Lower Churchill Hydroelectric Generation Project

Environmental Impact Statement

VOLUME I PART A

Project Planning and Description



nalcor energy

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February 2009

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PREFACE

For over 50 years, Nalcor Energy and its predecessors have been providing electric power to the people of the Province of Newfoundland and Labrador (the Province). In 1974, the Churchill Falls Power Station was completed and planning commenced for the generation of more power on the Churchill River. In 1980, a proposed development on the lower Churchill River was designed and a full Environmental Impact Statement (EIS) produced which went through regulatory review including public hearings. That project was approved but did not proceed for economic and other non-environmental reasons. In 2006, Hydro registered a new proposed project for assessment under the provincial and federal environmental assessment processes. This document forms one of the volumes of the environmental assessment of that project, the Lower Churchill Hydroelectric Generation Project (the Project).

The Project will include hydroelectric generation facilities at Gull Island and Muskrat Falls, and interconnecting transmission lines to the existing Labrador grid. The Gull Island site will consist of a generation facility with a capacity of 2,250 MW and include a dam and a reservoir. The Gull Island Reservoir will be 232 km long, and the area of inundated land will be 85 km². The Muskrat Falls site will consist of a generation facility 824 MW in capacity and will also include dams and a reservoir. The Muskrat Falls Reservoir will be 59 km long and the area of inundated land will be 41 km². The transmission lines will consist of a 735 kV link between Gull Island and Churchill Falls and a double circuit 230 kV transmission line between Muskrat Falls and Gull Island. The 735 kV transmission line will be 203 km long and the 230 kV transmission line will be 60 km long. Both lines will be north of the lower Churchill River generally parallel to an existing right-of-way and the tower structures will be built of lattice-type steel.

In accordance with federal and provincial environmental assessment legislation and before Project construction, Nalcor Energy has prepared this EIS to determine the environmental effects of the Project, and to propose effects management measures that would reduce adverse environmental effects and enhance positive environmental effects. This EIS is available for public review and comment, and it forms the basis of information for future hearings to be conducted by an environmental assessment panel.

The EIS is presented in an Executive Summary and three volumes (in five binders), accompanied by appendices and component studies. The Executive Summary presents key findings of the EIS, focusing on an overview of the Project, its interactions with and effects on the environment, and mitigative measures to eliminate, reduce or control adverse effects. Volume IA and Volume IB describe the Project, including its need and purpose, components and assessment methodology. These volumes also describe the detailed public and Aboriginal consultation program that Nalcor Energy carried out for the Project. Volume IIA and Volume IIB are the biophysical assessment, which includes the atmospheric, aquatic and terrestrial environments. Volume III is the socio-economic assessment. There have also been over 65 studies for the Project carried out over the period 1974 to 2008. In cooperation with the Innu Nation, Innu Traditional Knowledge was collected and has been incorporated in verbatim quotes throughout the EIS. The quotes are identified by boxed and italicized text, so that the information is not misrepresented.

AUTHENTICATION

The EIS document was prepared by a team of environmental consultants working with personnel from Nalcor Energy. The lead consultant companies were Minaskuat Inc./Jacques Whitford Limited, AMEC Earth and Environmental Ltd., Sikumiut Environmental Management Ltd., Keith Storey Consulting, and Hatch Ltd. with essential assistance from Aura Environmental Research and Consulting Ltd., Black Spruce Heritage, EnFor Consulting, FMA Heritage Resources, Golder Associates, LGL Limited, Memorial University Health Unit, Northwest Hydraulic Consultants, Strategic Concepts Inc. and Tetra Tech.

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The EIS was prepared under the direction of Ms. Marion Organ, Environmental Assessment Lead - Generation with Nalcor Energy.

ENVIRONMENTAL IMPACT STATEMENT DOCUMENT ORGANIZATION

EIS EXECUTIVE SUMMARY

VOLUME I: INTRODUCTION, PROJECT PLANNING AND DESCRIPTION

1. Volume IA: Introduction
2. Volume IA: Need, Purpose, Alternatives to and Rationale for the Project
3. Volume IA: Project Planning
4. Volume IA: Project Description
5. Volume IA: Regional Environmental Setting and Context
6. Volume IA: Regulatory Context and Scope of Assessment
7. Volume IA: Public Consultation
8. Volume IA: Aboriginal Consultation
9. Volume IA: Environmental Assessment Approach and Methods
10. Volume IA: Effects of the Environment on the Project
11. Volume IA: References
12. Volume IA: Glossary and Abbreviations

Volume IB: Appendices

VOLUME II: BIOPHYSICAL ASSESSMENT

1. Volume IIA: Introduction
2. Volume IIA: Existing Environment
3. Volume IIA: Environmental Effects Assessment - Atmospheric Environment
4. Volume IIA: Environmental Effects Assessment – Aquatic Environment

Volume IIA: References, Glossary and Abbreviations, and Appendix

5. Volume IIB: Environmental Effects Assessment - Terrestrial Environment
6. Volume IIB: Environmental Effects Assessment - Accidents and Malfunctions
7. Volume IIB: Conclusions and Sustainability
8. Volume IIB: References
9. Volume IIB: Glossary and Abbreviations

Volume IIB: Appendices

VOLUME III: SOCIO-ECONOMIC ASSESSMENT

1 Introduction
2. Existing Environment
3. Environmental Assessment of Socio-economic Effects – Economy, Employment and Business
4. Environmental Assessment of Socio-economic Effects - Communities
5. Environmental Effects Assessment - Land and Resource Use
6. Environmental Effects Assessment - Cultural Heritage Resources
7. Environmental Effects Assessment – Accidents and Malfunctions
8. Conclusions and Sustainability
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1.0 INTRODUCTION

This chapter is a general introduction to Volume IA and Volume IB of the Lower Churchill Hydroelectric Generation Project (the Project, Figure 1-1) Environmental Impact Statement (EIS). First, it includes the identification of the Proponent, followed by a brief overview of the Project and description of the EIS purpose. The relationships of the Project to existing legislation and policy, land claims and other agreements are presented for context. An overview of land claim agreements is presented before historical context, which describes previous environmental assessment work for earlier proposed hydroelectric developments on the lower Churchill River. Finally, this chapter discusses other registrations that might result from this Project.

1.1 The Proponent

Newfoundland and Labrador has an immense and diverse energy warehouse. Guided by a long-term Energy Plan to manage these energy resources, the Government of Newfoundland and Labrador created a new provincial Crown corporation, branded "Nalcor Energy" in 2008. Nalcor Energy is the Project Proponent.

Nalcor Energy's foundation is built on its core business: the generation and transmission of electrical power. Nalcor Energy makes a strong commitment to provide safe, reliable and dependable electricity to its utility, industrial, residential and retail customers. Beyond its core business, Nalcor Energy has expanded into the broader energy sector, including oil and gas, wind energy, and research and development. Nalcor Energy is leading the development of the Province's energy resources and is focussed on environmentally responsible and sustainable growth.

The *Energy Corporation Act* authorizes Nalcor Energy to invest in, engage in and carry out activities in all areas of the energy sector (except nuclear) within the Province and, with approval, outside the Province, including:

- development, generation, production, transmission, distribution, delivery, supply, sale, export, purchase and use of energy from wind, water, steam, gas, coal, oil, hydrogen or other products used in power production;
- exploration for development, production, refining, marketing and transportation of hydrocarbons and products made from hydrocarbons;
- manufacturing, production, distribution and sale of energy-related products and services; and
- research and development.

Nalcor Energy's vision is to build a strong economic future for successive generations of Newfoundlanders and Labradorians. Nalcor Energy's employees share a set of common values. Nalcor Energy is a proud, diverse energy company, whose people are committed to a bright future for Newfoundland and Labrador, united by core values::

- **Open Communication** - Fostering an environment where information moves freely in a timely manner;
- **Accountability** - Holding ourselves responsible for our actions and performance;
- **Safety** - Relentless commitment to protecting ourselves, our colleagues, and our community;
- **Honesty and Trust** - Being sincere in everything we say and do;
- **Teamwork** - Sharing our ideas in an open and supportive manner to achieve excellence;
- **Respect and Dignity** - Appreciating the individuality of others by our words and actions; and
- **Leadership** - Empowering individuals to help guide and inspire others.

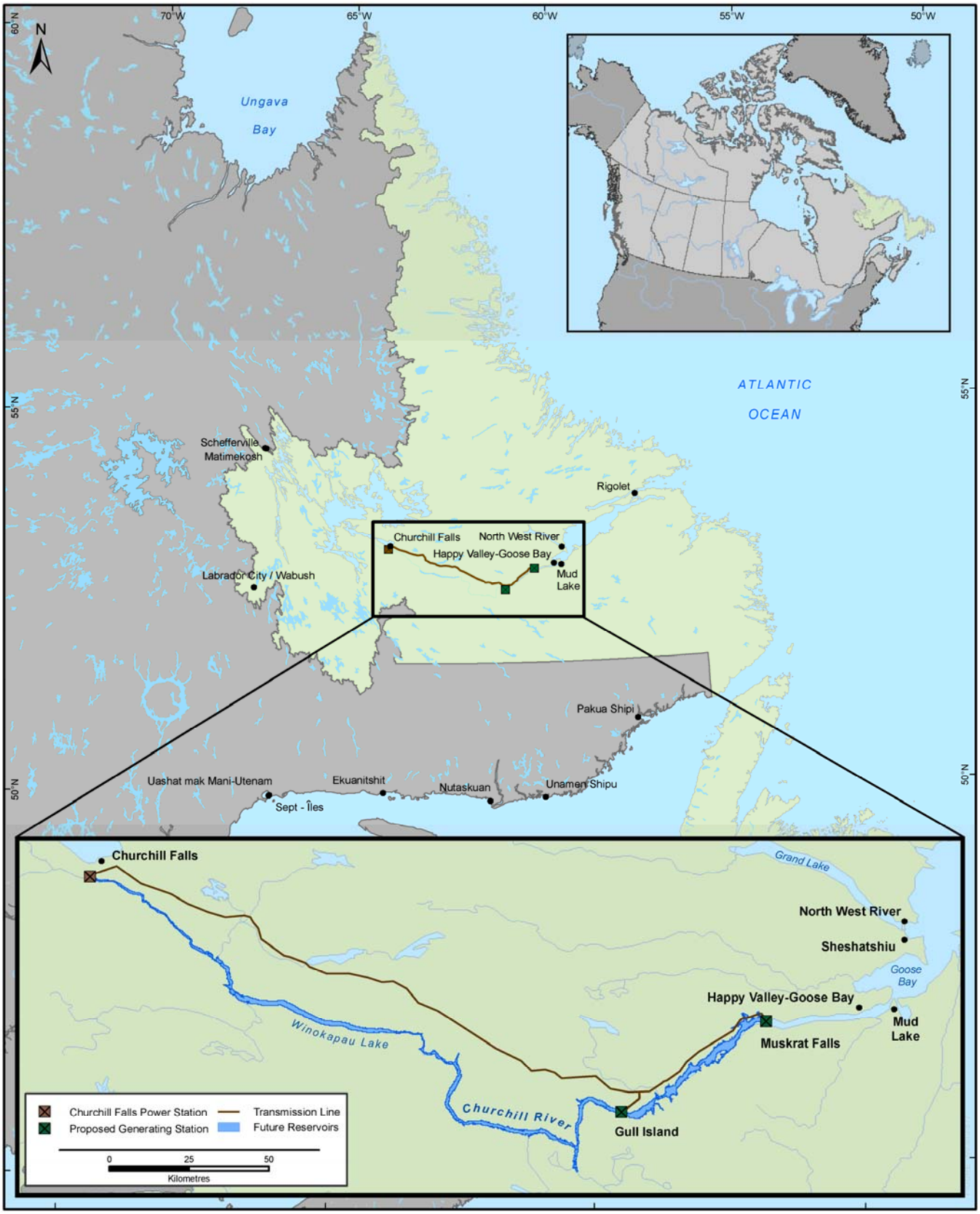


Figure 1-1 Lower Churchill Hydroelectric Generation Project

Nalcor Energy's head office is in St. John's. The President and Chief Executive Officer is Mr. Edmund J. Martin.

The contact for the environmental assessment is:

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Manager, Environment and Aboriginal Affairs
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1.1.1 Corporate Structure and Assets

Nalcor Energy is the parent company of Newfoundland and Labrador Hydro, the Churchill Falls (Labrador) Corporation, and Nalcor Energy – Oil and Gas Inc. It is the provincial lead for the development of the Lower Churchill Project and has also taken ownership of the Bull Arm Site Corporation (Figure 1-2).

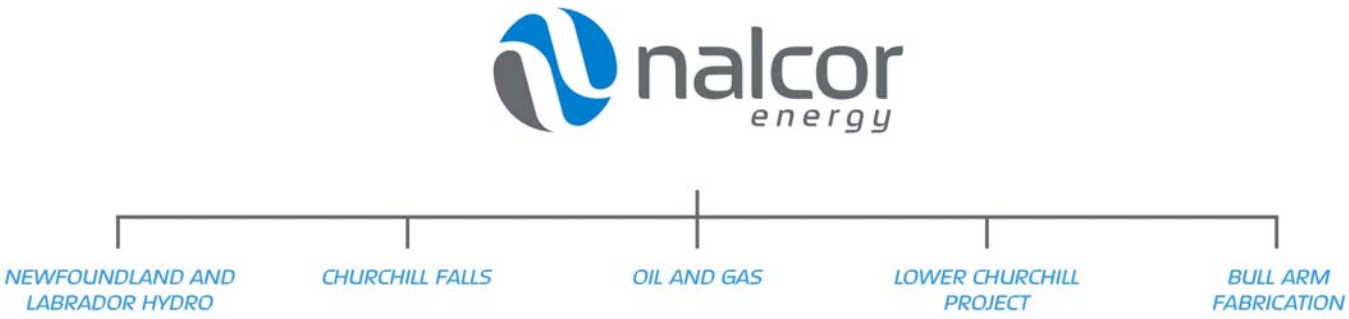


Figure 1-2 Nalcor Energy Corporate Structure

Newfoundland and Labrador Hydro

Newfoundland and Labrador Hydro (Hydro) is a Crown corporation and a wholly-owned subsidiary of Nalcor Energy. Committed to operational excellence, Hydro is dedicated to delivering safe, reliable, least-cost power to industrial, utility and over 35,000 direct customers in rural Newfoundland and Labrador. Hydro's installed generating capacity in 2008 was 1,635 MW of which 58 percent is hydroelectric generation. Its power generating assets consist of nine hydroelectric plants, one oil-fired plant, four gas turbines, 25 diesel plants, and 6,807 kilometers of transmission and distribution lines (Figure 1-3).

Hydro's power generation sources in Labrador (Newfoundland and Labrador Hydro 2007) include:

- 15 rural isolated diesel plants with a total capacity of 22.7 MW;
- interconnected stand-by diesel plants at Happy Valley-Goose Bay (11.7 MW) and Mud Lake (0.1 MW);
- one thermal gas turbine (stand-by) at Happy Valley-Goose Bay (27 MW); and
- 525 MW from Nalcor Energy - Churchill Falls is available for use in Labrador, of which 225 MW is committed to Twin Falls Corporation under contract to mining operations in western Labrador. The remaining 300 MW is available to the Labrador interconnected system.



Figure 1-3 Hydro Provincial Generation and Transmission Grid

Power generation assets on the Island of Newfoundland (Newfoundland and Labrador Hydro 2007) include:

- nine hydroelectric plants with a total installed capacity of 940 MW;
- the 490 MW oil-fired Holyrood Thermal Generating Plant;
- three gas turbines with a total capacity of 123 MW; and
- eight diesel plants (six isolated) with a total capacity of 21.5 MW.

Hydro generates, transmits and distributes electrical power and energy to industrial, utility and residential customers in Newfoundland and Labrador. Hydro recognizes that a dependable source of electricity is an essential part of daily life and has provided safe and reliable electricity for over 50 years to customers across the province.

Hydro is focused on long term strategic asset maintenance and planning to ensure a continued reliable and dependable source of electricity. Its continuous infrastructure upgrades and use of new technology is one way it commits to providing excellent customer service and will continue to search for the best way to provide power that is safe, cost efficient, sustainable and environmentally sound.

Churchill Falls

The Churchill Falls Power Station is one of the largest hydroelectric generating stations in the world. The plant has 11 turbines with a rated capacity of 5,428 MW.

In 2007, more than 33 terawatt hours of electricity was produced, with the majority of that energy sold to Hydro-Québec through a long-term power purchase contract set to expire in 2041. Most of the remaining production is used for mining operations in Labrador West and Hydro's Labrador Interconnected System, with any excess power sold to Hydro-Québec under a short-term recall agreement.

Nalcor Energy-Churchill Falls ensures that the men and women who operate the Churchill Falls Power Station, as well as their families, live in a comfortable community with the expected amenities of any town. The town of Churchill Falls has a population of 650 people. The company operates the town, including a school, grocery store, theatre, library and recreational facilities.

The focus of Nalcor Energy-Churchill Falls, is to deliver high-quality, reliable power to customers and ensure future generations benefit from this world-class provincial resource through long-term asset management.

Oil and Gas

Nalcor Energy-Oil and Gas holds and manages oil and gas interests on behalf of the Province of Newfoundland and Labrador. The Company is committed to the growth and marketing of oil and gas development opportunities around the world and are currently partners in two developments offshore Newfoundland and Labrador - the Hebron oil fields, the province's fourth offshore oil project, and the White Rose Expansion Project.

Lower Churchill Project

The Churchill River in Labrador is a significant source of renewable, electrical energy; however, the potential of this river has yet to be fully developed. The existing 5,428 MW Churchill Falls Power Station, which began producing power in 1971, harnesses about 65 per cent of the potential generating capacity of the river. The remaining 35 per cent is located at two sites on the lower Churchill River, known as the Lower Churchill Project.

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The lower Churchill River hydroelectric resource is one of the key elements in the province's energy warehouse. The potential of the lower Churchill resource, one of the best undeveloped hydro resources in North America, is immense.

This much needed resource of clean, stable, renewable energy provides the opportunity for Newfoundland and Labrador to meet its own domestic and industrial needs in an environmentally sustainable way, with enough power remaining to export to other jurisdictions where the demand for clean energy continues to grow.

Bull Arm Fabrication

The Bull Arm facility was constructed by the Hibernia Management and Development Company (HMDC) in 1990 for the Hibernia project. In 1998, HMDC transferred ownership of the site to the Province and the Bull Arm Site Corporation (BASC) was formed. Since that time, fabrication and other work associated with the Terra Nova FPSO, White Rose project, Voisey's Bay nickel project and the Henry Goodrich drill rig has been completed at the site.

This world-class facility is located close to the communities of Sunnyside, Arnold's Cove and Come By Chance and has provided employment and economic spin-off benefits through the purchase of goods and services in this area. The site has provided broader benefits to the province through new infrastructure, technical knowledge and expertise, technology transfer and an experienced labour force.

