way including access and disturbance-related effects on wildlife. The EIS also provided a description and maps of other hydroelectric and non-hydroelectric infrastructure in the region.

The Gillam to Churchill transmission line environmental impact assessment (I.D. Systems Ltd. 1984) described the size of two alternative right-of-way corridors between the Nelson River (Area 2) and Churchill (Area 4), including potential effects on wildlife due to construction and access. The Split Lake Transmission Line Project EIS (Manitoba Hydro 1992) described the final route of the proposed right-of-way, which runs between the Kelsey GS and the community of Split Lake, along with anticipated impacts. Impacts discussed in general include potential right-of-way edge effects, and the potential for habitat fragmentation and increased access affecting wildlife I.D. Systems Ltd. (1990) described pre-development topography, soils and vegetation along the route of the proposed Conawapa construction power transmission line.

Several studies described how vegetation recovers within transmission line rights-of-way, and ongoing post-development effects on vegetation. For the North Central Project, Kroupa and Krindle (2000a, b) described natural re-vegetation within the rights-of-way, and at stream crossings along the route, including plant lists with invasive species. Effects of vegetation management within the rights-of-way were also described (Kroupa 2000). MacLellan (1982) described the variation of vegetation communities and their habitats, including weedy invasive species, within the Bipole I and II transmission line rights-of-way. Magnusson and Stewart (1987) studied the effects of ongoing vegetation control on vegetation communities and habitat within Bipole I and II transmission line rights-of-way.

Habitat fragmentation was studied as part of the Bipole III Transmission Project EIS (Joro Consultants Inc. 2011), in a 4.8 km (3 mi) wide corridor centered on the right-of-way. The Bipole III EIS (Manitoba Hydro 2011; MMM Group Ltd. 2011) also described the project components and their dimensions in detail.

Information relevant to intactness is available from I.D. Systems Ltd. (1989), which described the route of the Conawapa all-weather road and its anticipated impacts.

Didiuk (1975) assessed the effects of human development, including roads and transmissions lines, on wildlife resources in the lower Nelson River area. Other studies regarding the ecological effects of linear disturbance and hydroelectric development include Rosenberg *et al.* (2005), who discussed historical impacts in the Nelson and Churchill rivers system. A broad study by Rosenberg *et al.* (1997) on hydroelectric development, which included the Churchill-Nelson rivers system as an example, provided some general discussion of impacts related to increased access due to hydroelectric-related infrastructure.

Other studies for broad regions that happen to overlap Area 2 provide some information relevant for this project. Wulder *et al.* (2003) outlined a small-scale (1:250,000) land cover mapping program using Landsat data, which could possibly be used to map human features. This is one of many land cover mapping products available for various years starting in the 1980s. Most of the existing land cover maps produced from satellite imagery are of limited use for documenting historical hydroelectric development impacts due to the timing of their data acquisition relative to when impacts occurred and their coarse spatial resolution.

Descriptions of transportation corridors in the Lake Winnipeg, Churchill and Nelson River Study Board reports do not extend into Area 2 (Rosin *et al.* 1973).

DATA

Manitoba Hydro has footprint information for all of its developments in the RCEA Region of Interest. This information exists in paper form for older developments and as GIS data for some of the older and all of the more recent developments.

Data sources that may provide useful information in addition to that already provided by the above mentioned studies include provincial forest resource inventories, 1:50,000 NTS maps, aerial photography and satellite imagery, and linear feature mapping under development for the Conawapa Generation Project EIS.

The most extensive recent intactness data for other areas includes satellite imagery data from various years starting in 1972. A limitation of these datasets is that narrow linear features and small footprints were not captured due to the low spatial resolution relative to the size of these footprints. This limitation is not applicable to the high resolution imagery that has become available in recent years.

Provincial forest resource inventories include large scale mapping of selected types of human footprints. Limitations of these inventories for this project include less accurate georeferencing of the older inventory datasets, and some inventories only exist in paper form.

Available historical aerial photography, which dates back to 1946, is of variable quality and scale (Barber 1987; Manitoba Conservation air photo library). Typically, linear features and permanent infrastructure can be detected in smaller-scale photography, so the main limitation to this data source is availability and area coverage.

A historical video, "Seaport of the Prairies" (Manitoba Archives 1925), provides some documentation of conditions along the route of the Hudson Bay Railway line during its construction.

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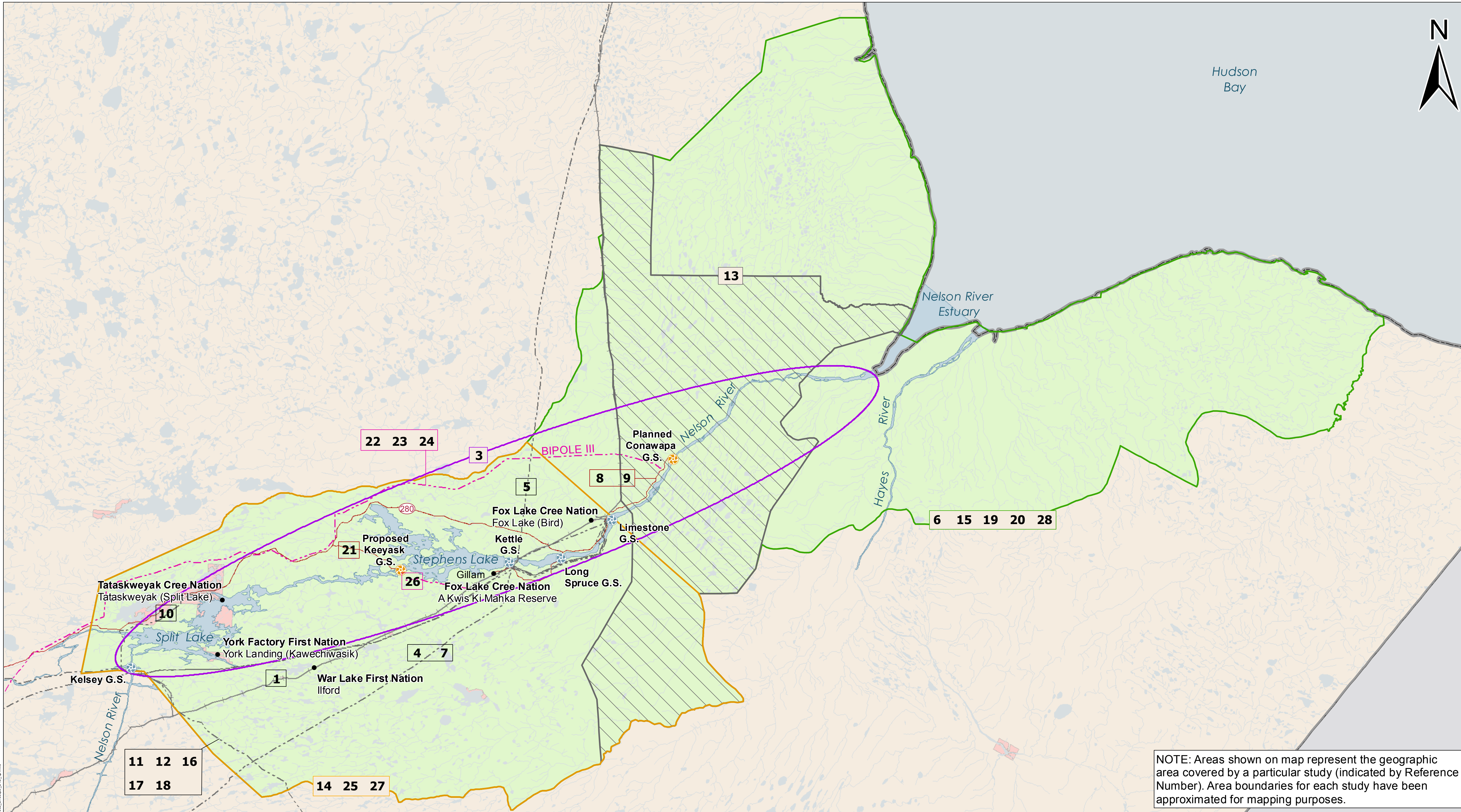

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	27-MAY-14
0 10 20 30 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

Intactness
Area 2

5.3.2.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

5.3.2.3.1 SUMMARY OF SCIENTIFIC INFORMATION

The following provides a summary of terrestrial intactness information available for Area 3. Intactness essentially refers to the degree to which an ecosystem remains undisturbed by human development and activities that remove habitat, increase fragmentation and alter ecological flows. Human effects on intactness are typically inferred from the sizes and locations of human footprints and the density of human linear features (*e.g.*, lineal kilometres of human features per square kilometre of land area).

LITERATURE

A number of studies are available for Area 3, but the predominant geographic focus of the associated reports was on the CRD route and the immediately surrounding area. The majority of studies conducted in Southern Indian Lake and the Rat and Burntwood rivers area prior to the CRD focused on aquatic environments, water quality, and fisheries (Beak 1962). In general, early EIAs did not study terrestrial intactness other than with reference to wildlife habitat.

The most detailed and extensive information related to intactness, with respect to both hydroelectric and non-hydroelectric features (the first impacts not related to hydroelectric development began around 1957 with the construction of the Hudson Bay Railway line to the planned Thompson town site), was provided by several recent hydroelectric project EIAs conducted in the area, including the Wuskwatim Transmission Project EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003a) and Environmental Protection Plan (EPP) (E. Hicks & Associates Ltd. and MMM Group 2006, 2007). The Wuskwatim Transmission Project EIS includes detailed human features mapping from Forest Resource Inventory data, a description of the proposed transmission line route, and predicted impacts on wildlife related to clearing and increased access. There is also discussion of other non-hydroelectric activities planned in the area, such as timber harvesting and mining. The latter report also includes information on the degree of impact anticipated for the project. Information on linear feature density, including detailed human feature mapping in a 23,000 km^2 (8,880 mi^2) area surrounding Wuskwatim Lake was produced as part of the Wuskwatim Generation Project EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003b). Some discussion of access and disturbance-related effects on wildlife was included in the EIS.

Studies conducted in support of the cumulative effects assessment of the Keeyask Generation Project (Keeyask Hydropower Limited Partnership 2012) detailed current linear feature densities and core areas for an approximately 12,400 km^2 (4,788 mi^2) region surrounding the Nelson and Burntwood rivers between Thompson and the Long Spruce GS. These documents included detailed linear feature and human infrastructure maps for the areas, including specific analysis for the Thompson vicinity.

Habitat fragmentation was studied as part of the Bipole III Transmission Project EIS (Joro Consultants Inc. 2011), in a 4.82 km (3 mi) wide corridor extending through the southeast portions of Area 3. The Bipole III EIS (Manitoba Hydro 2011; MMM Group Ltd. 2011) also describes the project components and their dimensions in detail.

The most extensive information available for non-hydroelectric features that affected intactness was provided in the Lake Winnipeg, Churchill and Nelson Rivers Study Board reports published from 1971 to 1975. These include maps and a description of transportation corridors throughout the area as of 1973, prior to the CRD (Rosin *et al.* 1973). Other Lake Winnipeg, Churchill and Nelson Rivers Study Board reports also include descriptions of the CRD-related infrastructure, such as channel construction, the related vegetation clearing, and the predicted level of impact (Flanders *et al.* 1973; Whidden *et al.* 1973; Whidden and Lamont 1974), giving a general picture of the degree of impact in areas supporting hydroelectric infrastructure.

Another important information source for documenting impacts on intactness is historical highway maps archived by Manitoba Infrastructure and Transportation, which include Area 3 coverage dating back to 1961.

The Split Lake Cree Post Project Environmental Review (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996) study area extends into the southwestern portion of the Area 3. This study provided some information on hydroelectric and non-hydroelectric development within the report's study area, although there is only a small amount of spatial overlap with Area 3. While there is some qualitative discussion of pre-hydroelectric developments, there is no specific information on specific locations and extents of features that influenced pre-hydroelectric intactness. Some general qualitative information regarding how transmission lines affect wildlife behaviour, as well as non-hydroelectric development is also provided, but it is likely not adequate for quantitative analysis of intactness. Another study reviewed historical, existing and potential future hydroelectric and non-hydroelectric developments in the area, and provided discussion of issues of concern (Cooley 2001).

Ehnes and ECOSTEM Ltd. (2006) reported on the width of right-of-way edge effects on overstorey vegetation and ecosite type for selected transmission projects ranging in age from approximately 20 to 48 years.

Other potentially relevant studies included several that were focused on carbon flux and nitrogen processes in the boreal forest near Thompson (Harden *et al.* 1997; Potter *et al.* 2001; Parisian *et al.* 2006; Bond-Lamberty and Gower 2008). These studies may provide information on the potential regional effects of vegetation clearing with respect to ecological processes.

Other studies for broad regions that happened to overlap Area 3 provide some relevant information. Wulder *et al.* (2003) outlined a small-scale (1:250,000) land cover mapping program using Landsat data, which could possibly be used to map human features. This is one of many land cover mapping products available for various years starting in the 1980s. Most of the existing land cover maps produced from satellite imagery are of limited use for documenting historical hydroelectric development impacts due to the timing of their data acquisition relative to when impacts occurred and/or their coarse spatial resolution. A broad study by Rosenberg *et al.* (1997) on hydroelectric development, which included the Churchill-Nelson rivers system as an example, provided some general discussion of impacts related to increased access due to hydroelectric-related infrastructure.

DATA

Manitoba Hydro has footprint information for all of its developments in the Region of Interest. This information exists in paper form for older developments and as GIS data for some of the older and all of the more recent developments.

Data sources that may provide useful information in addition to that already provided by the above-mentioned studies include provincial forest resource inventories, 1:50,000 NTS maps, aerial photography and satellite imagery. Provincial forest resource inventories include large scale mapping of selected types of human footprints. Limitations of these inventories for this project include less accurate georeferencing of the older inventory datasets and some inventories only exist in paper format.

The most extensive recent data for other areas includes satellite imagery data from various years starting in 1972. A limitation of these datasets is that narrow linear features and small footprints were not captured due to the low spatial resolution relative to the size of these footprints. This limitation is not applicable to the high resolution imagery that has become available in recent years.

Available historical aerial photography, which dates back to 1946, is of variable quality and scale (Barber 1987; Manitoba Conservation air photo library). Typically, linear features and permanent infrastructure can be detected in smaller-scale photography, so the only limitation to this data source is availability and area coverage.

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Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro; North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
0 4 8 Kilometres / 0 3 6 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Intactness
Area 3

Map 5-38

5.3.2.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.3.2.4.1 SUMMARY OF SCIENTIFIC INFORMATION

The following provides a summary of terrestrial intactness information available for Area 4. Intactness essentially refers to the degree to which an ecosystem remains undisturbed by human development and activities that remove habitat, increase fragmentation and alter ecological flows. Human effects on intactness are typically inferred from the sizes and locations of human footprints and the density of human linear features (*e.g.*, lineal kilometres of human features per square kilometre of land area).

LITERATURE

While numerous studies provide scientific information for Area 4, the predominant focus of these reports was on the Churchill River and the immediately surrounding area. The majority of pre-hydroelectric development studies focused on aquatic environments, water quality and fisheries. In general, early environmental impact assessments did not study terrestrial intactness other than with reference to wildlife habitat.

The most extensive pre-hydroelectric development information available was provided in the Lake Winnipeg, Churchill and Nelson Rivers Study Board reports published from 1971 to 1975 (the first non-hydroelectric development impacts began with the construction of the Hudson Bay Railway and the Port of Churchill in the mid-1920s). Rosin *et al.* (1973) included a description and maps of transportation corridors extending from the outlet of Southern Indian Lake to the Churchill River estuary. This report also included a map of the Churchill roads and facilities, and the Hudson Bay Railway line.

The most detailed studies focusing on intactness were completed in support of the cumulative effects assessment of the Keeyask Generation Project (Keeyask Hydropower Limited Partnership 2012, 2013). Detailed current linear feature density and core habitat area analyses were conducted for an approximately 12,400 km^2 (4,788 mi^2) region surrounding the Nelson and Burntwood rivers between Thompson and the Long Spruce generating station (Keeyask Hydropower Limited Partnership 2012), and for an approximately 3,667 km^2 (1,416 mi^2) region surrounding the Nelson River between the Long Spruce GS and just past the site of the planned Conawapa GS (Keeyask Hydropower Limited Partnership 2013), both of which are relevant for southern portions of Area 4. These documents included detailed linear feature and human infrastructure maps for the areas.

The Split Lake Cree Post Project Environmental Review (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996) study area included a large portion of the lower Churchill River and surrounding lands. This report provided detailed information on hydroelectric development within its study area, including land areas impacted by transmission lines and supporting infrastructure; however, while there was some qualitative discussion of pre-hydroelectric developments, there was no information on specific locations and extents of features that influenced pre-hydroelectric intactness. Some general qualitative information regarding how transmission lines affect wildlife behaviour is applicable, but it is likely not adequate for quantitative analysis of intactness.

Other studies for broad regions that happened to overlap Area 4 provide some relevant information. Wulder *et al.* (2003) described a small-scale (1:250,000) land cover mapping program using Landsat data, which could possibly be used to map human features developed after 1967. This is one of many land cover mapping products available for various years starting in the 1980s. Most of the existing land cover maps produced from satellite imagery are of limited use for documenting historical hydroelectric development impacts due to the timing of their data acquisition relative to when impacts occurred and/or their coarse spatial resolution.

DATA

Manitoba Hydro has footprint information for all of its developments in the region of interest. This information exists in paper form for older developments and as GIS data for some of the older and all of the more recent developments.

Data sources that may provide useful information in addition to that already provided by the abovementioned studies include provincial forest resource inventories, 1:50,000 NTS maps, aerial photography and satellite imagery. Provincial forest resource inventories include large-scale mapping of selected types of human footprints. Limitations of these inventories for this project include less accurate georeferencing of the older inventory datasets and some inventories only exist in paper format.

The most extensive recent intactness data for other areas includes satellite imagery data from various years starting in 1972. A limitation of these datasets is that narrow linear features and small footprints were not captured due to the low spatial resolution relative to the size of these footprints. This limitation is not applicable to the high resolution imagery that has become available in recent years.

Available historical aerial photography, which dates back to 1946, is of variable quality and scale (Barber 1987; Manitoba Conservation air photo library). Typically, linear features and permanent infrastructure can be detected in smaller-scale photography, so the only limitation to this data source is availability and area coverage.

5.3.2.4.2 SCIENTIFIC REFERENCES

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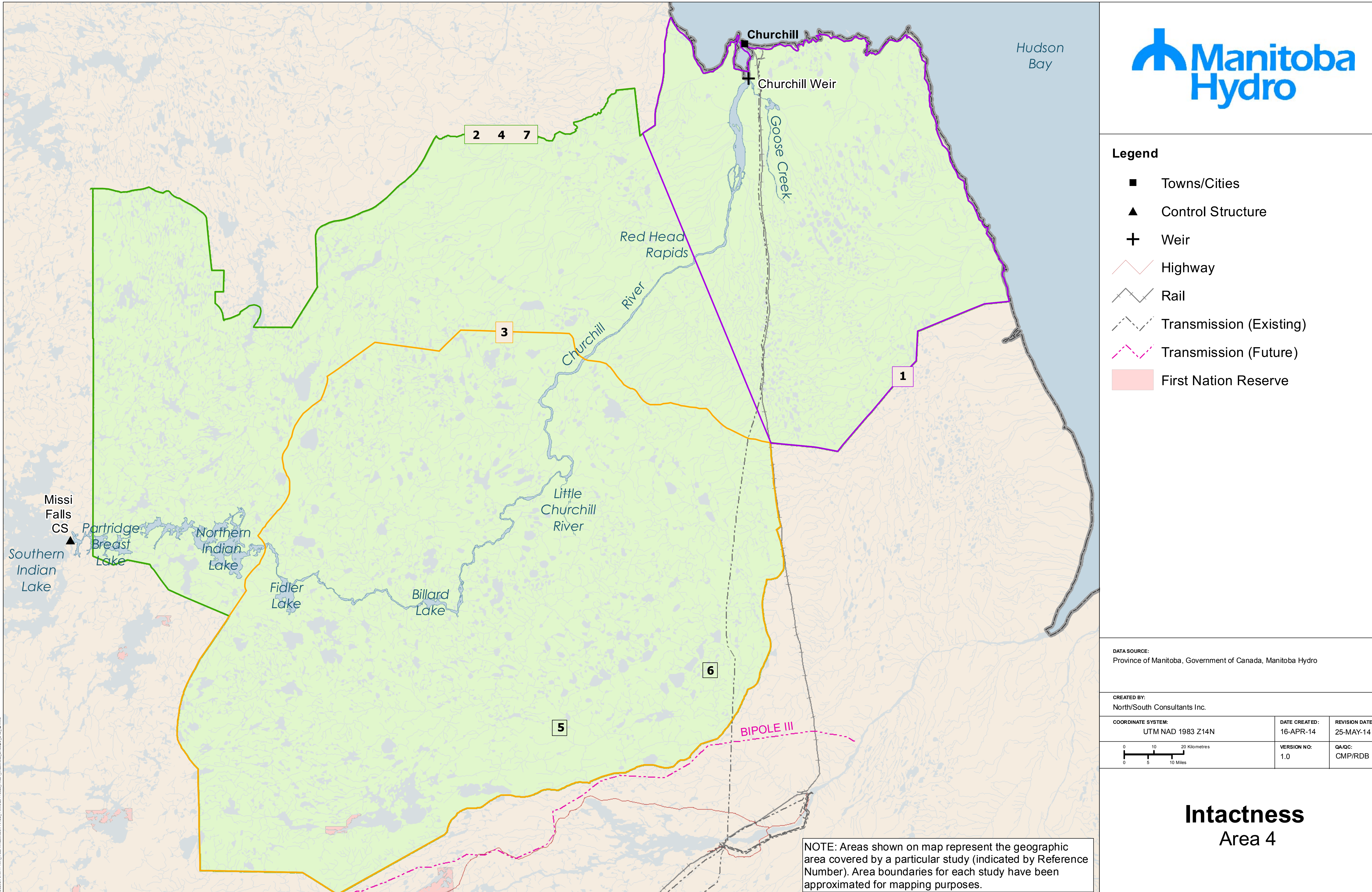

Intactness
Area 4

Map 5-39

5.3.3 BOREAL FOREST BIRDS

5.3.3.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

5.3.3.1.1 SUMMARY OF SCIENTIFIC INFORMATION

Detailed published information on forest bird populations in Area 1 is minimal. The Lake Winnipeg, Churchill and Nelson Rivers Study Board reports generally discussed distribution and habitat of birds in the outlet lakes area (*e.g.*, raptors and songbirds). A list of species observed or known to occur is included as an appendix in Webb (1973). Rakowski (1976) observed a pair of bald eagles flying in the Kiskitto Lake area, but no nest sites. As part of the 1993 study on the hydroelectric route/site selection for the North Central Project, Epstein Associates Inc. (1993a) described particular bird species which could include a small portion of Area 1, along with potential environmental impacts and mitigation measures. Additionally, biophysical details, and tables on species and species-habitat relationships in the North Central Project study area were presented (Epstein Associates Inc. 1993b).

Bird studies were also conducted for Manitoba Hydro in 2009 and 2010 as part of the Bipole III Transmission Project to assess possible environmental effects (Manitoba Hydro 2011). Field studies conducted in the Bipole III study area included breeding bird and owl (auditory) surveys that focused on a 10 km (6.2 mi) wide corridor around the "preliminary preferred route". Breeding bird surveys involved point count methods and incidental observations of all bird species including raptors and nests were recorded. Species and habitat types, potential adverse effects on species and habitat types, proposed mitigation strategies, and biophysical aspects of the land were all described for the larger study area. Twenty-one bird species were selected as Valued Environmental Components including species at risk, birds of prey, songbirds, woodpeckers, and upland game birds. Detailed information was published in a birds technical report in support of Manitoba Hydro's Bipole III Transmission Project environmental impact statement (Manitoba Hydro 2011; Wildlife Resource Consulting Services MB Inc. 2011).

As part of monitoring work conducted for the Wuskwatim Transmission Project, breeding bird surveys were conducted in 2011 and 2012 to assess the abundance and distribution of *Species at Risk Act* and Manitoba *Endangered Species Act* listed bird species along portions of the Wuskwatim transmission line route (Wildlife Resource Consulting Services MB Inc. 2012). Bird diverters that were installed at sensitive sites were monitored, along with reference areas, using ground searches for bird-wire collisions.

The Manitoba Breeding Bird Atlas is a five-year, scientifically-designed project initiated to assess the status, abundance, and distribution of bird species that breed within Manitoba (Bird Studies Canada 2014). From 2010 to the present, bird occurrence data have been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including survey sites located in Area 1. The Boreal Avian Modelling Project uses sampling information on boreal birds and their habitats for monitoring purposes and to assess the impacts of industrial development and climate change on bird populations in the boreal forest. The geographic scope of these datasets encompasses much of the boreal forest region of Manitoba (Boreal Avian Modelling Project 2014).

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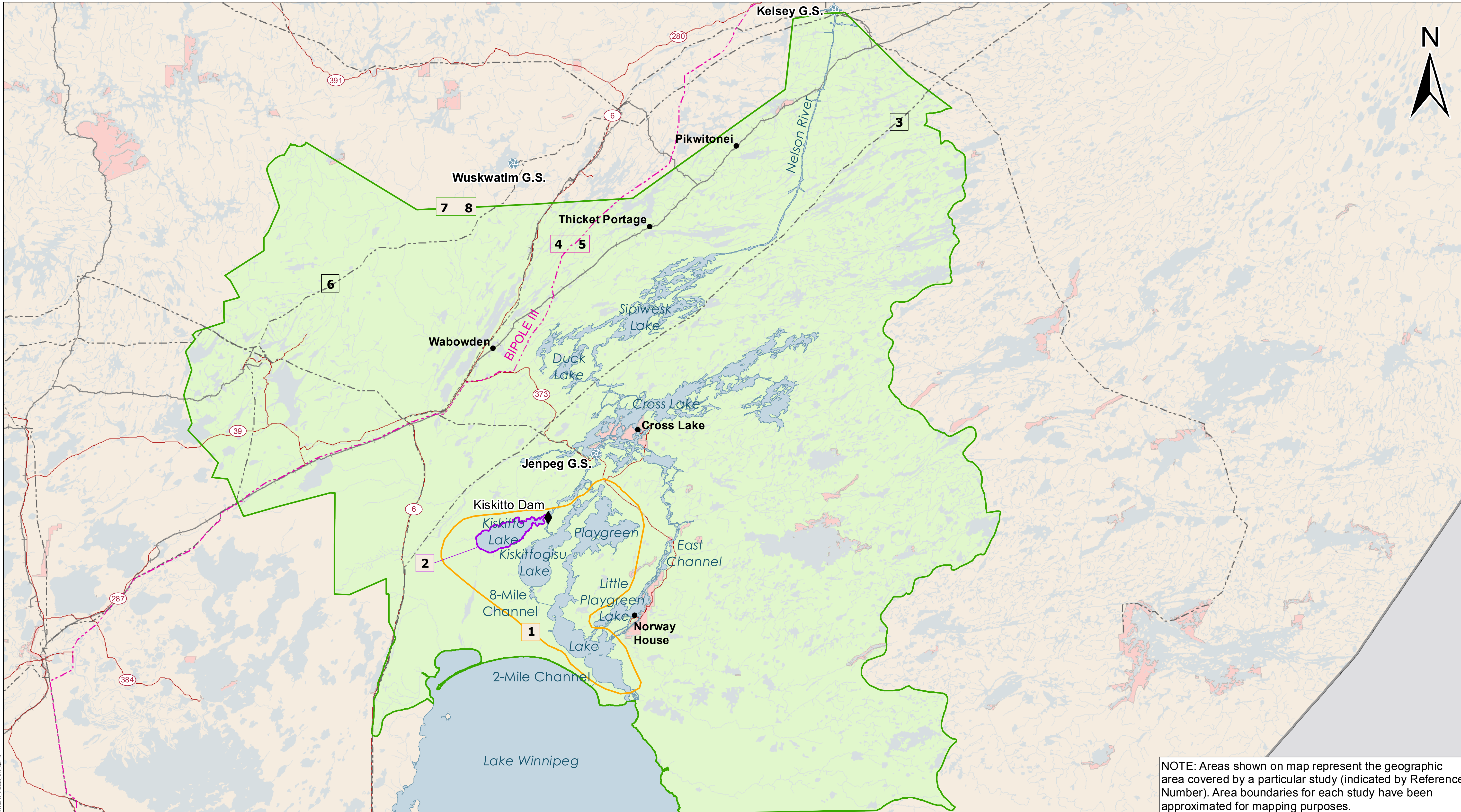

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM: UTM NAD 1983 Z14N

DATE CREATED: 07-APR-14

REVISION DATE: 27-MAY-14

0 20 40 Kilometres
0 10 20 Miles

VERSION NO: 1.0

QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Dam
- Generating Station (Existing)
- Highway
- Rail
- Transmission (Future)
- Transmission (Existing)
- First Nation Reserve

Forest Birds
Area 1

Map 5-40

5.3.3.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

5.3.3.2.1 SUMMARY OF SCIENTIFIC INFORMATION

Specific studies, inventories and published information on forest bird populations from Split Lake inlet to the Nelson River estuary are limited; however, the majority of available forest bird information in the RCEA region of interest exists in Area 2. Available information is mainly associated with environmental assessment work conducted for major hydroelectric projects including: North Central; Bipole III; the proposed Keeyask transmission lines; and the proposed Keeyask and Conawapa generation projects. Other studies include the Polar Gas Project study by McLaren and McLaren (1981), who reported on abundance and habitat of mainly songbirds along a portion of the pipeline corridor running north from Northwest Ontario, along Hudson Bay, into the eastern coastline of Nunavut, and a breeding bird study conducted in forest and forest-edge plots near the towns of Churchill and Gillam (Gillespie and Kendeigh 1982).

Preliminary surveys on birds were conducted by I.D. Systems Ltd. (1989) for the Conawapa Generation Project, identifying raptor corridors and nesting sites along the Nelson River, and upland game birds and songbirds near the Conawapa access road. Habitat assessments for selected indicator species (*e.g.*, bald eagle, great gray owl, and ruffed grouse) were utilized in the environmental impact assessments for the Conawapa road and transmission line. Environmental assessment studies of the Split Lake Transmission Line Project area discussed the potential effects of the project and ground surveys identified habitat for upland birds and nesting sites for eagles (Manitoba Hydro 1992). Bird surveys carried out for the environmental assessment of the planned Conawapa Generation Project continued from 1990-1993 along the lower Nelson River (I.D. Systems 1994). Data on bald eagle densities, nest sites and 11 other raptor densities were reported. A study by Epstein Associates Inc. (1993a) on the North Central Project listed bird species in the area, along with potential environmental impacts and mitigation measures; tables on species presence and species-habitat relationships area were also presented (Epstein Associates Inc. 1993b).