The transfer of the site, to be operated as a subsidiary of Nalcor Energy, ensures this key asset is ready and available to maximize the benefits to the Province from the number of large-scale construction and fabrication projects on the horizon. The Bull Arm facility is a critical asset for the Province to the development of the oil and gas industry in Newfoundland and Labrador and the advancement of the Province's fabrication capacity.

1.1.2 Environmental Management

An Environmental Services Department was established in 1975. Since that time, the corporation has demonstrated leadership in managing the environmental aspects of its activities and will continue to do so under Nalcor Energy. Through the 1970s and 1980s, Hydro (now a subsidiary of Nalcor Energy) was an innovator both provincially and nationally with respect to environmental assessment, environmental compliance and effects monitoring, environmental auditing and environmental protection planning. Hydro has confirmed its leadership role in environmental management by adopting the stringent International Organization for Standardization (ISO) 14001 standard for its Environmental Management System (EMS) at its facilities. ISO certification is a demonstration of a high level of commitment to the policy and practice of environmental management, including review and audit.

Environmental Policy and Guiding Principles (Policy) were established by Hydro in 1997 and updated in 2006. This Policy has been adopted by all lines of business of Nalcor Energy and is provided below.

ENVIRONMENTAL POLICY AND GUIDING PRINCIPLES

> The Newfoundland and Labrador Hydro Group of Companies will help sustain a diverse and healthy environment for present and future Newfoundlanders and Labradorians by maintaining a high standard of environmental responsibility and performance through the implementation of a comprehensive environmental management system.
>
> The following guiding principles set out the Hydro Group’s environmental responsibility:

PREVENTION OF POLLUTION

- implement reasonable actions for prevention of pollution of air, water, and soil and minimize the impact of any pollution which is accidental or unavoidable;
- use the Province's natural resources in a wise and efficient manner;
- use energy as efficiently as possible during the generation, transmission, and distribution of electricity, and the operation of its facilities, and promote efficient use of electricity by customers;
- maintain a state of preparedness in order to respond quickly and effectively to environmental emergencies;
- recover, reduce, reuse and recycle waste materials whenever feasible;

IMPROVE CONTINUALLY

- audit facilities to assess potential environmental risks and continually improve environmental performance;
- integrate environmental considerations into decision-making processes at all levels;
- empower employees to be responsible for the environmental aspects of their jobs and ensure that they have the skills and knowledge necessary to conduct their work in an environmentally responsible manner;

COMPLY WITH LEGISLATION

- comply with all applicable environmental laws and regulations, and participate in the Canadian Electricity Association's *Environmental Commitment and Responsibility Program*;
- periodically report to the Board of Directors, Executive Management, employees, government agencies, and the general public which we serve on environmental performance, commitments and activities;
- monitor compliance with environmental laws and regulations, and quantify predicted environmental impacts of selected activities on the environment;
- respect the cultural heritage of the people of the Province and strive to minimize the potential impact of Corporate activities on heritage resources.

The Policy is based on the principle of sustainable development, which espouses a balance among environmental, economic and social aspects of business. Specifically, as required by the ISO 14001 Standard, the Policy commits to preventing pollution, complying with legal and other requirements, and continually improving environmental performance. Nalcor Energy also supports and implements the principles and goals of the Canadian Electricity Association Environmental Commitment and Responsibility Program (Canadian Electricity Association 2008, Internet site).

Hydro has been recognized for outstanding stewardship and environmental management by such organizations as the Newfoundland and Labrador Association of Professional Engineers and Geoscientists and the National Hydropower Association.

In 2002, the provincial Department of Environment and Conservation selected Hydro for the *Newfoundland and Labrador Environmental Award* in the Business Category for "a business that has demonstrated the exemplary

attitude and concern for the environment through sound environmental management policy, and has demonstrated action to prevent or reduce pollution".

1.2 Overview of the Project

Nalcor Energy is proposing to construct and operate the Project on the lower section of the Churchill River (Mishta-shipu in Innu-Aimun, see Appendix IB-A for other Innu-Aimun place names (and species names)) in Labrador (Figure 1-1). Generation facilities with a combined capacity of 3,074 MW will be installed at Gull Island (100 km southwest of Happy Valley-Goose Bay) and Muskrat Falls (30 km southwest of Happy Valley-Goose Bay). Transmission lines will be installed between these generation sites and Churchill Falls.

The Project will complete an important step toward maximizing the hydroelectric potential of the Churchill River watershed. It will produce approximately half the energy now generated at the Churchill Falls Power Station. The Project is described in detail in Chapter 4.

1.2.1 Project Components

The Project consists of generation facilities at Gull Island (Figure 1-4) and Muskrat Falls (Figure 1-5), as well as transmission lines (Appendix IB-B contains detailed mapping) between Gull Island and Churchill Falls and between Muskrat Falls and Gull Island.

Gull Island

The Gull Island facility will consist of a generation station with a capacity of 2,250 MW and the powerhouse will contain five Francis turbines.

The dam will be a concrete faced, rock-fill construction 99 m high and 1,315 m long establishing a 213 km² reservoir with a full supply level of 125 m above sea level (m asl) (Appendix IB-C contains detailed mapping). The reservoir will be 232 km long and the incremental area of inundated land will be 85 km² at full supply level.

Muskrat Falls

The Muskrat Falls facility will consist of a generation station with a capacity of 824 MW and the powerhouse will contain four propeller or Kaplan turbines.

The concrete dam will be built in two sections (on the north and south abutments of the river): the north dam will be 32 m high and 432 m long and the south dam will be 29 m high and 325 m long. The reservoir will be 59 km long with an area of 101 km². The area of inundated land will be 41 km² at full supply level (39 m asl) (Appendix IB-C).

Supporting Infrastructure to the Generation Facilities

The following additional construction activities are planned:

- access (both permanent and temporary) to the sites and to the reservoirs will require approximately 345 km of temporary road and 30 km of permanent road. Most of the temporary roads will be constructed to facilitate vegetation clearing within each reservoir. Temporary access roads will be inundated during flooding or decommissioned upon completion of construction;
- temporary construction bridges which will be removed when construction is complete;

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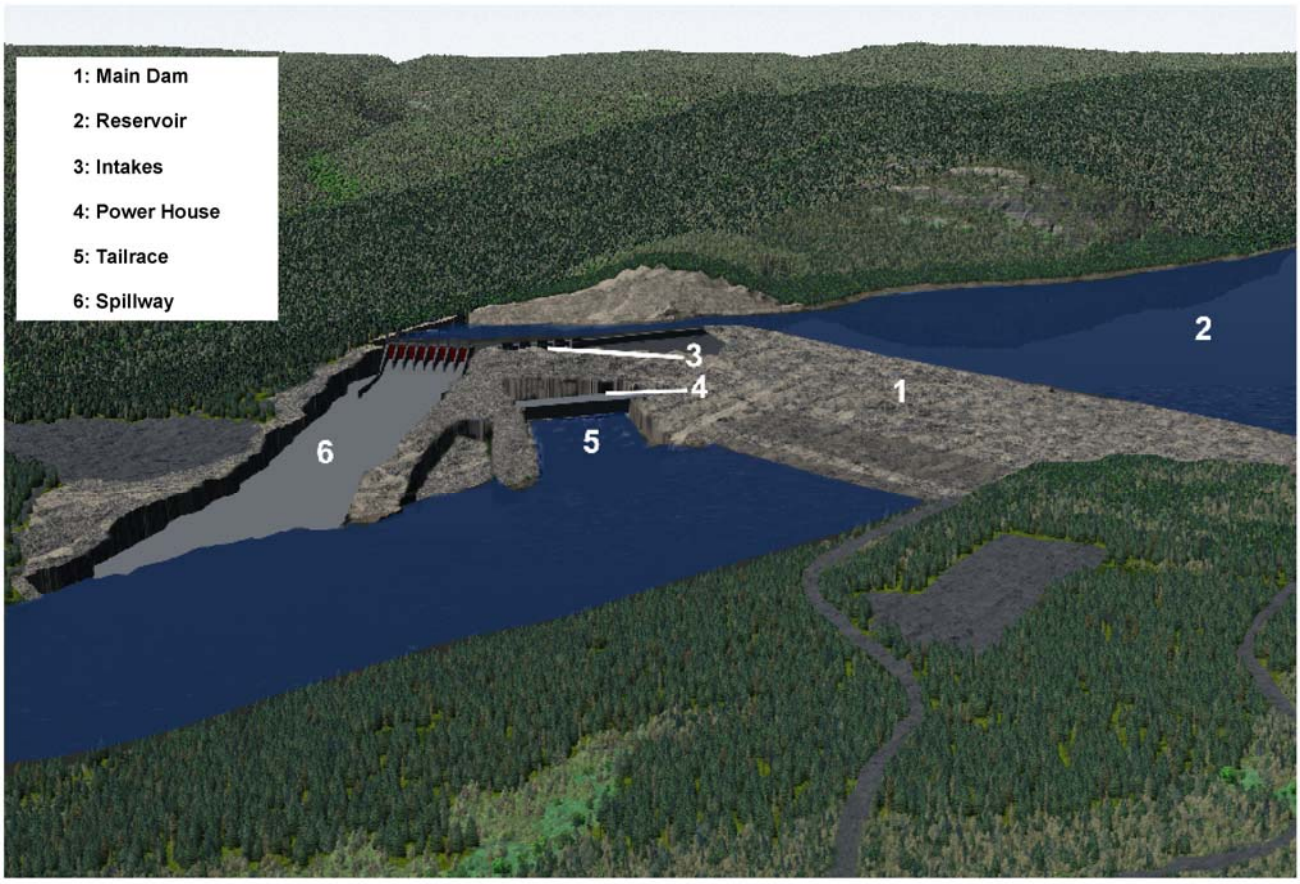


Figure 1-4 Conceptual Illustration of the Gull Island Generation Facility



Figure 1-5 Conceptual Illustration of the Muskrat Falls Generation Facility

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- accommodations at the Gull Island construction site are designed for up to 2,000 people and the Muskrat Falls construction site accommodations are designed for up to 1,000 people. Both facilities will be removed when construction is complete;
- borrow pits and quarry sites will be decommissioned and rehabilitated when construction is complete;
- diversion facilities will include diversion tunnels at the Gull Island construction site and cofferdams at both sites;
- spoil areas, consisting of waste overburden and rock, will be rehabilitated when construction is complete; and
- reservoir preparation will involve clearing a portion of the vegetation from both reservoirs (Appendix IB-D contains detailed mapping).

Transmission Lines

The transmission lines are designed to be:

- 203 km long for the 735 kilovolt (kV) line between Gull Island and Churchill Falls; and
- 60 km long for the double-circuit 230 kV line between Muskrat Falls and Gull Island.

Both transmission lines will be supported by lattice-type steel structures and located north of the Churchill River, requiring a cleared right-of-way approximately 80 m wide in addition to the existing right-of-way. Temporary construction camps, of a capacity between 10 and 150 people, will be required to support transmission line construction.

Construction Schedule

The 10 year construction period will begin at the Gull Island Generation Facility in the summer of Year 1. First power from the Gull Island Generation Facility is scheduled for Year 6. Construction at the Muskrat Falls Generation Facility will begin during Year 5. Transmission line construction is scheduled to span Year 2 through Year 9.

1.2.2 A Sustainable Project

Sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development 1987, Internet site).

As the Province’s *Sustainable Development Discussion Document* states “The economic and social prosperity of Newfoundland and Labrador is inextricably tied to its abundant natural resources” (Government of Newfoundland and Labrador 2006). Development of the hydroelectric potential of the lower Churchill River is a natural resource project that can provide an important, long term, reliable source of renewable energy. It is essential that the Project be planned and implemented for long term sustainability, integrating economic, environmental and social factors effectively so that the benefits of each factor are realized for present and future generations.

Nalcor Energy is committed to the principle of sustainable development throughout all phases of the Project, from early planning and design through to construction and operation and maintenance. The environmental assessment research and field studies provide an understanding of the ecology of the area as well as the traditional use of the lower Churchill River and valley and its resources for cultural, recreational and subsistence

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activities. Nalcor Energy has adjusted aspects of Project design, construction practices and operation and maintenance to balance environmental, economic and social considerations.

The Project will play an essential role in the sustainable development of Newfoundland and Labrador by providing the Province's economy with a long term stable supply of renewable energy. In conjunction with the existing Churchill Falls Power Station, this Project will provide a foundation of renewable energy to drive the Province's economy for generations to come. Therefore, the Project will meet the sustainability principle of the Energy Plan (Government of Newfoundland and Labrador 2007a):

> *Energy developments must be environmentally and economically sustainable. We will protect and enhance our environment. We will also ensure the economic benefits from the development of our energy resources will be shared with future generations.*

Sustainable development is one of the guiding principles of environmental assessment and has these objectives:

- the preservation of ecological integrity, including the capability of natural systems to maintain their structure and functions and to support biological diversity;
- the respect for the right of future generations to the sustainable use of renewable and non-renewable resources; and
- the attainment of durable and equitable social and economic benefits.

The EIS addresses these three aspects of sustainability. The biophysical assessment (Volume IIA and Volume IIB) examines the ability of the affected areas to retain biodiversity, in terms of whether the species assessed will continue to have suitable habitat. The Project will directly affect 16 percent of the lower Churchill River valley; however, with mitigation, the ecological integrity of the atmospheric, aquatic and terrestrial environments will be maintained and will continue to support biological diversity.

To protect the right of future generations to have continued access to renewable and non-renewable resources, the Project approach to planning has been to respect existing uses of the lower Churchill River and to provide for continued access, as demonstrated in the socio-economic assessment (Volume III).

The rationale for the Project is in line with the attainment of durable and equitable social and economic benefits. The Project will provide revenue to the Province to support social benefits and will also provide long-term economic benefits. These benefits will continue to accrue for decades, given the long life of the Project. Residents of the Province will benefit through job creation and business activity. Socio-economic benefits from the Project will increase through training initiatives and supplier development programs. Labrador residents will be direct beneficiaries of these initiatives. The Project will greatly increase the power available for economic development, more than doubling the amount of electricity currently available to the Province.

In order to maximize economic benefits, Nalcor Energy will plan and implement strategies to provide long term employment and business opportunities for local people. The Project can:

- increase opportunities for training, certification and employment related to the industry;
- provide opportunities for business diversification and growth; and
- improve local infrastructure.

Future opportunities for industrial development will become more likely with the availability of a reliable and renewable source of electric power.

Hydroelectric technology is one of the most effective and reliable electricity generation options to reduce greenhouse gases (GHG). In addition, hydroelectricity also displaces emissions of nitrous oxides and sulphur dioxide that result from fossil fuel generation and contribute to acid rain.

The life span of hydroelectric generation sites is 50 to 100 years or more. Over the life of the Project, GHG emissions will be negligible. In comparison to alternate sources of electricity, hydroelectric generation produces less than two percent of the emissions produced by a comparable coal-fired plant and less than five percent of the emissions of a comparable natural gas-fired plant.

Nalcor Energy is committed to maintaining a sustainable and healthy environment for future generations. Nalcor Energy consistently reviews its business and operational practices to meet its mandate to deliver safe, reliable least-cost power balanced with its environmental commitments. Nalcor Energy staff are professionally trained in environmental sciences, ecology and engineering, and they are responsible for staying current with environmental management processes, issues, techniques, and ensuring that Nalcor Energy is meeting its regulatory, sustainability and environmental responsibilities (Nalcor Energy 2008, Internet site).

1.3 Environmental Impact Statement Purpose and Context

The Project is subject to the environmental assessment provisions of the *Newfoundland and Labrador Environmental Protection Act* (*NLEPA*) and the *Canadian Environmental Assessment Act* (*CEAA*). In accordance with these two environmental assessment processes, Nalcor Energy has prepared this EIS.

A joint Registration/Project Description document was filed with the Newfoundland and Labrador Department of Environment and Conservation (NLDEC), and the Canadian Environmental Assessment (CEA) Agency on December 1, 2006 (Newfoundland and Labrador Hydro 2006). In response, the federal and provincial governments each determined that a full environmental assessment would be required in accordance with their respective legislation. As well, the governments of Canada and Newfoundland and Labrador developed a joint review process agreement so that a single environmental process could satisfy both the *NLEPA* (Section 72) as well as *CEAA* (Sections 40 and 41). Through this agreement, EIS Guidelines were developed and issued (Appendix IB-E). This EIS complies with these Guidelines.

The submission of the EIS is an important step in the environmental assessment review process. The joint review process agreement includes the appointment of a Joint Review Panel, which will receive all public review comments on the EIS, hold hearings at designated locations and provide a report to governments that makes recommendations on the environmental implications of the Project.

The EIS is a careful and detailed consideration of how the Project could affect the residents, communities and natural environment surrounding the lower Churchill River. The EIS has been prepared by Nalcor Energy and is based on 30 years of research, planning and engineering design. The document consists of an Executive Summary and five binders of three volumes:

- Volume IA: Introduction, Project Planning and Description;
- Volume IB: Appendices to Volume IA;
- Volume IIA: Biophysical Assessment (Introduction, Existing Environment, Atmospheric Environment, Aquatic Environment);
- Volume IIB: Biophysical Assessment (Terrestrial Environment, Accidents and Malfunctions, Conclusions and Sustainability); and
- Volume III: Socio-economic Assessment.

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Component Studies and a Key Subject Index (as required in the EIS Guidelines) (Appendix IB-E) were completed to support the analysis and predictions made in the EIS:

- Large Mammals
  - Moose (*Alces alces*) Interim Report; Minaskuat Inc. 2009a
  - Caribou (R*angifer tarandus caribou*) Baseline Report; Minaskuat Inc. 2009b
  - Black Bear (*Ursus americanus*) Interim Report; Minaskuat Inc. 2009c
  - Wildlife Habitat Associations Environmental Baseline Report; Minaskuat Inc. 2008a
  - Moose and the Proposed Churchill River Power Project: A Literature Review; Conor Pacific Environmental Technologies Inc. and Westworth Associates Environmental Ltd. 2000
  - Churchill River Power Project 1999 Environmental Studies: Winter Moose Survey; Northland Associates and Jacques Whitford 2000
- Furbearers
  - Inventory of Beaver Colonies in the Lower Churchill River Valley; Minaskuat Inc. 2008b
  - Furbearer Winter Habitat Use; Sikumiut Environmental Management Ltd. 2008a
- Avifauna
  - Forest Songbird Survey; Minaskuat Inc. 2008c
  - Waterfowl in the Lower Churchill River Area; LGL Limited 2008
  - Inventory of Osprey, Bald Eagle & Golden Eagle Nest Sites in the Lower Churchill River Valley; Minaskuat Inc. 2008d
  - Osprey and Bald Eagle Study; Jacques Whitford 1999a
  - Churchill River Power Project Waterfowl; AGRA Earth and Environmental and Harlequin Enterprises 1999
- Species at Risk
  - Rare Plant Survey in the Lower Churchill River Valley; Minaskuat Inc. 2008e
  - Caribou (*Rangifer tarandus caribou*) Baseline Report; Minaskuat Inc. 2009b
- Fish and Fish Habitat
  - Aquatic Vegetation Study; AMEC Earth and Environmental Ltd. 2008a
  - Lower Churchill River Fish Consumption and Angling Survey; Minaskuat Inc. 2009d
  - Seal Abundance and Distribution; Sikumiut Environmental Management Ltd. 2007
  - Habitat Quantification; AMEC Earth and Environmental Ltd. and Sikumiut Environmental Management Ltd. 2007
  - 2006 Fish and Fish Habitat Baseline Study: Catch-based Utilization Index Validation and Additional Habitat Surveys; AMEC Earth and Environmental Ltd. 2007
  - HADD Determination Methodology Churchill River, Labrador; AMEC Earth and Environmental Ltd. 2001
  - Biological Study of the Goose Bay Estuary; Jacques Whitford 2001a
  - Fish Migration and Habitat Use of the Churchill River; Jacques Whitford 2000
  - Fish and Fish Habitat; AGRA Earth and Environmental 2000
  - Primary Productivity and Plankton Biomass; Jacques Whitford 1999b
  - Benthic Invertebrate Study of the Churchill River; Jacques Whitford 1999c

- Water Quality and Quantity
  - Water and Sediment Modelling in the Lower Churchill River; Minaskuat Inc. 2008f
  - Water and Sediment Quality in the Lower Churchill River; Minaskuat Limited Partnership 2007
  - Sedimentation and Morphodynamics Study; Northwest Hydraulic Consultants 2008
  - Water Quality and Chlorophyll Study; Jacques Whitford 2001b
  - Water and Sediment Quality in the Churchill River; Jacques Whitford 1998a
- Hydrology
  - Bank Stability Study; AMEC Earth and Environmental Ltd. 2008b
  - Salt Water Intrusion 3D Model Study; Hatch 2008a
  - Sediment Plume Analysis; Hatch 2008b
  - Hydraulic Modelling; Hatch 2008c
  - Ice Dynamics of the Lower Churchill River; Hatch 2007
  - Aquatic Environment in the Goose Bay Estuary; Agra Earth and Environmental and BAE-Newplan Group Limited SNC-Lavalin 2001
- Mercury
  - Assessment of the Potential for Increased Mercury Concentrations; Tetra Tech Inc. 2008
  - Calculation of Anticipated Consumption Advisory Levels of Fish in the Lower Churchill Area; Minaskuat Inc. 2008g
  - Existing Mercury Concentrations in Osprey and Ecological Risk Assessment; Minaskuat Limited Partnership 2008
  - Statistical Analysis of Mercury Data from Churchill Falls (Labrador) Corporation Reservoirs; Jacques Whitford 2006
  - Freshwater Fish Mercury Sampling Churchill River Labrador; AMEC Earth and Environmental Ltd. 2000
- Cultural Heritage Resources
  - Historic Resources Overview and Impact Assessment of Muskrat Falls Generation Facility and Reservoir and Muskrat Falls to Gull Island Interconnecting Transmission Line Corridor; Minaskuat Inc. 2008h
  - Innu Environmental Knowledge of the Mishta-shipu (Churchill River) Area of Labrador in Relation to the Proposed Lower Churchill Project; Innu Nation 2007
  - Report on the Fieldtrip to Ushkan-shipiss; Innu Nation 2008
  - Churchill River Power Project Historic Resources Overview Assessment 1998-2000 Volume 1 Interpretation Summary and Recommendations; Jacques Whitford and Innu Environmental Limited Partnership 2001a
  - Historic Resources (Labrador Study); Jacques Whitford and Innu Environmental Limited Partnership 2001b
  - Historic Resources Overview Assessment (Labrador Component); Jacques Whitford and Innu Environmental Limited Partnership 2000
  - Historic Resources Potential Mapping; Jacques Whitford and Innu Environmental Limited Partnership 2001c
  - Sea Level History and Geomorphology of the Churchill River and Strait of Belle Isle; Jacques Whitford 1998b

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- Timber Resources
  - Forest Inventory; Sikumiut Environmental Management Ltd. 2009
  - Reservoir Preparation Report; Sikumiut Environmental Management Ltd. 2008b
  - Reservoir Preparation Workshop Report; Duerden & Keane Environmental Inc. 2007
- Socio-economic Studies
  - Socio-economic Environmental Baseline Report; Minaskuat Inc. 2008i
  - Calculation of Anticipated Consumption Advisory Levels of Fish in the Lower Churchill Area; Minaskuat Inc. 2008g
  - Lower Churchill River Fish Consumption and Angling Survey; Minaskuat Inc. 2009d
  - Forecasted Labour Resource Requirements by National Occupation Classification for Generation Projects; Nalcor Energy 2008
  - Community Health Study; Aura Environmental Research and Consulting Ltd 2008
  - Current Land and Resource Use in the Lower Churchill River Area; Minaskuat Inc. 2009e
- Air Quality
  - Greenhouse Gas Emissions Study; Minaskuat Inc. 2008j
  - Greenhouse Gas Fluxes; Environnement Illimite & Environnement d'Hydro-Québec 2007
- Other
  - Wetland Assessment and Evaluation; Minaskuat Inc. 2008k
  - Regional Ecological Land Classification (ELC); Minaskuat Inc. 2008l
  - Project Area ELC; Minaskuat Inc. 2008m
  - Herpetile Surveys in the Lower Churchill River Valley; Minaskuat Inc. 2008n
  - Interconnecting Transmission Line Constraint Mapping Atlas; AMEC Earth and Environmental Ltd. 2008c

1.4 Relationship to Legislation, Permitting, Regulatory Agencies and Policies

The regulatory context of the Project is addressed in Chapter 6.

Two general public policy statements have particular relevance to the Project. The Energy Plan (Government of Newfoundland and Labrador 2007a) sets out government policies and plans for energy development and management in the Province, and stresses the important role of hydroelectric energy generation. This resource is recognized, not only for its economic and social potential, but also for its capacity to help reduce GHG emissions.

The Energy Plan (Government of Newfoundland and Labrador 2007a) recognizes that, "*In addition to petroleum, our great store of clean, renewable energy resources means we have the capacity to not only provide for our long-term energy security, but also to be environmental leaders in the energy sector. We have the potential to replace GHG-emitting energy sources with our clean hydroelectricity and wind, both here at home and in the North American marketplace.*"

The existing facility at Churchill Falls and the Project, together, have the potential to offset (or replace) approximately 225,000 barrels of oil per day.

The Province has also issued a Northern Strategic Plan for Labrador (Government of Newfoundland and Labrador 2007b) which provides an overall context for development of the region. Nalcor Energy will focus efforts on realizing benefits to Labrador through training opportunities and supplier development and providing

first consideration for employment on the Project to Labrador residents. Details about these commitments are provided in Volume III, Section 3.6.5.

1.5 Land Claim Agreements and Interim Agreements

The EIS Guidelines identify two agreements that need to be discussed with respect to their potential interaction with the Project: the Interim Forest Agreement and the Labrador Inuit Land Claims Agreement. Each is discussed below. As well, the Tshash Petapen (New Dawn) Agreement (Government of Newfoundland and Labrador 2008, Internet site) is directly relevant to the Project and is also addressed.

The Interim Forest Agreement provides for full participation by Innu Nation in management planning, information sharing, development of sustainable forestry practices and preparation of ecosystem-based management plans for the Labrador forest resource. The agreement also provides for consultation by the Province with Innu Nation on decisions that affect land and resource use. One important result of the agreement has been the Forest Ecosystem Management Plan for District 19 (NLDNR 2007, Internet site), an area encompassing much of the lower Churchill River watershed. In preparing the EIS, Nalcor Energy has referred extensively to and used the information contained in this plan.

The Labrador Inuit Land Claims Agreement designates Labrador Inuit Lands that are under the jurisdiction of Nunatsiavut Government. A larger area, known as Labrador Inuit Settlement Area (LISA), includes land and water areas extending into Lake Melville. Sections 11.5.11 and 11.6.1 of the Labrador Inuit Land Claims Agreement address the situation where a project or undertaking outside LISA could affect Inuit land or rights. In such cases, Nunatsiavut Government can participate in the applicable federal or provincial assessment processes. The western extent of the Labrador Inuit Settlement Area lands does not reach the lower Churchill watershed and is, at its closest, 50 km from the river mouth. The influence of the Project does not extend beyond the mouth of the Churchill River and, consequently, there is no reasonable possibility that the Project would have an adverse environmental effect on the Labrador Inuit Settlement Area.

In September 2008, the Province and Innu Nation signed the Tshash Petapen (New Dawn) Agreement (Government of Newfoundland and Labrador 2008, Internet site). The Agreement resolves key issues related to the land claims (Innu Rights Agreement), Innu redress for the Upper Churchill hydroelectric development and the lower Churchill Impact and Benefits Agreement (Project IBA). Final agreements based on the Tshash Petapen (New Dawn) Agreement will be subject to ratification by Innu Nation membership. The Agreement lays out commercial terms of the Project IBA, including a structured royalty regime and implementation funding to support Innu Nation involvement in the Project during construction. This Agreement represents important progress towards conclusion of the Project IBA and enables Project planning and approval processes to continue. Negotiations are now under way to execute a final IBA in 2009.

1.6 Previous Environmental Assessments

Previous proposals to develop the hydroelectric potential of the lower Churchill River were also subject to environmental assessment requirements and proceeded to varying degrees through approval processes. Development of the hydroelectric potential of the Churchill River watershed began in 1954 with the construction of the 18 MW Menihek Power Plant to provide electric power to the iron ore mines developed in Shefferville, Quebec, near the Labrador border. This was followed in 1960 with the construction of the Twin Falls Power Plant. This plant was built to provide power to the iron ore mines at Labrador City and Wabush. The Menihek Power Plant is still operating. Twin Falls was decommissioned in 1974 subsequent to the full commissioning of the Churchill Falls Power Station. The 5,225 MW (upgraded to 5,428 MW in 1985) Churchill

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Falls Power Station is one of the largest underground powerhouses in the world. In total, the site captures about two-thirds of the hydroelectric potential of the Churchill River. Most of the flow in the Churchill River has been regulated since the Churchill Falls Power Station started operation in 1971.

Environmental assessment processes were not in place during development of either the Menihek, Twin Falls or Churchill Falls facilities. Environmental baseline information has been collected since 1974 in the region where the Project will operate, beginning with the initial proposal to develop the hydroelectric potential of the lower section of the Churchill River in the 1970s.

A full federal government Panel Review was completed in 1980 to assess the environmental effects of the project proposed for the lower Churchill River in 1978. This involved the collection and analysis of environmental baseline data, the preparation of an EIS and the holding of public hearings. The Panel found that the proposed project was acceptable, provided environmental and socio-economic conditions were met.

More recently, additional environmental studies have been conducted, contributing to the extensive body of knowledge on the surrounding environment. Where relevant, a summary of this information is provided in Volumes II (A and B) and III. Appendix IB-F presents a summary of environmental and socio-economic baseline studies undertaken by Hydro over the period 1974 to 2001.

During each of these efforts, some level of environmental assessment was completed and with the exception of the 1990 effort, field surveys were conducted. The results of these efforts are summarized as follows:

- 1974 to 1976: Gull Island Power Co. produced an Environmental Overview of the Gull Island Project (Thurlow and Associates 1976) in response to requests and expectations from the provincial and federal governments. The document was based primarily on a literature review and focused on the generation site.
- 1978 to 1985: LCDC carried out a full environmental assessment of the two generation sites (Gull Island and Muskrat Falls) and the HVDC interconnection to the Island (LCDC 1980a). The work included a full array of baseline studies, field data collection and consultation over the period 1978 to 1980. An EIS was submitted in 1980 to a federal-provincial Panel, which held hearings that fall throughout the Province. The Panel submitted a report in December 1980 (LCDC 1980b), which recommended approval of the Project subject to conditions. While the Project did not commence at that time, follow-up studies were conducted from 1981 to 1985.
- 1990: Based on encouraging discussions related to market access, Hydro prepared and submitted a Project Registration for Gull Island and Muskrat Falls generation stations, as well as associated transmission facilities. The Province determined that an EIS would be required and issued guidelines in May 1991. The failure to reach agreement on access to external markets resulted in suspension of this effort.
- 1998 to 2001: The Labrador Hydro Project Office was established in 1998 to plan and develop the Churchill River Power Project (CRPP). Hydro-Québec acted as a joint partner in this initiative; however, it later withdrew from the agreement. The CRPP concept involved a diversion of the headwaters of the Romaine River into the Smallwood Reservoir, with the consequent increase in electric power generation possible at the existing Churchill Falls site, as well as at the proposed Gull Island and Muskrat Falls facilities. Thirty-five baseline studies were conducted from 1998 to 2000. However, the development plans were determined not to be feasible. Efforts then focused on the identification of a project that did not rely on diversions.
- 2005 to 2008: Hydro assembled a team to examine a lower Churchill River project that could meet the needs within the Province and could access export markets. The Project was defined and registered for environmental assessment in November 2006.

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Additional studies were undertaken over this timeframe by resource management agencies. For example, Fisheries and Oceans Canada (DFO) undertook a two year field sampling program (1975 to 1976) along the lower Churchill main stem and produced a substantial report describing the fish and fish production in that area.

The suite of biophysical studies used as a basis for the EIS (Section 1.3) provides information of substantial depth that was collected over a long duration. As will be shown throughout the EIS, this information base has been supplemented with another suite of studies completed in reference to the current Project design and in keeping with contemporary sampling protocols and analytical techniques.

In addition to providing extensive baseline results, previous studies have been available from the onset to provide useful input to issues scoping, Project planning and design processes. For example, there is a sound knowledge and understanding of physical processes (e.g., ice growth and ablation) and biological phenomena (e.g., seasonal patterns of fish movements) within the watershed.

1.7 Other Registrations

The EIS Guidelines (Section 4.2.7 Other Registrations, Appendix IB-E) state that the EIS shall indicate whether any other registrations are to be submitted for environmental assessment in the future as a result of this Project. At the time of this filing/submission, Nalcor Energy expects that there has or will be a registration and project description filed for the proposed Nalcor Energy Labrador-Island Transmission Link project. The Labrador-Island Transmission Link project would provide additional transmission line capacity in the region and take advantage of the opportunities presented by this project. For the purpose of cumulative effects assessment in this EIS, the Labrador-Island Transmission Link project is considered reasonably foreseeable and is included under “Additional Transmission”. Other transmission options are also being considered for this Project and would also be included under “Additional Transmission” as part of the cumulative effects assessment.

Nalcor Energy is engaged in identifying and defining power purchase agreements with prospective customers in eastern Canada and the United States. A transmission corridor will have to be determined, and regulatory requirements, including environmental assessment, will be required. While no corridor can be identified at this time, the transmission lines will be subject to *NLEPA* and *CEAA*, and both a project registration and a project description will be prepared and submitted to regulators.

The availability of hydroelectric power may attract new industry to Labrador or the Island; however, such development is hypothetical and would be subject to whatever regulatory requirements might apply.

2.0 NEED, PURPOSE, ALTERNATIVES TO AND RATIONALE FOR THE PROJECT

The EIS Guidelines (Appendix IB-E) require a comprehensive discussion of the need, purpose, alternatives to and rationale for the proposed Project. The discussion includes consideration of technical, economic and environmental factors (i.e., fundamental rationale for the Project). The need for the Project considers the problem or opportunity the Project is intended to solve or satisfy (i.e., to meet the identified need). The purpose of the Project defines what the Project is intended to achieve. The alternatives to the Project are the functionally different ways to meet the Project need and purpose. The rationale for the Project provides the foundation for the Project need.

The following discussions are consistent with the Guidance of the CEA Agency found in its Operational Policy Statement (OPS; CEA Agency 2007). No analyses of environmental effects are provided where there are no technically and economically feasible alternatives to the Project, remaining consistent with the OPS and the *CEAA* or where the alternative does not meet the need and purpose of the Project.

2.1 Introduction

Newfoundland and Labrador's Energy Plan (Government of Newfoundland and Labrador 2007a) provides the government's policies and plans for energy development and management in the Province. Hydroelectric energy generation is recognized for its economic and social importance as a source of renewable energy. Forecasts indicate as much as 32 percent growth in energy demand in the Province between 2007 and 2027, with additional demand for cleaner energy elsewhere in North America. In response to these needs, the Project can provide 3,074 MW of renewable electricity through further development of the hydroelectric potential of the Churchill River.

2.2 Need for the Project

The Project is needed to:

1) address the future demand for hydroelectric generation in the Province;
2) provide an electric energy supply for sale to third parties; and
3) develop the Province's natural resource assets for the benefit of the Province and its people.

2.3 Purpose of the Project

The purpose of the Project is to develop the hydroelectric potential of the lower Churchill River. In achieving this purpose, the Project will generate revenue for the Province, reduce fossil fuel use and contribute to security of energy supply for the Province and Canada. Nalcor Energy's role is to develop energy resources on behalf of the people of the Province. The Project is the best undeveloped renewable resource available to the Province. Once completed, the Project will provide 3,074 MW of hydroelectric power to residents, communities and industries in the Province and elsewhere. The Project fits within the Province's Energy Plan (Government of Newfoundland and Labrador 2007a) and will contribute to the objective of reducing GHG emissions in Newfoundland and Labrador and beyond through a reduction in the use of fossil fuels.

2.4 Project Rationale

Hydroelectric power generation has an important role in energy supply; it offers economic and social benefits within the Province and beyond. Several international agencies such as the World Summit for Sustainable

Development, the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Symposium on Hydropower and Sustainable Development have identified hydroelectric power as a key means to address the worldwide need to lower emissions and enhance the use of clean, renewable energy.

The value of the Project lies not only in financial benefits from the development itself, but also in the beneficial environmental effect it will have by displacing a large amount of GHG emissions. The displacement of emissions in eastern Canada will help the federal government meet its international commitments to GHG reductions. The Project will be in an optimal position to make a substantive contribution to meeting the targets established by the federal regulatory framework. As a source of clean, renewable power, the Project expects to benefit economically from opportunities associated with the various compliance mechanisms outlined in the framework.

The Project meets the needs identified in the Province and elsewhere for cleaner, renewable energy and addresses the principles of sustainable development along with Nalcor Energy's mandate to develop, deliver and use electrical power and energy for both domestic consumption and export.

2.4.1 Demand for New Renewable Generation

The demand for new renewable generation has been increasing across North America in recent years, driven largely by four factors:

- the increasing demand for electricity in general;
- the need to upgrade or replace aging infrastructure in the industry;
- rising costs of fossil fuels; and
- the need to address the contribution to climate change.