As part of the environmental assessment for the Keeyask Generation Project, terrestrial point count surveys along the proposed north and/or south Keeyask access road(s) and Stephens Lake (north arm) shoreline, and helicopter surveys over Stephens Lake (north arm) were undertaken from 2001-2007(Tetr*ES* 2004, 2005a, b, c, 2006a, 2007, 2008b). Relative abundance, distribution, and habitat use within the project area was described for a number of bird species (76 songbirds, 3 woodpeckers, 6 upland game birds, and 19 raptor species) for the study area in the environmental impact statement (Keeyask Hydropower Limited Partnership 2012). Breeding bird (point count), and habitat-classification studies were undertaken from 2009-2011 along two preferred route options for the Keeyask Transmission Line Project (Stantec Consulting Ltd. 2012). Songbird, raptor, upland bird, and woodpecker abundance and distribution were described. Helicopter surveys were also undertaken in 2009 for large-bodied birds, including raptor species, along inland lakes and waterways in the project area.

From 2004-2009, breeding bird point count surveys and helicopter multi-species surveys for waterfowl and raptors were carried out along boreal habitats within the Conawapa Generation Project area and bird abundance, distribution and habitat use was reported (Tetr*ES* 2005d, 2006b, 2008a, 2009, 2010a, b). Terrestrial nocturnal owl point count (auditory) surveys were also conducted in 2008 (Tetr*ES* 2010a).

Bird studies were conducted in 2009 and 2010 as part of the environmental assessment for the Bipole III Transmission Project (Manitoba Hydro 2011). Bipole III studies conducted in Area 2 included breeding bird, owl (auditory) and raptor surveys that focused on a 10 km (6.2 mi) wide corridor around the "preliminary preferred route". Breeding bird surveys involved point count methods, and incidental observations of raptors and nests were recorded. Species and habitat types, potential adverse effects on species and habitat types, proposed mitigation strategies, and biophysical aspects of the surrounding area were all described for the larger Bipole III study area. Twenty-one bird species were selected as Valued Environmental Components including species at risk, birds of prey, songbirds, woodpeckers, and upland game birds. Detailed information is provided in a birds technical report (Manitoba Hydro 2011; Wildlife Resource Consulting Services MB Inc. 2011). Further analysis on habitat relationships and habitat quality modelling was conducted to assess effects of the project on three bird species at risk by ECOSTEM *et al.* (2013).

The Manitoba Breeding Bird Atlas provides a source of bird data as this is a five-year, scientifically-designed project initiated to assess the status, abundance and distribution of bird species that breed within Manitoba (Bird Studies Canada 2014). From 2010 to the present, bird occurrence data have been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including survey squares within areas Area 2. The Boreal Avian Modelling Project uses sampling information of boreal birds and their habitats for monitoring purposes and to assess the impacts of industrial development and climate change on bird populations in the boreal forest. The geographic scope of these datasets encompasses much of the boreal forest region of Manitoba (Boreal Avian Modelling Project 2014).

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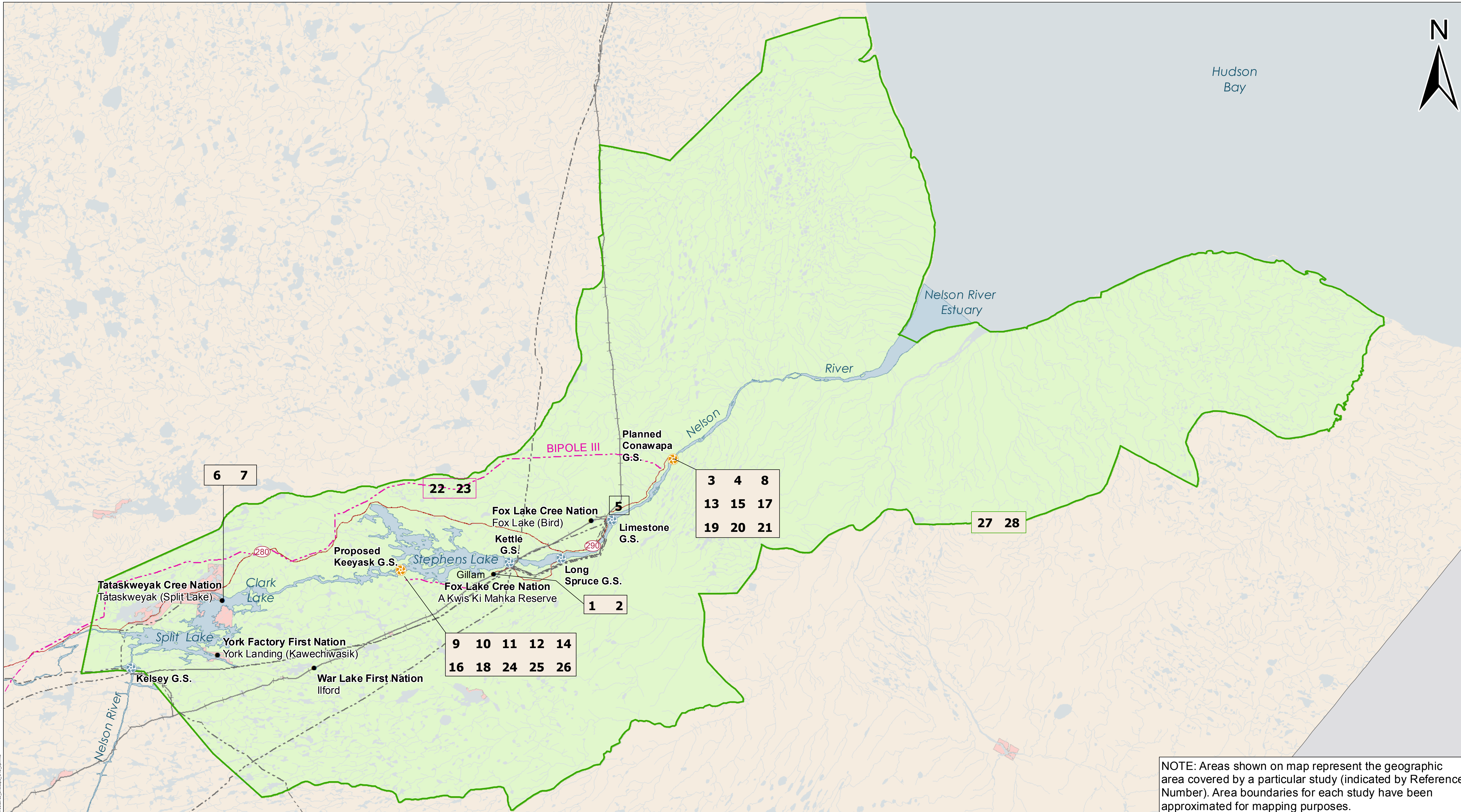

NOTE: Areas shown on map represent the geographic area covered by a particular study (indicated by Reference Number). Area boundaries for each study have been approximated for mapping purposes.

Manitoba Hydro

Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY: North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	28-MAY-14
0 10 20 30 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

Forest Birds
Area 2

5.3.3.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

5.3.3.3.1 SUMMARY OF SCIENTIFIC INFORMATION

There is little published information on forest bird populations from Southern Indian Lake to the Split Lake Inlet (Area 3). Raptors, songbirds and upland birds were noted in the upper Churchill-Reindeer lakes study area, and are included in reports produced for the Manitoba Department of Mines, Resources and Environmental Management (Koonz 1973; Koonz and Storey 1975). The Lake Winnipeg, Churchill and Nelson Rivers Study Board reports generally discussed distribution and habitat of birds within the Southern Indian Lake (Webb 1974) and Rat-Burntwood diversion areas (Webb and Foster 1974). Wildlife resource studies for an environmental overview of the Burntwood River system included aerial surveys of eagle abundance and distribution (MacLaren Engineers Inc. and InterGroup Consulting Economists Ltd. 1984). Potential effects of development on bald eagle and osprey in the Burntwood River area, and importance of the boreal forest for breeding and nesting sites, were also discussed.

Forest bird surveys conducted for the Wuskwatim Transmission Line Project were completed in 2002 for breeding bird distribution and abundance. Habitat suitability index models were developed to assess habitat use for 10 passerines and two birds of prey (Manitoba Hydro and Nisichawayasihk Cree Nation 2003a). Both Aboriginal Traditional Knowledge and results of the scientific studies conducted for the Wuskwatim transmission and generation projects were included in the environmental assessments of these projects. During 2000-2002, point count methods (mainly passerine species) and helicopter surveys (bald eagle) were conducted to assess bird abundance and distribution for the Wuskwatim Generation Project (Manitoba Hydro and Nisichawayasihk Cree Nation 2003b; Tetr*ES* 2003a, b). Bird monitoring studies began in 2004 (Tetr*ES* 2004) to provide baseline data prior to the start of construction work, and construction-phase monitoring data were collected in 2007, 2009 and 2011 (Tetr*ES* 2008, 2009; Stantec Consulting Ltd. 2011).

Bird studies were also conducted in 2010 as part of the Bipole III Transmission Project to assess potential environmental effects of the project (Manitoba Hydro 2011). Bipole III studies conducted in Area 3 included breeding bird surveys that focused on a 10 km (6.2 mi) wide corridor around the "preliminary preferred route". Breeding bird surveys involved point count methods, and incidental observations of raptors and nests were recorded. Species and habitat types, potential adverse effects on species and habitat types, proposed mitigation strategies, and biophysical aspects were all described for the larger Bipole III study area. Twenty-one bird species were selected as Valued Environmental Components, including species at risk, birds of prey, songbirds, woodpeckers, and upland game birds. Detailed information was published in a birds technical report (Manitoba Hydro 2011; Wildlife Resource Consulting Services MB Inc. 2011).

As part of monitoring work conducted for the Wuskwatim Transmission Project, breeding bird surveys were conducted in 2011 and 2012 to assess the abundance and distribution of *Species at Risk Act* and Manitoba *Endangered Species Act* listed bird species along portions of the Wuskwatim transmission line. Other studies included aerial surveys of common raven and raptor nests. Finally, bird diverters that were installed at sensitive sites were monitored, along with reference areas, using ground searches for bird-wire collisions.

The Manitoba Breeding Bird Atlas provides a source of bird data as it is a five-year, scientifically designed project initiated to assess the status, abundance and distribution of bird species that breed within Manitoba (Bird Studies Canada 2014). From 2010 to the present, bird occurrence data have been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including within Area 3. The Boreal Avian Modelling Project uses sampling information on boreal birds and their habitats for monitoring purposes and to assess the impacts of industrial development and climate change on bird populations in the boreal forest. The geographic scope of these datasets encompasses much of the boreal forest region of Manitoba (Boreal Avian Modelling Project 2014).

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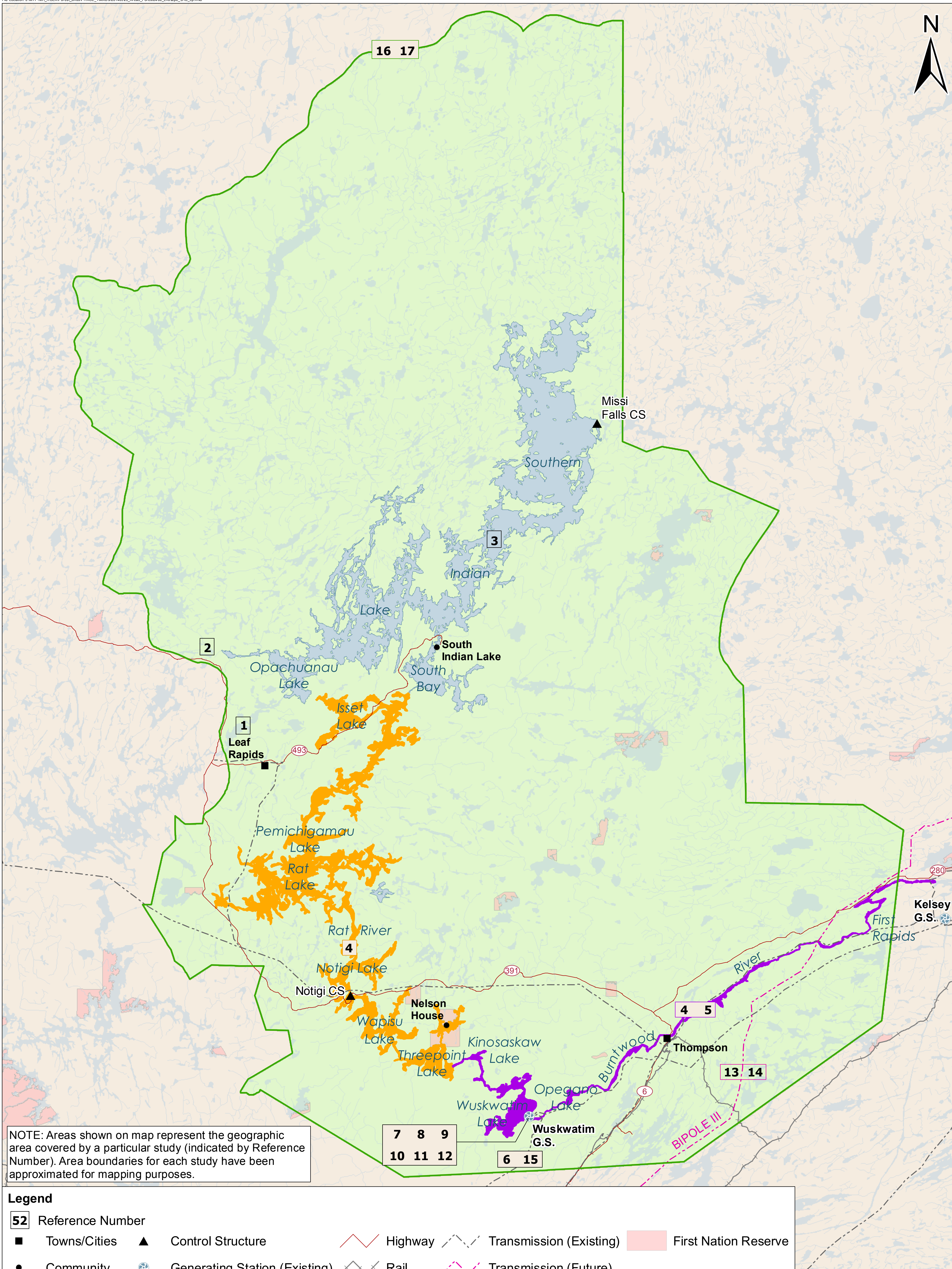

Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro; North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	28-MAY-14
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Forest Birds
Area 3

Map 5-42

5.3.3.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.3.3.4.1 SUMMARY OF SCIENTIFIC INFORMATION

Published information on forest bird populations from Southern Indian Lake to the Churchill River estuary (Area 4) is minimal. The early Lake Winnipeg, Churchill and Nelson Rivers Study Board reports generally discussed raptor observations along the lower Churchill River and provided a checklist of bird species in the area (Webb and Foster 1974). McLaren and McLaren (1981) conducted line transect surveys at numerous sites on the Nelson, Churchill, Seal, and Caribou rivers and reported on abundance and habitat of mainly songbirds along a portion of the proposed pipeline corridor (Polar Gas Project) running north from Northwest Ontario, along Hudson Bay, into the eastern coastline of Nunavut. Breeding bird counts were also conducted in forest and forest-edge plots in the Town of Churchill and Gillam areas (Gillespie and Kendeigh 1982).

Baseline studies were also completed by Tetr*ES* Consultants (1996, 1997, 1998) to collect information on the terrestrial environment in the vicinity of the lower Churchill River and included breeding bird transects and aerial raptor surveys that were completed in 1995, 1996 and 1997 to estimate abundance and distribution of species along the Churchill River (Manitoba Hydro and the Town of Churchill 1997).

The Manitoba Breeding Bird Atlas provides a further source of bird data as this is a five-year, scientifically-designed project initiated to assess the status, abundance and distribution of bird species that breed within Manitoba (Bird Studies Canada 2014). From 2010 to the present, bird occurrence data have been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including Area 4. The Boreal Avian Modelling Project uses sampling information on boreal birds and their habitats for monitoring purposes and to assess the impacts of industrial development and climate change on bird populations in the boreal forest. The geographic scope of these datasets encompasses much of the boreal forest region of Manitoba (Boreal Avian Modelling Project 2014).

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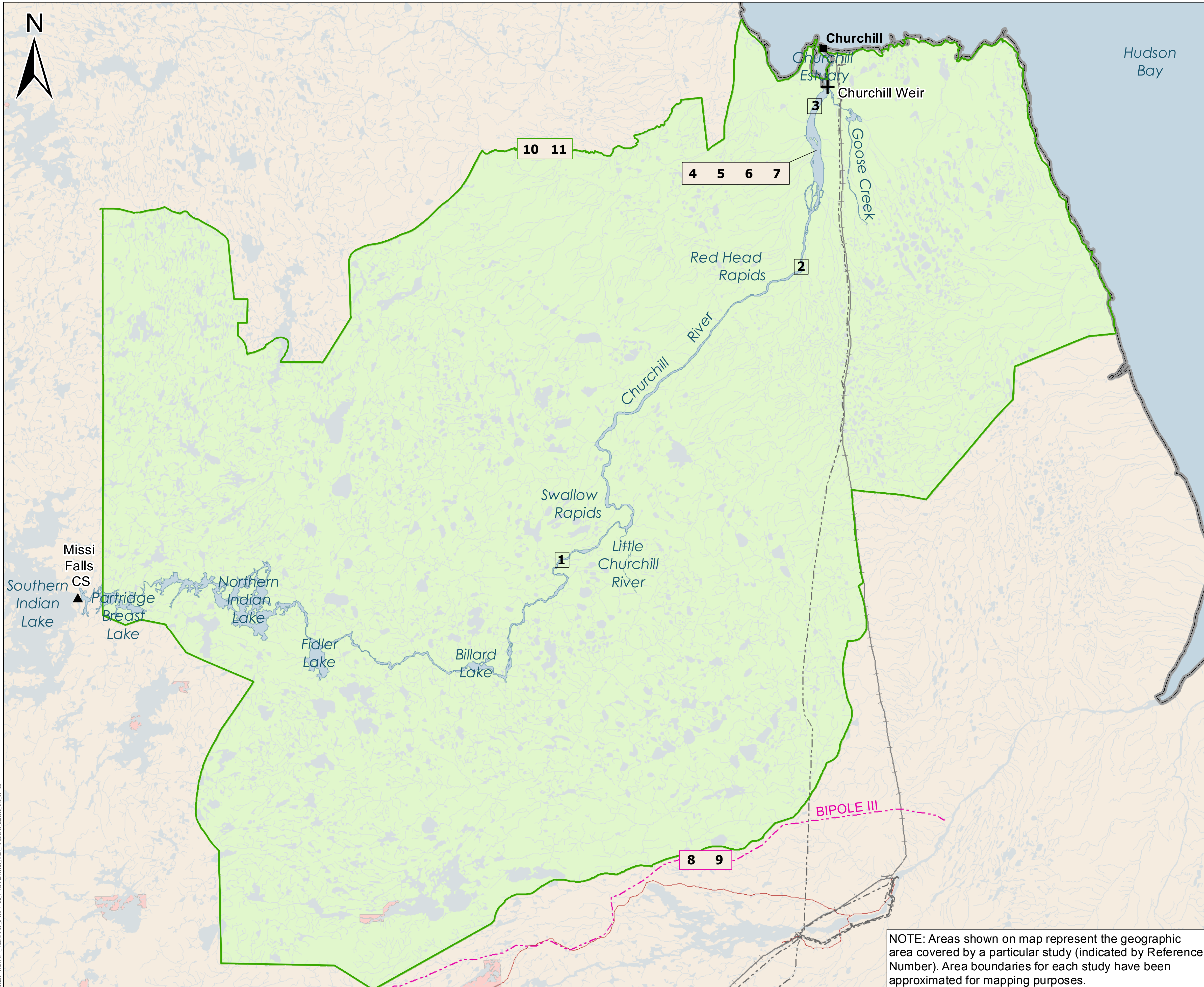

Manitoba Hydro

Legend

- Towns/Cities
- Control Structure
- Weir
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

DATA SOURCE:
Province of Manitoba, Government of Canada, Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	16-APR-14	26-MAY-14
0 10 20 Kilometres / 0 5 10 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Forest Birds
Area 4

5.3.4 COLONIAL WATERBIRDS

5.3.4.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

5.3.4.1.1 SUMMARY OF SCIENTIFIC INFORMATION

Peer-reviewed population and habitat information for colonial waterbirds in Area 1 was not found. Population data for colonial waterbirds along the upper Nelson River and its lakes are very limited. The distribution and habitat requirements of colonial waterbird species were generally discussed as part of the Lake Winnipeg, Churchill and Nelson Rivers Study Board studies (Webb 1973). The wildlife resource impact assessment for the outlet lakes area (F.F. Slaney & Company Limited 1973) reports that the outlet lakes do not support large breeding or migratory concentrations of red-necked, horned and pied-billed grebes, though the area does contain relatively good habitat for these species.

In the early 1970s, the Canadian Wildlife Service (Rakowski 1975) inventoried migratory bird use in the vicinity of the 8-Mile Channel between Kiskittogisu and Playgreen lakes, and the Kiskittogisu River; however, no colonial waterbird observations were reported. To evaluate past and potential importance of Kiskitto Lake to waterfowl, ground-based and aerial surveys were conducted in 1973 by Canadian Wildlife Service and Manitoba Department of Mines, Resources and Environmental Management biologists (Rakowski 1976). The distribution and abundance of common tern and gull colonies on islands in Kiskitto Lake are provided in this report.

As part of resource allocation studies, Manitoba reported on wildlife resources in the Cross Lake and Norway House areas in the late 1970s (Teillet *et al.* 1977; Teillet 1978), reporting low concentrations of three grebe species (horned, red-necked, and pied-billed) in both the breeding season and during migration. The authors note that the American white pelican also inhabits these areas but no evidence of breeding has been observed. The Resource Information Package for mid-north Manitoba (Teillet 1979) contains a list of birds, including colonial waterbirds, the manner of their occurrences (*e.g.*, winters only, breeding, transient, formerly), and their range in the “mid north planning zone”; however, population estimates are not provided.

In describing the existing environment for birds in the Bipole III study area, a colonial waterbird survey was conducted within a 10 km (6.2 mi) wide corridor around the preliminary preferred route in July 2010. In addition, colonial waterbird (*e.g.*, great-blue heron, grebes, and gulls) observations made during waterfowl surveys conducted in September 2010 were mapped in the vicinity of the Bipole III final preferred route west of Sipiwesk Lake near Wabowden (Wildlife Resource Consulting Services MB Inc. 2011; Manitoba Hydro 2012).

Data sources that may provide useful information in addition to those discussed above include the Manitoba Breeding Bird Atlas. The Atlas is a five-year, scientifically-designed project initiated to assess the status, abundance and distribution of bird species that breed within Manitoba (Bird Studies Canada 2014). From 2010 to present, bird occurrence data have been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including Area 1.

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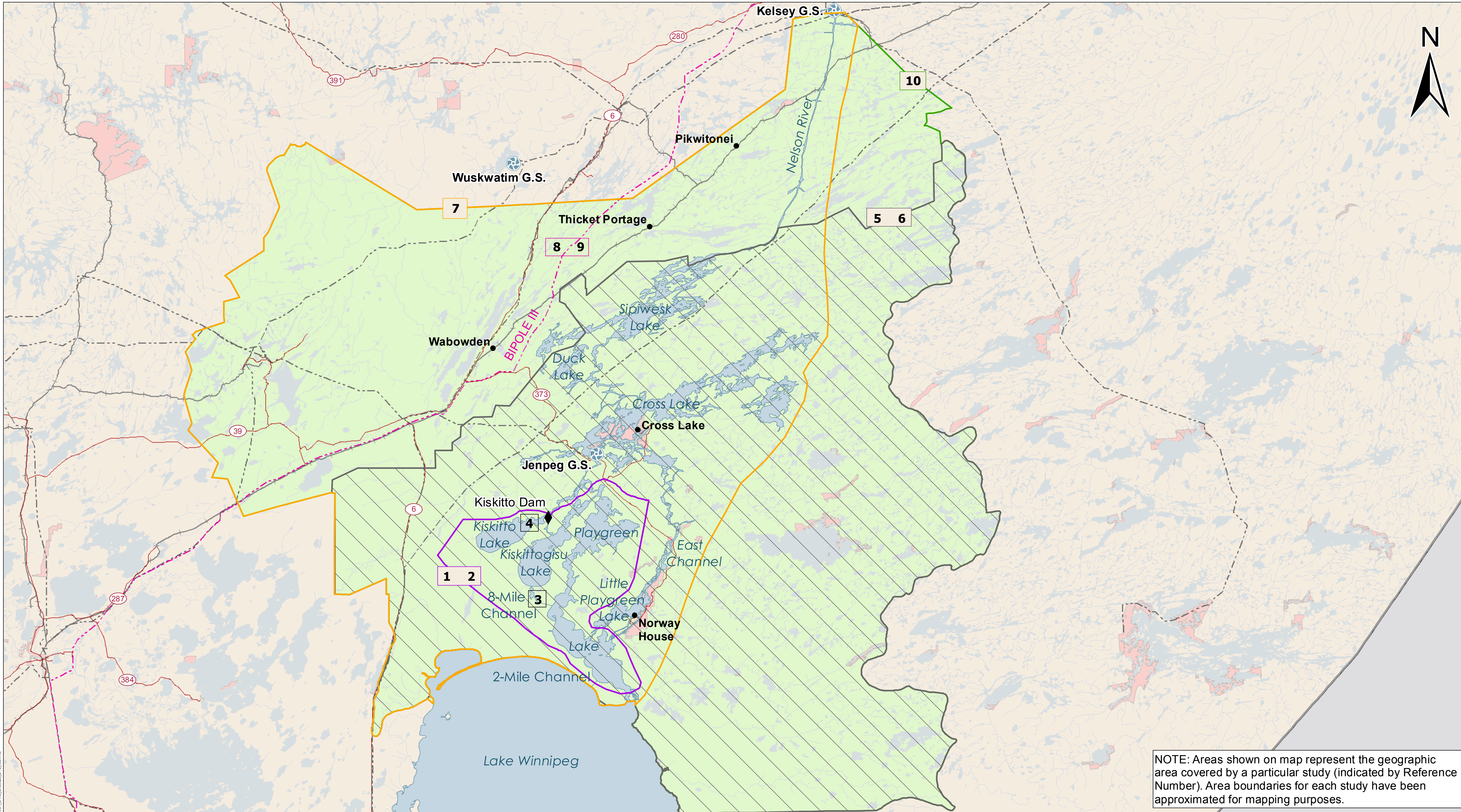

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
0 20 40 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

52 Reference Number
Community
Dam
Generating Station (Existing)
Highway
Rail
Transmission (Future)
Transmission (Existing)
First Nation Reserve

Colonial Waterbirds
Area 1

5.3.4.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

5.3.4.2.1 SUMMARY OF SCIENTIFIC INFORMATION

Peer-reviewed colonial waterbird population and habitat information from Area 2 is non-existent. Population data for colonial waterbirds from Split Lake to the Nelson River estuary are very limited. The only study of wildlife resources in the area was conducted by the Lower Nelson River Advisory Board in 1974 and 1975 along the lower Nelson River and its tributaries to assess potential impacts of access roads and development of hydroelectric generating stations (Didiuk 1975). Briscoe (1975) presents species lists for birds that were observed, and those expected to occur in this area in the early 1970s. Didiuk (1975) also provides a list of birds that are expected to occur in the lower Nelson River area and classifies their status (*e.g.*, expected to breed, possible breeding, recorded during migration, casual, resident, recorded during the study period). Also provided is the results of bird surveys conducted along sections of the lower Nelson River, Limestone River, and Kettle River.

Numbers and distribution of birds during migration were examined along the length of a proposed pipeline from Nunavut to Ontario (McLaren *et al.* 1977). Spring and late summer aerial surveys for birds included portions of the Nelson, Hayes, Fox, Stuppart, and God's rivers in the vicinity of where the pipeline was proposed to cross these waterbodies. These surveys provide density indices (number of birds/mi and number of birds/mi^2) and minimum estimates of the number of loons, gulls, and terns in these areas.

The Resource Information Package for mid-north Manitoba (Teillet 1979) contains a list of birds, including colonial waterbirds, the manner of their occurrences (*e.g.*, winters only, breeding, transient, formerly), and their range in the "mid north planning zone"; however, population estimates are not provided. Epstein Associates Inc. (1993a) identified a regionally important Caspian tern breeding range and nesting site in Area 2, and indicated that great blue heron rookeries occurred in the region. Lists of bird species and their habitat were also included (Epstein Associates Inc. 1993b).

Bird species distribution and abundance was examined within the Keeyask Generation Project and Keeyask Infrastructure Project study areas through terrestrial breeding bird surveys and helicopter surveys from 2001 to 2007 (Tetr*ES* 2004, 2005a, b, c, 2007a, 2008). Bird densities and habitat preferences are reported for gulls and terns.

Colonial waterbird distribution and abundance was examined in the Conawapa Generation Project study area through helicopter surveys from 2004 to 2009 (Tetr*ES* 2005d, 2006, 2007b, 2010a, b). These reports provide numbers of colonial waterbirds observed along the Nelson River and adjacent waterbodies and the locations of nesting islands. Summaries of 2004-2009 surveys are available in Tetr*ES* (2010b), as are trends in relative colonial waterbird densities along the Nelson River.

In describing the existing environment for birds in the Bipole III study area, a colonial waterbird survey was conducted within a 10 km (6.2 mi) wide corridor around the preliminary preferred route in July 2010. (Wildlife Resource Consulting Services MB Inc. 2011; Manitoba Hydro 2012). Surveys were also conducted for the Keeyask Transmission Project and gull species were identified in the study area (Stantec Consulting Ltd. 2012).

Data sources that may provide useful information in addition to those discussed above include the Manitoba Breeding Bird Atlas. From 2010 to present, bird occurrence data has been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including in Area 2 (Bird Studies Canada 2014).

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Nilsson, C., and Dynesius, M. 1994. Ecological effects of river regulation on mammals and birds: A review. Regulated Rivers: Research and Management 9: 45-53 pp.