2.4.1.1 Increasing Demand

The increasing demand for electricity is a national and international trend that is fuelled by population growth, growth in economic activity and technological advances. The demand is predicted to continue well into the future. The National Energy Board (NEB) is forecasting growth in energy demand in Canada from 2010 to 2020 of almost 14 percent, or 82 terawatt hours (TWh) over this 10 year period (NEB 2008, Internet site). The United States Department of Energy (USDE) is forecasting that electricity consumption in that country will grow to 4,972 TWh by 2030, approximately 30 percent over 2006 levels (USDE 2008a, Internet site). This growth in demand presents an opportunity for benefits to accrue from inter-provincial and international trade of power for regions with an excess of electricity supply.

2.4.1.2 Aging Infrastructure

The electricity industry in Canada and the United States is also dealing with the consequences of aging infrastructure. Investment is required in new infrastructure as existing facilities reach the end of their service lives and new capacity is required to meet increasing demand. The International Energy Agency projects that approximately $95 billion will need to be invested in generation infrastructure in Canada between 2005 and 2030, with another $27 billion required for transmission infrastructure (Canadian Electricity Association 2007, Internet site).

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2.4.1.3 Fossil Fuels

The increasing cost of fossil fuels is creating demand for new sources of energy. With 72 percent of all generation in the United States dependent on fossil fuel (USDE 2008a, Internet site), many regions, including the northeastern United States, are actively seeking other sources of energy to meet current and future demands.

2.4.1.4 Climate Change

The growing awareness of the environmental effects of GHG emissions and air pollutants and substantial increases in fuel prices has resulted in a surge in demand for sources of cleaner, renewable generation. Most developed countries have made national and international commitments to meet emission reduction targets. In the 2007 Speech from the Throne, Canada committed to implementing a national strategy to reduce the country's total GHG emissions by 20 percent below 2006 levels by 2020 (Government of Canada 2007, Internet site). Numerous bills and resolutions are currently before the United States Congress for consideration with various options for limiting emissions. Regulatory requirements targeting emissions reductions are an important factor influencing electricity industry planning in markets across both countries as the number of provinces and states enacting legislation specific to this issue continues to grow.

Hydroelectric developments have a number of unique characteristics that enhance their value, including proven and reliable technology, long lifespan and non-emitting generation. This makes power from hydroelectric sources attractive, particularly for regions that are heavily dependent on older, thermal generation facilities for power and with limited availability to new sources of cleaner, renewable power.

2.4.2 Energy Plan

The development of renewable energy sources, most notably the lower Churchill River, is a major component of the Newfoundland and Labrador Energy Plan (Government of Newfoundland and Labrador 2007a). Development of the lower Churchill River will provide people of the Province with access to renewable energy. It will also support industrial growth in Labrador and on the Island.

2.4.2.1 Provincial Needs

Meeting the current and future energy needs of the Province is the first priority for the power from the lower Churchill River. The Proponent will meet these needs with renewable hydroelectric power from the lower Churchill River.

2.4.2.2 Industrial Development

The second priority for lower Churchill River power is to support possible new industrial growth within the Province. The Project will more than double the amount of renewable electricity available to the Province and will dramatically increase the amount of power available over the long term for new economic development both in Labrador and on the Island.

2.4.2.3 Labrador

Employment opportunities and business activity resulting from the construction and operation of the Project are the primary direct benefits. A substantial portion of the secondary employment and business opportunities will occur naturally in Labrador. Nalcor Energy will focus its efforts on maximizing benefits to Labrador through training and supplier development and will require that qualified Labrador residents have first consideration for employment on the Project.

The Project Team has engaged key stakeholders regarding labour requirements, and is working with educational institutions to identify training opportunities. The Project Team is also working with stakeholders to identify supplier opportunities and will continue to do so as planning progresses.

Substantial benefits will accrue to the people of Labrador and to the provincial government from the Project. With the input of people from all regions of Labrador, investments made to secure greater benefits from the Project development (such as job training) will help build a sustainable economy and continue to improve access to quality public services. The vehicle through which the provincial government will make these investments is the Northern Strategic Plan (NSP) for Labrador (Government of Newfoundland and Labrador 2007b).

2.4.2.4 Electricity Exports

Once the current and future needs of the Province are met, the remaining electricity will be exported to avail of opportunities elsewhere. Participation in the North American electricity markets will generate considerable revenue for the benefit of the Province and will establish Nalcor Energy as a market participant in a lucrative export business.

2.4.2.5 Economic Foundation

The Project will require a large capital investment and will generate more than 15,000 person-years of employment during its construction, as well as provide economic benefits from generation of electricity for decades to come. The lower Churchill River development will be the foundation for the Province's sustainable economy. Once the initial investment in the Project has been recovered, the infrastructure will produce electricity at very low cost over a long service life (in excess of 75 years). Through ownership, the people of the Province will be the principal beneficiaries of substantial financial returns.

2.4.3 Addressing Climate Change

The Project is the largest undeveloped hydroelectric resource in North America with the potential to have a substantial positive effect on GHG reductions in eastern North America, an area that is currently heavily reliant on thermal generation.

The Project will contribute to GHG emissions reduction, not only within the Province, but also nationally and internationally. Renewable electricity from the lower Churchill River will potentially eliminate the need for the thermal generating station at Holyrood. As well, excess electricity from the Project has the potential to displace existing fossil-fuel generation in export markets.

2.4.3.1 International Climate Change Research

The IPCC was established in 1988 by the World Meteorological Organization and the United Nations Environment Programme to provide objective scientific information related to climate change. Participation on the IPCC is open to all member countries of both organizations and scientists from around the world contribute to its body of work.

In its Fourth Assessment Report released in November 2007, the IPCC found that global GHG emissions resulting from human activity increased by 70 percent from 1970 to 2004, with carbon dioxide (CO_2) emissions alone having increased by 80 percent. The IPCC estimates that CO_2 emissions resulting from the use of fossil fuels accounted for almost 57 percent of the global GHG emissions in 2004. On a sector basis, the energy supply sector was responsible for over 25 percent of the emissions with industry placing second with just over 19 percent (IPCC 2007, Internet site).

The IPCC recognizes that the ability of nations to adapt to the environmental effects of climate change is limited by social, cultural, institutional, financial and political factors including human capital, social networks, national income and technology constraints. As such, the IPCC recommends that the global community apply both adaptation and mitigation strategies to reduce the risks of climate change. Adaptation and mitigation strategies are interdependent. Adaptation will help to address the effects of global warming in both the short and long term, while mitigation will reduce risks in the long term by reducing GHG emissions and stabilizing atmospheric levels of various GHGs. The available evidence suggests that reliance on adaptation alone could eventually lead to a magnitude of climate change for which effective adaptation is either not possible or will incur very high social, environmental and economic costs.

The Fourth Assessment Report identifies numerous sector strategies and technologies that can be employed to help nations adapt to global climate change, while at the same time contributing to the stabilization of atmospheric GHG levels. Possible strategies include energy efficiency, use of renewable resources and strengthening of overhead transmission and distribution infrastructure. Some of the mitigation measures identified for the energy sector are improved supply and distribution efficiency, nuclear power, renewable heat and power such as hydropower and solar energy, and the early application of carbon capture and storage.

In December 2007, the delegates from over 180 countries that participated in the United Nations Climate Change Conference in Bali reached agreement on the Bali Action Plan (Bali Road Map) to address global climate change (Bali 2007, Internet site). The Bali Action Plan recognized the Fourth Assessment Report as "*the most comprehensive and authoritative assessment of climate change to date providing an integrated scientific, technical and socio-economic perspective on a relevant issue*". This recognition reinforces the necessity of both adaptation and mitigation strategies, including hydroelectric power developments, in dealing with GHG emission levels.

2.4.3.2 Regulatory Framework for Air Emissions

In April 2007, the Government of Canada outlined its initial plans for reductions in GHG emissions and other air pollutants through its Regulatory Framework for Air Emissions (Environment Canada 2007, Internet site). Environment Canada announced further details March 10, 2008. The framework is not yet finalized and further announcements are pending. The Framework establishes mandatory emission reductions for industry, as well as a number of other initiatives designed to reduce Canada's total GHG emissions and air pollutants. The GHG emissions reduction targets under the Framework are based on emission intensity levels (amount of GHG emissions per unit of production), with a reduction of 18 percent in emission intensity mandated for the electricity sector by 2010 and an additional two percent reduction required in subsequent years. The federal government is forecasting that the intensity reduction requirements will result in a 30 megatonne (Mt) reduction in annual GHG emissions from 2006 levels in the electricity sector by 2020. In contrast, reductions in air pollutant emissions are based on national caps for industrial emissions from 2012 to 2015 with the following targets:

- 40 percent reduction in nitrogen oxides (NO_X) from 2006 levels;
- 55 percent reduction in sulphur oxides (SO_X) from 2006 levels; and
- 20 percent reduction in particulate matter from 2006 levels.

2.4.3.3 Clean Energy Task Force

The Framework indicates that the federal government will be establishing a Clean Energy Task Force to work with industry and provinces to identify another 25 Mt of annual GHG emission reductions from the electricity

sector by 2020, in addition to the base target of 30 Mt per year by 2020. These targets will help drive the demand for clean, renewable power as well as price increases over the next 10 to 15 years. Initiatives identified for consideration by the Task Force that are directly related to the Project include the development of an east-west transmission grid and subsea cable on the Atlantic coast, the development of major hydroelectric projects, and retirement of fossil-fuel electricity generation facilities at the end of their expected life.

While the demand for electricity continues to increase across the country, the electricity sector is expected to reduce their annual GHG emissions by almost 48 percent from 2006 levels (30 Mt base reductions and 25 Mt to be identified by the Task Force (Environment Canada 2008, Internet site)). The Framework outlines a number of compliance mechanisms to provide industry with some flexibility in meeting their targets while lessening the economic effect on individual companies and still achieving compliance under the Framework. Examples include the Technology Fund, Pre-certified Credits and offset credits, among others.

2.4.3.4 National/Regional Solution

The Project is a source of renewable energy, and will play a key role in emissions reductions for Canada. The development of the Gull Island and Muskrat Falls sites has the potential to displace an estimated 16.9 Mt of CO_2 emissions annually compared to electricity produced by coal-fired thermal generation (Table 2-1). Combined with the existing Churchill Falls Power Station, the two sites could produce the electrical equivalent to thermal generation from 225,000 barrels of oil a day.

Table 2-1 Carbon Dioxide Displacement – Lower Churchill River

Generation Alternative	CO_2 Emissions (Mt/yr)
Coal	16.9
Natural gas/ combined cycle	6.0
Diesel/heavy fuel	13.0

As described in Table 2-2, the electricity sector in eastern Canada is responsible for a substantial amount of GHG emissions. With limited options available within their respective jurisdictions, these provinces are also seeking solutions from other jurisdictions to help reduce emissions and, at the same time, meet increasing demand for additional power.

Table 2-2 Greenhouse Gas Emissions from the Electricity Sector (Annual Average 2004 to 2006)

Province	CO_2 Emissions (Mt/yr)	Estimated Cost of Emissions (million/yr)[A]
Newfoundland and Labrador	1.0	$15.0
New Brunswick	7.9	$118.9
Nova Scotia	10.4	$156.5
Ontario	32.7	$489.8
Source: Environment Canada 2008, Internet site [A] Note: Assumes $15 per tonne for the price of carbon		

2.4.3.5 Cost of Emissions

Ultimately, GHG regulation will impose a price on GHG emissions, which will translate into a price increase for the electricity sector either because of the cost of GHG credits or the cost of non-emitting supplies, which can be more expensive than traditional sources such as coal generation. Furthermore, it is anticipated that

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displacement of GHG emissions by non-emitting generation will create emission credits or offset credits that will have monetary value in an emission credit trading system such as is currently being established in Canada.

As noted, the federal government is forecasting that the intensity reduction requirements outlined in the Regulatory Framework will result in a 30 Mt reduction in annual GHG emissions from 2006 levels in the electricity sector by 2020. Combined with Clean Energy Task Force mandate for an additional 25 Mt reduction in annual emission levels, this means that the electricity sector will have to secure a 55 Mt reduction in annual GHG emission by 2020. Using an estimate of $15 per tonne (the Technology Fund contribution rate from 2010 to 2012), the value of the overall GHG emission reductions alone would be $825 million annually.

2.4.4 Market Opportunities

The Project has a generation capacity of 3,074 MW of renewable power. It is anticipated that 800 MW will be required to meet provincial needs, including the potential replacement of Holyrood as well as load growth and from industrial development. The remaining capacity will be available either to meet the needs of new large-scale industrial developments that may decide to locate within the Province because of the availability of power, or for export to customers and markets in northeastern North America.

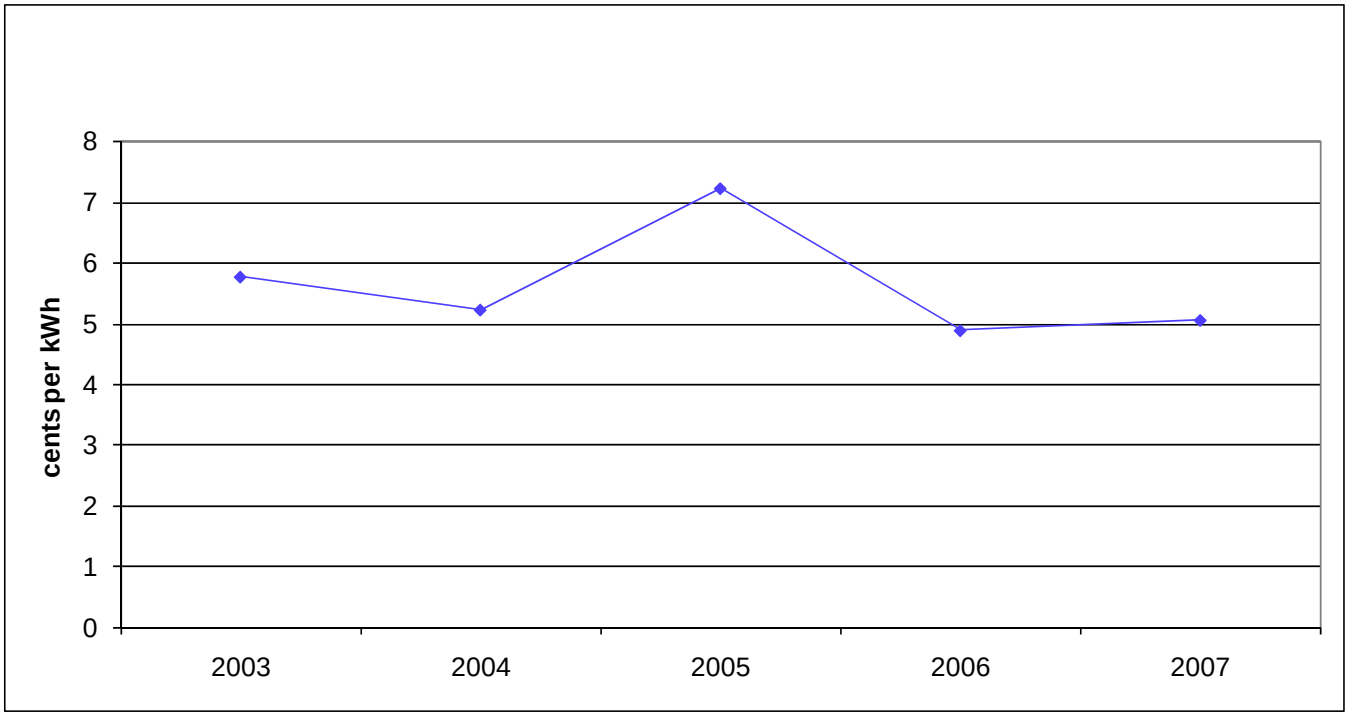
Hydroelectricity can contribute to stability for electricity prices in volatile electricity markets. Higher fuel prices have been a key contributor to the increasing cost of generating electricity in many regions of North America, resulting in higher rates for industrial, commercial and residential customers. Generation of electricity from hydroelectric developments is not dependent on fossil fuels and, as such, results in stable predictable electricity rates over the long term.

2.4.4.1 Electricity Prices: Canada

In 2007, almost 600 TWh of electricity was generated in Canada. Hydroelectric sources accounted for almost 60 percent of the generation, nuclear 15 percent, with the remaining 25 percent from thermal generation sources. Exports to the United States accounted for eight percent of the total power generated in Canada (50.1 TWh), while inter-provincial transfers accounted for another 47.7 TWh (NEB 2008, Internet site).

As in the United States, rising fuel prices have affected electricity prices in Canada. Price increases were the norm in 2007 in Canada due to higher fuel costs, as well as increased costs of new generation and investment in transmission infrastructure. The effect of fuel prices is reflected in the variations from market to market. Electricity prices are generally lower in the Canadian markets than in the United States given the higher proportion of hydroelectric generation.

In Ontario, the price for electricity in the wholesale market has remained consistent, with a five year average of 5.63 cents per kWh between 2003 and 2007 (Figure 2-1). The price spike experienced in 2005 was the result of a severe hurricane season and was reflected in energy prices across all of eastern North America for that year.



Source: IESO 2008, Internet site.