Poole, A. (ed.). 2005. The birds of North America [online]. Available from http://bna.birds.cornell.edu/BNA/

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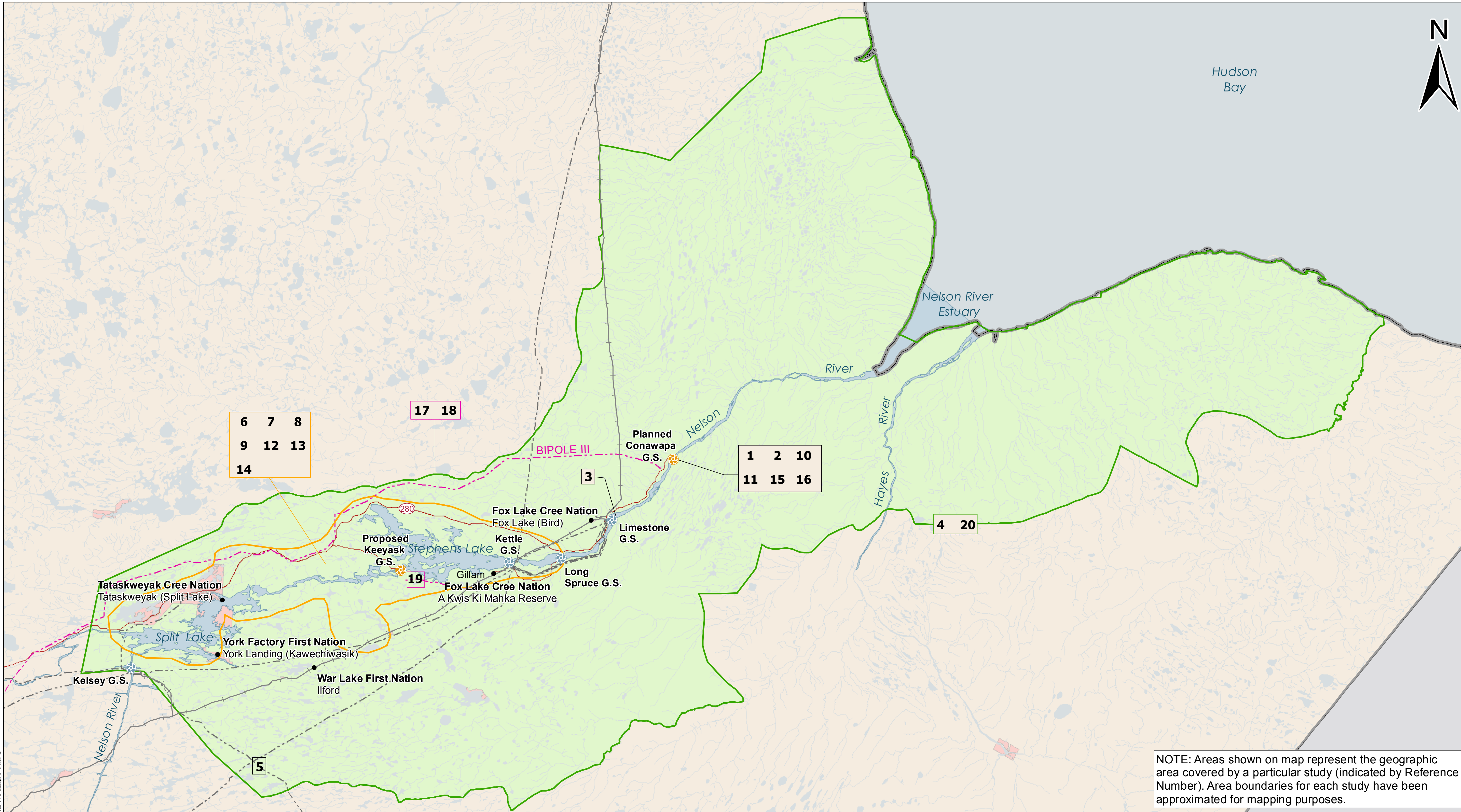

NOTE: Areas shown on map represent the geographic area covered by a particular study (indicated by Reference Number). Area boundaries for each study have been approximated for mapping purposes.

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM: UTM NAD 1983 Z15N

DATE CREATED: 07-APR-14

REVISION DATE: 26-MAY-14

0 10 20 30 Kilometres
0 10 20 Miles

VERSION NO: 1.0

QA/QC: CMP/LDB/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

Colonial Waterbirds
Area 2

5.3.4.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

5.3.4.3.1 SUMMARY OF SCIENTIFIC INFORMATION

Peer-reviewed colonial waterbird population and habitat information from Area 3 was not found. Population data for colonial waterbirds from Southern Indian Lake to Split Lake are very limited. Between 1966 and 1968, two studies were conducted to determine the effects of diversion on the wildlife resources of South Indian Lake, Pukatawagan, and Nelson House (Goulden *et al.* 1968). Riddle (1972) described wildlife observations during a canoe trip in 1971 from Issett Lake downstream along the Rat and Burntwood rivers to Split Lake. The distribution and habitat requirements of colonial waterbirds were generally discussed as part of the Lake Winnipeg, Churchill and Nelson Rivers Study Board studies (Webb 1973). Colony locations, number of nests, and clutch sizes for gulls and terns in South Indian Lake are detailed in this report. The Study Board also provides a list of breeding birds in the Southern Indian Lake area (Webb 1974) and in the Rat-Burntwood diversion (Webb and Foster 1974). The Lake Winnipeg, Churchill and Nelson Rivers Study Board (1975) remarked that flooding in South Indian Lake would negatively affect gull and tern colonies and reproduction would decline unless alternative habitats were provided through mitigation.

The Resource Information Package for mid-north Manitoba (Teillet 1979) contains a list of birds, including colonial waterbirds, the manner of their occurrences (*e.g.*, winters only, breeding, transient, formerly), and their range in the “mid north planning zone”; however, population estimates are not provided.

In support of the Wuskwatim Generation Project environmental impact statement, aerial, boat-based and terrestrial breeding bird surveys were conducted in the Wuskwatim study area in 2000 and 2001 – both on and off the Rat-Burntwood river system (Manitoba Hydro and Nisichawayasihk Cree Nation 2003). Manitoba Hydro and Nisichawayasihk Cree Nation (2003) reports the locations of nests, broods and areas of highest densities for colonial waterbird species. Aboriginal Traditional Knowledge reported by Manitoba Hydro and Nisichawayasihk Cree Nation (2003) includes locations of a great-blue heron colony, a gull colony, and observations that terns are no longer observed in the area whereas pelicans and cormorants are more commonly observed.

In describing the existing environment for birds in the Bipole III study area, a colonial waterbird survey was conducted along the Bipole III “final preferred route” between Orr Lake and Thompson in July 2010. Observations within Area 3 were largely dominated by Bonaparte's gull with a few ring-billed gull observations. In addition, colonial waterbird (*e.g.*, great-blue heron, grebes, and gulls) incidental observations made during waterfowl surveys conducted in September 2010 were mapped in the vicinity of the Bipole III final preferred route between Orr Lake and Thompson (Wildlife Resource Consulting Services MB Inc. 2011; Manitoba Hydro 2012). Observations of colonial waterbirds were listed as part of the Wuskwatim Transmission Line Monitoring Program in 2012, including known locations of great blue heron rookeries (Wildlife Resource Consulting Services MB Inc. 2012).

Data sources that may provide useful information in addition to those discussed above include the Manitoba Breeding Bird Atlas. From 2010 to present, bird occurrence data has been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including in Area 3 (Bird Studies Canada 2014).

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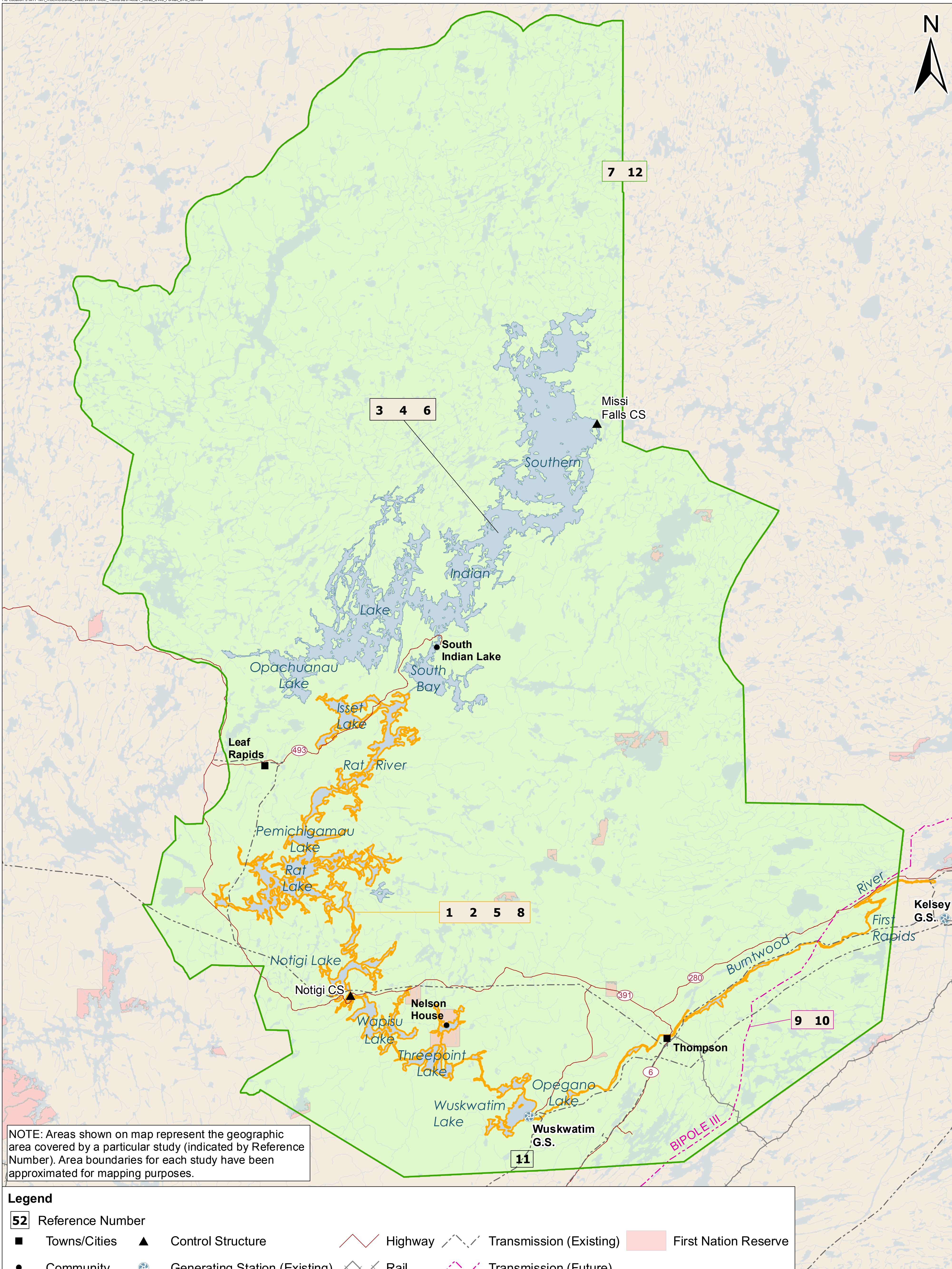

Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro; North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	28-MAY-14
0 4 8 Kilometres / 0 3 6 Miles	VERSION NO: 1.0	QA/QC: CMP/LDB/RDB

Colonial Waterbirds
Area 3

5.3.4.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.3.4.4.1 SUMMARY OF SCIENTIFIC INFORMATION

Peer-reviewed colonial waterbird population and habitat information from Area 4 are sparse, and population data for colonial waterbirds from Southern Indian Lake to Churchill are very limited. The most northerly breeding population of black tern in Manitoba occurs in Area 4, but colony size, number or habitat association is not reported (Godfrey 1966). Didiuk (1975) notes that the breeding population of black tern near Churchill was isolated. There is only one peer-reviewed publication concerning colonial waterbirds in Area 4. Evans and McNicholl (1972) reported the number of nests in 16 arctic tern colonies in 1967 and 1968 within 10 km (6.2 mi) to the south and east of the town of Churchill. The distribution and habitat requirements of colonial waterbirds were generally discussed as part of the Lake Winnipeg, Churchill and Nelson Rivers Study Board studies (Webb 1973). Colonial waterbird data for Area 4 in Webb (1973) is limited to an observation of a small common tern colony at Fidler Lake on the Churchill River east of Southern Indian Lake.

Numbers and distribution of birds during migration were examined along the length of a proposed pipeline from Nunavut to Ontario (McLaren *et al.* 1977). Spring and late summer aerial surveys for birds included portions of the Caribou, Seal, North Knife, and Churchill rivers in the vicinity of where the pipeline was proposed to cross these waterbodies. These surveys provide density indices (number of birds/mi and number of birds/mi^2) and minimum estimates of the number of loons, gulls, and terns in these areas.

The Resource Information Package for mid-north Manitoba (Teillet 1979) contains a list of birds, including colonial waterbirds, the manner of their occurrences (*e.g.*, winters only, breeding, transient, formerly), and their range in the "mid north planning zone"; however, population estimates are not provided.

Information on colonial waterbird populations was not collected after CRD until 1995, as part of the water level enhancement weir project. Observations of colonial waterbirds were recorded during boat-based waterbird surveys conducted prior to weir construction (1995 to 1997) from the mouth of the Churchill River upstream to the mouth of the Deer River (Tetr*ES* 1996, 1997, 1998; Manitoba Hydro and the Town of Churchill 1997). Breeding bird inventories (including some colonial species) were conducted along the Churchill River between the mouth of Goose Creek and Deer River.

Sammler (2001) conducted line transect bird surveys at Cape Churchill in June 1984, 1999, and 2000. Population estimates for herring gull and encounter rates for arctic terns (birds within 100 m of transect/total survey length) are provided within Sammler's (2001) thesis. Rockwell *et al.* (2009) provide an overview of bird species in Wapusk National Park, also including herring gull, Bonaparte's gull, Ross's gull, Sabine's gull, and arctic tern. The information in this paper draws on literature summaries and surveys, and by species, discusses habitat diversity, habitat issues, abundance and avifaunal trends for some key species.

Data sources that may provide useful information in addition to those discussed above include the Manitoba Breeding Bird Atlas. From 2010 to present, bird occurrence data has been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including in Area 4 (Bird Studies Canada 2014).

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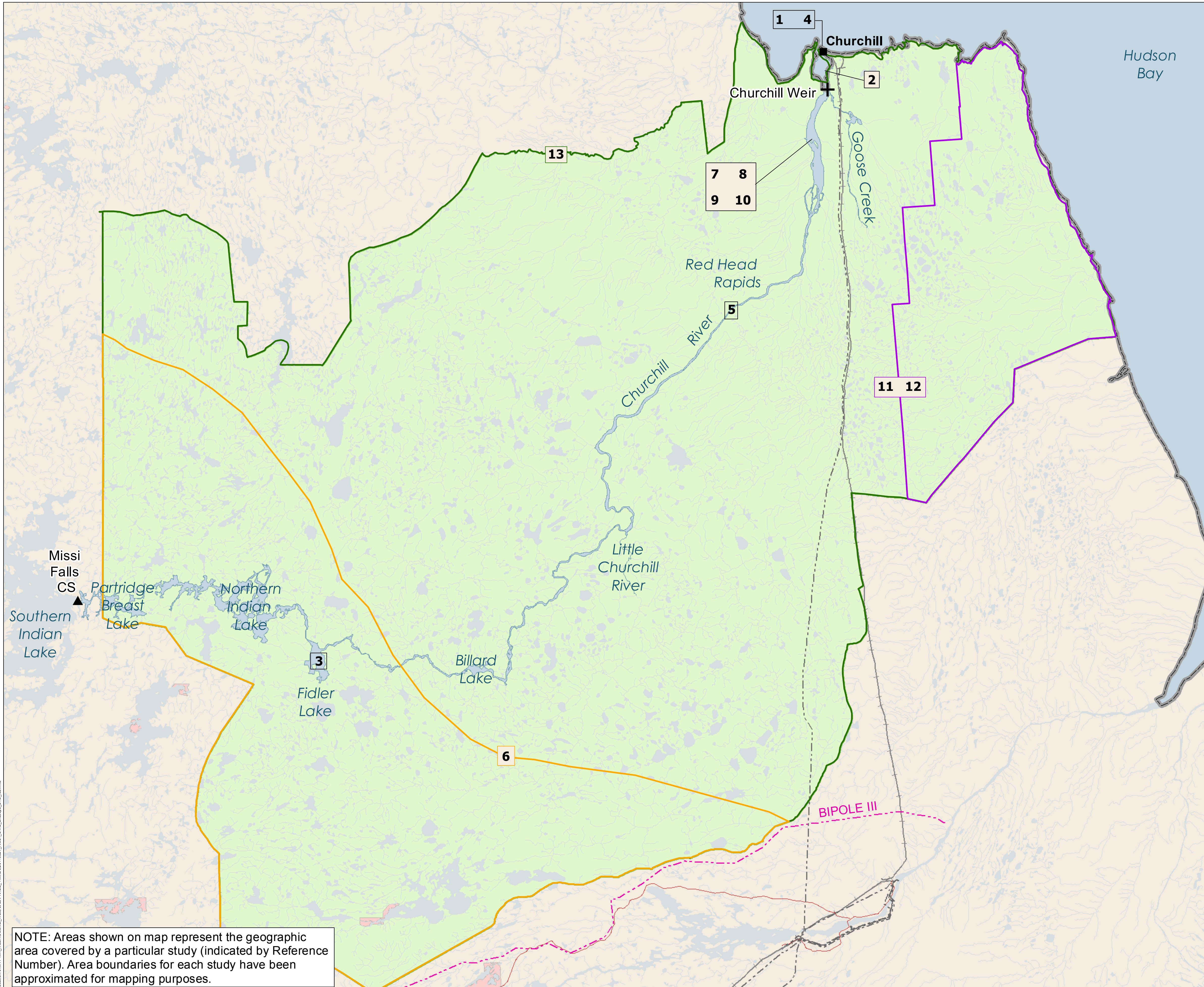

Manitoba Hydro

Legend

- Towns/Cities
- Control Structure
- Weir
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

DATA SOURCE:
Province of Manitoba, Government of Canada, Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	16-APR-14	26-MAY-14
0 10 20 Kilometres / 0 5 10 Miles	VERSION NO: 1.0	QA/QC: CMP/LDB/RDB

Colonial Waterbirds
Area 4

5.3.5 WATERFOWL

5.3.5.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

5.3.5.1.1 SUMMARY OF SCIENTIFIC INFORMATION

The United States (US) Fish and Wildlife Service and Canadian Wildlife Service have conducted annual spring waterfowl breeding surveys in northern Manitoba since 1955. The surveys were initiated experimentally in 1947, and became operational and annual in 1955, providing information regarding spring population size and distribution for all indigenous duck species, as well as Canada geese. The data provide an extended time series for monitoring regional-scale trends in waterfowl populations and the relevant habitat, and are used to help establish hunting regulations in the United States and Canada (US Fish and Wildlife Service 2013). Area 1 is contained within the southwestern portion of Survey Strata 24 in the waterfowl breeding survey (US Fish and Wildlife Service 2004). Aerial survey data from 1955-2013 can be downloaded from the US Fish and Wildlife Service's Migratory Bird Data Center.

Townsend (1969) describes potential outcomes for waterfowl in Area 1 due to LWR. Unies Ltd. (1973) defined the probable effects on natural, physical processes (*i.e.*, shoreline erosion, lagoon inundation) and subsequently waterfowl habitat associated with Kiskittogisu Lake due to channel excavation required by LWR.

Aerial surveys were conducted in the area of Kiskittogisu Lake, and the Kiskittogisu River and associated lagoons to assess nesting and fall staging use by waterfowl and to predict the related effects of LWR (Rakowski 1975, 1976). Webb (1973) and Webb and Foster (1974) provide a summary of implications for waterfowl habitat in Area 1, and considerations of related mitigation and enhancement, associated with the proposed LWR. Webb (1973) also discusses the duck and goose harvest for the entire "game bird management unit no. 1", which encompasses most of the northern two-thirds of Manitoba, including Area 1.

Environment Canada initiated the Federal Ecological Monitoring Program in 1986 which included studies along the Churchill and Nelson rivers (McKerness 1989). Due to concerns expressed by resource harvesters regarding reduced opportunities for waterfowl hunting, the Canadian Wildlife Service undertook studies to address the communities' concerns (McKerness 1989).

Poston *et al.* (1990) include specific regions of northern Manitoba, defined by their physical attributes, in a comprehensive description of important habitats for migratory birds, including waterfowl.

Aerial surveys were conducted during 1986 and 1987 (Boothroyd 1990; Boothroyd and Schmidt 1991) and during 1992 (I.D. Systems Ltd. 1993) to assess fall staging use by waterfowl. The survey routes established in 1986 and 1987 followed the shorelines of Playgreen, Kiskitto, and Kiskittogisu lakes; 'control' segments were later added for the 1992 surveys. The additional segments included: Warren Landing to 8-Mile Channel, and along the eastern shore of the south basin from Warren Landing to Wightman Point (Playgreen Lake); the southeastern shore of Kiskittogisu Lake; and a loop from Kisipachewik Rapids and through the Ominawin Bypass Channel, connecting Playgreen, Kiskitto, and Kiskittogisu lakes (I.D. Systems Ltd. 1993).

Austin *et al.* (2000) and Austin *et al.* (2006) summarize issues of concern regarding lesser scaup and greater scaup, including potential factors contributing to their population decline, research and management needs, and delineation of where declines have occurred. The primary focus is the western Canadian boreal forest (which includes Area 1) where declines appear to be most pronounced. Alan and Anderson (2001) also examined long-term databases concerning scaup populations, and their related harvest statistics, to identify factors potentially limiting population growth.

Avian surveys were conducted in 2010 as part of the Bipole III EIS to describe the potential effects of the transmission line development on the environment. Mallard duck was selected as a valued environmental component (VEC) and its habitat was mapped along the proposed transmission line route (Manitoba Hydro 2011; Wildlife Resource Consulting Services MB Inc. 2011). Waterfowl fall staging surveys were conducted in portions of Area 1, and other surveys for colonial waterbirds, breeding birds, and raptors also recorded incidental observations of waterfowl in Area 1.

Data sources that may provide useful information in addition to those discussed above include the Manitoba Breeding Bird Atlas. The Atlas is a 5-year, scientifically-designed project initiated to assess the status, abundance and distribution of bird species that breed within Manitoba (Bird Studies Canada 2014). From 2010 to present, bird occurrence data has been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including within Area 1.

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Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	26-MAY-14
0 10 20 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: EGF/RDB

Legend

- 52 Reference Number
- Community
- Dam
- Generating Station (Existing)
- Highway
- Rail
- First Nation Reserve

Waterfowl
Area 1

5.3.5.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

5.3.5.2.1 SUMMARY OF SCIENTIFIC INFORMATION

The US Fish and Wildlife Service and Canadian Wildlife Service have conducted annual spring waterfowl breeding surveys in northern Manitoba since 1955. The surveys were initiated experimentally in 1947, and became operational and annual in 1955, providing information regarding spring population size and distribution for all indigenous duck species, as well as Canada geese. The data provide an extended time series for monitoring regional-scale trends in waterfowl populations and the relevant habitat, and are used to help establish hunting regulations in the United States and Canada (US Fish and Wildlife Service 2013). Area 2 is contained within the southwestern portion of Survey Strata 24 in the US Fish and Wildlife Service and Canadian Wildlife Service annual waterfowl breeding population survey (US Fish and Wildlife Service 2004). Aerial survey data from 1955-2013 can be downloaded from the US Fish and Wildlife's Migratory Bird Data Center.

Webb (1974) and Webb and Foster (1974) summarize the duck and goose harvest in "game bird management unit no. 1", which encompasses most of the northern two-thirds of Manitoba, including Area 2, stating that its harvest comprises a relatively small portion of the total in Manitoba. Briscoe (1975) examines use of salt marsh habitats by lesser snow geese in the Nelson and Hayes rivers' estuaries during 1974, prior to upstream alteration of Nelson River flows due to the CRD and operation of the Long Spruce GS.

Environment Canada initiated the Federal Ecological Monitoring Program in 1986 that included studies along the Churchill and Nelson rivers (McKerness 1989). Due to concerns expressed by resource harvesters regarding reduced opportunities for waterfowl hunting, the Canadian Wildlife Service undertook studies to address the communities' concerns (McKerness 1989).

Poston *et al.* (1990) include specific regions of northern Manitoba, defined by their physical attributes, in a comprehensive description of important habitats for migratory birds, including waterfowl.

Austin *et al.* (2000) and Austin *et al.* (2006) summarize issues of concern regarding lesser scaup and greater scaup, including potential factors contributing to their population decline, research and management needs, and delineation of where declines have occurred. The primary focus is the western Canadian boreal forest (which includes Area 2) where declines appear to be most pronounced. Alan and Anderson (2001) also examined long-term databases concerning scaup populations, and their related harvest statistics, to identify factors potentially limiting population growth.

Avian surveys were conducted as a component of the EIS for the proposed Keeyask Generation Project (Tetr*ES* Consultants Inc. 2005a, b, c, 2006a, 2007, 2008a), the Keeyask Transmission Project (Stantec Consultants Inc. 2012) and the EIS for the planned Conawapa Generating Station (Tetr*ES* Consultants Inc. 2005d, 2006b, 2008b, 2010a, b). Waterfowl observations (ducks and geese) are included in the studies' waterbird category.

Avian surveys were conducted in 2010 as part of the Bipole III Project to describe the potential effects of the transmission line development on the environment. Mallard duck was selected as a VEC and its habitat was mapped along the proposed transmission line route (Manitoba Hydro 2011; Wildlife

Resource Consulting Services MB Inc. 2011). Waterfowl fall staging surveys were conducted in portions of Area 2, and other surveys for colonial waterbirds, breeding birds, and raptors also recorded incidental observations of waterfowl in Area 2.

Data sources that may provide useful information in addition to those discussed above include the Manitoba Breeding Bird Atlas. The Atlas is a 5-year, scientifically-designed project initiated to assess the status, abundance and distribution of bird species that breed within Manitoba (Bird Studies Canada 2014). From 2010 to present, bird occurrence data has been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including within Area 2.

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Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	27-MAY-14
0 8.5 17 Kilometres / 0 7 14 Miles	VERSION NO: 1.0	QA/QC: EGF/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- First Nation Reserve

Waterfowl

Area 2

Map 5-49

5.3.5.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

5.3.5.3.1 SUMMARY OF SCIENTIFIC INFORMATION

The US Fish and Wildlife Service and Canadian Wildlife Service have conducted annual spring waterfowl breeding surveys in northern Manitoba since 1955. The surveys were initiated experimentally in 1947, and became operational and annual in 1955, providing information regarding spring population size and distribution for all indigenous duck species, as well as Canada geese. The data provide an extended time series for monitoring regional-scale trends in waterfowl populations and the relevant habitat, and are used to help establish hunting regulations in the United States and Canada (US Fish and Wildlife Service 2013). Southern Indian Lake, and the Rat and Burntwood rivers region is contained within the northwestern portion of Survey Strata 24 in the waterfowl breeding survey (US Fish and Wildlife Service 2004). Aerial survey data from 1955-2013 can be downloaded from the US Fish and Wildlife Service's Migratory Bird Data Center.

Webb (1974) and Webb and Foster (1974) provide a summary of implications for waterfowl habitat in the Southern Indian Lake area, and considerations of related mitigation, associated with the CRD. Webb (1974) also discusses the duck and goose harvest for the entire "game bird management unit no. 1", which encompasses most of the northern two-thirds of Manitoba, including the Southern Indian Lake and Rat and Burntwood rivers region.

Environment Canada initiated the federal ecological monitoring program in 1986 which conducted studies along the Churchill and Nelson rivers (McKerness 1989). Due to concerns expressed by resource harvesters regarding reduced opportunities for waterfowl hunting, the Canadian Wildlife Service undertook studies to address the communities' concerns (McKerness 1989). The Canadian Wildlife Service subsequently undertook studies to determine effects of development (McKerness 1989).

Poston *et al.* (1990) include specific regions of northern Manitoba, defined by their physical attributes, in a comprehensive description of important habitats for migratory birds, including waterfowl.

Aerial surveys were conducted in the Rat and Burntwood rivers system, including Wapisu, Threepoint, Footprint, Wuskwatim, and Honeymoon lakes, following completion of the CRD to assess fall staging use by waterfowl (I.D. Systems Ltd. 1991). The survey routes followed the shorelines of the Rat and Burntwood rivers, and the associated lakes, as well as the shoreline of Notakikwaywin Lake, included as a control or lake offset from the study area. The study also included key person interviews with several waterfowl hunters from Nelson House First Nation.

Austin *et al.* (2000) and Austin *et al.* (2006) summarize issues of concern regarding lesser scaup and greater scaup, including potential factors contributing to their population decline, research and management needs, and delineation of where declines have occurred. The primary focus is the western Canadian boreal forest (which includes the Southern Indian Lake, and Rat and Burntwood rivers system) where declines appear to be most pronounced. Alan and Anderson (2001) also examined long-term databases concerning scaup populations, and their related harvest statistics to identify factors potentially limiting population growth.

Avian surveys were conducted as part of the EIS and construction monitoring for the Wuskwatim Generation Project (Tetr*ES* Consultants Inc. 2003a, b, 2004, 2008, 2009; Stantec Consulting Ltd. 2011). Waterfowl observations (ducks and geese) are included in the studies' waterbird category. However, during the 2004 and subsequent study years, survey effort focused solely on the terrestrial landscape associated with the generating station's construction footprint, thereby reducing the likelihood of waterfowl observations.

Avian surveys were conducted as part of Bipole III EIS fieldwork in 2010 to describe the potential effects of the transmission project on the environment. Mallard was selected as a Valued Environmental Component and its habitat was mapped along the proposed transmission line route (Manitoba Hydro 2011; Wildlife Resource Consulting Services MB Inc. 2011). Waterfowl fall staging surveys were conducted which included portions of Area 3. Other surveys for colonial water birds, breeding birds, and raptors also recorded incidental observations of waterfowl occurring in Area 3.

Data sources that may provide useful information in addition to those discussed above include the Manitoba Breeding Bird Atlas. The Atlas is a 5-year, scientifically-designed project initiated to assess the status, abundance and distribution of bird species that breed within Manitoba (Bird Studies Canada 2014). From 2010 to present, bird occurrence data has been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including within Area 3.

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Legend

52 Reference Number

■ Towns/Cities ▲ Control Structure Highway First Nation Reserve

• Community Generating Station (Existing) Rail

Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
0 4 8 Kilometres 0 2 4 Miles	VERSION NO: 1.0	QA/QC: EGF/RDB

Waterfowl
Area 3

Map 5-50

5.3.5.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.3.5.4.1 SUMMARY OF SCIENTIFIC INFORMATION

The US Fish and Wildlife Service and Canadian Wildlife Service have conducted annual spring waterfowl breeding surveys in northern Manitoba since 1955. The surveys were initiated experimentally in 1947, and became operational and annual in 1955, providing information regarding spring population size and distribution for all indigenous duck species, as well as Canada geese. The data provide an extended time series for monitoring regional-scale trends in waterfowl populations and the relevant habitat, and are used to help establish hunting regulations in the United States and Canada (US Fish and Wildlife Service 2013). The lower Churchill River region is contained within the northern extent of Survey Strata 24 in the waterfowl breeding survey (US Fish and Wildlife Service 2004). Aerial survey data from 1955-2013 can be downloaded from the US Fish and Wildlife Service's Migratory Bird Data Center.

The general ecology of lesser snow geese in the Churchill region is described in Pakulak (1966). Pakulak (1968) conducted aerial surveys over the Utik, Dafoe, and Little Churchill rivers to identify habitat types associated with Canada goose spring staging areas. The nesting ecology of Canada geese in the Churchill region is described in Pakulak (1969), as well as in Pakulak and Schmidt (1970). Childress (1971) describes the general ecology of Canada geese in the Churchill River basin. Webb (1973) discusses the duck and goose harvest for the entire "game bird management unit no. 1", which encompasses the majority of the northern two-thirds of Manitoba, including Area 3. Webb and Foster (1974) provide a summary of implications for waterfowl habitat in the lower Churchill River area, and considerations for related mitigation, associated with the CRD.

Aerial surveys were conducted between 1969 and 1973 along the lower Churchill River to assess duck and Canada goose nesting, and contribute to a prediction of effects of the CRD on waterfowl use (Webb and Foster 1974; Cowan 1975; Raveling 1977). The study areas ranged between Missi Falls and Mountain Rapids, and the survey route included the four large basins in between – Partridge Breast, Northern Indian, Fidler, and Billard lakes. The surveys initially followed any creeks, rivers, lake shorelines, and wetlands encountered that appeared suitable for nesting Canada geese and other waterfowl. Cowan (1975) later established a series of transects that were used in his, as well as subsequent, surveys.

Malecki *et al.* (1980) conducted aerial surveys of the Hudson Bay coastal region (1972-77) to determine indices of spring breeding populations and distributions of the eastern prairie population Canada geese. MacLaren Plansearch Inc. (1984) describes the monitoring of Canada goose breeding populations along the lower Churchill River.

Environment Canada initiated the Federal Ecological Monitoring Program in 1986 that conducted studies along the Churchill and Nelson rivers (McKerness 1989). Due to concerns expressed by resource harvesters regarding reduced opportunities for waterfowl hunting, the Canadian Wildlife Service undertook studies to address the communities' concerns (McKerness 1989).

Following completion of the CRD, Boothroyd (1981, 1983, 1985) followed the transects established by Cowan (1975), and described effects of the CRD on waterfowl use along the lower Churchill River from the perspective of trends in duck and Canada goose densities, and nesting effort.

Jacques (1982) determined that LANDSAT imagery was an appropriate tool for monitoring habitat (*i.e.*, vegetation) change influenced by reductions in water level on the Churchill River after operation of the CRD. Jacques (1986) analysed LANDSAT imagery from 1981 and 1984 of Northern Indian and Fidler lakes, and the reach of the Churchill River between the two basins, to monitor vegetation succession and shifts in habitat quality for Canada geese.

Poston *et al.* (1990) include specific regions of northern Manitoba, defined by their physical attributes, in a comprehensive description of important habitats for migratory birds, including waterfowl. Francis (1999) developed a matrix-based population model to quantify the relative impact of spring versus autumn harvests on the population dynamics of lesser snow geese nesting in the salt areas of the Hudson Bay lowlands.

Austin *et al.* (2000) and Austin *et al.* (2006) summarize issues of concern regarding lesser scaup and greater scaup, including potential factors contributing to their population decline, research and management needs, and delineation of where declines have occurred. The primary focus is the western Canadian boreal forest (which includes Area 4) where declines appear to be most pronounced. Alan and Anderson (2001) also examined long-term databases concerning scaup populations, and their related harvest statistics to identify factors potentially limiting population growth.

Rockwell *et al.* (2009) provide an overview of bird species in Wapusk National Park, including many species of waterfowl. The information in this paper draws on 39 years of research (*i.e.*, literature summaries and surveys), and discusses habitat diversity, habitat issues, abundance and avifaunal trends for key species.

Data sources that may provide useful information in addition to those discussed above include the Manitoba Breeding Bird Atlas. The Atlas is a 5-year, scientifically-designed project initiated to assess the status, abundance and distribution of bird species that breed within Manitoba (Bird Studies Canada 2014). From 2010 to present, bird occurrence data has been collected within 10 km (6.2 mi) by 10 km (6.2 mi) survey squares throughout the province, including within Area 3.

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Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
0 10 20 30 Kilometres / 0 9 18 Miles	VERSION NO: 1.0	QA/QC: EGF/RDB

Legend

- 52 Reference Number
- ■ Towns/Cities
- ▲ Control Structure
- + Weir
- Rail
- First Nation Reserve

Waterfowl
Area 4

5.3.6 AQUATIC FURBEARERS

5.3.6.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

5.3.6.1.1 SUMMARY OF SCIENTIFIC INFORMATION

Population data for aquatic furbearers (*e.g.*, muskrat, beaver, mink, and otter) along the upper Nelson River and its lakes are very limited. The Manitoba Department of Mines and Natural Resources (1961) presents beaver lodge census data by trapping district for the period 1951-1961. The distribution and habitat requirements of furbearer species commonly trapped in the outlet lakes area were discussed generally as part of the work conducted by the LWCNR Study Board (Webb 1973). Prior to regulation, important areas in terms of shoreline habitat were identified in lower Playgreen Lake, Little Playgreen Lake, and Cross Lake for muskrat, the East Channel and Cross Lake for beaver, and the East and West channels, upper Playgreen Lake, and Cross Lake for mink. The Kiskitto Lake Regulation Committee (1977) discussed the potential impacts of a dyke and channel system constructed on Kiskitto Lake in 1973 to regulate water levels on the lake, in part, to enhance wildlife resources on the lake by reducing natural water level fluctuations. The Lake Winnipeg, Churchill and Nelson River Study Board (1975) did not include Sipiwesk Lake in their impact assessment as it had already been affected by development of the Kelsey GS. No baseline data were located for aquatic furbearer populations in the Sipiwesk Lake area that would have been affected by impoundment at the Kelsey GS.

As part of community resource allocation studies, the province reported on wildlife resources in the Cross Lake and Norway House areas in the late 1970s (Teillet *et al.* 1977, 1978), noting that muskrat, beaver, mink, and otter were among the most numerous furbearer species but that population estimates were not available.

A few studies have been undertaken to assess possible impacts of regulation on aquatic furbearers harvested by communities located along the upper Nelson River. A study of furbearer habitat was recommended in 1983 as part of the Manitoba Ecological Monitoring Program. MacLaren Plansearch Inc. (1986) reported that historic aerial photography and satellite data for shoreline areas of Playgreen Lake had been assembled; however, a subsequent progress report noted that this type of study was not pursued (MacLaren Plansearch Inc. 1989). As part of an impact assessment for Cross Lake, the Nelson River Group (1986) compared census data from pre-LWR (1950s) and post-LWR (1982) surveys of beaver lodges on 48 affected traplines along portions of the upper Nelson River. An impact assessment was conducted by MacKay *et al.* (1990) on the effects of hydroelectric development on the town of Wabowden, which included impacts to furbearer habitat on RTLs located near Sipiwesk and Duck lakes. In 1996, Manitoba Hydro and the Split Lake Cree conducted a joint assessment of the effects of hydroelectric development in the Split Lake Resource Management Area, which includes a portion of the upper Nelson River downstream of Sipiwesk Lake (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996).

Beaver were selected as a Valued Environmental Component for the environmental impact assessment for the Bipole III project (Manitoba Hydro 2011). Beaver habitat was modeled for the entire Bipole III study area and their sign were observed along the Bipole III route, a portion of which runs near Sipiwesk

Lake, as part of mammal tracking surveys and trail camera studies as well as incidentally during waterfowl surveys in 2010. Otherwise, no current information on furbearer populations was located.

Fur harvest records are available from Manitoba Conservation and Water Stewardship, but may not be complete for some areas. Although trapping records do exist for Manitoba, there is not a particularly close correlation in the amount of fur harvested and furbearer populations as trapping levels are often more closely related to current fur prices.

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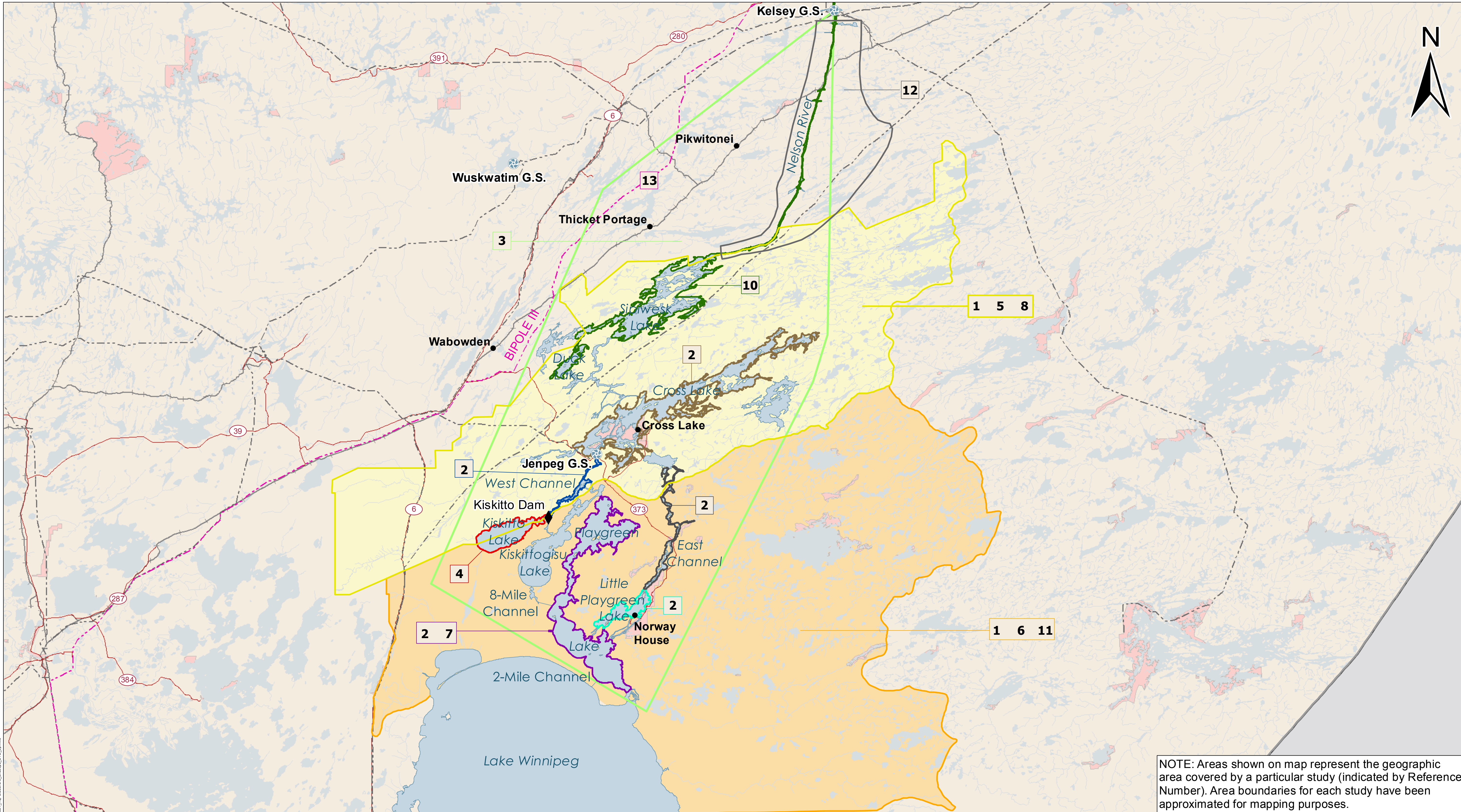

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
0 20 40 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

52 Reference Number
- Community
- Dam
- Generating Station (Existing)
- Highway
- Rail
- Transmission (Future)
- Transmission (Existing)
- First Nation Reserve

Aquatic Furbearers
Area 1

Map 5-52

5.3.6.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

5.3.6.2.1 SUMMARY OF SCIENTIFIC INFORMATION

There is a general lack of quantitative information pertaining to aquatic furbearer populations inhabiting the shoreline areas of the lower Nelson River and its associated waterbodies prior to LWR and CRD. The Manitoba Department of Mines and Natural Resources (1961) presents beaver lodge census data by trapping district for the period 1951-1961. The only study of wildlife resources in the area was conducted in 1974 and 1975 along the lower Nelson River and its tributaries to assess potential impacts of access roads and development of hydroelectric generating stations (Didiuk 1975). Muskrat were observed along the Weir River. Numerous beaver sign were observed on smaller creeks, less on larger tributaries, and none along the mainstem. The Lake Winnipeg, Churchill and Nelson Rivers Study Board (1975) did not undertake wildlife studies along the lower Nelson River.

A few studies have undertaken to assess possible impacts of CRD/LWR and other hydroelectric developments on aquatic furbearers along the lower Nelson River. A study of furbearer habitat was recommended in 1983 as part of the Manitoba Ecological Monitoring Program, which was conducted in response to NFA claim # 18. MacLaren Plansearch Inc. (1986) reported that historic aerial photography and satellite data for shoreline areas of Split Lake had been assembled; however, a subsequent progress report noted that this type of study was not pursued (MacLaren Plansearch Inc. 1989). As part of the environmental impact study for the Limestone GS, MacLaren Plansearch Inc. and InterGroup Consultants Ltd. (1986) identified project impacts to beaver and muskrat as well as recommendations for impact management (*e.g.*, monitoring, education, habitat enhancement). In 1989, an environmental evaluation was conducted on the effects of the augmented flow program on numerous environmental components, including wildlife such as beaver and mink, along the diversion route, up to and including Split Lake (Rempel *et al.* 1989). Manitoba Hydro and the Split Lake Cree conducted a joint assessment of the effects of hydroelectric development in 1996 on parameters including shoreline wildlife in the Split Lake Resource Management Area, which includes much of the lower Nelson River (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996). Aquatic furbearer habitat was one of the parameters considered as part of an assessment of potential impacts resulting from a change in operation of the Kettle GS in response to modifications made to the dam in 1996 (Manitoba Hydro 1998).

Aquatic furbearer populations have been monitored since 1988 as part of environmental studies conducted along the lower Nelson River and its lakes and tributaries by Manitoba Hydro; these studies are discussed separately by reach below.

Beaver and mink sign were recorded at transmission line crossings as part of field work conducted in 1992 for the impact assessment of upgrades to the distribution lines to Split Lake and York Landing (Manitoba Hydro 1992). From 2001 to 2004, mammal studies were conducted on Split Lake, Gull Lake and Stephens Lake in support of environmental studies for the Keeyask Generation Project (Patenaude and Berger 2004a, b; Patenaude *et al.* 2005; Kibbins and Berger 2007; Keeyask Hydropower Limited Partnership 2012) and its supporting infrastructure (Keeyask Hydropower Limited Partnership 2009). Muskrat were commonly observed on ponds and streams along the perimeter of inland lakes, but were rare to absent on the Nelson River, including Gull Lake. Ponds and streams in the reach between Kettle

GS and Kelsey GS provided important habitat to beaver, but densities were low. Mink and otter were common on the Nelson River shorelines, including Gull Lake, and were also common on lake shorelines in this reach. A habitat quality model was developed for beaver in the Keeyask project region (ECOSTEM Ltd. *et al.* 2013).

Aquatic furbearer populations along the lower Nelson River were monitored from 1988 to 1992 in support of environmental studies for the Conawapa Generation Project (Manitoba Hydro, *unpubl. data*) and supporting infrastructure (*e.g.*, construction transmission line [I.D. Systems 1990] and all-weather road [I.D. Systems Ltd. 1989]). Beaver and muskrat were common in the upper reaches of tributaries but not along the lower Nelson River mainstem. Furbearer population studies resumed in the Conawapa area starting in 2004. Aquatic furbearer sign (*e.g.*, muskrat push ups, beaver lodges, caches, dams, otter tracks) were recorded through transect and aerial surveys conducted to determine species presence, abundance, and distribution (Kibbins and Berger 2008; Ambrose and Berger 2012a, b; Ambrose *et al.* 2013).

TRANSMISSION

Beaver were selected as a Valued Environmental Component for the environmental impact assessment for the Bipole III Project (Joro Consultants Inc. and Wildlife Resource Consulting Services MB Inc. 2011). Beaver habitat was modeled for the entire Bipole III study area and their sign were observed along the proposed Bipole III route, a portion of which falls within Area 3, as part of mammal tracking surveys and trail camera studies. Beaver sign were also collected incidentally during waterfowl surveys conducted for the Bipole III Project in 2010. An aerial survey for beaver was conducted in fall 2009 and an aerial survey for muskrat was conducted in spring 2010 for the Keeyask Transmission Project (Wildlife Resource Consulting Services MB Inc. 2012).

DATA

Fur harvest records are available from Manitoba Conservation and Water Stewardship, but may not be complete for some areas. Although trapping records do exist for Manitoba, there is not a particularly close correlation in the amount of fur harvested and furbearer populations as trapping levels are often more closely related to current fur prices.

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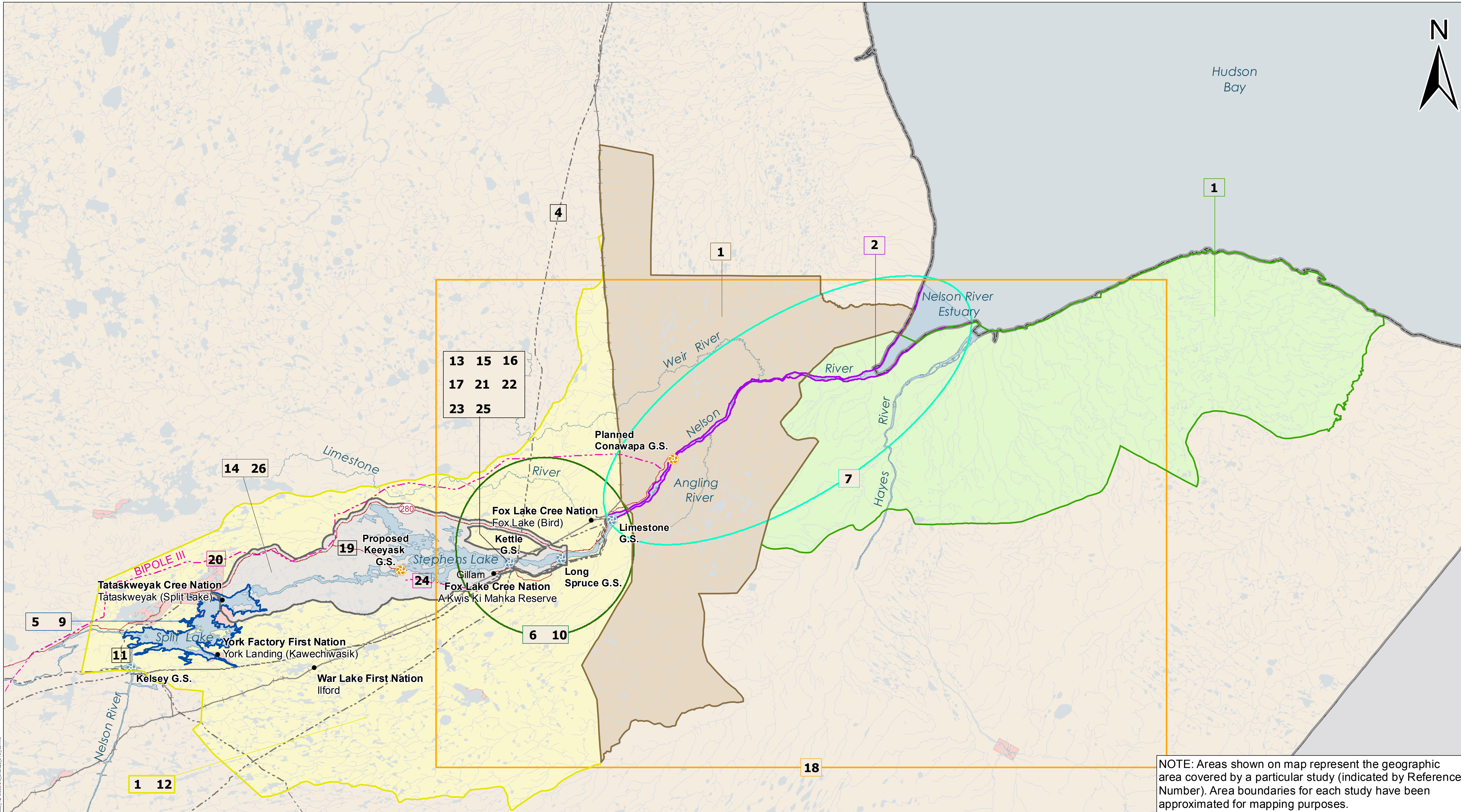

NOTE: Areas shown on map represent the geographic area covered by a particular study (indicated by Reference Number). Area boundaries for each study have been approximated for mapping purposes.

Manitoba Hydro

DATA SOURCE: Government of Manitoba; Government of Canada; Manitoba Hydro North/South Consultants

CREATED BY: North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	26-MAY-14

0 10 20 Kilometres
0 10 20 Miles

VERSION NO: 1.0
QA/QC: LDB/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

Aquatic Furbearers
Area 2

5.3.6.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

5.3.6.3.1 SUMMARY OF SCIENTIFIC INFORMATION

Population data for aquatic furbearers (*e.g.*, muskrat, beaver, mink, and otter) in Area 3 are limited. The Manitoba Department of Mines and Natural Resources (1961) presents beaver lodge census data by trapping district for the period 1951-1961. The first study in the area was conducted in 1954 to investigate the potential for improvements to muskrat production on the upper Rat River (Bryant 1954 cited in Goulden *et al.* 1968). Between 1966 and 1968, two studies were conducted to determine the effects of diversion on wildlife resources of South Indian Lake, Pukatawagan, and Nelson House (Goulden *et al.* 1968). Hamilton (c.1970) assessed the effects of diversion on aquatic furbearer along the diversion route. Riddle (1972) described wildlife observations during a canoe trip in 1971 from Issett Lake, downstream along the Rat and Burntwood rivers to Split Lake. As part of the Lake Winnipeg, Churchill and Nelson Rivers Study Board studies, the distribution and habitat requirements of species were generally discussed for the Southern Indian Lake area (Webb 1974) and the Rat-Burntwood rivers system (Webb and Foster 1974).

Several high level reviews have been undertaken to assess possible impacts of diversion on aquatic furbearers harvested by communities located along the diversion route. An impact assessment was conducted by Shawinigan Consultants Inc. *et al.* (1987) of the effects of the augmented flow program on Southern Indian Lake, which included a description of potential impacts to beaver and muskrat. In 1989, an environmental evaluation was conducted on the effects of the augmented flow program on numerous environmental components, including wildlife such beaver and mink, along the diversion route (Rempel *et al.* 1989). Manitoba Hydro and the Split Lake Cree conducted a joint assessment in 1996 of the effects of hydroelectric development in the Split Lake Resource Management Area, which includes a portion of the Burntwood River downstream of Apussigamasi Lake (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996).

Prior to development of the Wuskwatim Generation Project, Manitoba Hydro assessed effects of potential hydroelectric development options for a reach of the Burntwood River between Notigi and Split lakes on factors including furbearer resources (J.F. MacLaren Plansearch Inc. and InterGroup Consulting Economists Ltd. 1984). Information on aquatic furbearers used in the assessment included counts of beaver lodges from aerial surveys conducted during fall 1980. Starting in 2000, Manitoba Hydro and Nisichawayasihk Cree Nation have conducted shoreline habitat and aerial surveys for aquatic furbearer sign in order to establish baseline abundance and distribution information in the Wuskwatim project area as part of the licensing process for the Wuskwatim Generation Project (Manitoba Hydro and Nisichawayasihk Cree Nation 2003a; Berger and Blouw 2007; Blouw and Berger 2007a; Patenaude *et al.* 2007; Schmidt and Berger 2007). Peat islands in sheltered bays in Wuskwatim and Notigi lakes were reported to provide forage, cover, and burrow sites for muskrat in both summer and winter, and beaver were observed to be widespread and abundant from Notigi Lake, along the Burntwood River, and throughout Wuskwatim Lake (Patenaude *et al.* 2007). In addition, incidental observations of aquatic furbearers were reported as part of transect surveys conducted in 2004 and 2005 to determine mammal activity along the access road leading to the Wuskwatim generating station (Blouw and Berger 2007b). Habitat models were produced for beaver, muskrat, otter, and mink for the Wuskwatim Generation Project EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003a). Habitat models were also produced to assess the impacts of the Wuskwatim transmission lines on beaver, and trapping records for beaver, muskrat, river otter, and mink were listed as part of the Environmental Impact Statement for the Wuskwatim Transmission Project (Manitoba Hydro and Nisichawayasihk Cree Nation 2003b).

Wildlife encounters (including mink and otter) that occurred along the access road, in the camp, and near the Wuskwatim generating station during the construction period (2007-2009) were reported by Ambrose *et al.* (2011). Boat-based surveys to characterize beaver lodges/caches and shoreline habitat and aerial surveys to document aquatic furbearer sign have continued during the construction period (2009-2011) as part of the Wuskwatim Generation Project terrestrial effects monitoring program (Johnstone *et al.* 2010; Paillé and Berger 2010; Guay *et al.* 2012; Kelly *et al.* 2012). Monitoring will continue into the operations phase of the Wuskwatim project.

No current information on aquatic furbearer populations was located for the Southern Indian Lake or lower Burntwood River areas. Fur harvest records are available from Manitoba Conservation and Water Stewardship, but may not be complete for some areas. Although trapping records do exist for Manitoba, there is not a close correlation between the amount of fur harvested and furbearer populations, as trapping levels are often more closely related to current fur prices.

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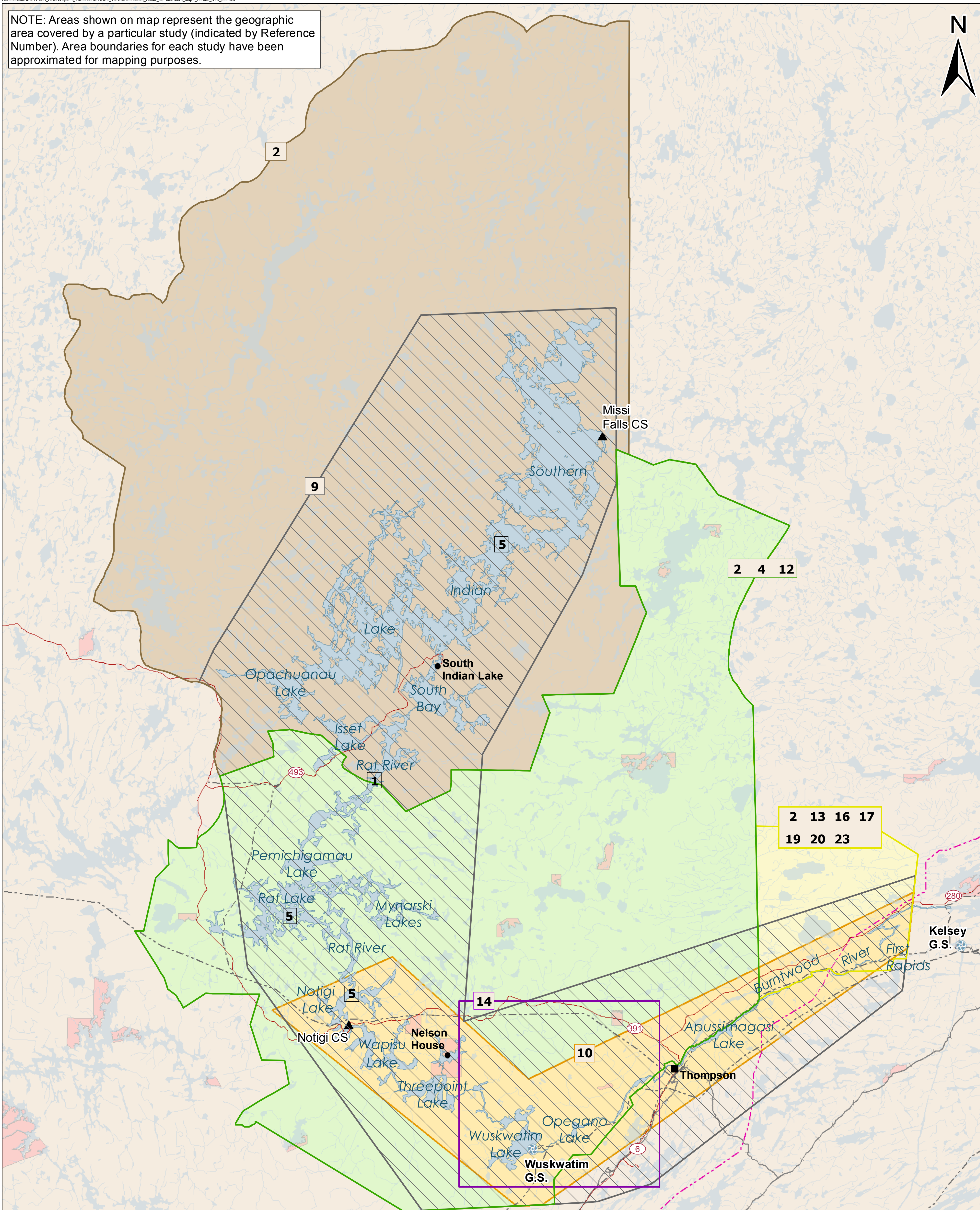


Legend

52	Reference Number						
■	Towns/Cities	▲	Control Structure		Transmission (Existing)		Highway		First Nation Reserve
●	Community		Generating Station (Existing)		Transmission (Future)		Rail

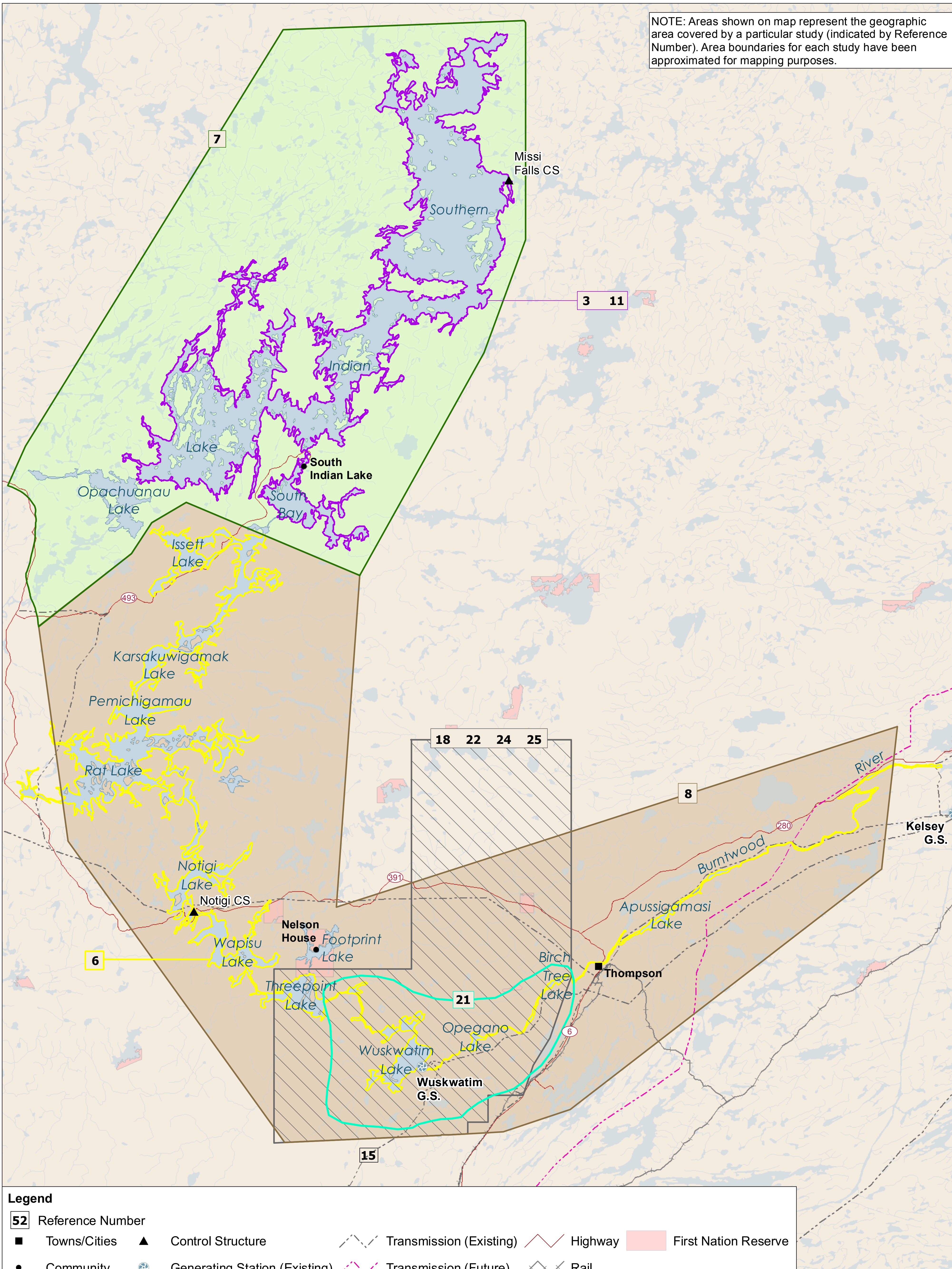
Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	26-MAY-14
0 4 8 Kilometres / 0 3 6 Miles	VERSION NO: 1.0	QA/QC: LDB/RDB

Aquatic Furbearers
Area 3 - Map 1



Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	26-MAY-14
0 4 8 Kilometres / 0 2 4 6 Miles	VERSION NO: 1.0	QA/QC: LDB/RDB

Aquatic Furbearers
Area 3 - Map 2

Map 5-54B

5.3.6.4 Area 4: Missi Falls Control Structure to the Churchill River estuary

5.3.6.4.1 Summary of Scientific Information

Population data for aquatic furbearers (*e.g.*, muskrat, beaver, mink, and otter) along the lower Churchill River and its lakes are very limited. The Manitoba Department of Mines and Natural Resources (1961) presents beaver lodge census data by trapping district for the period 1951-1961. In 1968, Goulden *et al.* evaluated the potential effects of diversion on the furbearer resources of Pukatawagan and Nelson House and conducted aerial surveys of wildlife habitat in the study area, including the lower Churchill River upstream of Fidler Lake. Hamilton (c.1970) assessed the effects of diversion on aquatic furbearer along the diversion route. As part of Lake Winnipeg, Churchill and Nelson Rivers Study Board studies, Webb and Foster (1974) reported that aquatic furbearer habitat was restricted mainly to shorelines of the lower Churchill River and lakes within the system and that the potential for furbearer production diminished downstream of Billard Lake. Several small streams entering the system had narrow bands of marsh vegetation but muskrat densities were expected to be low due to the stress of climatic extremes. Beaver lodges were observed in several of the streams and ponds draining into the lower Churchill River.