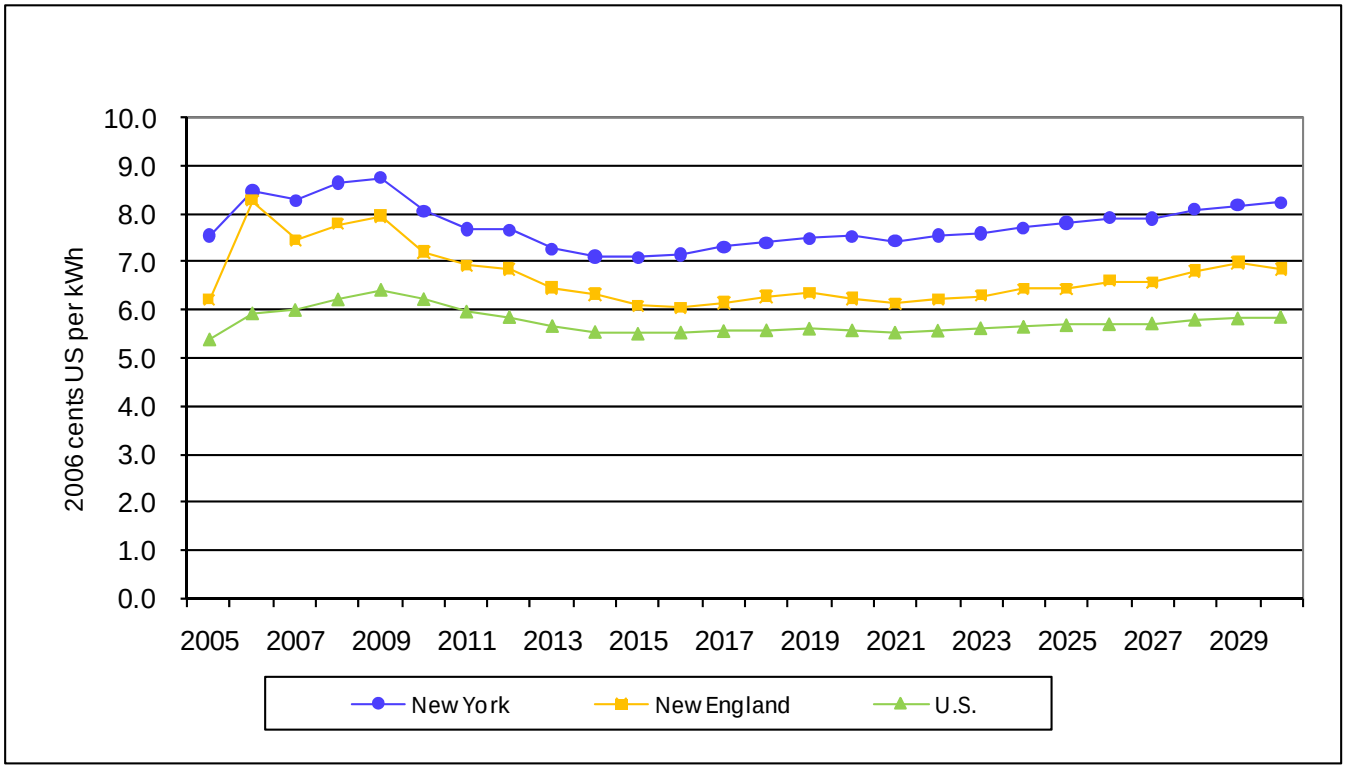
Figure 2-1 Ontario Average Weighted Hourly Electricity Price

2.4.4.2 Electricity Prices: United States

Electricity prices have increased substantially since 2004 in the northeastern states, where there are limitations on supply but the demand for power continues to grow (FERC 2008, Internet site). Between 2004 and 2007, there have been substantial increases in New York City (22 percent), Massachusetts (Independent System Operator-New England (ISO-NE)) (26 percent) and Long Island (38 percent).

Electricity prices in the northeastern United States continue to be heavily influenced by natural gas prices, since a large proportion of the generating capacity within the region is fuelled by natural gas. While forecasts by the USDE indicate a decline in natural gas prices from 2010 to 2016, for the most part, the price is expected to continue in an upward trend post-2016 (Figure 2-2). This trend will add pressure on demand for clean, renewable sources of power in the New York and New England markets.

The effect of the price of natural gas on electricity prices is also reflected in the forecasts published by the USDE (Figure 2-2) in its annual energy outlook. The price of electricity in both the New England and New York markets is consistently higher than the national average because of the high demand in the area and the amount of installed generating capacity that is fuelled by natural gas. In 2005, more than 53 percent of the generating capacity in New England and almost 59 percent of New York's generating capacity came from natural gas as either a primary or secondary fuel source (USDE 2008a, Internet site).

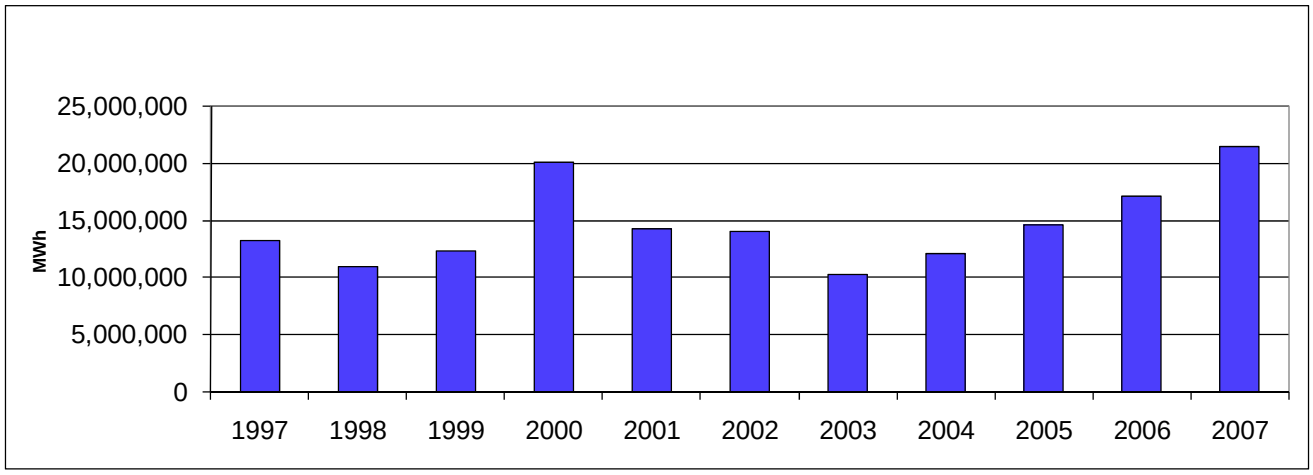


Source: USDE 2008b, Internet site

Figure 2-2 United States Department of Energy Natural Gas Price Forecast

2.4.4.3 Canadian Electricity Exports

In 2007, Canada exported a total of 50.1 million MWh of electricity to the United States, an increase of seven million MWh from 1997 exports. Canadian power exports to the United States have increased by over 37 percent since 2002. As illustrated in Figure 2-3, Canadian power exports to New England and New York have been increasing steadily since 2003. In 2007, these two markets combined received approximately 21.5 million MWh or 43 percent of total Canadian power exports, compared to 31 percent in 1997.



Source: NEB 2008, Electricity Imports and Exports Monthly Statistics

Figure 2-3 Canadian Electricity Exports to New England and New York

As the demand continues to grow in eastern Canada, electricity exports to the United States are expected to grow with the markets in the northeastern states continuing to seek supplies of additional power beyond their borders. Eastern Canadian power exports to the United States increased from 21.2 million MWh in 1997 to 28.1 million MWh in 2007, an increase of over 32 percent in 10 years. As seen in Figure 2-4, the value of the eastern Canadian power exports has increased since 1997, providing additional incentive to develop new generation resources in the region (NEB 2008).



Source: NEB 2008, Electricity Imports and Exports Monthly Statistics

Figure 2-4 Price of Eastern Canadian Electricity Exports

2.4.4.4 Sales Portfolio

There will be a portfolio of sales of lower Churchill River power comprising a balance of long, medium and short term sales arrangements. Diversity in the sales portfolio will make the development more attractive in the financing markets and will allow future sales of power from the Project to not depend on any one contract. This portfolio will also provide flexibility to respond to changes in market conditions and provincial requirements.

Most of the power markets in the northeastern United States have evolved into fully competitive wholesale markets whereby purchase contracts generally are short term in nature (five years or less). Spot and day-ahead markets have been established for energy transactions as well as auctions for capacity and other products. The only comparable market in Canada is in Alberta, which has adopted a fully competitive market structure for electricity. The markets in eastern Canada have undergone some restructuring, moving them towards a competitive market structure, but have not adopted wholesale and retail competition. There are opportunities for medium to long term sales arrangements in Ontario, New Brunswick, Nova Scotia and Quebec.

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Development of the Project portfolio is an ongoing initiative that involves balancing the objectives of optimizing financial returns and mitigating market risks. Market opportunities will be considered not only in terms of revenue generating potential and credit worthiness, but also in terms of the costs of accessing the markets.

The current focus of the portfolio development is on procuring long term sales arrangements with credit-worthy customers for a portion of the power. Once the long term elements of the portfolio are secured, attention will focus on medium and short term sales plans.

2.4.4.5 Newfoundland and Labrador

Currently, the majority of demand in the Province is on the Island (73 percent in 2006), with the baseload supplied from approximately 1,250 MW of hydroelectricity complemented with thermal generation from the 490 MW Holyrood Generating Station (primarily used to meet winter load requirements) and smaller diesel plants in more remote communities. The majority of the load in Labrador is currently met by the Churchill Falls Power Station. The average annual load growth is forecast to be 1.1 percent on the Island and 0.2 percent annually in Labrador. Forecasts indicate that by 2027, an additional 582 MW of generating capacity will be required to meet the demand in the Province, an increase of more than 29 percent over requirements in 2007 (Table 2-3). These additional requirements can be met using generation sources available within the Province.

Table 2-3 Load Growth Forecasts and Capacity Requirements, Newfoundland and Labrador Hydro

	2007	2009	2012	2015	2018	2021	2024	2027
Consumption (GWh)	10,916	11,084	12,029	13,320	13,450	13,735	14,096	14,469
Required Capacity (MW)	1,984	2,035	2,273	2,357	2,369	2,426	2,493	2,566
Source: Market Analysis Section, System Planning Department, Hydro								

Under the current structure, the electrical systems in Labrador and on the Island are not connected, limiting future supply options for the Island. There are no large undeveloped hydroelectric sites remaining on the Island. However, there is some undeveloped small hydroelectricity (60 to 100 MW). The wind development potential on the Island is capped at 80 MW due to limitations in maintaining the integrity of the system. Contracts have been awarded for two 27 MW suppliers of wind generation that are currently under construction.

In the absence of other solutions, power to address future load growth on the Island beyond the remaining small hydroelectric sites would have to be obtained through additional thermal generation, thereby increasing reliance on fossil-fuel generation. If the Province's reliance on thermal generation were to increase or even continue at current levels, substantial financial investment into the Holyrood Generating Station would be required to comply with proposed new federal regulations for GHG emissions and air pollutants. Also, the Holyrood Generating Station will reach the end of its service life in the next 20 years and would require substantial upgrades to extend the life of the facility. In the event that the development of a second refinery on the Island proceeds, the demands on the existing Holyrood Generating Station would increase substantially, heightening the need for alternative sources of power.

Forecasts indicate that peak generation capacity requirements on the proposed Island interconnection are expected to be in the range of 600 to 800 MW of electricity from the lower Churchill River, allowing for the potential displacement of Holyrood, some load growth and new industrial load (such as the Long Harbour Nickel Processing Plant).

Displacement of Holyrood

Annual production at the Holyrood Generating Station varies with hydraulic conditions on the Island. If production decreases at the hydroelectric facilities due to low water inflows to reservoirs, production at Holyrood will increase, ensuring the integrity of the energy supply. Over the past decade, production at Holyrood has varied from a low of 800 GWh in 2006 to a high of 2,300 GWh in 2002. With a forecasted annual load growth of 1.1 percent on the Island, the annual energy required from the Project to displace thermal generation is forecasted to increase by more than double from 2015 to 2050.

The 2007 emission levels for the Holyrood Generating Station are indicated in Table 2-4. Under the Federal Regulatory Framework for Air Emissions, Hydro is mandated to begin reducing levels of CO_2 emissions from its facilities in 2010 and begin reducing levels of the other air pollutants emissions possibly as early as 2012. With relatively limited cleaner generating options remaining on the Island, capacity to meet any additional demand for power would have to come from new thermal sources, adding to the current emission levels, making it increasingly difficult to comply with the new regulations.

Table 2-4 Holyrood Generating Station 2004 to 2007 Emissions

Year	CO_2 (tonnes)	SO_2 (tonnes)	NO_X (tonnes)	PM (tonnes)
2004	1,290,828	16,819	3,239	780
2005	1,062,231	13,648	2,792	1,374
2006	625,084	5,370	1,710	564
2007	1,012,280	6,234	2,489	551
Source: Environmental Services Department, Hydro				

Load Growth - Labrador

The Province has the right to acquire 2,365 GWh of energy per year from Nalcor Energy – Churchill Falls for use in Labrador. This quantity of energy is expected to be sufficient to satisfy Labrador's requirements until at least 2025, given the region's 0.2 percent anticipated annual load growth; however, a large-scale development in the region would likely require an additional source of energy supply.

Industrial Customers

There are a number of proposed and potential major industrial development opportunities in the Province, which could substantially influence the load in Labrador and on the Island (Table 2-5). These potential requirements will also be considered in the market portfolio development that is currently underway. Uncertainties associated with new development in the Province present challenges in developing a long term portfolio. These challenges are alleviated in part by short and medium term contracts and the staged development of Muskrat Falls, both of which will provide flexibility to meet additional demand for power from potential future developments.

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Table 2-5 Industrial Load Opportunities in Newfoundland and Labrador

Potential Industrial Opportunity		Annual Capacity (MW)	Annual Energy (GWh)
Labrador	Aluminum smelter	560	5,000
	New iron ore mine	255	1,750
	Silicon smelter	50	394
	Uranium mine	35 to 45	230
	Iron Ore Company of Canada expansion	20 to 30	200
	Voisey's Bay underground mine	40 to 50	270
Island	Oil refinery	175 to 235	1,780
	Nickel Refinery	80	500
Source: Systems Planning Department, Hydro			

2.4.4.6 Ontario

Ontario is a large market, with peak demand of 25,737 MW and total energy use of 152 TWh in 2007 (IESO 2008, Internet site). This potential is further enhanced by market circumstances, including aging nuclear generation facilities, government policy to shut down coal-fired generation facilities by 2014 and a forecasted growth in energy consumption to 170 TWh in 2015, a 0.9 percent average annual growth rate.

In 2006, the Government of Ontario outlined its intention to move away from coal generation in favour of nuclear power and renewable energy. The government is looking to achieve a doubling of energy efficiency through conservation and doubling the amount of energy from renewable sources by 2025. In August 2007, the Ontario Power Authority (OPA) filed its Integrated Power System Plan (IPSP) with the Ontario Energy Board (OPA 2007, Internet site). The IPSP is a 20 year action plan designed to meet the directives from the Government of Ontario and provide a reliable, adequate and sustainable long term supply of electricity. The Plan outlines several goals, including doubling the amount of renewable energy on the grid by 2025, phasing out coal-fired generation by the end of 2014, refurbishment or replacement of the province's baseload nuclear generation capacity and the completion of transmission upgrades necessary to implement the plan.

While the Government of Ontario has announced plans to address the gap in energy supply partially through conservation, refurbishment of nuclear facilities and by focusing efforts on new renewable sources of power within Ontario, forecasts indicate a capacity shortage of 10,000 MW by the year 2025 (Ontario Ministry of Environment (OME) 2008, Internet site). The IPSP outlines a number of initiatives to address this need, including increasing imports of renewable power from other provinces. It is possible that the Project can play an important role in helping Ontario meet its future energy needs.

2.4.4.7 Quebec

Quebec is a large market, with 173 TWh of electricity sold in the province in 2007 and a peak demand of 35,352 MW for the same year. The hydroelectric generating capacity (43,000 MW) is 93 percent of the generating capacity in the Province. In its energy strategy, Using Energy to Build the Quebec of Tomorrow, the Government of Quebec estimates that of the remaining undeveloped water resources, developments totalling another 20,000 MW in capacity are considered economically feasible at this time. Quebec intends to launch additional hydroelectric generating capacity of 4,500 MW by 2010 (Government of Quebec 2008, Internet site).

In addition to new hydroelectric resources, the energy strategy for Quebec has also identified the potential for wind energy development. Wind power generation works well with hydroelectric generation resources, as the

amount of power generated through hydroelectric resources can be adjusted quickly to counter the variability inherent with wind generation, thus ensuring reliability of the overall power supply. The Government of Quebec has established a target of 4,000 MW of wind energy capacity to be developed by 2015. In May 2008, the Government of Quebec announced the approval of $5.5 billion in wind power projects that will provide 2,004 MW by 2015 (Government of Quebec 2008, Internet site).

With a large network of transmission lines and 18 interconnections, Quebec imports and exports large amounts of power to and from neighbouring sources. The province has an import capacity of 9,575 MW and export capacity of 7,100 MW, with access to the large power markets in Ontario and the northeastern United States. In 2006, Quebec and Ontario signed an agreement for the construction of a new Quebec-Ontario interconnection to be in full service by 2010 (Government of Quebec 2008, Internet site). The proximity of Quebec to Newfoundland and Labrador and its transmission network and interconnections can provide ready access to power markets in the northeast region of North America.

2.4.4.8 New Brunswick

The New Brunswick market is relatively small compared to Ontario and Quebec, with a 2007/2008 forecast peak demand of 3,229 MW and system net energy requirement of 15.7 TWh. It is heavily reliant on fossil fuels, with 64 percent of the 4,175 MW of total generating capacity coming from fossil-fuel generating sources (New Brunswick System Operator 2008).

In addition to the possible purchase of power from the Project, the Government of New Brunswick is assessing the market demand for a second nuclear reactor in the region. Because of its strategic location with transmission access into the eastern United States and linkages to Nova Scotia and Quebec, New Brunswick is planning to increase its role as an energy hub. The province can provide eastern Canadian power suppliers with access into the northeastern United States power markets.

2.4.4.9 Nova Scotia

Nova Scotia is a relatively small, winter-peaking market. Peak load is currently in the range of 2,200 MW and the annual load growth is estimated to be 1.7 percent. The market has about 2,310 MW of installed capacity and is heavily reliant on coal generation, with approximately 88 percent of the power in Nova Scotia currently coming from fossil-fuel sources (Nova Scotia Department of Energy 2007, Internet site).

The key market opportunities in Nova Scotia are the displacement of existing thermal generation (coal and heavy fuel oil) and the minimization of new thermal sources in order to meet load growth and to address emission reduction targets as established by the federal Regulatory Framework for Air Emissions. A block of lower Churchill River power could help displace thermal generation in the province and help to balance new wind power generation planned in the region.

2.4.4.10 New England

The New England wholesale electricity market pool is a large market comprised of the six northeast states (Maine, Vermont, New Hampshire, Massachusetts, Connecticut and Rhode Island), which have a total population of approximately 14 million, including 6.5 million households and businesses. The six New England states have a combined market value of $10 billion in energy transactions annually (ISO-NE 2008, Internet site).

The New England market is summer-peaking, with a record peak demand of 28,310 MW set in August 2006. There is approximately 31,100 MW of total supply capacity and in excess of 350 generators and power plants. The 2007 market base load totalled 134 TWh, with approximately 39 TWh from gas generation, 37 TWh from

nuclear, 16 TWh from dual supply oil/gas, 16 TWh from coal and 26 TWh from a mixture of other sources (CELT 2008, Internet site). The region's heavy reliance on natural gas generation and dual fuel (gas/oil) generation makes New England an attractive market, because energy prices are consistently higher than in neighbouring markets and this trend is expected to continue.

The New England Regional System Plan 2006 identifies substantial needs for the region, in particular during summer periods, for greater fuel diversity to dampen the effect of natural gas and oil prices on energy prices and for additional resources to meet forecasted load growth (an additional 4,300 MW is required by 2015). The six ISO-NE states are also participants in RGGI, which will subject them to a declining cap on GHG emissions, further heightening the need for new non-emitting sources of generation.

The New England market is an attractive market given:

- the heavy reliance on thermal powered generation;
- the forecast role Combined Cycle Gas Turbine (CCGT) will play in setting prices in the region; and
- increasing demand for clean, renewable power.