Information on aquatic furbearer populations was not collected after the CRD until 1995, as part of a water level enhancement weir project. Observations of mammals were recorded as part of helicopter and ground-based surveys conducted prior to weir construction (1995 to 1997) in the area of the Churchill River between Mosquito Point and Herriot Creek (Tetr*ES* 1996, 1997, 1998; Manitoba Hydro and the Town of Churchill 1997). Manitoba Hydro and the Split Lake Cree conducted a joint assessment on the effects of hydroelectric development on various environmental components, including shoreline wildlife, in the Split Lake Resource Management Area, which includes a portion of Area 3, along the lower Churchill River downstream of Partridge Breast Lake (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996).

No current information on aquatic furbearer populations was located for the lower Churchill River or its estuary. Fur harvest records are available from Manitoba Conservation and Water Stewardship, but may not be complete for some areas. Although trapping records do exist for Manitoba, there is not a close correlation between the amount of fur harvested and furbearer populations, as trapping levels are often more closely related to fur prices.

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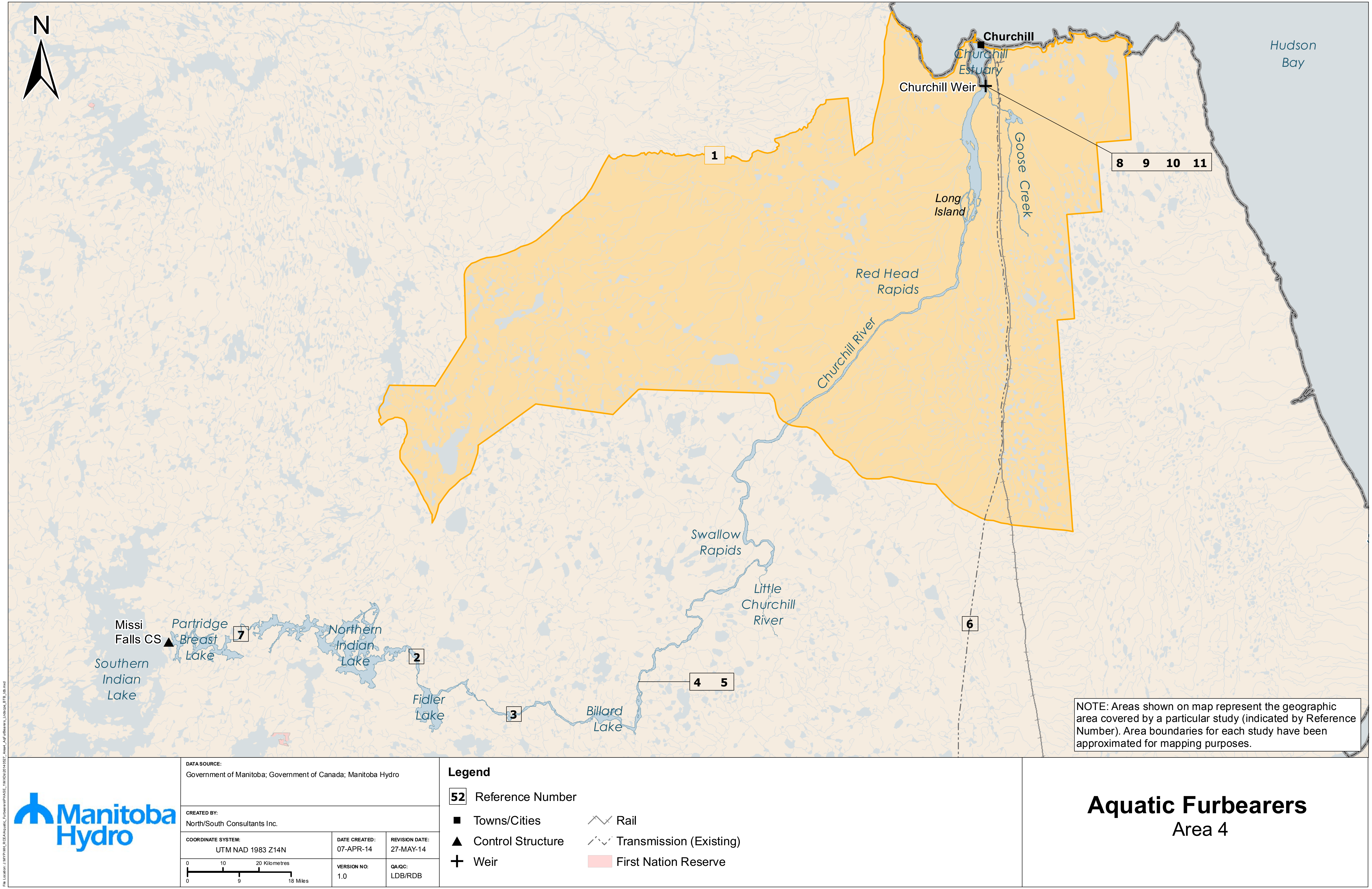
N
Churchill
Churchill Estuary
Churchill Weir
Hudson Bay
1
8 9 10 11
Goose Creek
Long Island
Red Head Rapids
Churchill River
Swallow Rapids
Little Churchill River
6
4 5
Missi Falls CS
Partridge Breast Lake
7
Northern Indian Lake
2
Southern Indian Lake
Fidler Lake
3
Billard Lake
NOTE: Areas shown on map represent the geographic area covered by a particular study (indicated by Reference Number). Area boundaries for each study have been approximated for mapping purposes.
Manitoba Hydro
DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
CREATED BY:
North/South Consultants Inc.
COORDINATE SYSTEM:
UTM NAD 1983 Z14N
DATE CREATED:
07-APR-14
REVISION DATE:
27-MAY-14
VERSION NO:
1.0
QA/QC:
LDB/RDB
0 10 20 Kilometres
0 9 18 Miles
Legend
52 Reference Number
Towns/Cities
Control Structure
Weir
Rail
Transmission (Existing)
First Nation Reserve
Aquatic Furbearers
Area 4

5.3.7 TERRESTRIAL FURBEARERS

5.3.7.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

5.3.7.1.1 SUMMARY OF SCIENTIFIC INFORMATION

Peer-reviewed population and habitat information for terrestrial furbearers from Area 1 was not found. Population data for terrestrial furbearers along the upper Nelson River and its lakes are very limited. The Registered Traplines Conference of Conservation Officers (Manitoba Department of Mines and Natural Resources 1950, 1951, 1952) provides annual trapping records of furbearers (*e.g.*, weasels, red squirrel, fox, striped skunk, gray wolf, lynx, and fisher) for Cross Lake. The Department of Mines, Resources, and Environmental Management (Thrall 1961) reports that the north central portion of Manitoba (*i.e.*, outlet lakes region) contains the most dense lynx population in Manitoba; it also provides annual gray wolf census numbers by Trapping District, and reports the size of 33 wolf populations and their locations in northern Manitoba in 1968 and 1969 (Harper 1968, 1969). However, population numbers were determined from the area covered by Conservation Officers and thus, may cover only a part of the true range of a wolf population, and/or may overlap with one or more other wolf ranges.

The distribution and habitat requirements of terrestrial furbearer species were generally discussed as part of the Lake Winnipeg Churchill and Nelson Rivers Study Board studies (Webb 1973). Prior to regulation of the fur industry, lynx were found throughout Area 1 with highest abundance in southern sections (van Zyll de Jong 1970 in Webb 1973). The importance of deciduous vegetation in the outlet lakes area to lynx prey (hares) and thus to lynx is noted, as is the presence of weasel, fox, red squirrel, American marten, and wolf. However, these terrestrial furbearer species accounted for only 9% of total annual fur harvest returns. Lynx fur harvest returns from 1966/67 to 1970/71 for RTLs in the outlet lakes area for Cross Lake and Norway House, as one of four most important harvested species besides aquatic furbearers (Webb 1973). The wildlife resource impact assessment for the outlet lakes area (F.F. Slaney & Company Limited 1973) notes that lynx, red squirrel, weasel, fox, marten, wolverine, and wolf are harvested in the outlet lakes region.

As part of community resource allocation studies, the province reported on wildlife resources in the Cross Lake and Norway House areas in the late 1970s (Teillet *et al.* 1977; Teillet 1978), noting that ermine, lynx, fisher and red squirrel are found in significant numbers in both areas though population estimates are not available. The resource information package for mid-north Manitoba (Teillet 1979) contains a list of mammals (in Appendix E) thought to or known to occur within the zone, including terrestrial furbearers, and whether they are found throughout, or only occur in a portion of, the "planning zone". Although population estimates are not reported, terrestrial furbearer fur production (lynx, ermine, red squirrel) data by RTL sections (*i.e.*, Pikwitonei, Thicket-Portage, Cross Lake, and Norway House) are presented as percent species composition of total zone harvest over a 15-year (1964-1977) period.

A few studies have been undertaken to assess possible impacts of regulation on furbearer harvested by communities along the upper Nelson River. A study of furbearer habitat was recommended in 1983 as part of the Manitoba Ecological Monitoring Program, which was conducted in response to Northern Flood Agreement Claim #18. MacLaren Plansearch Inc. (1986) reported that historic aerial photography and satellite data for shoreline areas of Playgreen Lake had been assembled. However, a subsequent progress report noted this type of study was not pursued (MacLaren Plansearch Inc. and InterGroup Consultants Ltd. 1986). As part of an impact assessment for Cross Lake, the community of Cross Lake estimated average fur harvest (including ermine, fisher, fox, and red squirrel) from their community trapline (RTL 56); however population estimates are not provided (Nelson River Group 1984). It was noted that as a community trapline, RTL 56 is utilized to a higher degree than other RTLs in Cross Lake. Two provincial reports (Johnson 1988, 1989) provide population estimates (production and trappers' estimates of how many animals are remaining on RTLs) for lynx between 1987 and 1999 and are broken down by Trapline Areas (*i.e.*, Norway House, Cross Lake, Wabowden, Thicket Portage, Pikwitonei).

An impact assessment was conducted by MacKay *et al.* (1990) on the effects of hydroelectric development on the town of Wabowden, which included impacts to furbearer habitat on RTLs located near Sipiwesk and Duck lakes. In 1996, a joint assessment was conducted on the effects of hydroelectric development in the Split Lake Resource Management Area, which includes a portion of the upper Nelson River, downstream of Sipiwesk Lake (Split Lake Cree-Manitoba Hydro Joint Studies Group 1996).

The Cross Lake harvest and consumption study-context report (McKerness 1997) contains lynx harvest rates from 1945/46 to 1993/94 in Cross Lake. Johnson (1990) contains wolverine pelt sales by trapline section from 1960 to 1989; however, no current information on terrestrial furbearer populations was reported. Although trapping records do exist for RTLs in Manitoba, there is not a particularly strong correlation between the amount of fur harvested and furbearer populations as trapping levels are often more closely related to current fur prices.

Observations of gray wolf, wolverine and American marten tracks and sightings were reported as part of aerial and ground surveys conducted in 2010 and 2011 across the Bipole III study area as part of boreal woodland caribou, moose and furbearer investigations in Area 1. Marten habitat was also modeled for the entire Bipole III study area (Joro Consultants Inc. and Wildlife Resource Consulting Services MB Inc. 2011; Joro Consultants Inc. 2011a, b). Global positioning system (GPS) collaring of wolves was also conducted as part of the Wuskwatim transmission project environmental monitoring program (boreal woodland caribou component) and the Bipole III environmental studies, providing distribution and population information on wolves (Joro Consultants Inc. 2011a, b; Manitoba Hydro 2011, 2012, 2013).

A two-year (2010-2012) pilot project to assess the effects of the Wuskwatim transmission line on furbearers and trapline harvest assessed abundance and distribution of terrestrial furbearers through trapping trials and small mammal monitoring along RTLs in the right-of-way area (Eagle Vision Resources and Joro Consultants Inc. 2011, 2012). Trail camera surveys and trapper observation of animal movement also indicated presence of various furbearers. Aerial gray wolf and wolverine track surveys along transects on the right-of-way (ROW) indicated the presence of both species.

Another data source that may provide useful information in addition to those discussed above is the Manitoba Conservation Data Centre. The Centre collects science-based information of variable quality and scale on Manitoba's plant communities and plant and animal species. It is part of the network of centres under Nature Serve.

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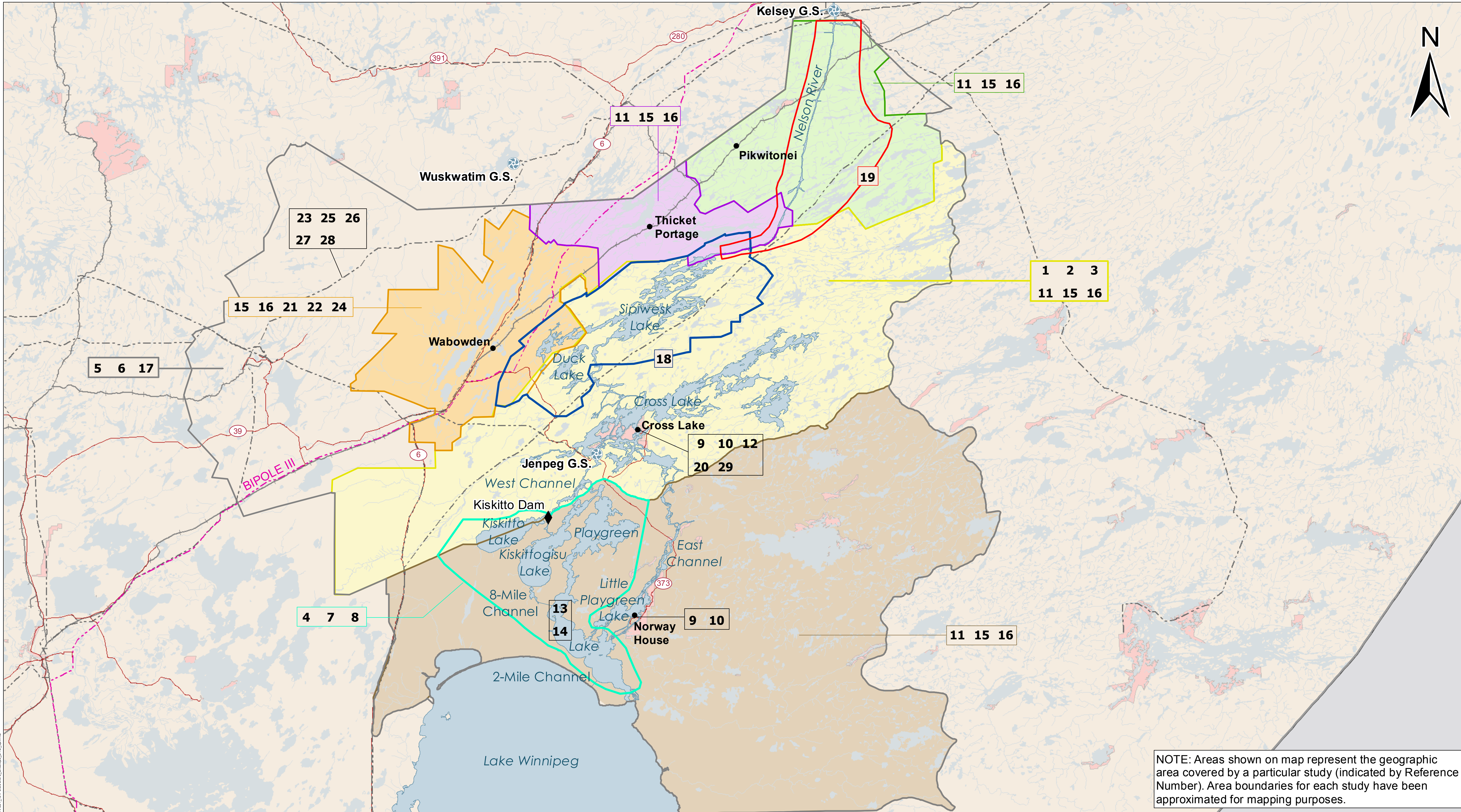

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
0 20 40 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Dam
- Generating Station (Existing)
- Highway
- Rail
- Transmission (Future)
- Transmission (Existing)
- First Nation Reserve

Terrestrial Furbearers
Area 1

5.3.7.2 Area 2: Split Lake Inlet to Nelson River Estuary

5.3.7.2.1 Summary of Scientific Information

Peer-reviewed population and habitat information for terrestrial furbearers from Area 2 was not found. There is a general lack of quantitative information pertaining to terrestrial furbearer populations inhabiting the lower Nelson River and its associated waterbodies prior to LWR/CRD. Thrall (1961) provides annual gray wolf census numbers by Trapping District, and reports the size of 33 wolf populations and their locations in northern Manitoba in 1968 and 1969 (Harper 1968, 1969). However, population numbers were determined from the area covered by Conservation Officers and thus, may cover only a part of the true range of a wolf population, and/or may overlap with one or more other wolf ranges.

The only study of wildlife resources in the area was conducted in 1974 and 1975 along the lower Nelson River and its tributaries to assess potential impacts of access roads and development of hydroelectric generating stations (Didiuk 1975). Black bear sign was observed at several locations along the Limestone River and many stream mouths flowing into the Nelson River, in the Gillam area, and at the mouth of and along the Weir River. Least and short-tail weasels occur regularly within the area, whereas American marten, fisher, and wolverine occur irregularly and in low numbers. Red fox and coyote were observed near Gillam and gray wolf tracks were observed along the coast near Marsh Point and Sam Creek. Lynx was not recorded. Red squirrel was recorded frequently. Lake Winnipeg, Churchill and Nelson Rivers Study Board (1975) notes that effects on furbearers in the lower Nelson River are expected to be minor.

A few studies have undertaken to assess possible impacts of CRD/LWR and other hydroelectric developments on furbearers along the lower Nelson River. A study of furbearer habitat was recommended in 1983 as part of the Manitoba Ecological Monitoring Program, which was conducted in response to Northern Flood Agreement Claim # 18. MacLaren Plansearch Inc. (1986) reported that historic aerial photography and satellite data for shoreline areas of Split Lake had been assembled; however, a subsequent progress report noted that this type of study was not pursued (MacLaren Plansearch Inc. and InterGroup Consultants Ltd. 1986). In 1989, an environmental evaluation was conducted on the effects of the augmented flow program on numerous components along the diversion route, up to and including Split Lake (Miles *et al.* 1989; Rempel *et al.* 1989).

Epstein Associates Inc. (1993) listed terrestrial furbearers and their densities as part of the North Central Project Route/Site Selection and Environmental Assessment. Habitat characteristics were described for these species and potential project effects were reported. The Split Lake Cree-Manitoba Hydro Joint Studies Group (1996) conducted an assessment of the effects of hydroelectric development on parameters including shoreline wildlife in the Split Lake Resource Management Area, which includes the lower Nelson River downstream to the estuary; however, the authors note a lack of sufficient wildlife population data. Terrestrial habitat was one of the parameters assessed as potential impacts resulting from a change in operation of the Kettle generating station in response to modifications made to the dam in 1996; however, no terrestrial impacts were identified (Manitoba Hydro 1998).

Furbearer populations along the lower Nelson River were monitored from 1988 to 1992 in support of initial environmental studies for the Conawapa Generation Project (Manitoba Hydro unpublished data) and supporting infrastructure (*e.g.*, all weather road in I.D. Systems Ltd. [1989]; and construction transmission line in I.D. Systems [1990]). Terrestrial furbearer sign were recorded at transmission line crossings as part of field work conducted in 1992 for the impact assessment of upgrades to the distribution lines to Split Lake and York Landing (Manitoba Hydro 1992). From 2001 to 2004, mammal studies were conducted on Split Lake, Gull Lake, and Stephens Lake in support of environmental studies for the licensing of the Keeyask Generation Project (Patenaude and Berger 2004a, b; Patenaude *et al.* 2005; Kibbins and Berger 2007; Keeyask Hydropower Limited Partnership 2012) and its supporting infrastructure (Keeyask Hydropower Limited Partnership 2009). Terrestrial furbearer species presence, distribution, and abundance are contained in these reports. Furbearer population studies were conducted in the Conawapa area starting in 2004. Mammal sign transect surveys were conducted annually to determine species presence, abundance, and distribution (Kibbins and Berger 2008; Ambrose and Berger 2012a, b; Ambrose *et al.* 2013).

Observations of terrestrial furbearers were reported as part of aerial surveys conducted in 2010 and 2011 for the assessment of alternative routes along the Bipole III Project from Gillam to Split Lake (Joro Consultants Inc. and Wildlife Resource Consulting Services MB Inc. 2011; Joro Consultants Inc. 2011a, b). American marten habitat was also modeled for the portion of the Bipole III Project within Area 2 (Joro Consultants Inc. and Wildlife Resource Consulting Services MB Inc. 2011).

Although trapping records do exist for RTLs in Manitoba, there is not a particularly strong correlation between the amount of fur harvested and furbearer populations as trapping levels are often more closely related to current fur prices. Another data sources that may provide useful information in addition to those discussed above is the Manitoba Conservation Data Centre. The Centre collects science-based information of variable quality and scale about Manitoba's plant communities and plant and animal species. It is part of the network of centres under NatureServe (NatureServe Canada 2014).

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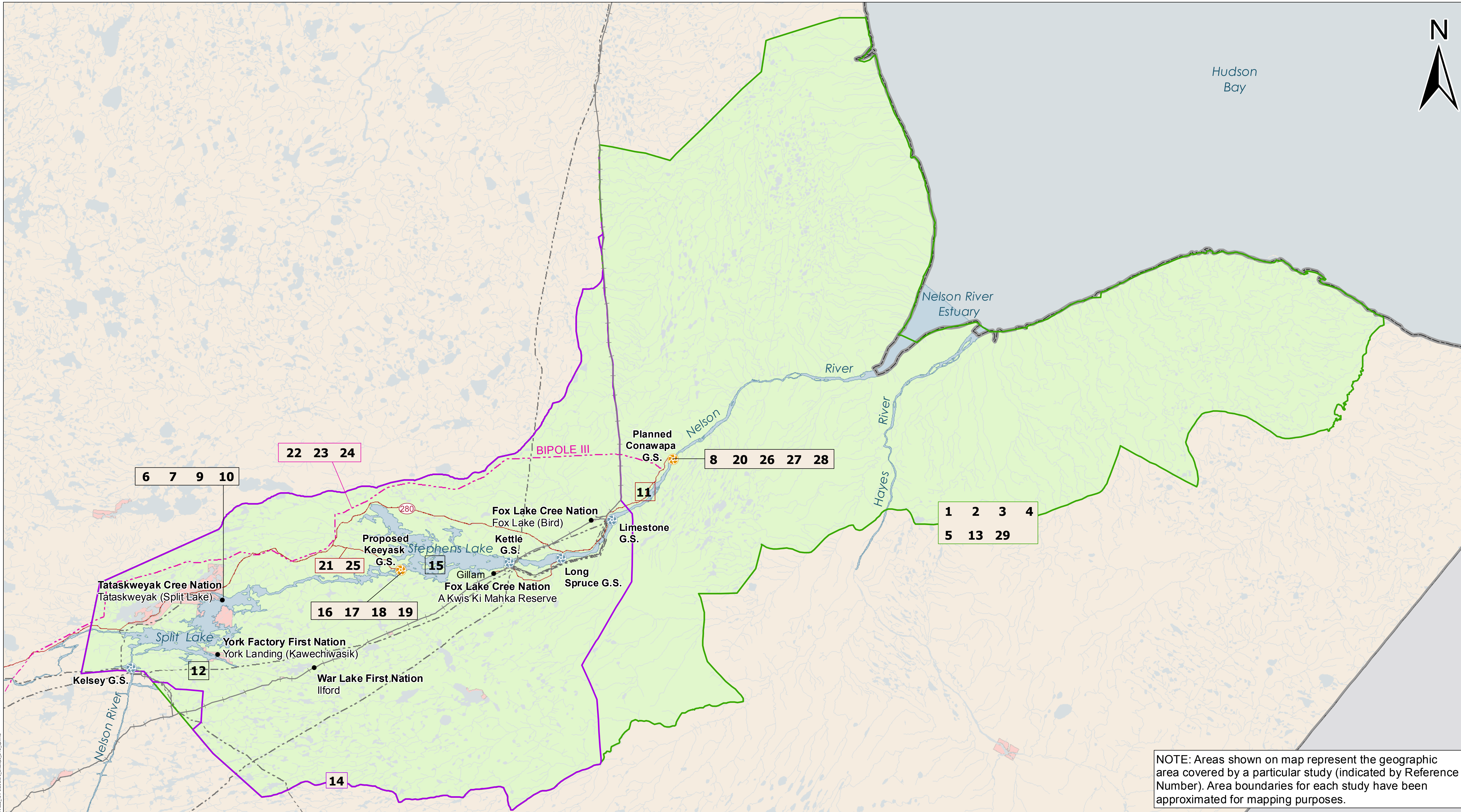

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	27-MAY-14
0 10 20 30 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

Terrestrial Furbearers
Area 2

5.3.7.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

5.3.7.3.1 SUMMARY OF SCIENTIFIC INFORMATION

Peer-reviewed population and habitat information for terrestrial furbearers from Area 3 was not found. Population data for terrestrial furbearers in Southern Indian Lake and along the diversion route are limited. The first study in the area was conducted in 1954 to investigate the potential for improvements to muskrat production on the upper Rat River (Bryant 1954 in Goulden *et al.* 1968). The Manitoba Department of Mines, Resources, and Environmental Management (Thrall 1961) provides annual gray wolf census numbers by Trapping District, and reports the size of 33 wolf populations and their locations in northern Manitoba in 1968 and 1969 (Harper 1968, 1969). However, population numbers were determined from the area covered by Conservation Officers and thus, may cover only a part of the true range of a wolf population, and/or may overlap with one or more other wolf ranges. Between 1966 and 1968, two studies were conducted to determine the effects of diversion on wildlife resources of South Indian Lake and Nelson House (Bryant 1966 in Goulden *et al.* 1968). Riddle (1972) described wildlife observations during a canoe trip in 1971 from Issett Lake, downstream along the Rat and Burntwood rivers to Split Lake. As part of the Lake Winnipeg Churchill and Nelson River Study Board (LWCNRSB) reports, the distribution and habitat requirements of furbearer species were generally discussed for the Southern Indian Lake area (Webb 1974) and the Rat-Burntwood river system (Webb and Foster 1974). The LWCNRSB (1975) noted that South Indian Lake residents trap lynx, wolverine, wolf, and red fox.

Prior to development of the Wuskwatim GS, Manitoba Hydro assessed effects of potential hydroelectric development options for a reach of the Burntwood River between Notigi and Split lakes on factors including furbearer resources, but not on terrestrial furbearers (MacLaren Engineers Inc. and InterGroup Consulting Economists Ltd. 1984). Information on terrestrial furbearers used in the assessment included an estimated carrying capacity of 0.2 lynx/mi^2 in areas to be affected by flooding. The estimate is derived from lynx population studies in northern Alberta by Nellis *et al.* (1972).

Several high level reviews have been undertaken to assess possible impacts of diversion on aquatic furbearers harvested by communities located along the diversion route, but not on terrestrial furbearers. An impact assessment was conducted by Shawinigan Consultants Inc. *et al.* (1987) of the effects of the augmented flow program on Southern Indian Lake, which included a description of potential impacts to beaver and muskrat but not to terrestrial furbearers. In 1989, an environmental evaluation was conducted on the effects of the augmented flow program on numerous components, including wildlife such as beaver and mink, but not terrestrial furbearers, along the diversion route (Rempel *et al.* 1989). Manitoba Hydro and the Split Lake Cree (1996) conducted a joint assessment of the effects of hydroelectric development in the Split Lake Resource Management Area, which includes a portion of the Burntwood River downstream of Apussigamasi Lake, though the authors note a lack of wildlife population data.

Data collected for mammal investigations for the Wuskwatim Transmission Line EIS (Tetr*ES* 2003) and the Wuskwatim GS EIS (Blouw and Berger 2007a, b; Patenaude *et al.* 2007; Schmidt and Berger 2007), were used to produce habitat use indices and habitat quality and distribution maps for upland mammal species, including terrestrial furbearers (Manitoba Hydro and Nisichawayasihk Cree Nation 2003).

Incidental observations of terrestrial furbearers were reported as part of transect surveys conducted in 2004 and 2005 to determine mammal activity along the proposed access road leading to the Wuskwatim GS (Blouw and Berger 2007c). Gray wolf and black bear ground sign abundances were reported from the pre-construction (2004-2006) and construction (2007-2009) periods of the Wuskwatim GS (Ambrose *et al.* 2011). Wildlife encounters (*e.g.*, fox, gray wolf, and black bear) that occurred during the construction period along the road, camp, and generating station during the construction period are also reported in Ambrose *et al.* (2011).

Observations of terrestrial furbearers were reported as part of aerial surveys conducted in 2010 and 2011 for the assessment of alternative routes and specific surveys along the Bipole III Project including southern portions of Area 3 (Joro Consultants Inc. and Wildlife Resource Consulting Services MB Inc. 2011; Joro Consultants Inc. 2011a, b). GPS collaring of gray wolf was also conducted as part of the Wuskwatim Transmission Project Environmental Monitoring Program (boreal woodland caribou component) and the Bipole III Transmission SSEA (Manitoba Hydro 2011, 2012, 2013; Joro Consultants Inc. 2011a, b). Data from collared wolves fall within Area 3. A list of terrestrial furbearers photographed during monitoring studies for the Wuskwatim transmission line was reported in 2012 (Wildlife Resource Consulting Services MB Inc. 2012).

No current information on terrestrial furbearer populations was located for the Southern Indian Lake or lower Burntwood River areas. Although trapping records do exist for Manitoba, there is not a particularly close correlation between the amount of fur harvested and furbearer populations, as trapping levels are often more closely related to current fur prices. Another data source that may provide useful information in addition to those discussed above is the Manitoba Conservation Data Centre. The Centre collects science-based information of variable quality and scale about Manitoba's plant communities and plant and animal species. It is part of the network of centres under NatureServe (Nature Serve Canada 2014).

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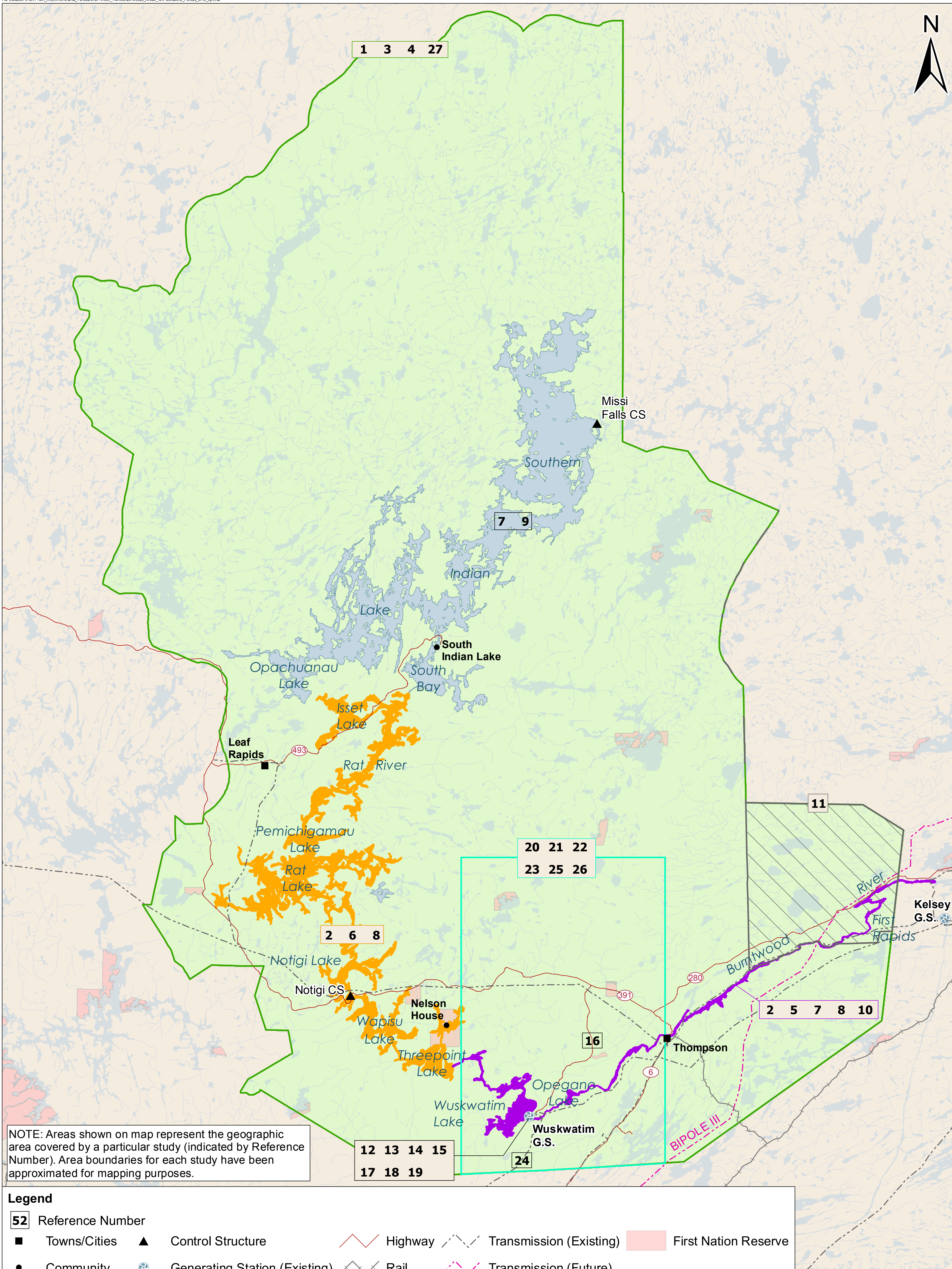

Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro; North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	28-MAY-14
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Terrestrial Furbearers
Area 3

5.3.7.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.3.7.4.1 SUMMARY OF SCIENTIFIC INFORMATION

Peer-reviewed population and habitat information for terrestrial furbearers from Area 4 was not found. Population data for terrestrial furbearers along the lower Churchill River and its lakes are very limited. The pre-CRD data that exists on aquatic furbearers along the Churchill River is mostly qualitative in nature. The Manitoba Department of Mines, Resources, and Environmental Management (Thrall 1961) provides annual gray wolf census numbers by Trapping District, and reports the size of 33 wolf populations and their locations in northern Manitoba in 1968 and 1969 (Harper 1968, 1969). However, population numbers were determined from the area covered by Conservation Officers and thus, may cover only a part of the true range of a wolf population, and/or may overlap with one or more other wolf ranges. In 1968, Goulden *et al.* predicted the effects of diversion on furbearer resources of Nelson House and conducted aerial surveys of wildlife habitat in Area 4, including the lower Churchill River upstream of Fidler Lake. As part of the Lake Winnipeg, Churchill and Nelson River Study Board (LWCNRSB) studies, Webb and Foster (1974) reported that the potential for furbearer production diminished downstream of Billard Lake. The LWCNRSB (1975) noted that the lower Churchill has a small furbearer population. The results of a questionnaire on domestic harvesting indicated in which domestic survey areas (Estuary, Morrier Island, Goose Creek, Long Island, and Upper Churchill River) terrestrial furbearers were harvested prior to 1976 (North/South Consultants Inc. 1996).

Information on furbearer populations was not collected after diversion until 1995, as part of a water level enhancement weir project. Observations of mammals were recorded as part of helicopter and ground-based surveys conducted prior to weir construction (1995 to 1997) in the area of the Churchill River between Mosquito Point and Herriot Creek (Tetr*ES* 1996, 1997, 1998; Manitoba Hydro and the Town of Churchill 1997). The Split Lake Cree-Manitoba Hydro Joint Studies Group (1996) conducted a joint assessment of the effects of hydroelectric development on various components, including shoreline wildlife, in the Split Lake Resource Management Area, which includes a portion of the lower Churchill River downstream of Partridge Breast Lake.

Limited observations of terrestrial furbearers were reported as part of aerial surveys conducted in 2010 and 2011 for the assessment of alternative routes and specific surveys along the Bipole III Project , including southern portions of Area 4 (Joro Consultants Inc. 2011a, b; Joro Consultants Inc. and Wildlife Resource Consulting Services MB Inc. 2011).

No current information on terrestrial furbearer populations was located for the lower Churchill River or its estuary. Although trapping records do exist for Manitoba, there is not a particularly close correlation between the amount of fur harvested and furbearer populations, as trapping levels are often more closely related to current fur prices. Another data source that may provide useful information in addition to those discussed above is the Manitoba Conservation Data Centre. The Centre collects science-based information of variable quality and scale about Manitoba's plant communities and plant and animal species. It is part of the network of centres under NatureServe (NatureServe Canada 2014).

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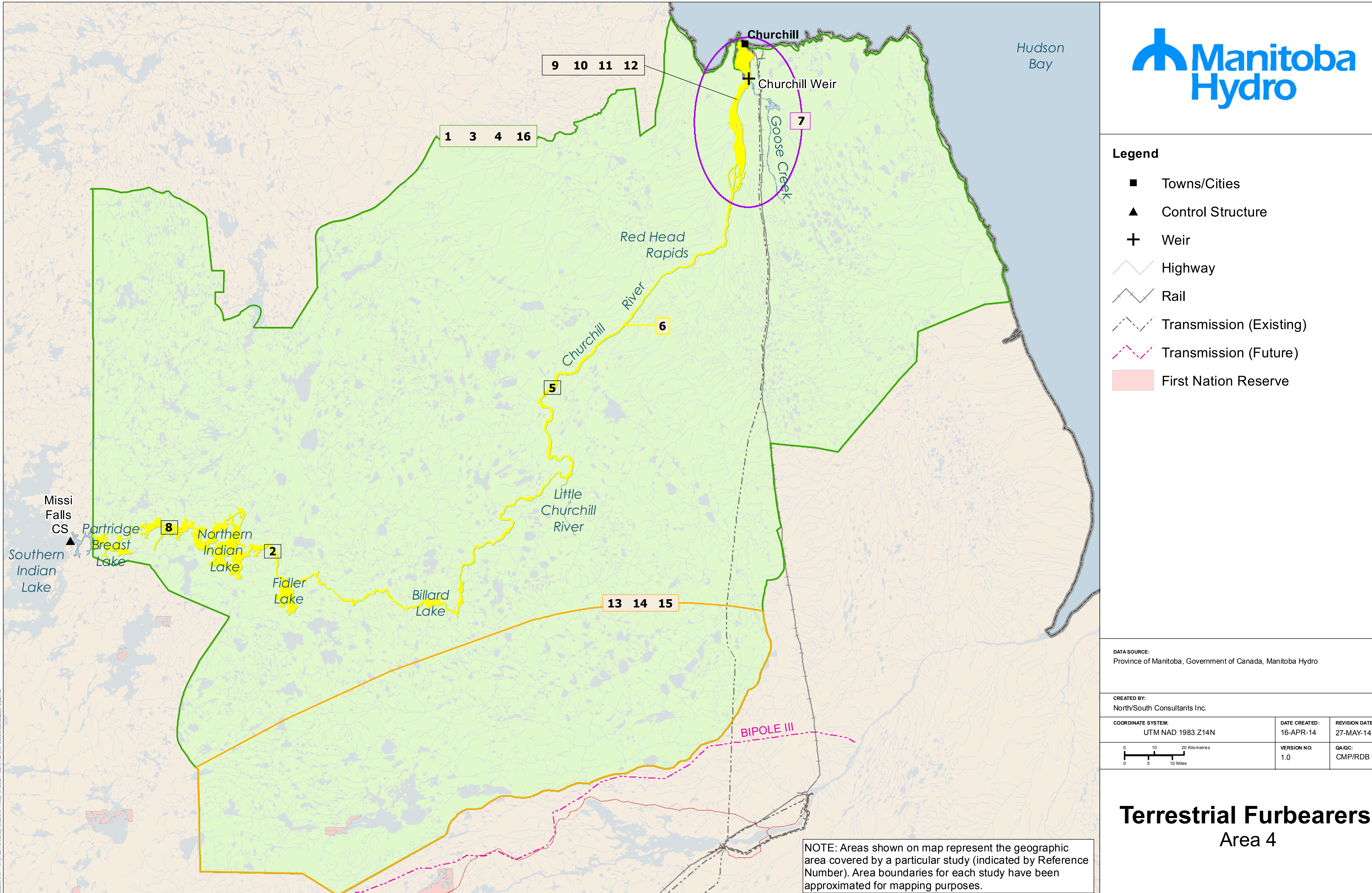

Terrestrial Furbearers

Area 4

5.3.8 MOOSE (*ALCES ALCES*)

5.3.8.1 AREA 1: LAKE WINNIPEG OUTLET TO SPLIT LAKE INLET

5.3.8.1.1 SUMMARY OF SCIENTIFIC INFORMATION

Moose densities in the area between Lake Winnipeg and Split Lake were estimated by Bryant (1955) as part of his study of moose populations north of 53°N in Manitoba. He reviewed the historical literature from the earliest days of the fur trade in Hudson Bay, determining the locations and details of references to moose and moose hunting. He also used first-hand reports of moose abundance from trappers and natural resource managers, and his own observations. His thesis includes a map of northern Manitoba which shows his estimates of moose densities derived from accumulated moose numbers for individual registered traplines. Bryant's data appear to be the only extensive quantitative estimates of moose densities in northern Manitoba before northern hydropower projects. They will be used as a baseline with which subsequent moose populations in the Region of Interest can be compared.

Didiuk (1975) reported on the general absence of more recent abundance data for moose in Area 1. He provided qualitative estimates of moose abundance, as well as the status of suitable habitat. Knudsen and Didiuk (1985) conducted an aerial survey of moose within the Cross Lake and Norway House RTL sections (also included in Elliott 1988). The boundaries of their study area (approximately 30,000 km^2 [11,583 mi^2]) correspond reasonably well with Area 1. Their data on abundance and distribution in different habitat types (based on LANDSAT data in Bowles *et al.* 1984) provide useful assistance in interpreting other data, in this and other areas.

Elliott and Hedman (2001) report on an aerial survey of moose in Game Hunting Areas (GHAs) 9 and 9A. Their survey included much of Area 1. They relate moose density in the broader region of northeastern Manitoba to fire history and forestry activities, which will be important in assessing the cumulative effects of hydropower development. A map of fires in all four areas (including Area 1) is included in Elliott and Hedman (2001).

MacKay *et al.* (1990) placed the status of moose in Area 1 in an economic context, with specific reference to the impact on Wabowden.

Moose sampling also occurred as part of the monitoring work that was conducted for the Wuskwatim Transmission Line by Manitoba Hydro. These surveys were carried out in proximity to the transmission line ROW and involved the use of ground tracking and trail camera studies. The monitoring compared the distribution of moose in proximity to the transmission line ROW over time (Manitoba Hydro 2009, 2010a, 2010b, 2011; Wildlife Resource Consulting Services MB Inc. 2012). The use of the ROWs by predators was also monitored.

Manitoba Hydro also sampled moose in 2010 and 2011 along the extent of the proposed Bipole III transmission line route. A variety of methods were employed, including aerial block surveys, multi-species aerial transect surveys, and trail camera surveys (Joro Consultants Inc. and Wildlife Resource Consulting Services MB Inc. 2011). Other work included the identification of, and an estimation of quantities of high quality moose habitat areas along the extent of the Bipole III transmission line route. White-tailed deer were also monitored to address concerns regarding their use of the transmission ROW for moving into more northern areas.

Manitoba Conservation has unpublished data from moose harvest statistics ranging from 1993 to 2007 in all GHAs, and from 1982 (age and sex), 2013 and 2014 aerial surveys of moose in GHA 9A, which may become available. Aerial moose survey data (age and sex) for GHAs 7 and 7a are available from 1973-1986.

Because there are many factors which influence the abundance and distribution of moose, it will be important to consider literature from other locations when assessing the impact of hydroelectric development. These sources, from within Manitoba and elsewhere, will provide a context for local data. For example, Scaife (1980) provides some insight into the impact of forestry and Crichton (1981) provides comparative data on abundance of moose in other areas of Manitoba. Fire history data are also available from 1928 to present and provide some opportunity to assess the spatial and temporal distribution of moose through time.

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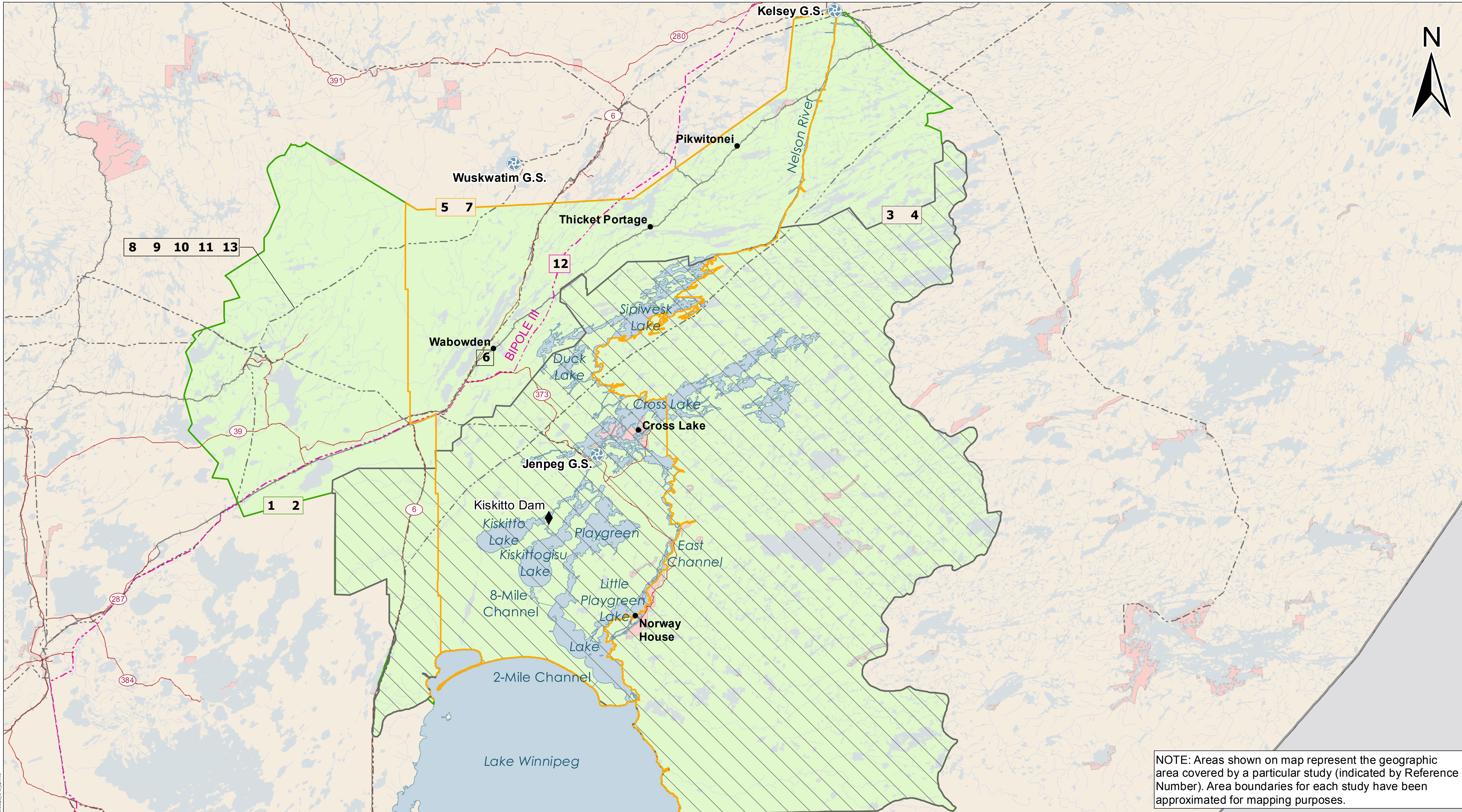

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	26-MAY-14
0 20 40 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Dam
- Generating Station (Existing)
- Highway
- Rail
- Transmission (Future)
- Transmission (Existing)
- First Nation Reserve

Moose
Area 1

5.3.8.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

5.3.8.2.1 SUMMARY OF SCIENTIFIC INFORMATION

Moose densities in the area between Lake Winnipeg and Split Lake were estimated by Bryant (1955) as part of his study of moose populations north of 53°N in Manitoba. He reviewed the historical literature from the earliest days of the fur trade in Hudson Bay, determining the locations and details of references to moose and moose hunting. He also used first-hand reports of moose abundance from trappers and natural resource managers, and his own observations. His thesis includes a map of northern Manitoba which shows his estimates of moose densities derived from accumulated moose numbers for individual registered traplines. Bryant's data appear to be the only extensive quantitative estimates of moose densities in northern Manitoba before northern hydropower projects. They will be used in the Region of Interest as a baseline with which subsequent moose populations can be compared.

Elliot (1988) reported on aerial surveys of moose from 1983 to 1985 in northern Manitoba. One of his study areas covered much of the Split Lake RTL section, including the Split Lake and Stephens Lake areas. He provides habitat-specific densities and herd composition.

The status of moose in the western half of the study area, as of 1993 and 1994 was summarized in a moose management plan (Split Lake Resource Management Board 1995). Abundance, distribution and composition are summarized, and recommendations made for sustainable harvests.

Elliott and Hedman (2001) report on an aerial survey of moose in Game Hunting Areas (GHAs) 9 and 9A. Their GHA 9 data included the area around Split Lake and Stephens Lake, and the areas just north of those lakes within Area 2. They relate moose density in the broader region of northeastern Manitoba to fire history and forestry activities, which will be important in assessing the cumulative effects of hydroelectric development. A map of fires in all four study areas (including Area 2) between 1980 and 1997 is included in Elliott and Hedman (2001).

A number of recent studies provide an ongoing record of moose presence and distribution within the study area: Elliott (1989a, b), Patenaude and Berger (2004a, b), Patenaude *et al.* (2005), Kibbins and Berger (2007, 2008), Ambrose and Berger (2008, 2012a, b), and Ambrose *et al.* (2013). These studies provide valuable information on variation between years of data such as track counts, which are the main variable used in stratification of aerial survey sampling.

Knudsen *et al.* (2010) conducted an aerial survey of the Split Lake Resource Management Area (RMA) during 2009 and 2010. The southern portions of this survey provide distribution, abundance and composition data for the moose population in the western half of Area 2. These data were used in the development of a Moose Harvest Sustainability Plan for the Split Lake RMA by the Cree Nation Partners (Cree Nation Partners 2013). Comparable data for the eastern half of the study area were gathered in an aerial survey of the Fox Lake RMA, which was conducted in 2013 (Knudsen and Berger 2014).

Manitoba Hydro also sampled moose along the extent of the Bipole III proposed transmission line route utilizing different methods, including aerial block surveys, multi-species aerial transect surveys, and trail camera surveys (Joro Consultants Inc. and Wildlife Resource Consulting Services MB Inc. 2011). Surveys were conducted in 2010 and 2011.Other work included the identification and estimation of quantities of high quality moose habitat areas along the extent of the Bipole III transmission line route. White-tailed deer were also monitored due to their potential use of the transmission line right-of way to move northward.

Manitoba Conservation has unpublished data from licensed moose harvest statistics ranging from 1993 to 2007 in all GHAs, and from 2013 and 2014 aerial surveys of moose in GHA 9A, which may become available. Rights-based moose harvest information is currently available for the Split Lake RMA; however, statistics beyond the Split Lake RMA, yet within Area 2, are not well known (Cree Nation Partners 2013).

Because there are many factors which influence the abundance and distribution of moose, it will be important to consider literature from other locations when assessing the impact of hydroelectric development. These sources, from within Manitoba and from elsewhere, will provide a context for local data. For example, Scaife (1980) provides some insight into the impact of forestry, and Crichton (1981) provides comparative data on abundance of moose in other areas of Manitoba. Available fire history data provide some opportunity to assess the spatial and temporal distribution of moose through time.

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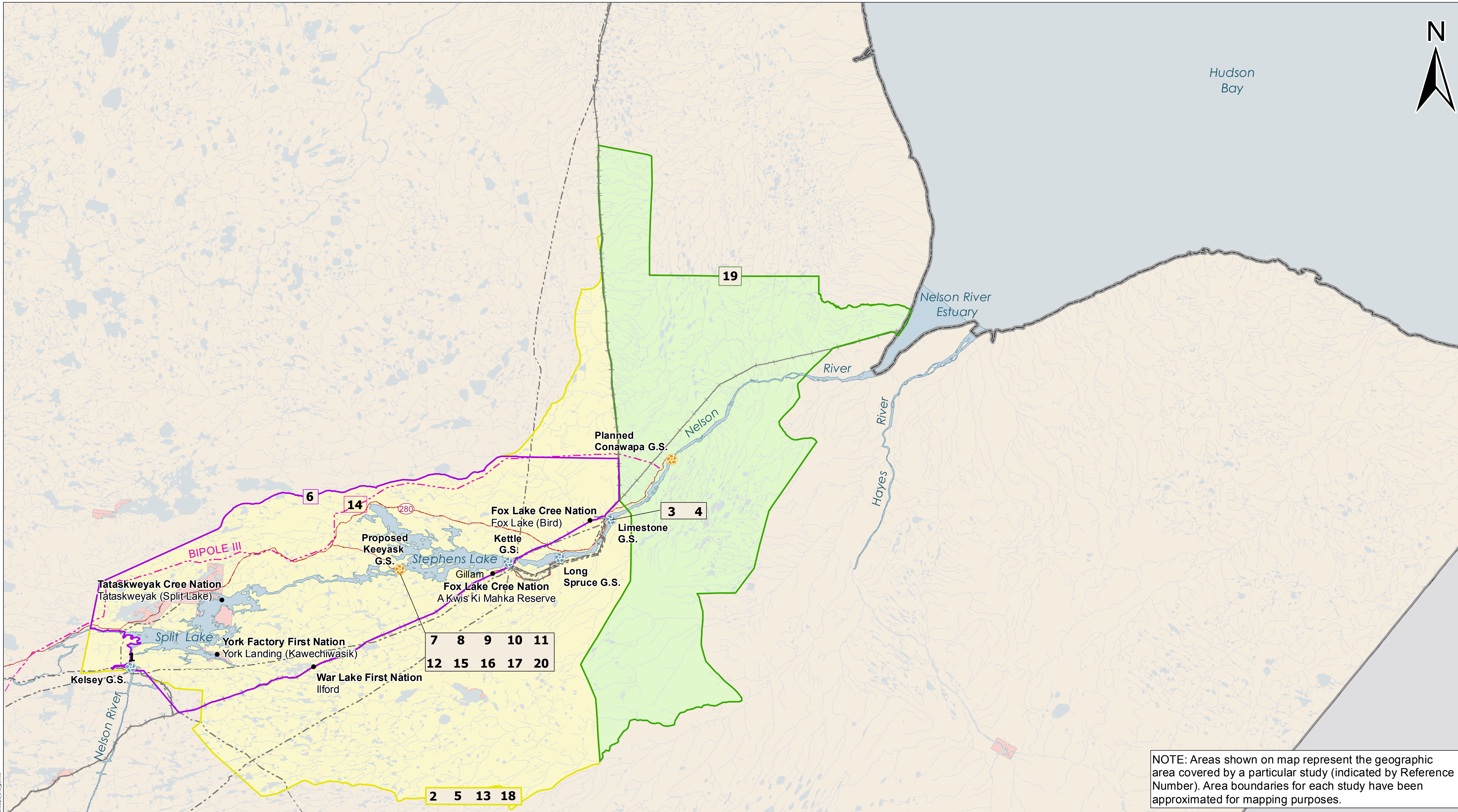

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro
North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	27-MAY-14
0 10 20 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

Moose
Area 2

Map 5-61

5.3.8.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

5.3.8.3.1 SUMMARY OF SCIENTIFIC INFORMATION

Moose densities in the Southern Indian Lake and Rat River areas were estimated by Bryant (1955) as part of his study of moose populations north of 53°N in Manitoba. He reviewed the historical literature from the earliest days of the fur trade in Hudson Bay, determining the locations and details of references to moose and moose hunting. He also used first-hand reports of moose abundance from trappers and natural resource managers, and his own observations. His thesis includes a map of northern Manitoba which shows his estimates of moose densities derived from accumulated moose numbers for individual registered traplines. Bryant's data appear to be the only extensive quantitative estimates of moose densities in northern Manitoba before northern hydroelectric projects. They will be used in the Region of Interest as a baseline with which subsequent moose populations can be compared.

Goulden *et al.* (1968) provide qualitative estimates of moose densities in the Southern Indian Lake area.

Elliot (1985, 1988) reported on aerial surveys of moose from 1983 to 1985 in northern Manitoba. Two of his study areas cover Area 3. As with other study areas, he provides habitat-specific densities and herd composition.