Currently, given the market structure, this market presents short term sales arrangements and spot market participation.

2.4.4.11 New York

New York State is a very large market with approximately 340 industry participants and almost $9.5 billion in energy transactions in 2007. New York's installed generating capacity in 2007 was 38,966 MW and comprised 38 percent oil and gas generation, 15 percent hydroelectric, 13 percent nuclear, eight percent coal-fired generation and 26 percent from a combination of other sources (NYISO 2008, Internet site). Like New England, New York is heavily reliant on oil and natural gas and the NYISO recognizes the need for a fuel diversification strategy for the region. Also, older generation facilities are reaching the end of their service lives.

The record peak load in the New York market of 33,939 MW was set in August 2006. The total energy demand in 2007 was 167 TWh, the highest annual energy consumption to date for this market, with a projected annual load growth of 1.2 percent. Forecasts indicate that by 2017, an additional 2,750 MW will be required to accommodate retirements of existing facilities and to meet increased demand (NYISO 2008, Internet site).

The current structure of this market is conducive to short term sales arrangements and spot market participation.

As a participant in RGGI, New York will be expected to reduce GHG emissions from power generation by 10 percent by 2019. Renewable energy currently accounts for approximately 19 percent of the power supply in New York, but more will be required to meet emissions targets.

2.4.5 Economic Benefits

Development of the lower Churchill River resource will result in financial benefits to the Province. While the Province is currently receiving revenue from offshore oil developments, these are limited in duration as they are tied to a depleting resource. In contrast, the development of the lower Churchill River represents a long term secure source of revenue for the Province. A detailed socio-economic assessment of the effects of Project expenditures is provided in Volume III, Chapter 3.

The total potential direct and indirect (spin-off) employment from the Project ranges from a low of 34,000 person-years of employment to a high of 82,000. Employment directly resulting from the Project will be 34,000

person-years. If other large-scale industrial developments occur as a result of the Project, the person-years of employment will be as high as 82,000.

Pricing arrangements, quantities of power and other terms of sales contracts are commercially sensitive information and cannot be publicly released or specifically used to estimate revenues from the Project.

2.5 Alternatives to the Project

This section considers alternatives to the Project that are functionally different ways to meet the need and purpose for the Project (Sections 2.2 and 2.3) and the Project rationale (Section 2.4). This section provides comparative analysis and detailed discussion of the various alternatives to the Project. The analysis supports the conclusion that the chosen Project is the only technically and economically feasible alternative to meet the identified need and achieve the Project purpose. In the distant future, economic conditions could change enough that the value and technical feasibility of alternative energy technologies might offer alternatives to the Project as now contemplated. However, such alternatives are not yet feasible.

This Project addresses the demand by current and future consumers in the Province and elsewhere in North America for energy, as well as cleaner energy. Cleaner energy is produced from renewable sources and/or associated with reduced carbon emissions relative to traditional fossil fuels (e.g., coal and oil).

The EIS Guidelines (Appendix IB-E) require that certain alternatives to the Project be discussed:

- management of electricity demand through utility-based energy efficiency and conservation initiatives;
- alternative generation sources (e.g., hydrocarbons and wind);
- run-of-river hydroelectric development;
- combinations of alternative generation sources with hydroelectricity (e.g., hydro-wind);
- the addition by the Proponent of more capacity at existing generation facilities;
- utility-based energy efficiency; and
- no Project.

As part of the Project planning process, Nalcor Energy has considered these alternatives, as well as others suggested by individuals and groups who have been consulted (i.e., nuclear power, tidal power and solar power).

The criteria used in consideration of alternatives are economic and technical feasibility, environmental considerations, social responsibility, government policy, and the mandate of Nalcor Energy to provide safe, reliable, least-cost power in an environmentally responsible manner. In order to continue to meet its mandate, Nalcor Energy continually monitors best practices and technologies in the electricity industry and regularly examines alternatives to generate and transmit electric power.

2.5.1 Utility-based Conservation Initiatives

Nalcor Energy and Newfoundland Power work in unison to improve the efficiency of energy generation, transmission and distribution, and curb the demand of its customers. In 2007, Hydro (a Nalcor Energy company) and Newfoundland Power worked together on a Conservation Demand Management (CDM) Potential Study, which will serve as a foundation for a long term conservation strategy. CDM refers to a range of activities that influence the use of electricity by consumers, either by reducing the amount of electricity consumed or improving the efficiency of its use. It also refers to reducing electricity use at periods of peak load by controlling the demand for electricity with technologies that help manage use. The CDM Potential Study examined

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economically feasible opportunities to help electricity consumers conserve energy. The results provide a strong foundation for provincial energy conservation and efficiency programming. Using profiles created for typical energy uses by residential, commercial and industrial customers, the study examined the energy and economic effects of more than 100 energy conservation technologies. A final list of potential savings and cost-effective technologies for each consumer sector was developed.

The next step for Hydro and Newfoundland Power in encouraging CDM is to refine the data and explore ways to bring these energy conservation technologies to electricity consumers. The two utilities are developing a five year plan that will describe the technologies targeted, the expected savings and the costs for delivering programs to consumers.

Hydro will be conducting a pilot project to explore conservation and efficiency opportunities in two coastal communities of Labrador. The study will involve energy reviews with residential and commercial customers to identify opportunities for improvement in energy efficiency and cost.

Conservation Demand Management alone cannot result in savings that would negate the need for the Project. While conservation is and will remain an important part of Hydro's planning and education efforts, the Province's projections are for a 29 percent growth in demand from 2007 to 2027, while the CDM can achieve maximum savings of 12 percent over the same period.

2.5.2 Alternative Generation Sources

Nalcor Energy has discussed alternative energy sources with groups and individuals in the Province through technical workshops in Labrador and in St. John's. Participants included environmental interest groups (some of whom are formal interveners in the Project's environmental assessment process), Aboriginal organizations and community representatives. A summary used in the workshops that reflects some of the considerations used in examining alternative energy sources is provided in Table 2-6. The use of run-of-river generation in place of the Project on the lower Churchill River is considered later in this section. However, as demonstrated by its consideration for the lower Churchill River, run-of-river projects typically have considerably lower energy production and capacity factors that greatly affect technical and economic feasibility.

Table 2-6 Summary Assessment of Selected Alternative Generation Sources

Criteria	Lower Churchill	Wind	Nuclear	Solar	Tidal
Included in the Energy Plan	Yes	Yes	No	Yes	Yes
Power available for export	Yes	Partially	No	No	No
Meet projected domestic needs	Yes	No	No	No	No
Reduction of GHG	Yes	Yes	No	Yes	Yes
Displace fossil-fuel generation	Yes	Partially	No	No	No
Operational flexibility	Yes	No	No	No	No

2.5.2.1 Wind

Nalcor Energy continues to investigate alternative sources of generation. A major focus at present is wind power. Nalcor Energy's wind development strategy involves the separate electricity systems in the Province: the Labrador Interconnected System; the Island Interconnected System; and the Isolated Diesel Systems (comprising 21 diesel generation sites located in remote coastal communities around the Province). Nalcor Energy is pursuing opportunities to incorporate wind power into each of these separate systems. Nalcor Energy is

conducting a study in seven coastal Labrador communities to determine the potential for alternative energy sources to complement diesel generation. The study is considering solar, wind and mini-hydro alternatives.

Labrador has a huge wind resource and development potential of thousands of megawatts. In Labrador, monitoring is ongoing to determine the wind resource potential in conjunction with the Churchill Falls Power Station. Since generation in Labrador connects to the North American electricity grid, the focus of wind energy will be for both domestic use and for export. This monitoring program, near the Churchill Falls Power Station, will provide information for a complete feasibility study for the potential development of wind resources in Labrador.

The Island electrical system is isolated from the North American grid and has an existing generating capacity of 1,919 MW provided by approximately 65 percent hydroelectric and 35 percent fossil-fuel generation. In 2007, Hydro secured power purchase agreements for 54 MW of wind power on the Island from two 27 MW wind projects in St. Lawrence on the Burin Peninsula, and Fermeuse on the southern shore of the Avalon Peninsula. Both are scheduled to be in production by the end of 2008.

System isolation and other factors limit the incorporation of wind and other renewable energy sources to the Island grid. The Island Interconnected System experiences wide variations in load on both a daily and seasonal basis. For example, in 2005, the Island system experienced swings in load from a high of approximately 1,600 MW during peak winter conditions to lows of approximately 600 MW during the early morning summer hours. As the power system operator, Hydro is responsible for dispatching its generation resources to meet the variable demands of consumers while compensating for variability in the output of those energy sources that it does not directly own or control. At the present time, approximately 350 MW, or 18 percent of the existing net capacity on the Island system, is not directly controlled by Hydro. As intermittent and non-dispatchable generation, such as wind, is added to the system, a point is reached where the ability to maintain stability and acceptable voltages throughout the system is compromised, leading to reduced service quality. As such sources are added to the system, there would be increased spilling at hydroelectric facilities during high inflow and low load periods, as hydraulic production is reduced to accept non-dispatchable production. The large size of units at the Holyrood Generating Station adds complexity and limitation to the management of the isolated system where renewable sources have low capacity factors (e.g., wind). Hydro estimates that under current conditions the Island system can accommodate an upper limit of 80 MW of wind generation with minimal adverse economic effect. Amounts of wind generation beyond this level would impose additional costs to Hydro and its ratepayers beyond the cost of the purchased generation. If ultimately the Island grid is interconnected with the Labrador grid, increased use of wind and other renewable energy sources may be feasible.

Diesel-fuelled generation systems provide power to 21 small, coastal communities across the Province. The remote island community of Ramea, on the South Coast of the Island, has been the location of a pilot project with wind and diesel generation since 2004, when Hydro began purchasing wind energy from Frontier Power Systems, a non-utility generator. Since then, Hydro has purchased 1,200,000 kWh of wind energy, approximately 10 percent of Ramea's energy requirements, and has offset over 325,000 L of fuel and 500 tonnes of air emissions. Similar projects may be feasible in the future and could involve a range of renewable technologies in remote locations where interconnection continues to be unfeasible. A study is now under way for the communities of Cartwright, Charlottetown, Hopedale, Makkovik, Mary's Harbour, Nain and Port Hope Simpson. This study examines opportunities to reduce fuel consumption and complement existing diesel generation. Economic and technical feasibility of interconnection or alternative renewable generation sources is and will continue to be a challenge for isolated coastal communities.

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2.5.2.2 Natural Gas

Natural gas, while a fossil fuel, produces fewer GHG emissions than oil when burned. The Province has acquired equity in offshore oil and gas projects off the Province's coasts. At present, the natural gas associated with the oil in the offshore fields is not commercially produced; a small amount may be used on board the production platforms but most is re-injected into the formations for conservation and reservoir pressure management. Both industry and Memorial University are considering ways in which the gas can be effectively produced and transported to markets, domestic or export. One possibility envisions its use in electric power generation on the Island. At present, the economic and technical feasibility of this possibility has not been established.

2.5.2.3 Other

In addition to the above alternative generation sources, other alternatives have been suggested and are discussed below.

Among the comments received from the public on the need to consider alternatives to the Project was the suggestion that Hydro should consider nuclear power. However, since the *Electrical Power Control Act* of 1994, there has been a legislative ban on nuclear energy development in the Province.

Nalcor Energy also follows research and development of alternative energy sources and in 2001 reviewed a number of potential sources: wind; solar thermal; photovoltaic; biomass; fuel cells and micro turbines. None of these technologies is capable of producing the quantity of power to be produced by the Project. Such sources may be viable in the future.

Nalcor Energy has concluded that alternative generation sources are not, at present, technically or economically feasible alternatives for producing the amount of electricity that will result from the Project.

2.5.3 Run-of-River Hydroelectric Development

A run-of-river development at Gull Island could include a partial diversion/overflow weir at the upstream end of Gull Rapids, a power intake and penstock(s) along one side of the river, and a powerhouse located below the rapids, near the proposed dam site. The development would have a head of approximately 3 m, a capacity of approximately 12 MW (when operating), based on a minimum flow of approximately 470 m^3/s. The minimum flow is determined by the minimum contractual output of the Churchill Falls Power Station plus the minimum natural runoff between that plant and Gull Island. It would have an average capacity of less than 47 MW based on a long term average flow of approximately 1,758 m^3/s and restricting downtimes due to frazil ice.

In northern latitudes, a major design consideration for any hydroelectric development is the potential for frazil ice. Under low temperature conditions, ice crystals can form in relatively fast-moving water. These ice crystals, called frazil ice, remain suspended in the water column; however, when velocities are reduced the crystals join together to form larger pieces of surface ice or slush pans. As a layer of ice expands it can act to obstruct water flow. This phenomenon can greatly restrict any potential for a run-of-river hydroelectric generation facility.

At Muskrat Falls, a similar development configuration would have a head of approximately 16 m, a minimum capacity of approximately 66 MW (when operating), based on a minimum flow of approximately 473 m^3/s. It would have an average capacity of less than 258 MW, considering a long term average flow of approximately 1,850 m^3/s and substantial downtimes due to frazil ice. Capital cost of either relative to the energy output and availability render these options not economically feasible. The frazil ice problems represent substantial technical feasibility issues and further reduce economic feasibility.

A run-of-river hydroelectric development is not technically or economically feasible on the lower Churchill River. Either development, without a large reservoir, would be unable to control the frazil ice, or to regulate the flow of water to generate firm, or guaranteed, power and energy normally required by consumers, domestic or industrial. Also, the lack of regulation would decrease the generation flexibility of the plant that would be necessary to meet the demand patterns of consumers. The flexibility would be lacking to complement the generation technologies (coal/fossil fuel) that could be displaced in the market place. Both sites would experience substantive operational problems and downtimes without a stable ice cover due to the annual frazil ice presence in the river. Without a reservoir to regulate flows, the energy potential of the sites would not be optimized and fail to meet the Project purpose of developing the full potential of the resources.

2.5.4 Combinations of Generation Sources

Nalcor Energy has investigated the generation potential from combining generation sources. In particular, Nalcor Energy believes that there will be future initiatives with wind generation in association with the Smallwood Reservoir, which is part of the reservoir system for the existing Churchill Falls Power Station. The integration of wind generation and hydroelectric power presents both unique opportunities as well as technical challenges. One of the challenges of wind power is its variable nature and its requirement for ancillary services and supplemental generation sources. Hydroelectric power can match well as a generation partner to wind. The storage capacity in hydroelectric reservoirs can provide near real-time smoothing of wind's variability, as well as a reliable energy storage source. However, there is limited storage available in either of the Project reservoirs; hence, an adjacent wind generation facility would not be able to avail of any such means to store energy. Consequently, a combination of wind generation in concert with the Project was rejected as not technically feasible.

Nalcor Energy is actively involved in research on wind-hydrogen-diesel. That research is focused on a pilot project at Ramea. With some support from the Atlantic Innovation Fund, Hydro initiated a five year, $10 million research and development project for an isolated wind-hydrogen-diesel generation solution. This unique energy project has the potential to reduce reliance on diesel generation and provide renewable energy to isolated customers. The Project is one of the first in the world to integrate generation from wind, hydrogen and diesel in a remote, isolated electricity system. Success of the Project will enable Nalcor Energy to develop and implement innovative renewable energy systems to serve isolated and remote areas throughout the province and elsewhere in the world. The scale of any such project could be applicable to isolated locations, but is not a technically or economically feasible alternative to the Project.

Nalcor Energy will continue to investigate and work with other partners to further consider the integration of alternative generation sources with existing and planned projects. At present, combining alternative energy sources is not an alternative to the proposed Project.

2.5.5 Adding Capacity

The EIS Guidelines (Appendix IB-E) directed the Proponent to consider adding capacity at existing generation facilities as an alternative to the Project. For hydroelectric facilities, adding capacity can reasonably be considered only for sites where water spillage occurs (i.e., water is released through the spillway and is not used in generating electricity). If there is no history of such spills, there is probably no potential for adding capacity. Hydroelectric facilities on the Island include Cat Arm, Bay D'Espoir, Hinds Lake, and Upper Salmon. These are well-optimized facilities with excellent reservoir and regulation capacity. Other facilities like Granite Canal were recently constructed to optimize their energy potential. Spillage occurs infrequently at these facilities, therefore

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adding generation capacity at existing Hydro hydroelectric generation facilities on the Island is not economically or technically feasible.

Hydro is considering adding additional hydroelectric capacity on the Island. The most recent studies of new potential hydroelectric sites, completed in 2007, considered sites at Island Pond and Portland Creek. These are two of the few potentially economically feasible new developments remaining on the Island.

The studies determined that the Island Pond and Portland Creek developments were technically and economically feasible and would provide an additional capacity of 36 MW from Island Pond and 23 MW from Portland Creek. These developments would provide for only the Island's short term power and energy requirements; however, its long term requirements would necessitate development of non-hydroelectric sources such as thermal generation or additional, less economic, small hydroelectric sites.

Increasing capacity of the Churchill Falls Power Station was studied in 1998. The proposal was to divert water from an adjacent watershed in Quebec (St. Jean and the Romaine Rivers) through Lake Atikonak into the Smallwood Reservoir. An extension to the Churchill Falls Power Station would increase generation capacity. The results of the study concluded that the concept was not economically feasible.

Additional capacity was considered for the thermal plant at Holyrood. However, Hydro does not want to add capacity through additional use of high carbon emission sources such as the heavy fuel oil used at Holyrood. It is the intent of the Project to enable replacement of the thermal generation from Holyrood with hydroelectric power, thereby greatly reducing GHG emissions within the Province.

2.5.6 Utility-based Energy Efficiency

Maintenance and ongoing changes to facilities can serve to improve the efficiency of operation by maximizing generation from renewable sources, minimizing generation from fossil fuel, and reducing energy loss as in transmission and distribution. The inclusion of some wind energy on the Island will improve the efficiency of operation and the ability to maximize the use of renewable energy for generation.

In addition to new hydroelectric development projects, Hydro has considered increasing the efficiencies and thus improving the energy output of existing hydroelectric generating stations. The five major facilities that have been considered are Cat Arm (127 MW), Bay d'Espoir (604 MW), Hinds Lake (75 MW), Upper Salmon (84 MW), and Granite Canal (40 MW). Of these Cat Arm, Hinds Lake and Unit 7 at Bay d'Espoir present minor opportunities to increase current energy output. By replacing the turbine, stator rings and wicket gates with new up-to-date equipment the energy output of these three facilities can be increased by one to two percent and generation capacity by up to 30 MW. The Granite Canal facility has only been in operation since 2003 and is already equipped with the most up-to-date and efficient power generating technology. The original runners for Units 1 to 6 of the Bay d'Espoir plant have been replaced with new turbines. Thus, there are currently very limited opportunities to increase the energy output of these facilities and, even in total, these do not approach a level equivalent to the power to be produced by the Project.