Elliott and Hedman (2001) report on an aerial survey of moose in Game Hunting Areas 9 and 9A. The eastern portion of Game Hunting Area 9 includes Southern Indian Lake and the Rat River and Burntwood River, within Area 3. The report relates moose density in the broader region of northeastern Manitoba to fire history and forestry activities, which will be important in assessing the cumulative effects of hydroelectric development. A map of fires in all four study areas between 1980 and 1997 (including Area 3) is included in Elliott and Hedman (2001). To some extent, the unpublished moose harvest statistics could assist in demonstrating the relative change in moose harvest based on the expansion of anthropogenic activities and in relation to pressures faced by populations in various game hunting areas.

As in Area 2, a number of recent studies provide an ongoing record of moose presence and distribution within the study area: Berger and Blouw (2007), Blouw and Berger (2007a, b), Patenaude *et al.* (2007), Schmidt and Berger (2007), Ambrose *et al.* (2008), Berger and Armstrong (2009), Ambrose *et al.* (2011), Manitoba Hydro (2011), and Hettinga and Berger (2012). These studies provide valuable information on variation between years of data such as track counts, which are the main variable used in stratification of aerial survey sampling. As part of the Wuskwatim Generation Project EIS, the sampling of moose occurred through aerial ungulate surveys, conducted in 2001 and 2002, as well as based on fall/winter tracking surveys, conducted in 2000-2002 (Manitoba Hydro and Nisichawayasihk Cree Nation 2003a, b). Subsequent ground tracking and trail camera surveys of ungulate species were conducted in 2008-2012 through monitoring work conducted for the Wuskwatim Transmission Project (Manitoba Hydro 2009, 2010, 2011, and Wildlife Resource Consulting Services MB Inc. 2012).

Manitoba Hydro also sampled moose along the extent of the proposed Bipole III transmission line route utilizing different methods, including aerial block surveys, multi-species aerial transect surveys, and trail camera surveys (Joro Consultants Inc. and Wildlife Resource Consulting Services MB Inc. 2011). Surveys were conducted in 2010 and 2011. Other work included the identification of, and estimation of quantities of, high quality moose habitat areas along the extent of the Bipole III transmission line route. White-tailed deer were also monitored due to their potential use of the transmission right of ways.

Because there are many factors which influence the abundance and distribution of moose, it will be important to consider literature from other locations when assessing the impact of hydroelectric development. These sources, from within Manitoba and from elsewhere, will provide a context for local data. For example, Scaife (1980) provides some insight into the impact of forestry and Crichton (1981) provides comparative data on abundance of moose in other areas of Manitoba. Available fire history data provide some opportunity to assess the spatial and temporal distribution of moose through time.

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Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro; North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
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Moose
Area 3

5.3.8.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.3.8.4.1 SUMMARY OF SCIENTIFIC INFORMATION

Area 4 is on the northern edge of moose range in eastern Manitoba. Because of the remoteness of the area and the scarcity of moose, there is very little information available.

Bryant (1955) showed the area at the mouth of the Churchill River as the limit of moose populations, with very low densities along the lower reaches and a few pockets of higher density along the Churchill River and Little Churchill River. Bryant reviewed the historical literature from the earliest days of the fur trade in Hudson Bay, determining the locations and details of references to moose and moose hunting. He also used first-hand reports of moose abundance from trappers and natural resource managers, and his own observations. His estimates of moose densities are derived from accumulated moose numbers for individual registered traplines. Bryant's data appear to be the only extensive quantitative estimates of moose densities in northern Manitoba before northern hydropower projects. They will be used in the Region of Interest as a baseline with which subsequent moose populations can be compared.

Elliott (1985, 1988) covers a portion of Area 4 (Churchill and Little Churchill rivers near their junction) with one of his study areas for aerial surveys conducted in 1985.

Knudsen *et al.* (2010) include approximately the western half of Area 4 in their aerial survey study area.

Manitoba Hydro also sampled moose along the extent of the proposed Bipole III transmission line route and within the Project Study Area utilizing different methods, including aerial block surveys, multi-species aerial transect surveys, and trail camera surveys (Joro Consultants Inc. and Wildlife Resource Consulting Services MB Inc. 2011). Surveys were conducted in 2010 and 2011. Other work included the identification of, and the estimation of quantities of, high quality moose habitat areas along the extent of the Bipole III transmission line route. White-tailed deer were also monitored due to their potential use of the transmission right of ways.

As in other study areas, because there are many factors which influence the abundance and distribution of moose, it will be important to consider literature from other locations when assessing the impact of hydroelectric development. These sources, from within Manitoba and from elsewhere, will provide a context for local data. For example, Scaife (1980) provides some insight into the impact of forestry and Crichton (1981) provides comparative data on abundance of moose in other areas of Manitoba. Available fire history data provide some opportunity to assess the spatial and temporal distribution of moose through time.

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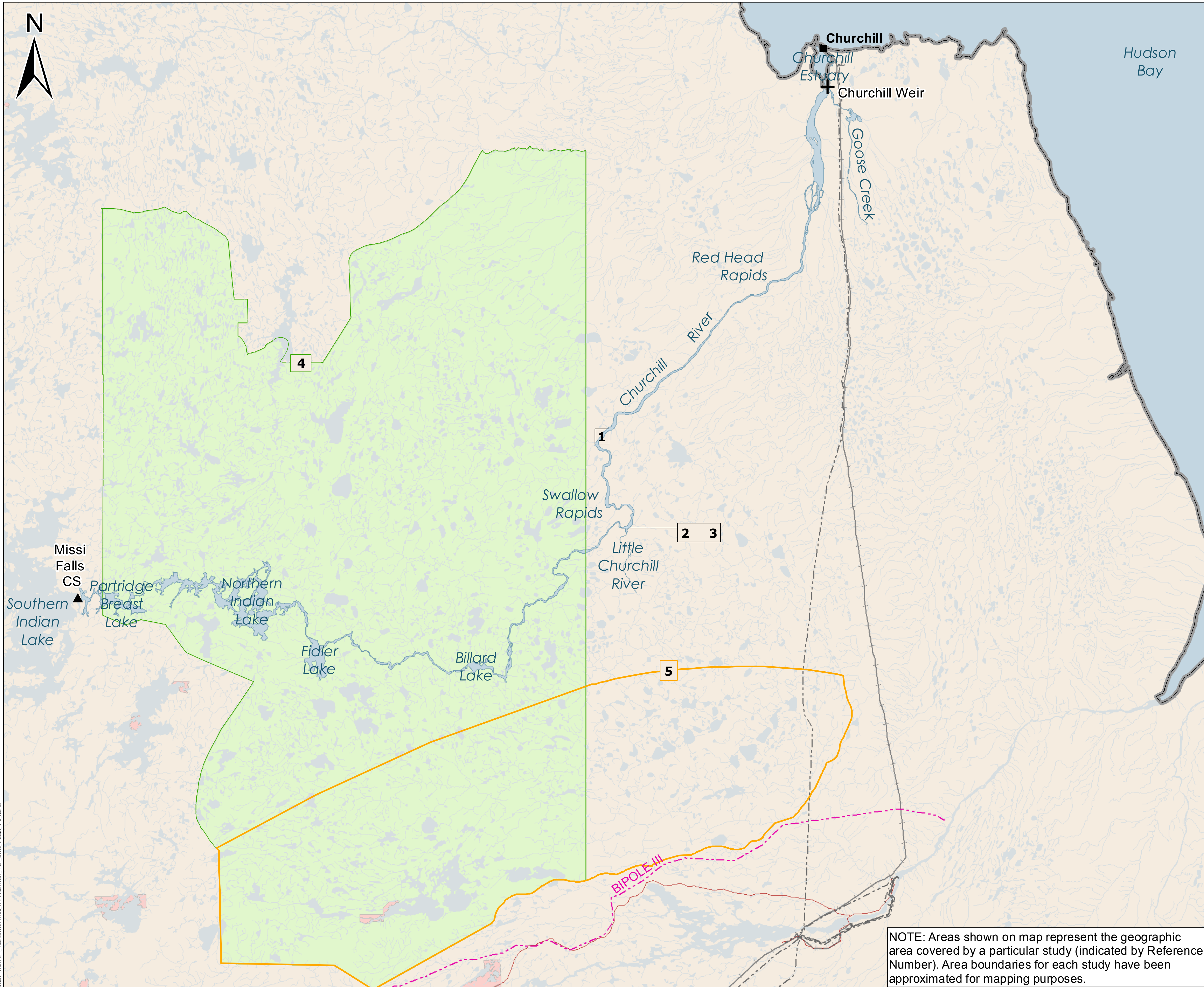

Manitoba Hydro

Legend

- ■ Towns/Cities
- ▲ Control Structure
- + Weir
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

DATA SOURCE:
Province of Manitoba, Government of Canada, Manitoba Hydro, North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	16-APR-14	27-MAY-14
0 10 20 Kilometres / 0 5 10 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Moose
Area 4

Map 5-63

5.3.9 Caribou (*Rangifer tarandus*)

5.3.9.1 Area 1: Lake Winnipeg Outlet to Split Lake Inlet

5.3.9.1.1 Summary of Scientific Information

Caribou occur in Areas 1 through 4, but the type of caribou present in each area differs. Generally speaking, there are four types of caribou to be considered for this report. (More precise terminology, which expresses the taxonomic relationships between groups and their life history strategies, can be found in the literature cited below.) The four types of caribou are:

- Boreal woodland caribou, distributed widely throughout the boreal forest in relatively distinct local herds;
- Cape Churchill caribou, moving seasonally between the coastal tundra and the adjacent boreal forest;
- Pen Island caribou, also moving seasonally between coastal tundra and the adjacent forest, but ranging widely along the Ontario coast; and
- Barren-ground caribou, moving seasonally between the calving grounds hundreds of kilometres north in Nunavut and the wintering grounds in the northern fringes of the boreal forest.

In Area 1, the caribou present are almost exclusively boreal woodland caribou. Boreal forest populations of woodland caribou across Canada were classified as threatened in 2002 (COSEWIC 2002). Barren-ground caribou have been known historically to make incursions this far south into the boreal forest (Bryant 1955) but these were rare.

Data on the abundance of boreal woodland caribou in Area 1 before hydroelectric development are few. Bryant (1955) makes qualitative statements about density and distribution. Howard (1960a, b) conducted aerial surveys, but was confounded by the high variability of caribou densities and distribution. Shoesmith and Storey (1977) reported definable herds along the western edge of Area 1 (see also Manitoba Conservation 2005; Manitoba Boreal Woodland Caribou Management Committee 2014). Didiuk (1975), MacKay *et al.* (1990), and Hirai (1998) make general statements about low levels of abundance.

An extensive series of studies since the late 1990s has provided insight into the abundance and distribution of caribou in this area, and the temporal and spatial variability of these data (Berger *et al.* 2001; Blouw and Berger 2007, 2008; Manitoba Hydro 2009, 2010, 2011a, 2012, 2013; Wildlife Resource Consulting Services MB Inc. 2010a, b, c, Joro Consultants Inc. 2011a, b, c, 2012; Hettinga and Berger 2012; Manitoba Hydro 2011c).

The most extensive information related to boreal woodland caribou with respect to both hydroelectric and non-hydroelectric features is provided as part of several recent hydroelectric project EIAs conducted in the area, including the Wuskwatim Generation Project EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003), which overlaps a portion of Area 1 in the north, the Wuskwatim Transmission Project EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003) and the Bipole III EIS (Manitoba Hydro 2011b).

The assessments noted above include detailed mapping from forest resource inventory and land cover classification data, a description of the generating station and transmission line routes, and predicted impacts on caribou related to flooding, clearing, increased access and other disturbances. There is also discussion of other non-hydroelectric activities planned in the area, such as timber harvesting and mining.

Extensive telemetry studies have been conducted (Brown *et al.*, 2000; Manitoba Hydro and Nisichawayasihk Cree Nation 2003), significant portions of which were part of boreal woodland caribou monitoring for the Wuskwatim and Bipole III transmission line projects (Joro Consultants Inc. 2011a, b) and a cumulative effects assessment on the Bipole III boreal woodland caribou evaluation ranges (Joro Consultants Inc. 2012).

Available data include observations of individuals and tracks from transect surveys, observations of proportions of calves and females seen, and trail camera images (Joro Consultants Inc. 2011b, c; Manitoba Hydro 2012, 2013). Caribou activity and access was assessed as part of a pilot project using trail cameras (Wildlife Resource Consulting Services MB Inc. 2010a, b).

Moayeri (2013) used stable isotope analysis to assess summer diet of gray wolves within registered trapline districts in Area 1. Boreal woodland caribou were found to be an important prey during summer.

Because of the variability of home ranges in woodland caribou, and their tendency to combine and split herds, this area will have to be evaluated not only in terms of the current presence of caribou, but with regard to its importance as an alternative range for nearby herds, taking into account the supply of key habitat components such as calving sites (Hirai 1998; Dyke 2008). Genetic information (*e.g.*, Hettinga 2010; Yannic *et al.* 2014) may reveal the degree to which herds have combined or remained distinct over the recent past, and also over longer periods in the evolution of caribou.

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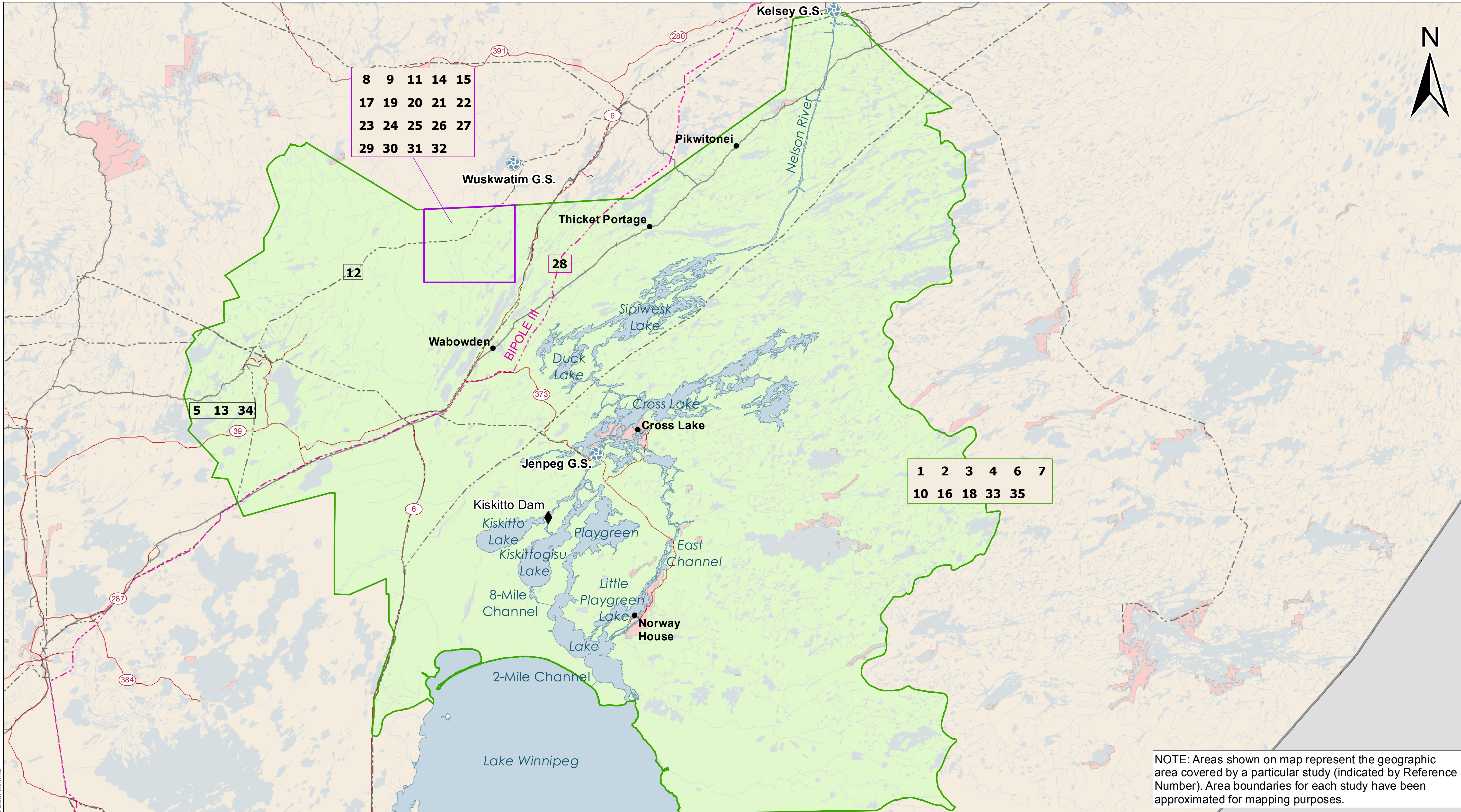

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	27-MAY-14
0 20 40 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Dam
- Generating Station (Existing)
- Highway
- Rail
- Transmission (Future)
- Transmission (Existing)
- First Nation Reserve

Caribou
Area 1

Map 5-64

5.3.9.2 AREA 2: SPLIT LAKE INLET TO NELSON RIVER ESTUARY

5.3.9.2.1 SUMMARY OF SCIENTIFIC INFORMATION

Caribou occur in Areas 1 through 4, but the types of caribou present in each area differ. Generally speaking, there are four types of caribou to be considered for this report. (More precise terminology, which expresses the taxonomic relationships between groups and their life history strategies, can be found in the literature cited below.) The four types of caribou are:

- Boreal woodland caribou, distributed widely throughout the boreal forest in relatively distinct local herds;
- Cape Churchill caribou, moving seasonally between the coastal tundra and the adjacent boreal forest;
- Pen Island caribou, also moving seasonally between coastal tundra and adjacent forest, but ranging widely along the Ontario coast; and
- Barren-ground caribou, moving seasonally between the calving grounds hundreds of kilometres north in Nunavut and the wintering grounds in the northern fringes of the boreal forest.

Although these types of caribou form relatively distinct groups, there seems to be a relatively high degree of genetic diversity within them and intermixing of genetic material between them (Yannic *et al.* 2014).

In Area 2, only three types of caribou are likely to be encountered. During the winter, Pen Island caribou and Cape Churchill caribou are usually found in the boreal forest of the central portion of the area, but their numbers and distribution vary considerably. These caribou move to the coastal plains along Hudson Bay during the summer. Boreal woodland caribou are found in the western portion of the study area, and remain in the boreal forest all year. These caribou are part of the widespread boreal forest populations that have been classified as threatened (COSEWIC 2002). Historically, barren-ground caribou have been known to cross the Nelson River (Bryant 1955) but no longer seem to do so.

Data on the abundance of boreal woodland caribou in Area 2 before hydroelectric development are few. Didiuk (1975) made general statements about low levels of abundance and Bryant (1955) makes qualitative statements about density and distribution.

Abraham and Thompson (1998) and Abraham *et al.* (2012) document the dramatic annual differences in abundance and location of the Pen Island caribou. More specific information about caribou in Area 2, relating caribou to hydroelectric projects (and other events) is contained in the Bipole III EIS (Manitoba Hydro 2011) and the Keeyask Generation Project EIS (Keeyask Hydropower Limited Partnership 2012), where caribou were included as Valued Environmental Components. These assessments include detailed features mapping from forest resource inventory, land cover classification and predicted impacts on caribou from flooding, clearing, increased access and other disturbances. There is also a discussion of planned timber harvesting and mining in the area. The Fox Lake Cree Nation Environment Evaluation Report discusses the types of caribou in the area and their behavioural patterns (Fox Lake Cree Nation 2012). Habitat assessments are provided in Joro Consultants Inc. (2011, 2012) and ECOSTEM *et al.* (2013).

A series of studies has provided more detail about caribou abundance and variability between years (Elliot 1989; Patenaude and Berger 2004a, b; Patenaude *et al.* 2005; Kibbins and Berger 2007; Ambrose and Berger 2008, 2012a, b; Hettinga and Berger 2012; Ambrose *et al.* 2013; La Porte *et al.* 2013).

Knudsen *et al.* (2010) recorded widespread abundance of caribou tracks as a part of an aerial survey of moose in the Split Lake Resource Management Area.

Caribou in Area 2 were assessed for the Bipole III Project (Joro Consultants Inc. 2011, 2012). Caribou in the Cape Churchill and Pen Island areas were monitored through GPS collaring programs in 2010 and 2011. Observations of individuals and tracks were collected in aerial surveys between 2009 and 2011. A cumulative effects assessment for both the Pen Islands and Cape Churchill herds was conducted based on disturbance thresholds defined by Environment Canada (2011). Joro Consultants Inc. (2012) provides a history of both coastal populations, indicating population growth, range estimations and movement patterns.

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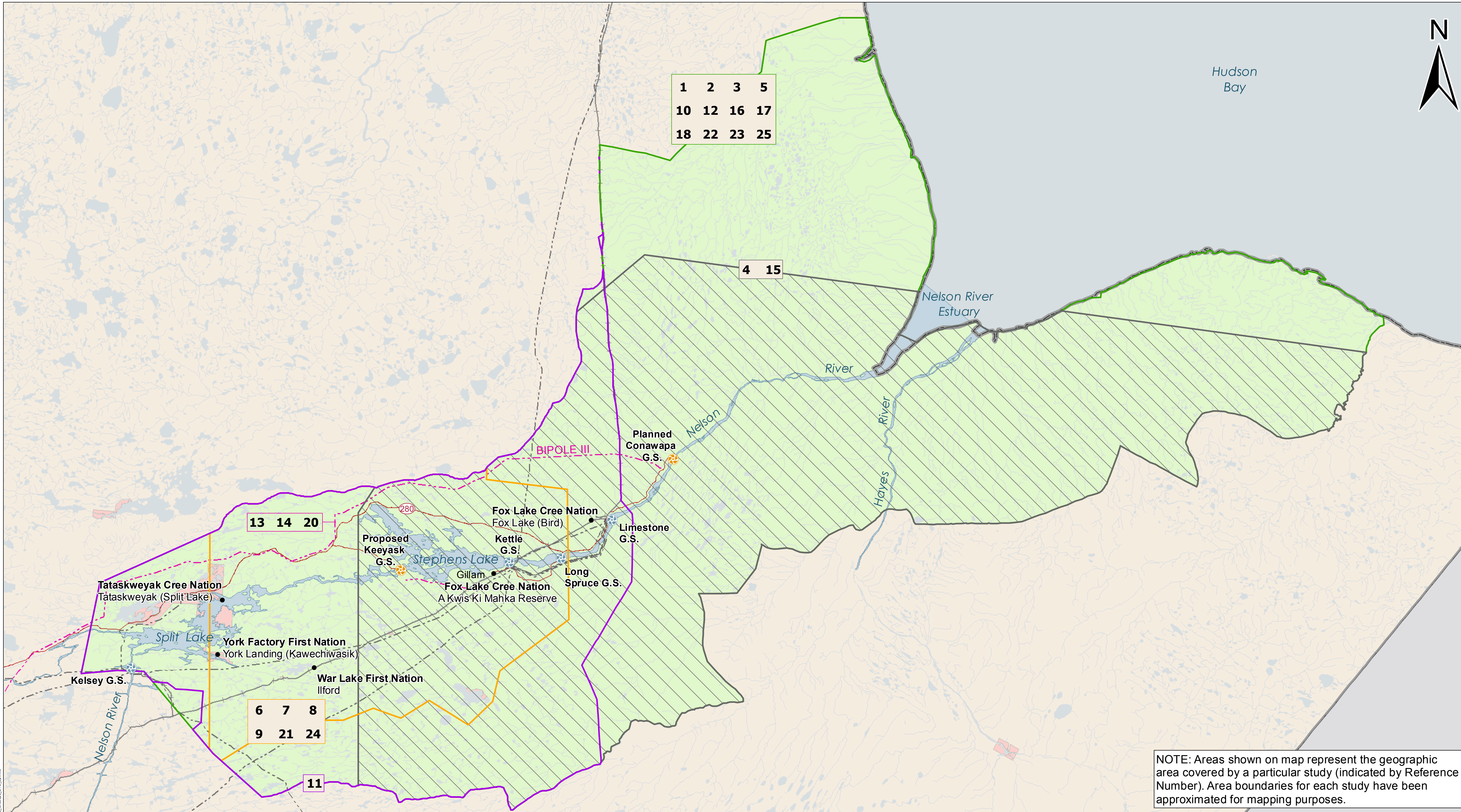

Manitoba Hydro

DATA SOURCE:
Government of Manitoba; Government of Canada; Manitoba Hydro North/South Consultants

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-APR-14	26-MAY-14
0 10 20 30 Kilometres / 0 10 20 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Legend

- 52 Reference Number
- Community
- Generating Station (Existing)
- Generating Station (Planned)
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

Caribou
Area 2

5.3.9.3 AREA 3: OPACHUANAU LAKE TO SPLIT LAKE INLET (INCLUDING SOUTHERN INDIAN LAKE)

5.3.9.3.1 SUMMARY OF SCIENTIFIC INFORMATION

Two types of caribou are found in Area 3; barren ground and boreal woodland caribou. Cape Churchill caribou and Pen Island caribou, found along Hudson Bay and within the adjacent boreal forest, do not range as far west as Area 3. Barren-ground caribou spend the winter in the boreal forest in the northern portions, and migrate south in the fall from their calving grounds on the tundra. The abundance and distribution of these caribou varies considerably between and within winters. Further south in Area 3, there are herds of boreal woodland caribou (Manitoba Conservation 2005; Environment Canada 2012). These animals are resident in the boreal forest all year. Boreal woodland caribou do not migrate long distances, but their movement patterns are sufficiently unpredictable to make aerial surveys difficult (Howard 1960a, b).

Goulden *et al.* (1968) reported generally low abundance of resident caribou in Area 3, speaking primarily of woodland caribou. More recently, a series of studies have provided more quantitative data (Berger *et al.* 2001; Berger and Blouw 2007a, b; Schmidt and Berger 2007; Blouw and Berger 2007a, b, 2008; Patenaude *et al.* 2007; Ambrose *et al.* 2008; Berger and Armstrong 2009; Ambrose *et al.* 2011; Joro Consultants Inc. 2011a, b, c, 2012, Manitoba Hydro 2011b, 2012; Hettinga and Berger 2012).

Several EISs contain boreal woodland caribou data: the Wuskwatim Generation Project EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003a), the Wuskwatim Transmission Project EIS (Manitoba Hydro and Nisichawayasihk Cree Nation 2003b), and the Bipole III EIS (Manitoba Hydro 2011a). Data included in the above noted assessments are drawn from feature mapping from forest resource inventory, land cover classification, predicted impacts on caribou related to flooding, clearing, increased access and other disturbances, and plans for timber harvesting and mining. Tracking and trail camera surveys were conducted from 2008 through 2012 for the Wuskwatim Transmission Project (Joro Consultants Inc. 2011b; Manitoba Hydro 2011b, 2012, 2013; Wildlife Resource Consulting Services MB Inc. 2012).

Telemetry studies were conducted in the south east portion of Area 3 as part of caribou studies for the Wuskwatim Generation Project (Wildlife Resource Consulting Services MB Inc. and R.K. Schmidt Environmental 2003) and the Bipole III Site Selection and Environmental Assessment (Joro Consultants Inc. 2011a, 2012).

Other data in the above studies include observations of individuals and tracks on transect surveys, calf recruitment estimates, estimates of survival rates of female adults, and presence/absence data from trail cameras.

Knudsen *et al.* (2010) recorded widespread abundance of caribou tracks on the eastern edge of Area 3 as part of an aerial survey of moose in the Split Lake Resource Management Area.

Because of the variability in home range in woodland caribou, and the pattern of the species to combine and split herds (Ball *et al.* 2010; Yannic *et al.* 2014), this area will have to be evaluated not only in terms of the current presence of caribou, but with regard to its importance as an alternative range for nearby herds, taking into account the supply of key habitat components, such as calving sites (Hirai 1998; Dyke 2008).

Nisichawayasihk Cree Nation and Manitoba Conservation and Water Stewardship collaborated on a boreal woodland caribou Aboriginal Traditional Knowledge study in 2001 that documented the traditional ranges of three caribou herds.

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Manitoba Hydro

DATA SOURCE:
Government of Manitoba, Hydrography (1:500 000); Government of Canada; Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	07-APR-14	26-MAY-14
0 4 8 Kilometres / 0 2 4 6 Miles	VERSION NO: 1.0	QA/QC: CMP/RDB

Caribou
Area 3

5.3.9.4 AREA 4: MISSI FALLS CONTROL STRUCTURE TO THE CHURCHILL RIVER ESTUARY

5.3.9.4.1 SUMMARY OF SCIENTIFIC INFORMATION

Caribou occur in Areas 1 through 4, but the type of caribou present in each area differs. Generally speaking, there are four types of caribou to be aware of when considering this report. (More precise terminology, which expresses the taxonomic relationships between groups and their life history strategies, can be found in the literature cited below.) The four types of caribou are:

- Boreal woodland caribou, distributed widely throughout the boreal forest in relatively distinct local herds (boreal forest populations of woodland caribou across Canada were classified as threatened in COSEWIC [2002]);
- Cape Churchill caribou, moving seasonally between the coastal tundra and the adjacent boreal forest;
- Pen Island caribou, also moving seasonally between coastal tundra and adjacent forest, but ranging widely along the Ontario coast; and
- Barren-ground caribou, moving seasonally between the calving grounds hundreds of kilometres north in Nunavut and the wintering grounds in the northern fringes of the boreal forest.

Only three of these types of caribou are present in Area 4. The Cape Churchill caribou range over the eastern portion of the area (Gunn *et al.* 2011; Joro Consultants Inc. 2011, 2012; ECOSTEM *et al.* 2013). Barren-ground caribou move annually into the western portions of the area. Details of the status of this herd can be found in Russell *et al.* (2008), Beverly and Qamanirjuaq Caribou Management Board (2005, 2013), Gunn *et al.* (2011), and Campbell *et al.* (2010). Woodland caribou occur in the southwest of the area ranges (Manitoba Conservation 2005; Environment Canada 2012). Pen Island animals move west into Manitoba in the winter, but are not known to move north of the Nelson River.

Knudsen *et al.* (2010) documented the distribution of caribou tracks in the southwestern portion of this study area as a part of an aerial survey of moose in the Split Lake Resource Management Area.

Manitoba Conservation and Water Stewardship has unpublished data from caribou harvest statistics in Game Hunting Areas 1 and 2. These records could be useful to demonstrate the relative presence or absence of caribou across the years, but the lack of alignment between Game Hunting Areas and the RCEA Region of Interest make comparisons difficult. There are a number of other data sources available for use in demonstrating historic changes in the quantity and location of anthropogenic development and forest fires. Many of these data sources will be the same as those used for intactness and terrestrial habitat, both regional study components.

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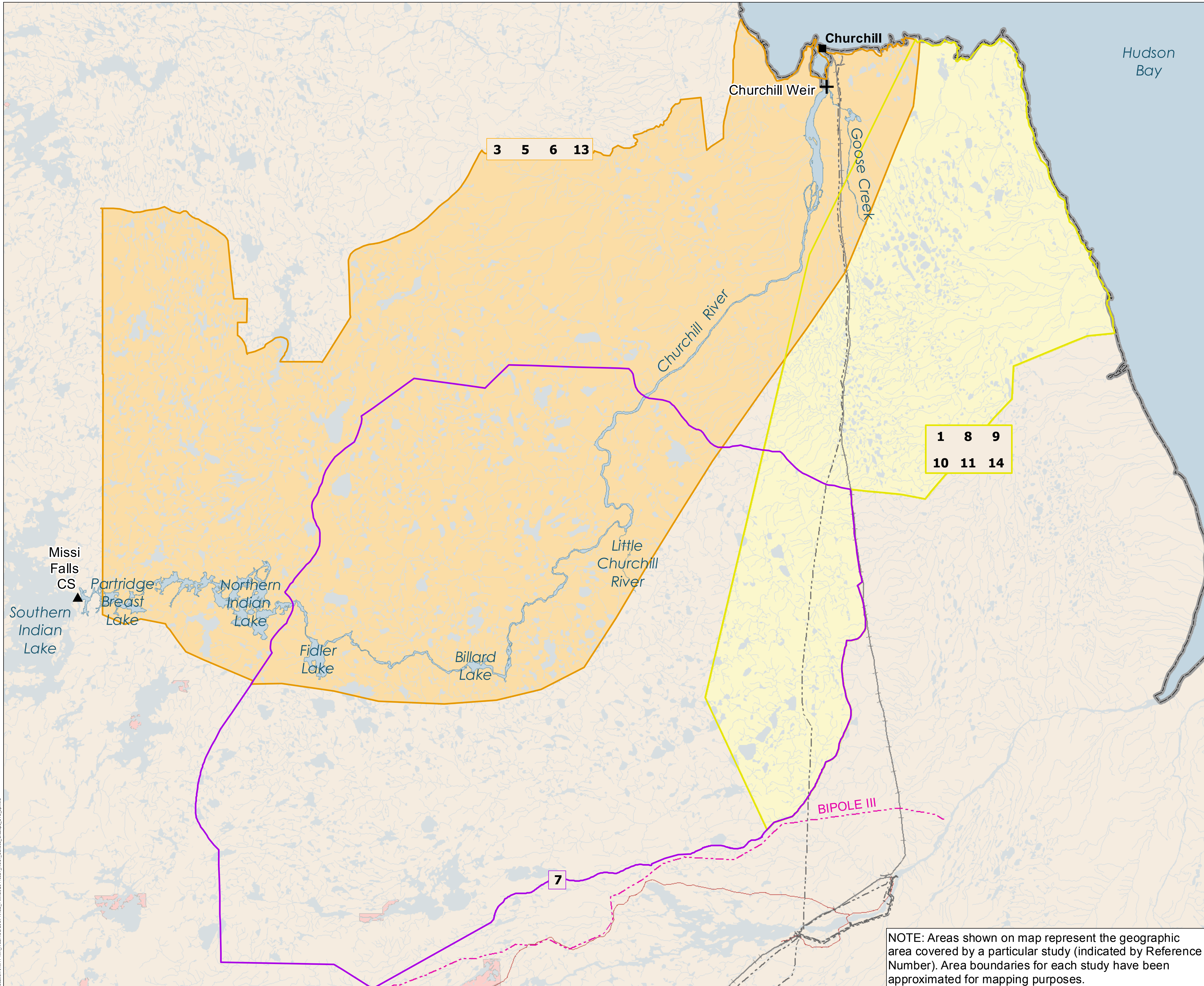

Manitoba Hydro

Legend

- Towns/Cities
- Control Structure
- Weir
- Highway
- Rail
- Transmission (Existing)
- Transmission (Future)
- First Nation Reserve

DATA SOURCE:
Province of Manitoba, Government of Canada, Manitoba Hydro

CREATED BY:
North/South Consultants Inc.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
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Caribou
Area 4

LIST OF REFERENCES

Manitoba Hydro

REGIONAL CUMULATIVE EFFECTS ASSESSMENT

LIST OF REFERENCES

TABLE OF CONTENTS

LIST OF REFERENCES

PART I: INTRODUCTION AND APPROACH

PART II: HISTORY OF HYDROELECTRIC DEVELOPMENT IN THE REGION OF INTEREST

PART III: PEOPLE

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5.0 PART V: WATER AND LAND

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REGIONAL CUMULATIVE EFFECTS ASSESSMENT

GLOSSARY

Abiotic: A nonliving physical or chemical attribute of a system, *e.g.,* light, temperature, wind patterns, rocks, soil, pH, pressure, *etc.*

Aboriginal Traditional Knowledge (ATK): Knowledge that is held by, and unique to, Aboriginal peoples. It is a living bit of knowledge that is cumulative and dynamic and adapted over time to reflect changes in the social, economic, environmental, spiritual and political spheres of the Aboriginal knowledge holders. It often includes knowledge about the land and its resources, spiritual beliefs, language, mythology, culture, laws, customs and medicines (Canadian Environmental Assessment Agency).

Acoustic-transmitter: A transmitter that emits signals detected by stationary or mobile acoustic receivers; often used to track movements of fish.

Adult Lake Sturgeon: Lake Sturgeon 834 mm long (fork length) or greater were assumed to be adults where sexually maturity was not evident at the time of sampling. This benchmark was based on sexual maturity data collected during the spawning season from a well-studied lake sturgeon population on the Lower Nelson River.

Adverse: Unfavourable or antagonistic in purpose or effect.

Alluvial: Pertaining to of composed of alluvium; clay, silt, sand, gravel, or similar detrital material deposited by running water.

Alternating Current (AC): Is the oscillating (back and forth) flow of electrical current, whereas dc (direct current) is the unidirectional continuous flow of electrical current. AC is the common household electrical current and is used in transmission lines; DC is the form of current produced by battery (*e.g.*, in a flashlight).

Aquatic: Living or found in water.

Attribute: A readily definable and inherent characteristic of a plant, animal, or habitat.

Backbay: Area in a river or stream isolated from the main flow where water velocities are typically low or nonexistent.

Backwater effect: In hydrologic terms, the effect that a dam or other obstruction has in raising the surface of the water upstream from it.

Bank recession: progressive landward movement of a distinct escarpment or bluff along a river or lake shoreline due to erosion and mass wasting.

Basin: A distinct section of a lake, separated from the remainder of the lake by a constriction.

Bathymetry: The area and water depth of a lake or river.

Bedload: Measure of moving particles over the bed by rolling, sliding or saltating (*i.e.*, bounce, jump or hop).

Bed material: Soil material that makes up the bed of the river or lake.

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

Benthic invertebrate: An animal lacking a backbone that lives on or in the bottom sediments of a waterbody (*e.g.*, mayfly, clam, aquatic earthworm, crayfish).

Benthic: Relating to the bottom of a waterbody (*e.g.*, lake).

Bioaccumulation: The accumulation of substances, such as methylmercury, in an organism or part of an organism. Bioaccumulation occurs when a substance is absorbed by an organism at a greater rate than it is lost.

Biophysical land classification: A delineation of distinct areas on a map based on soil, surficial deposits, landforms, permafrost and water.

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.

Boreal: Of or relating to the cold, northern, circumpolar area just south of the tundra, dominated by coniferous trees such as spruce, fir, or pine. Also called taiga.

Cache: A hiding place for concealing and preserving provisions.

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

Cause-effect linkage: The relationship between an event (the cause) and a second event (the effect) or subsequent event (an indirect effect), where the second event or subsequent event is a consequence of the first.

Channel Incision: The process of downcutting into a stream channel leading to a decrease in the channel bed elevation. Incision is often caused by a decrease in sediment supply and/or an increase in sediment transport capacity.

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 as authorized by the CRD Licence.

Cohesive: Sediment materials of very small sizes for which intermolecular forces between particles are significant and affect the material properties.

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. For people, a community is a social group of any size, whose members reside in a specific locality.

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; units are microSiemens per centimetre.

Control structure: A type of structure designed to control the outflow from a waterbody (e.g., Missi Falls control structure, Notigi control structure).

Converter Station: The terminal equipment for a high voltage direct current transmission line, in which alternating current is converted to direct current or direct current is converted to alternating current.

Core area: A natural area that meets a minimum size criteria after applying an edge buffer on human features. Various sizes (e.g., 200 hectares, 1,000 hectares) could be used in an intactness effects asessment.

Correlation: The study of simultaneous variation of two or more variables.

Cree Nation Partners: A partnership formed in 2001 amongst Tataskweyak Cree Nation and War Lake First Nation.

Cumulative effect: The effect on the environment, which results when the effects of a project combine with those of the past, existing, and future projects and; the incremental effects of an action on the environment when the effects are combined with those from other past, existing and future actions.

Cycling: A mode of operation for a generating station that uses reservoir storage to augment flows so that the maximum power can be generated during the day to coincide with peak power demand. For example, at night, when power demand is lower, flow through the generating station is reduced to store water in the reservoir for use during the following day.

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.

DELT: Acronym for the presence of Deformities (physical blemishes or distortions), Erosion (wearing away of a structure to reduce the size and effectiveness of that structure), Lesions (abnormal changes in a structure due to injury or disease, not including injuries due to predation or fishing), and Tumours (abnormal benign or malignant mass of tissue that does not arise from inflammation) in fish.

Delta: A river delta is a landform that forms at the mouth of a river, where the river flows into an ocean, sea, estuary, lake, or reservoir. Deltas form from deposition of sediment carried by a river as the flow leaves its mouth.

Deposition: Settling of sediment particles on the river/lake bottom.

Digital Elevation Model (DEM): A digital elevation model is a digital model or 3D representation of a terrain's surface created from terrain elevation data.

Direct Current (DC): Electrical current that flows in one direction only.

Driver: Any natural or human-induced factor that directly or indirectly causes a change in the environment.

Driving factor: Any natural or human-induced factor that directly or indirectly causes a change in the environment.

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

Ecosite type: A classification of site conditions that have important influences on ecosystem patterns and processes. Site attributes that were directly or indirectly used for terrestrial habitat classification included moisture regime, drainage regime, nutrient regime, surface organic layer thickness, organic deposit type, mineral soil conditions and permafrost conditions.

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

Ecosystem function: The outcomes of ecosystem patterns and processes viewed in terms of ecosystem services or benefits. Examples include producing oxygen to breathe, habitat for animals, purifying water and storing carbon.

Edge effect: The effect of an abrupt transition between two different adjoining ecological communities on the numbers and kinds of organisms in the transition between communities as well as the effects on organisms and environmental conditions adjacent to the abrupt transition.

Effect: Any change that a project may cause in the environment. More specifically, is a direct or indirect consequence of a particular project impact. The impact-effect terminology is a statement of a cause-effect relationship. A terrestrial habitat example would be 10 ha of vegetation clearing (*i.e.*, the impact) leads to habitat loss, permafrost melting, soil conversion, edge effects, *etc.* (*i.e.*, the direct and indirect effects).

Emergent: A plant rooted in shallow water and having most of its vegetative growth above water.

Endangered: A species facing imminent extirpation or extinction (COSEWIC).

Entrainment: 1) A process by which sediment from a surface is incorporated into a fluid flow (such as water) as part of the operation of erosion; and 2) Fish (larval or adult) that are drawn into a current and cannot escape.

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) (Canadian Environmental Assessment Agency).

Environmental assessment (EA): Process for identifying project and environment interactions, predicting environmental effects, identifying mitigation measures, evaluating significance, reporting and following-up to verify accuracy and effectiveness leading to the production of an EA report. Environmental Assessment is used as a planning tool to help guide decision-making, as well as project design and implementation (Canadian Environmental Assessment Agency).

Environmental component: Fundamental element of the physical, biological or socio-economic environment, including the air, water, soil, terrain, vegetation, wildlife, fish, birds and land use that may be affected by a proposed project, and may be individually assessed in an environmental assessment (Canadian Environmental Assessment Agency).

Environmental effect: In respect of a project, a) 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 impact assessment (EIA): See *Environmental Assessment*.

Environmental impact statement (EIS): A document that presents the findings of an environmental assessment (Canadian Environmental Assessment Agency).

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 (Canadian Environmental Assessment Agency).

Environmental protection plan (EPP): A practical tool that describes the actions required to minimize environmental effects before, during and after project implementation. The plan may include details about the implementation of the mitigation measures identified in the environmental assessment, such as who is responsible for implementation, where the measures are intended to be implemented, and within what timeframe (Canadian Environmental Assessment Agency); description of what will be done to minimize the effects before, during and after project construction and operation. This includes protection of the environment and mitigation of effects from project activities.

Erosion: A process, which is either naturally occurring or anthropogenic in origin, by which the Earth's surface is worn away by the actions of water and wind.

Existing environment: The present condition of a particular area; generally included in the assessment of a project or activity prior to the construction of a proposed project or activity.

Fen: Peatland in which the plants receive nutrients from mineral enriched ground and/or surface water. Water chemistry is neutral to alkaline. Sedges, brown mosses and/or Sphagnum mosses are usually the dominant peat forming vegetation.

Fetch: Length of water surface exposed to wind during generation of waves.

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.

Footprint: The surface area occupied by a structure or activity; the land or water area covered by a project. This includes direct physical coverage (*i.e.*, the area on which the project physically stands) and direct effects (*i.e.*, the disturbances that may directly emanate from the project, such as noise).

Forage fish: Small, schooling fish that are typically eaten by larger fish. Typically less than 150 mm as adults (*e.g.*, minnows, darters, sculpins, stickleback).

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 and how easy it is for animals, plant propagules and other ecological flows such as surface water to move from one area to another. Fragmentation can isolate habitat and create edges, which reduces habitat for interior species and may reduce habitat effectiveness for other species. OR The breaking up of contiguous blocks of habitat into increasingly smaller blocks as a result of direct loss and/or sensory disturbance (i.e., habitat alienation). Eventually, remaining blocks may be too small to provide usable or effective habitat for a species.

Frazil ice: Fine, small, needle-like structures of thin, flat circular plates of ice formed in super-cooled, turbulent water.

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 (GS): 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.

Glaciolacustrine: Pertaining to lakes fed by melting glaciers, or to the deposits forming therein.

Glacial Till: Glacial till is that part of glacial drift which was deposited directly by the glacier. Its content may vary from clays to mixtures of clay, sand, gravel, and boulders. This material is mostly derived from the subglacial erosion and entrainment by the moving ice of the glaciers of previously available unconsolidated sediments.

Grab Sample: A grab sample, also known as a catch sample, consists of a single sample taken at a specific time. It takes a snapshot of characteristics at a specific point and time and may not be a complete representation of the entire flow.

Granular: Composed of granules or grains of sand or gravel.

Gravel: An accumulation of loose or unconsolidated, rounded rock fragments larger than sand, and between 10 and 100 mm in diameter; rock larger than sand but smaller than cobble having a particle diameter between 2 and 64 mm.

Habitat loss: Conversion of terrestrial habitat into human features or aquatic areas.

Habitat suitability index (HSI): A numerical index ranging from 0 to 1 representing the capacity of a given habitat to support a selected species. A value of 1 represents optimal conditions for that species while a value of 0 represents unsuitable conditions. HSI models are based on hypothesized species-habitat relationships rather than statements of proven cause and effect relationships. Such models serve as a basis for improved decision-making and increased understanding of species-habitat relationships.

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

Hanging ice dam: A deposit of ice, typically at the downstream end of rapids that builds up through the winter by accumulating frazil ice, which then partially blocks the flow of water and causes water levels upstream to rise.

High Voltage Direct Current (HVdc) Transmission System: A high voltage electric power transmission system that uses direct current for the bulk transmission of electrical power. Direct Current flows constantly in only one direction (frequency of change or oscillation is 0 Hertz [Hz]).

Hydraulic: 1) of or relating to liquid in motion; and, 2) of or relating to the pressure created by forcing a liquid through a relatively small orifice, pipe, or other small channel.

Hydroelectric: Electricity produced by converting the energy of falling water into electrical energy (*i.e.*, at a hydro generating station).

Hydroelectric generating station: A generating station that converts the potential energy of elevated water or the kinetic energy of flowing water into electricity.

Hydrometric data: Records of water levels and flows obtained from gauging stations operated by either Water Survey of Canada or Manitoba Hydro.

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.

Impact: Essentially, a statement of what the Project is in terms of the ecosystem component of interest while a project effect is a direct or indirect consequence of that impact (i.e., a statement of the cause effect relationship). A terrestrial habitat example would be 10 hectares of vegetation clearing (i.e., the impact) leads to habitat loss, permafrost melting, soil conversion, edge effects, etc. (i.e., the direct and indirect effects). Note that while Canadian Environmental Assessment Act requires the proponent to assess project effects, Manitoba legislation uses the terms impact and effect interchangeably. See also **Effect**.

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

Indicator species: A species that is closely correlated with a particular environmental condition or habitat type such that its presence, absence, or state of well-being can be used as indicator of environmental conditions. A species whose population size and trend is assumed to reflect the population size and trend of other species associated with the same geographic area and habitats.

Indirect effect: A secondary environmental effect that occurs as a result of a change that a project may cause in the environment. An indirect effect is at least one step removed from a project activity in terms of cause-effect linkages (Canadian Environmental Assessment Agency). Or an effect in which the cause-effect relationship (e.g., between the project's impacts and the ultimate effect on a VEC) has intermediary effects. As an interaction with another action's effects is required to have a cumulative effect (hence, creating imtermediary effects), cumulative effects may be considered as indirect.

Infrastructure: Permanent or temporary structures or features required for the construction of the principal structures, including access roads, construction camps, construction power, batch plant and cofferdams.

In-situ: In place; undisturbed. An *in situ* environmental measurement is one that is taken in the field, without removal of a sample to the laboratory.

Keeyask Generation Project: A proposed 695-megawatt hydroelectric generating station located near Gull Rapids on the Nelson River in the Province of Manitoba.

Key person interview (KPI): Interview with an individual whose knowledge, creativity, inspiration, reputation, and/or skills are critical to the credibility of a study.

Kilometre (km): The unit measure of length equivalent to 1000 metres; one kilometre = 0.62 miles.

Kilovolt (kV): The unit of electromotive force or electrical pressure equivalent to 1,000 volts (V).

Lacustrine: Of or having to do with lakes, and also used in reference to soils deposited as sediments in a lake.

Lake Winnipeg Regulation (LWR): The LWR project was constructed by Manitoba Hydro in the 1970s to regulate the outflow from Lake Winnipeg to the Nelson River and store water in the lake as authorized by the LWR Licence. The project includes three excavated channels, the Jenpeg generating station and control structure and a dam at Kiskitto Lake. Lake Winnipeg is regulated for hydropower generation and flood control.

Land cover: The most general level in the hierarchical habitat classification used for the terrestrial assessment. From coarsest to finest, the levels in the habitat classification system are land cover, coarse habitat type, broad habitat type and fine habitat type.

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

Larva (ae; al): The young, immature form of an insect or animal.

LiDAR: LiDAR is a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light. It is used to make high-resolution maps.

Limnocorral: A method for performing *in situ* experiments in lakes. Typically consists of a large (several metres), flexible plastic tube that extends from the surface to the bottom of a body of water, is anchored in place and sealed at the bottom to prevent seepage. Isolated samples of water organisms can then be taken from within the limnocorral.

Limnology: It is the study of inland waters.

Lodge: An accommodation facility of a permanent or semi-permanent nature that accommodates nine or more persons. In general ecological usage, this term can refer to the den of certain animals, such as the dome-shaped structure built by beavers.

Mainstem: The unimpeded, main channel of a river.

Mark-recapture studies: Fish are captured, marked a Floy® tag, and then subsequent rounds of fishing are conducted to recapture the marked fish. Data are used to determine species population size and movements.

Marsh: A class in the Canadian Wetland Classification System which includes non-peat wetlands having at least 25% emergent vegetation cover in the water fluctuation zone.

Mass wasting: A general term of the dislodgement and downslope transport of soil and rock material under the direct application of gravitational body stresses. Includes slow displacements, such as creep and rotational slump failures, and rapid movements, such as rock and soil falls, rock slides, and debris flows.

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

Methylation: The addition of a methyl group to a metal or organic compound (*e.g.*, conversion of inorganic mercury to methylmercury); in the natural environment, this occurs most often by microbial action.

Methylmercury: An organic form of mercury that is able to concentrate in animal tissue.

Migration: The movement of an individual or group of individuals from one area to another.

Mineral erosion: Wearing away of minerals due to wind and water processes.

Mineral soil: Naturally occurring, unconsolidated material that has undergone some form of soil development as evidenced by the presence of one or more horizons and is at least 10 cm thick. If a surface organic layer (*i.e.*, contains more than 30% organic material or 17% organic carbon by weight) is present, it is less than 20 cm thick.

Mitigation: A means of reducing adverse Project 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 to determine whether change is occurring in something of interest. The primary goal of long term monitoring of lakes and rivers is to understand how aquatic communities and habitats respond to natural processes and to be able to distinguish differences between human-induced disturbance effects to aquatic ecosystems and those caused by natural processes; a continuing assessment of conditions at and surrounding the action. This determines if effects occur as predicted or if operations remain within acceptable limits, and if mitigation measures are as effective as predicted.

Movement: The act of individual or populations of animals moving from one habitat to another for spawning, foraging, overwintering, escape from predation, *etc.*

MW (Megawatts): A unit of power equal to one million watts. One megawatt is enough to power 50 average homes.

Nearshore downcutting: Erosion of the nearshore substrate by running water, waves or ice.

Nearshore: Aquatic habitat occurring at the interface between a lake or stream and adjacent terrestrial habitat; usually includes aquatic habitat up to 3 m in depth; shallow underwater slope near to shore.

Nocturnal: Active at night.

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 Cree Nations regarding the effects of the Churchill River Diversion and Lake Winnipeg Regulation.

Offshore: Aquatic habitat not adjacent to terrestrial habitat; usually greater than 3 m in depth.

Organic: The compounds formed by living organisms.

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

Overburden: Soil (including organic material) or loose material overlaying bedrock.

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

Peat: Material consisting of non-decomposed and/or partially decomposed organic matter, originating predominantly from plants.

Peat resurfacing: Process whereby all or portions of a peat mat that was submerged by flooding detaches and floats to the water surface.

Peatland disintegration: Processes related to flooded peat resurfacing; breakdown of non-flooded and resurfaced peatlands and peat mats; and peat formation on peatlands and peat mats that have hydrological connections to a regulated area.

Peatland: Wetland where organic material has accumulated because dead plant material production exceeds decomposition.

Percentile(s): A value on a scale of zero to one hundred that indicates the percentage of the data set values that are equal to or below it (e.g., 95% of the values in a data set are equal to or less than the 95th percentile value, and 5% of data set values are greater than the 95th percentile value).

Permafrost: Ground where the temperature remains below 0°C for two or more consecutive years.

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.

Physiographic/physiography: Physical geography, i.e., the study of physical features of the surface of the Earth.

Plume: A column of one fluid moving through another (*e.g.*, effluent in a stream or lake).

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.

Primary production: The production of organic compounds from atmospheric or aquatic carbon dioxide, principally through the process of photosynthesis by plants, with chemosynthesis being much less important. All life on earth is directly or indirectly reliant on primary production.

Productivity: Rate of formation of organic matter over a defined period; this can include the production of offspring.

Rapids: A section of shallow, fast moving water in a stream made turbulent by totally or partially submerged rocks.

Raptor: Any of the group known as "birds of prey", including eagles, hawks, owls, vultures and falcons.

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

Recruitment: New juvenile fish successfully being recruited into the population. Or New juvenile fish reaching a size/age where they represent a viable target for the commercial, subsistence or sport fishery for a given species.

Regime: The frequency, size, intensity, severity, patchiness, seasonality and sub-type of a periodic event or continual fluctuation.

Region of Interest: The main areas directly affected by Manitoba Hydro developments associated with the Lake Winnipeg Regulation (LWR), Churchill River Diversion (CRD) and associated transmission projects.

Regional study area: The regional comparison area used for a particular key topic. Or The spatial area within which cumulative effects are assessed (*i.e.* extending a distance from the project footprint in which both direct and indirect effects are anticipated to occur).

Regional Study Component (RSC): topics that have been selected to focus the assessment, represent the overall effects of hydroelectric developments within the Region of Interest and reflect key ecological and social concerns, or are of key importance to the people living in the area.

Relative abundance: The number of individuals of one species compared to the number of individuals of another species. The number of individuals at one location or time compared to the number of individuals at another location or time. Generally reported as an index of abundance.

Relief: Variation in elevation on the surface of the earth.

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

Resident: With respect to wildlife, resident refers to a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating (Canadian Environmental Assessment Agency).

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

Right-of-way (ROW): Area of land controlled or maintained for the development of a road, pipeline, or transmission line.

Riparian: Along the banks of rivers and streams.

Riprap: A layer of large stones, broken rock, boulder, or other suitable material placed on the upstream and downstream faces of embankments, dams or other land surfaces to protect them from erosion or scour caused by current, wind, wave, and/or ice action.

Riverine: Relating to, formed by, or resembling a river including tributaries, streams, brooks*, etc.*

River Morphology: Relating to form and structure of river.

Sand: 1) a small, somewhat rounded fragment or particle of rock ranging from 0.05 to 2 mm in diameter, and commonly composed of quartz; 2) a loose aggregate or more or less unconsolidated deposit, consisting essentially of sand-sized rock particles or medium-grained clastics.

Scarp: Also known as escarpment is a steep slope or long cliff that occurs from faulting and resulting erosion and separates two relatively level areas of differing elevations.

Scope: An activity that focuses the assessment on relevant issues and concerns and establishes the boundaries of the environmental assessment (Canadian Environmental Assessment Agency).

Secchi Disk: a ¼ m diameter disc, divided into alternating black and white quadrants. The depth in the water at which the disc disappears from view is used as a measure of water's transparency or turbidity.

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

Sediment budget: An accounting of the erosion, storage and transport processes of soil and sediment in drainage basins or smaller landscape units.

Sediment core: A sample of sediment obtained by driving a hollow tube into the bed and withdrawing it with its contained sample or core.

Sediment trap: Small cylindrical tube placed along the bottom of a water body to "trap" or capture a representative sample of deposited sediment.

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

Sentinel (or indicator) species: A species that is closely correlated with a particular environmental condition or habitat type such that its presence or absence can be used as an indicator of environmental conditions. In the case of mercury, a top-level predator may be used to monitor the highest levels of mercury that may bioaccumulate in the organs and tissues of mammals.

Setback lines: The lines reflecting the upper limit of the physical effects of flooding including wave uprush and geotechnical considerations.

Shallow waterbodies: A class in the Canadian Wetland Classification System which includes open water areas that are typically less than 2 metres deep, that may be periodically dewatered, and having less than 25% emergent vegetation cover.

Shore: The narrow strip of land in immediate contact with the sea, lake or river.

Shore zone: Areas along the shoreline of a waterbody including the shallow water, beach, bank and immediately adjacent inland area that is affected by the water body.

Silt: A very small rock fragment or mineral particle, smaller than a very fine grain of sand and larger than coarse clay; usually having a diameter of 0.002 to 0.06 mm; the smallest soil material that can be seen with the naked eye.

Site Selection and Environmental Assessment (SSEA): Site Selection and Environmental Assessment process used to select a site or route for a transmission facility (*i.e.*, a station or a transmission line) and assess any potential environmental impacts of that facility on the biophysical environment and socio-economic conditions.

Slumping: Slumping is a form of mass wasting that occurs when a coherent mass of loosely consolidated materials or rock layers moves a short distance down a slope.

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.

Specific conductance: Conductivity expressed at a standard temperature of 25°C.

Staging: The tendency of migratory organisms to stop temporarily (stage) at a site during migration; staging areas are stop-over sites where, for example, fish will rest and occasionally forage in preparation for imminent spawning or migratory birds will rest, forage, and/or moult along the course of a migration route.

Stocking program: Fish that are raised in captivity (generally from eggs and sperm collected from wild fish [brood stock]) are released into a designated water body to meet one or more specific management objectives. These management objectives can include population restoration, population enhancement, and/or establishment of a fishery.

Sub-adult: A fish that is older than one year but has not reached sexual maturity. Lake Sturgeon sub-adults measured between 200 and 833 mm long (fork length) based on sexual maturity data collected during the spawning season from a well-studied lake sturgeon population on the lower Nelson River.

Submergent: Plants that normally have all of their photosynthetic tissues under water.

Substrate(s)/Substrata: the material forming the streambed; also solid material upon which an organism lives or to which it is attached. See also bed material.

Suspended sediment concentration: Measure of the amount of sediment in a unit of water usually expressed in terms of milligrams of dry sediment measured down to approximately 1 micron (0.001 mm) in a litre of water.

Suspended sediment transport: Part of a stream's (or other waterbody's) total sediment load that is carried in the water column due to turbulence, currents or colloidal suspension.

Taxonomy: The classification of organisms in a hierarchical system or in taxonomic ranks (*e.g.*, order, family, genus, species) based on shared characteristics or relationships inferred from the fossil record or established by genetic analysis.

Telemetry: Automatic transmission and measurement of data from remote sources by wire or radio or other means.

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.

Thermal ice cover: An ice cover that forms where velocities are low.

Threshold: A limit or level which if exceeded likely results in a noticeable, detectable or measurable change or environmental effect that may be significant. Example thresholds include water quality guidelines, acute toxicity levels, critical population levels and wilderness criteria. See also benchmark. Or a limit of tolerance of a VEC to an effect, that if exceeded, results in an adverse response by that VEC.

Till: An unstratified, unconsolidated mass of boulders, pebbles, sand and mud deposited by the movement or melting of a glacier.

Timber: The wood of growing trees suitable for structural uses; the body, stem, or trunk of a tree.

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

Total Sediment Load: Measure of the total sediment being transported in suspension and on the bed.

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

Transect: A line located between points and then used to investigate changes in attributes along that line.

Transmission: A process of transporting electric energy in bulk from a source of supply to other parts of the electrical system (*e.g.*, load centres like large communities of major industrial customers).

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).

Tundra: Treeless plain characteristic of arctic and subarctic regions, with permanently frozen subsoil and dominant vegetation of mosses, lichens, herbs, and dwarf shrubs.

Umbrella indicator: An indicator for which changes represent changes for a broad group of species, several ecological pathways and/or an indicator of one or more other topics.

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.

Valued environmental component (VEC): Any part of the environment that is considered important by the proponent, public, scientists and government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concern.

Velocity: A measurement of speed.

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

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

Wildlife management area (WMA): Crown lands set aside for the better management, conservation and enhancement of wildlife resources of the province.