If the Project does not commence, there are plans to address the environmental concerns related to the Holyrood Generating Station (490 MW) by installing scrubbers and precipitators. The purpose of this equipment is to reduce emissions from the burning of fossil fuels. Combined, this equipment can reduce sulphur dioxide and particulate emissions by up to 95 percent along with other pollutants. However, although the studies to determine the effect on energy production are still underway, it is estimated that the energy required to operate the scrubbers and precipitators will reduce the efficiency of the plant by three to five percent and the cost of operation will be substantially increased by capital and operating expenditure.

With the exception of the small efficiencies yet to be attained at three hydroelectric sites, there are no remaining energy efficiencies that can be realized which would offer feasible alternatives to the Project that are technically and economically feasible.

2.5.7 No Project

Not proceeding with the Project would mean that the projected energy needs of the Province's residents, municipalities and industries would either not be met or would be met through more costly and GHG intensive alternatives. New industrial development in the Province would be at a disadvantage and there would continue to be reliance (possibly increased) on thermal generation and fossil fuels.

Not proceeding with the proposed Project would also mean the loss of an important economic opportunity for the Province, and an opportunity for the Province and the Atlantic region to reduce GHG emissions from current (e.g., Holyrood Generating Station, fossil fuel-fired plants in the Maritimes) sources of power with a new source of clean renewable power.

There are a number of approaches to the generation of electric power within the Province. These include conventional means such as smaller hydroelectric sites, fossil-fuel generation (including natural gas) and nuclear. Less conventional methods would include wood pellets, wind, solar and tidal. While each of these categories represents a method for electric power generation, none can be regarded as technically or economically feasible alternatives to the Project.

2.6 Alternatives Conclusion

The foregoing evaluation demonstrates that there are no technically and economically feasible alternatives to the chosen Project that can address the need for or purpose of the Project as proposed and described in the EIS.

3.0 PROJECT PLANNING

The Project has been the subject of four decades of studies and planning, during which time the corporate structure of Hydro has evolved. A brief introduction is presented to place the Project in the context of the current Nalcor Energy organization structure and policy framework. This chapter describes the Project policies, planning and design processes, research studies and modelling and the results of the examination of alternative means of carrying out the Project. The examination of alternative means to accomplish the Project reflects and benefits from the planning completed to date.

3.1 Introduction

The *Energy Corporation Act* authorizes Nalcor Energy to invest in, engage in and carry out activities in all areas of the energy sector (except nuclear) within the Province and, with approval, outside the Province, including:

- development, generation, production, transmission, distribution, delivery, supply, sale, export, purchase and use of energy from wind, water, steam, gas, coal, oil, hydrogen or other products used in power production;
- exploration for development, production, refining, marketing and transportation of hydrocarbons and products made from hydrocarbons;
- manufacturing, production, distribution and sale of energy-related products and services; and
- research and development.

Nalcor Energy has five distinct lines of business:

- Newfoundland and Labrador Hydro;
- Churchill Falls;
- Lower Churchill Project;
- Oil and Gas; and
- Bull Arm Fabrication.

Nalcor Energy took on the following Vision and Values:

Vision

Our vision is to build a strong economic future for successive generations of Newfoundlanders and Labradorians.

Values

At Nalcor Energy, our employees share a set of values that shape how we do business every day. Our core values set common direction on how to make decisions with a sense of pride and leadership. We recognize that it is not only what we achieve, but how we achieve it that truly makes us proud of our accomplishments. We believe our core values develop a culture based on high standards and expectations. We feel empowered to challenge the norms and seize new opportunities while working towards our corporate vision.

Nalcor Energy is a proud, diverse energy company, whose people are committed to building a bright future for Newfoundland and Labrador, unified by our core values.

- *Open Communication - Fostering an environment where information moves freely in a timely manner;*
- *Accountability - Holding ourselves responsible for our actions and performance;*
- *Safety - Relentless commitment to protecting ourselves, our colleagues, and our community;*
- *Honesty and Trust - Being sincere in everything we say and do;*
- *Teamwork - Sharing our ideas in an open and supportive manner to achieve excellence;*
- *Respect and Dignity - Appreciating the individuality of others by our words and actions; and*
- *Leadership - Empowering individuals to help guide and inspire others.*

The Project is planned, and will be constructed and operated, within the context of the above. Nalcor Energy values will be applied throughout the Project.

3.2 Policy Framework

Nalcor Energy has established a set of values that apply throughout the organization. For the Project, an overall Project Charter was developed (i.e., to develop the lower Churchill Project respecting shareholder and stakeholder requirements, using best-in-class planning and execution practices to facilitate a safe and environmentally sound delivery of an economically viable source of clean energy to the market place).

In addition to adopting the existing Environmental Policy (Section 1.1.2), the Project Team has developed key Project policies needed during the planning phase for:

- occupational health and safety;
- quality; and
- information management.

Each Project policy is organized to provide a statement of philosophy (in keeping with the Project Charter), a set of goals and a statement of commitments

The Project will use the relevant Nalcor Energy systems, policies, procedures and practices, and add others that specifically relate to the unique scope and nature of the Project. The Project will take the opportunity to develop and maintain one integrated management system for all aspects, using a process-oriented approach. This integrated approach identifies how people, processes and systems interact with and affect each other and promotes effective management of interactions.

The health, safety, environment and quality (HSEQ) aspects of the Project are ideally suited for integration because they are all based on well-known international standards that have common philosophies and approaches.

3.2.1 Benefits Strategy

Nalcor Energy is developing an overall benefits strategy and an adjacency policy for the Project, which will also be followed by contractors. First consideration for employment will be given to qualified workers who are adjacent to the resource. Newfoundland and Labrador businesses will have full and fair opportunities to participate in the Project, understanding that price, quality and delivery will be evaluated on a competitive basis.

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Nalcor Energy will communicate all Project opportunities to the people of Labrador and throughout the Province.

Nalcor Energy acknowledges the importance of training to realize maximum benefit of the adjacency policy. Nalcor Energy has and will continue to work with governments, Aboriginal groups, women's organizations, training institutions and labour organizations to:

- discuss the Project's labour requirements;
- identify Project research, studies and modelling for identifying existing or anticipated gaps in the labour supply pool; and
- explore and discuss potential approaches for addressing potential gaps.

All Aboriginal groups will be encouraged to participate actively in the Project. In accordance with the Tshash Petapen (New Dawn) Agreement between Innu Nation and the Province, Nalcor Energy is negotiating an IBA with Innu Nation that, once finished, will define how the Labrador Innu will participate in and benefit from the Project.

A diverse workforce is a planned feature of the Project. Nalcor Energy will encourage Aboriginal people, women, visible minorities and persons with disabilities to participate in the Project. To this end, a Diversity Plan will be prepared and implemented. The Diversity Plan commitment is discussed in Volume III, Section 3.6.5.

Nalcor Energy recognizes the importance for governments and the public to know and understand the nature and level of local and provincial economic activity associated with the Project during the construction phase. To determine whether the processes outlined in the benefits strategy are followed, a comprehensive reporting system will be implemented.

Nalcor Energy will continue with existing community investments program and local initiatives.

3.3 Project Planning and Design

3.3.1 Gateway Process

Any undertaking the size of the Project requires thorough planning and timely execution for success. As part of the Project management process, the Project Team is using a delivery method that is based on lessons learned and best practices that will be refined and optimized through to Project completion.

The over-arching execution process used by the Project Team is called the Gateway Process (Figure 3-1). The Gateway Process is a logical roadmap used to guide the development of a business opportunity from identification through to operations and onto final decommissioning. The roadmap is divided into six sequential phases, while the decision to move from one phase to the next is known as a Decision Gate.

At each of the five Decision Gates, a decision must be made with respect to the development of the asset. There are typically three outcomes: (1) hold all activity pending receipt of some final clarifications or supporting information is received; (2) move into the next sequential phase; or (3) stop/terminate all activity. Given the magnitude and nature of the decision at each gate, a pre-defined list of requirements for passage is established well in advance, which the Project Team works towards completing.

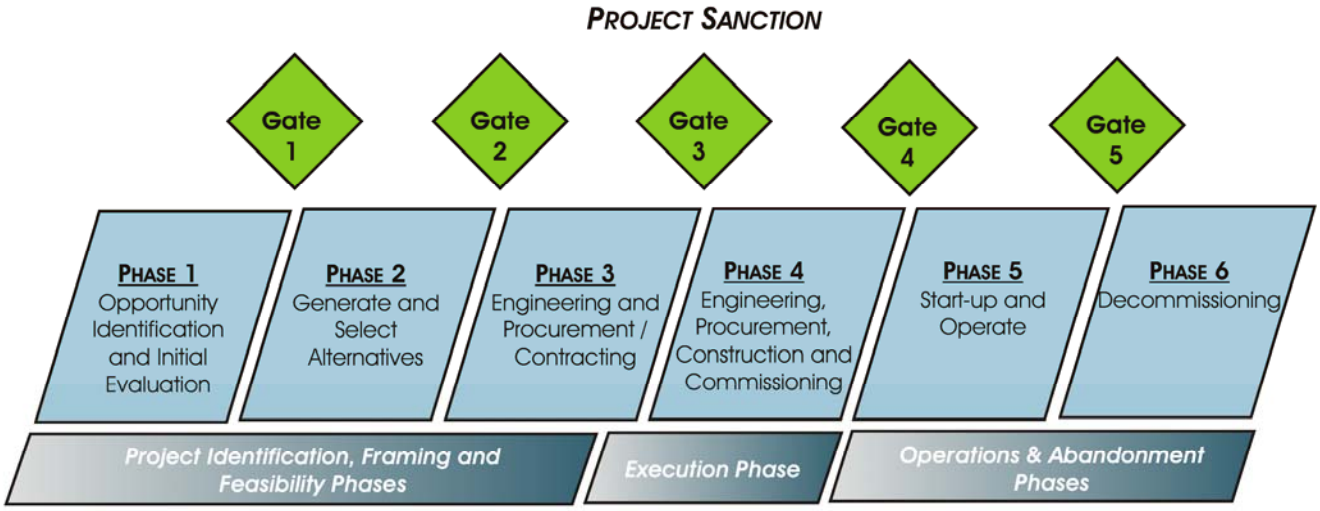


Figure 3-1 Gateway Process

The six phases of the Gateway Process are:

Phase 1 – Opportunity Identification and Initial Evaluation: Includes the initial feasibility evaluation of the identified business opportunity, which in the case of the Project is the development of the hydropower potential presented by the lower Churchill River. This phase culminates at Gate 1, at which time a decision on whether the Project is feasible and worth pursuing further is made.

Phase 2 – Generate and Select Alternatives: The objective of this phase is to generate and evaluate a number of development options from which a preferred option to develop the business opportunity is selected. This phase culminates at Decision Gate 2, at which point approval is sought for the recommended development option, the execution strategy, and to proceed with the start of detailed design. The Project is currently in the later stages of Phase 2, which involves aboriginal negotiations, the environmental assessment process, field work, power sales and access, financing strategy, advanced engineering studies, early construction planning and economic analysis.

Phase 3 – Engineering and Procurement/Contracting: Culminating at Gate 3, this phase involves the finalization of all front-end engineering work and completion of a sizeable portion of all engineering and procurement/contracting activities in order to meet the Project financing requirements and the requirement to be able to commence construction immediately after successful passage through Gate 3. Gate 3, known as Project Sanction, is when the Project is given the green light to finalize engineering and commence construction. In this phase, the environmental assessment is completed. The environmental assessment release is a predecessor to passage through Gate 3.

Phase 4 – Engineering, Procurement, Construction and Commissioning: This is the building phase of the Project in which the hydroelectric facility takes shape and peak employment occurs. Concurrent to the start of early construction activities, the remaining engineering, procurement and contracting activities are completed. This phase ends at Gate 4, which signifies a readiness to commence production of electricity.

Phase 5 – Start-up and Operate: The construction is completed and electricity production and transmission occurs. This includes facility maintenance and daily operation of the facility.

Phase 6 – Decommissioning: A decision regarding the decommissioning of the hydroelectric development when the facility has reached the end of its productive life occurs at the beginning of this phase, signified by Gate 5. Following passage through this Gate, decommissioning of the plant occurs.

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3.3.2 Engineering

One of the key elements developed during the Project planning process was a Basis of Design (BOD) document. The BOD is defined as *a compilation of the fundamental criteria, principles and/or assumptions upon which Design Criteria and Engineering Design Briefs will be developed for the Project.*

The BOD includes all components of the Project, including the Gull Island Generation Facility, the Muskrat Falls Generation Facility and the transmission lines between Muskrat Falls and Gull Island and between Gull Island and Churchill Falls.

The BOD forms the over-arching Project definition that will be used to prepare engineering design criteria, Project contract packaging, Project estimates, Project schedules, design briefs, detailed design specifications and drawings, construction planning and all other Project functions that require a clear definition of precisely what is to be constructed.

The BOD adheres to the following overarching principles:

- considering only proven technologies;
- respecting local climatic/service conditions such as ambient temperature, elevation, humidity and wind throughout the Project;
- remotely operating and monitoring all hydroelectric plants and transmission systems from the Energy Control Centre (ECC);
- maintaining consistency with Nalcor Energy's Environmental Policy and Guiding Principles;
- designing environmental mitigation and rehabilitation before issuing construction contracts for tender;
- no open burning of cleared vegetation;
- assuming the use of existing transportation infrastructure to the maximum extent possible. In particular, existing roads, bridges, railways and wharfs;
- observing good utility practice;
- employing fail safe design principles;
- employing principles of life-cycle cost analysis;
- maintaining consistency with all applicable standards, codes, acts and regulations; and
- designing all assets and systems to promote safety, reliability, efficiency and reducing environmental effects.

Design assumptions used to establish the BOD are frequently reviewed and refreshed as necessary (e.g., to incorporate the results of new research or modelling, including findings of the environmental assessment). The BOD is an important basis for the EIS; the EIS is based on the BOD. At the same time, the environmental assessment process informs the BOD. For example, the examination of various Project emissions indicated that the burning of slash (branches, leaves and other vegetation) would represent a major contribution to the Project's air emissions (Volume IIA, Chapter 3). As a consequence, the BOD document was revised to state that slash will not be burned. Some of the BOD principles are described further in the following subsections.

3.3.2.1 Proven Technology

The first principle of design for the Project is that proven technology will be used. Proven technology is defined as the state of technology used in the design, construction and operation of any system, including each piece of equipment, component or structure that has a proven record of performance. Project design considers first

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technology applications, but only after review by a design integrity group, comprising engineers with expertise in various technical areas, and with the approval of executive management.

3.3.2.2 Good Utility Practice

The principle of good utility practice incorporates the regulatory requirement for adherence to best practice in Canada, which the Project defines as:

> *The practices, methods and acts engaged in, or approved by, a significant portion of the electrical utility industry in North America, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, are expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. Good utility practice is not intended to be limited to one optimum practice, method or act to the exclusion of all others, but rather to include all practices, methods or acts generally accepted in North America.*

3.3.2.3 Fail Safe Design

The principle of fail safe design incorporates the key aspect of reliability and is defined by the Project as:

> *A design that with the failure of equipment, processes or systems, the event will produce minimum propagation beyond the immediate environment of the failing entity, that the failure will be economically acceptable, and that devices in the system will perform their intended function and eliminate danger upon the loss of actuating power.*

3.3.2.4 Life-Cycle Cost Analysis

The design will incorporate a life-cycle cost analysis. Life-cycle cost analysis is the process of selecting the most cost effective approach from a series of alternatives so that the least long term cost of ownership is achieved. Life-cycle costs are total costs estimated to be incurred in the design, development, production, operation, maintenance, support and final disposition of an asset over its anticipated useful life from inception to disposal.

3.4 Environmental Management Systems

The Project will use an integrated management system (IMS) for HSEQ to meet the requirements of CAN Z1000-06 (Health and Safety), ISO 14001:2004 (Environment) and ISO 9001:2000 (Quality). Although each of these systems has its own discrete focus and controls, there is value in adopting an integrated approach to common elements in the systems. Some of these common elements include:

- document and records control;
- communication;
- emergency preparedness and response;
- compliance and management system auditing; and
- management review.

In these common areas, the Project will employ current systems that are in place in the environmental and safety management system.

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The IMS is a framework of coordinated and controlled processes, procedures and tools that will facilitate management of all phases and aspects of the Project. The basis of the IMS will be a series of high level guiding policies including:

- Quality Policy;
- Risk Management Policy;
- Information Management Policy;
- Occupational Health and Safety Policy; and
- Environmental Management Policy.

The Project will use Hydro's existing EMS which meets ISO 14001 requirements. The Project has developed a Quality Management Policy and an Occupational Health and Safety Policy.

The environmental policy and guiding principles are set out in Section 1.1.2. The intent and practice is to maintain a high standard of environmental responsibility and performance through implementation of a comprehensive environmental management system. This policy establishes three key principles: prevention of pollution; improve continually; and comply with legislation.

As a Crown corporation, Nalcor Energy embraces the goals of sustainable development and the use of the Precautionary Principle as consistent with its role in the Province's Energy Plan (Government of Newfoundland and Labrador 2007).

3.4.1 Project Environmental Management

The EMS at all Hydro facilities have been registered as ISO 14001 compliant since 2003. ISO certification is a demonstration of a high level of commitment to the policy and practice of environmental management, including review and audit.

Environmental protection actions rely on the policies, procedures and approaches in the registered EMS maintained by Hydro. For example, the Project will adopt Hydro's environmental policy and guiding principles as the cornerstone of environmental management.

The environmental compliance directory will serve as an important resource for managing legal and other requirements for the Project. Before construction, a license, authorization and permits management plan will be prepared and regularly updated during construction to document compliance with legal and other requirements as committed to in the policy.

The Project-specific EMS will include a process for identifying and classifying environmental aspects, and developing objectives, targets and programs. The current environmental assessment process for the Project will serve to identify, prioritize and assess Project-environment interactions. Later sections of the EIS (assessment chapters in Volume IIA, Volume IIB and Volume III) describe environmental effects and compliance programs implemented specifically for the Project. Detailed plans will be developed in cooperation with regulators and other stakeholders before construction. During construction and operation, existing procedures will be used for identifying other objectives, targets and programs that may be required.

Consideration of environmental issues at the earliest stages of Project planning and design is integral to the overall EMS. This approach facilitates the use of designed-in mitigation, a very effective planning tool. The early identification of mitigation measures not only serves to reduce negative environmental effects but also improves the accuracy of Project cost and schedule definition. Section 4.8.1 outlines the EMS in more detail.

3.4.1.1 Environmental Stewardship

As part of its commitment to environmental stewardship, Nalcor Energy participates on the Labrador Woodland Caribou Recovery Team. Of direct relevance to the Project are the efforts to achieve recovery of the Red Wine Mountains (RWM) Caribou Herd that is considered threatened under federal and provincial legislation.

Nalcor Energy also relocates osprey nests, has active and successful flow maintenance agreements and fish habitat compensation programs at many facilities (Granite Canal, Grey River, Upper Salmon and Hind's Lake) and a flora assessment program in the limestone barrens habitat on the Northern Peninsula.

The Conservation Corps of Newfoundland and Labrador promotes conservation through a program of Green Teams involving youth in research and public awareness initiatives. Nalcor Energy is a sponsor of Green Teams and sponsored two teams in 2007, one in Happy Valley-Goose Bay and one in Whitbourne on the Island, and three in 2008, in Sheshatshiu, St. Alban's on the south coast of the Island and Flower's Cove on the Northern Peninsula.

Nalcor Energy has supported the Nature Conservancy of Canada (NCC) for a number of years and most recently, enabled NCC to acquire 60 ha of land in the internationally recognized Grand Codroy Estuary.

Nalcor Energy has also initiated several public awareness programs about energy conservation, including a Province-wide Holiday Lightswitch to exchange traditional holiday lights for the more efficient light-emitting diode (LED) lights in several communities. HYDROWISE energy conservation week, SAVE Energy events in Burin and Labrador West and Nalcor Energy partnering with Glenburnie-Birchy Head-Shoal Brook in the David Suzuki Nature Challenge—the first community in Canada to take this on as an entire community, are examples of other initiatives.

3.4.1.2 Environmental Protection Planning

All of the above environmental protection procedures, regardless of whether they are in response to regulatory requirements, designed-in mitigation or developed to meet a VEC-specific issue, will require implementation in the field. In other words, contractors responsible for Project construction will need to be aware of the commitments contained in this EIS and how they are to be specifically implemented. The Environmental Protection Plan (EPP) will consolidate all of this environmental information in a format that provides sufficient detail for the implementation of environmental protection measures on site. The main objectives of Nalcor Energy's EPP are to:

- consolidate information for planning;
- provide details of Nalcor Energy's commitment to environmental protection and planning;
- provide site specific environmental protection measures; and
- provide guidelines for field activities and decision making on environmental issues relevant to Nalcor Energy's construction, and operation and maintenance activities.

An EPP will be developed for the construction, and operation and maintenance phases of the Project as outlined in further detail in Section 4.8.2 and in Appendix IB-G.

3.4.1.3 Safety, Health and Environmental Emergency Response Plans

Given the complex nature of activities associated with the construction, operation and maintenance of a hydroelectric project, an accidental release or other unplanned event is possible. While the EPP addresses routine activities, separate plans are required to address response requirements for emergency situations.

Nalcor Energy has in place a Corporate Emergency Response Plan (CERP) which establishes a formal process for the provision of corporate based support activities such as engineering, safety and health to operational facilities in times of emergencies. The Project will build upon the CERP and Nalcor Energy will proactively identify potential emergency situations and will develop response procedures, including a Safety, Health and Environmental Emergency Response Plan (SHERP). The purpose of a SHERP is to identify responsibilities in the event of an unplanned incident (including dam failure or the accidental release of oil or other hazardous material), and to provide the information required for effective response and incident reporting. The establishment and maintenance of emergency response procedures allows for:

- protection and maintenance of human health and safety;
- identification of the potential for accidents and emergency situations;
- planned response to accidents and emergency situations; and
- prevention and mitigation of potential environmental effects associated with accidents and emergency situations.

A SHERP was developed and implemented during the engineering and environmental field programs. A further series of SHERPs will be prepared and implemented for the construction and operational phases of the Project. Each will address roles and responsibilities, personal protective equipment, materials storage, driving safety, working at heights, working near or over water, working near or on ice, vessel operation and safety, animal encounters, emergency response communications, spill response, personnel injury response, search and rescue, fire and explosion response, vehicle/vessel accidents and dam failure.

3.4.2 Environmental Assessment Role in Project Environmental Management

Section 2 of the EIS Guidelines (Appendix IB-E) provides a reminder of the important role of environmental assessment as a planning tool:

> *Environmental assessment is a planning tool that enables consideration of the potential effects of a project before actions are taken to allow the project to proceed. It is a process for identifying a project's potential interactions with the environment, predicting environmental effects, identifying mitigation measures and evaluating the significance of residual environmental effects.*

Examples of how design changes have occurred in relation to this Project due to the collaborative effort between the environmental and design team include the route selection for the transmission lines, modification of the reservoir preparation strategy to enhance the creation of the riparian zone and the consideration of the cultural importance of Muskrat Falls.

Hydro has participated in the environmental assessment process in the Province on many occasions and values the information and guidance that the process can bring to Project design and operational planning. A Review Panel provides an enhanced level of public participation in regulatory decisions relating to the Project.

A key aspect of the environmental assessment process is public participation. The many opportunities for the public to provide comment, at all stages of the process, add to the Project's knowledge about the environment and potential effects. The dialogue created through public consultation can also serve to increase the public's understanding of the Project.

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Chapter 7 (Public Consultation) and Chapter 8 (Aboriginal Consultation) outline the effort and processes undertaken and opportunities provided for information exchange with the public, in particular the residents in central Labrador.

3.5 Innu Task Force and Traditional Knowledge

During the planning and research for the Project, the Project Team worked closely with Innu Nation through a number of forums. A joint environmental Task Force was established in 2006. The Task Force included Project environmental and engineering personnel, as well as a technical advisor and an environmental assessment advisor hired by Innu Nation through the Process Agreement. The Task Force reviewed and discussed the environmental assessment approach, methodology for the assessment, and the format and content of the EIS. The Project Team also consulted with Innu Nation regarding the design, implementation and review of the Project's environmental baseline studies and the engineering program (including the technical designs for environmental and engineering studies). During 2006 and 2007, this group provided support for an Innu Traditional Knowledge Committee (ITKC) as a mechanism to bring this unique information into Project considerations.

Innu Nation provided Innu Traditional Knowledge (ITK) documented through this process to the Task Force for discussion and, as relevant and appropriate, incorporation into the environmental assessment, according to a protocol developed by the Project Team and Innu Nation (Section 9.1.1). The ITKC Report was provided to the Task Force (Appendix IB-H). The objective was to develop an understanding of the environment and the potential effects of the Project that is informed by both western science and traditional knowledge.

To facilitate this, an ITKC was established in August 2007, which served as the primary mechanism through which ITK was documented, shared and discussed.

The ITKC functioned as an adjunct to the Task Force, working separately but parallel to it with interaction between the two groups as required and appropriate.

Innu Nation and Nalcor Task Force representatives, while not formally serving as members of the ITKC, attended some meetings and discussions of the ITKC as required and appropriate to provide Project and other information directly and to answer questions.

The ITKC discussed, documented and provided information to the Parties through the Task Force:

- an Innu knowledge-based description of the key ecological, historical and cultural features of the project area;
- information on how Innu use this environment;
- comments on the environmental studies that have been and will be undertaken for the environmental assessment;
- perspectives on how the potential development may affect those components of the environment that are most valued by Innu; and
- comments on potential mitigation measures and their effectiveness, and on any likely residual environmental effects.

An example of how ITK influenced Project design includes the consideration of the cultural significance of the rock knoll at Muskrat Falls (along with technical and economic feasibility) in determining the site layout.

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The ITKC Report (presented in full as Appendix IB-H) includes a description of the chronology and purpose of the ITKC.

3.6 Project Research, Studies and Modelling

3.6.1 Engineering Studies and Analyses

The concept of a power development on the lower Churchill River has been under consideration since 1964, when a preliminary assessment of the lower Churchill River was completed. In 1965, the first detailed report on a power development at Gull Island was prepared. This report was the first of a series of engineering studies and field investigations that has grown to become an extensive body of technical knowledge upon which the current design is based.

Since 1965, several consultants have been engaged at various times by Hydro to study various aspects of the Project. These studies and associated consultants are outlined below.

Currently, Nalcor Energy has assembled a Project Engineering Group, which is leading the engineering design of the Project. It consists of engineering professionals from many disciplines, including civil, electrical, mechanical, transmission and environmental. In early 2007, Hydro entered into contract with two consulting firms, Hatch Ltd. and SNC-Lavalin, selected for their extensive experience in geotechnical, civil hydrological, mechanical, electrical and power transmission systems on hydroelectric generation projects. The most recent and ongoing engineering studies are summarized in Section 3.6.3.

3.6.2 Previous Engineering Studies and Field Work

After carrying out the preliminary site investigations in 1965, a second report was issued in 1969, followed by further field investigations in 1971. In 1974, the Lower Churchill Consultants (LCC) started a field investigation program and continued with an engineering report, which was issued in 1975 to Gull Island Power Company Limited. Gull Island engineering work was terminated in December 1975. Contracts had been awarded for the upgrading and construction of access roads from Happy Valley-Goose Bay and from Churchill Falls. Work was in progress on the installation of the accommodation complex and service facilities, and the contract packages for the excavation of the diversion tunnels, as well as for site clearing and camp facilities had been prepared.

In 1977, further power and energy studies were done on the lower Churchill River in order to determine the optimal installed capacity and reservoir elevations at Gull Island and Muskrat Falls. During 1979 and the early part of 1980, studies were undertaken to confirm the technical, economic and financial feasibility of developing one or two of the power sites, as well as the transmission of that power to several markets, including the Island.

In 1979, SNC-Lavalin Newfoundland Ltd. continued the engineering work and prepared cost estimates, construction schedules and work force requirements for the Gull Island and Muskrat Falls Power Developments and for the transmission facilities.

Two reports were done in March 1980. The first presented the results of the engineering review of all previous studies at the Gull Island hydroelectric site and the scheme of development, including the 735 kV alternating current (AC) transmission line to Churchill Falls; the second presented the results of the cost estimate and Project schedule.

In 1987, a summary update of the cost estimate was undertaken. In 1990, further energy studies were carried out for Hydro, covering Gull Island and Muskrat Falls. In September 1997, SNC-Lavalin Power Division, BAE

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Newplan Group Limited and AGRA ShawMont Limited were retained to update the capital cost estimate to 1997 dollars.

Examination of the 1997 report resulted in some modifications to the Project concept and construction methodology, such as the addition of a construction bridge and a reduction in the maximum flood level from 128 m to 127 m.

In August 1998, the following studies were commissioned:

- Power and Energy Study for the Churchill River Complex, by Acres International Ltd.;
- Final Feasibility Study of the Gull Island Hydroelectric Development, by SNC-AGRA; and
- Final Feasibility Study, Development of EHV Transmission Lines in Labrador, by RSW-EDM.

The final feasibility study of the Gull Island Hydroelectric Development resulted in new site and reservoir topographic mapping, hydrotechnical studies, including a construction flood study, optimization of the diversion facilities, optimization of the turbine number and size, optimization of the power conduit and a review of the spillway design. Also included was an optimized Project schedule, a cost estimate and cash flow in June 1998 dollars and an evaluation of operation and maintenance costs.

A final feasibility study of Muskrat Falls was done in January 1999 by SNC-AGRA. The main goal of this study was to reduce the cost of energy through structure and equipment optimization. It discussed diversion facility design, reservoir control structures, stabilization of the north spur, power generation and transmission facilities as well as main access types/routes and construction camp logistics.

In 2000, SNC-AGRA completed a Design Update and Optimization Study of the Gull Island Generation Facility. This study updated the Final Feasibility Study, dated December 1998. This study concluded that, based on the work completed and the design development work carried out, the Gull Island hydroelectric development was technically feasible and the cost of such a development compared well with other major hydro developments. The study recommended that a preliminary engineering and field investigation program be initiated to study the layout of the facility and identify design and scope revisions that could result in reduced capital costs and overall schedule.

3.6.3 Current Engineering Program

The Project has an extensive history both from an environmental assessment perspective, as well as from a technical perspective. Inherently, along with the benefit of a strong understanding of the Project, this history involves variations as to the manner in which the Project would be developed. These iterations are a result of increased understanding of the sites, improvements in technology and changing standards and guidelines. As well, these variations reflect changes in approach to Project development, construction and operation. Other changes include increased environmental input, changes in contracting strategies and the implementation of a risk management approach to construction.

For example, in 1975 when construction work began at the Gull Island site, the contracting strategy would have been quite different from today's business environment. Work began without the detailed design being completed on many components of the Project, with the intent that the design would be developed as the construction progressed, in conjunction with the construction contractor. Current practice, however, dictates that designs be much more advanced before starting construction, in order to mitigate risk and reduce cost uncertainty both of which are key to Project financing. For this Project, which will require sourced financing, risk and cost must be ascertained at a level acceptable to financers. Accordingly, detailed engineering will have to be substantially completed and the majority of key contracts will have to be prepared, tendered and evaluated in

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order to quantify Project costs. In addition, priority contracts that will have to be awarded early, to maintain the Project schedule, will have to be ready to award upon Project sanction. A few contracts (e.g., construction of the accommodations complex, access to the south side of the river and river diversion) may be awarded in advance of Project sanction in order to have equipment and materials at the ready when the Project is sanctioned.

In addition to changes in contracting strategies, another key aspect of the design philosophy is the incorporation of environmental considerations into the design process. As the environmental assessment has progressed, there has been a cooperative effort with the engineering design group to incorporate this information into Project design. This has led to what has been termed designed-in mitigation. Such mitigation measures are inherent in the current Project design process and form part of the design concept.

The most recent series of engineering studies began in March 2007 including:

- flood studies using updated flow and meteorological data;
- power and energy studies to better determine head losses, reservoir operation and power house size and capacity (size and number of turbines);
- studies of the main hydraulic structures and the selection of a preferred site layout for Muskrat Falls Generation Facility;
- ice studies;
- dam break studies to prepare breach scenarios for the main dams, evaluate flood conditions down to Lake Melville and to delineate inundated areas;
- optimization of structure layouts at both generation facilities;
- studies of Project infrastructure such as port requirements, warehousing, access roads, laydown and storage yards, camps and camp services; and
- transmission line studies to determine design parameters and corridor selection.

The most recent engineering and geological field program was carried out to support the layout optimizations and alternatives for Gull Island, Muskrat Falls, transmission lines and access roads. Previous investigations provided detailed information on site conditions including topography, bathymetry, geological and geotechnical conditions and construction material availability; however, additional field information was required to prepare for the final optimization, to evaluate quantities more precisely and to provide data for bidders.

Some of the key studies and engineering field programs are summarized in Table 3-1. The results of these studies are discussed as appropriate throughout the EIS.

Table 3-1 Summary of Key Engineering Studies and Field Programs, Lower Churchill Hydroelectric Generation Project

Consultant	Title	Scope
Gull Island Generation Facility		
SNC-Lavalin	Gull Island site investigations	Obtain all geotechnical, topographic and bathymetric information necessary for the final design of the Project
SNC-Lavalin	Study of concrete faced rockfill dam (CFRD)	Reassess the physical characteristics for the proposed earthfill dam, as well as investigate the advantages and latest developments of an alternative CFRD
SNC-Lavalin	Plant configuration	Complete a detailed study of various plant layouts. Update the comparative costs of alternative plant configurations, in comparison to the existing hydraulic model from the 2000 study
SNC-Lavalin	Tailrace channel improvements	Preliminary assessment to determine the optimal tailrace improvements at Gull Island to increase its power and energy production

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Table 3-1 Summary of Key Engineering Studies and Field Programs, Lower Churchill Hydroelectric Generation Project (cont.)

Consultant	Title	Scope
Gull Island Generation Facility (cont.)		
SNC-Lavalin	Review of structure layouts and interfaces	Optimization of the structure locations to reduce cost and schedule
SNC-Lavalin	Review of structure layouts and interfaces	Review of a new Project layout based on the findings of the 2007 studies and subsequent decisions made on different aspects of the Project, including the design floods
Hatch	Ice study (Gull Island and Muskrat Falls)	Determine the appropriate flow regimes to reduce ice formations during the ice season
SNC-Lavalin	Review of construction camp and other infrastructure	Review of locations and layouts of the camp and other on-site infrastructure and camp amenities required for the duration of the Project, as well as providing the basis for estimating the cost for these aspects
SNC-Lavalin	Review of access roads and bridges	Establish construction and maintenance requirements and costs for access throughout the duration of the Project
Hatch	Hydraulic modelling of the river	Design and construct a digital hydraulic model of the river that can be used to predict changes in various parameters during and post-construction of the Project
Hatch	River operation during construction and impounding	Identify and develop specific procedures for the operation of the river during the construction and impoundment of the reservoir
Hatch	Probable maximum flood (PMF) study	Determine the PMF, as well as, the required spillway discharges, for the Gull Island and Muskrat Falls facilities
SNC-Lavalin	Seismicity analysis	Determine if the impoundment of large reservoirs at Gull Island and Muskrat Falls would result in regional seismic activity. Also, confirm the earthquake coefficient to be used in the design of the structures for each facility
SNC-Lavalin	Review of site access, Goose Bay and off-site infrastructure	Assess the upgrading requirements and associated costs for the Project including a review of the Project site access, via TLH and other infrastructure requirements
Hatch	Dam break study	Acquire the magnitudes and arrival times of maximum flood flow and flood stage at key locations in the downstream river channel
Hatch	Constructability review	Provide a feasibility assessment of the construction schedule dated 2000 and provide the certainty required that the construction schedule is reasonable
SNC-Lavalin	Diversion facilities numerical modelling	Development of digital models and testing of the Project's structures to verify satisfactory operation of the structures and optimization of the design
Hatch	Hydraulic production model	Development of a software package to model the production from the Churchill River's existing and proposed developments
SNC-Lavalin	Workshop on reservoir clearing	Determine operational needs for reservoir clearing and discuss potential problems in clearing
SNC-Lavalin	Power intakes and spillway numerical modeling	Development of digital models and testing of the Project's structures to verify satisfactory operation of the structures and optimization of the design
Muskrat Falls Generation Facility		
SNC-Lavalin	Review of variants	Review the variants presented in the January 1999 Feasibility Study and determine a recommendation for the most cost effective variant for development of the Project
SNC-Lavalin	Muskrat Falls site investigations	Obtain all geotechnical, topographic and bathymetric information necessary for the final design of the Project
SNC-Lavalin	Spillway design review	Review of the current layout and design for the updated Project PMF and to confirm the design concepts for rubber dams and the discharge capacity of the spillway structures
SNC-Lavalin	Review of construction camp and other infrastructure	Review of locations and layouts of the camp and other on-site infrastructure and amenities required for the duration of the Project, as well as providing the basis for estimating the cost for these aspects

Table 3-1 Summary of Key Engineering Studies and Field Programs, Lower Churchill Hydroelectric Generation Project (cont.)

Consultant	Title	Scope
Muskrat Falls Generation Facility (cont.)		
SNC-Lavalin	Review of access roads and NLDTW bridge	Establish construction and maintenance costs for access throughout the duration of the Project
SNC-Lavalin	Potential impact of reservoir flooding and operation on the TLH	Obtain recommendations on actions concerning the stability of the reservoir shoreline adjacent to the TLH
Hatch	River operation during construction and reservoir impounding	Identify and develop specific procedures for the operation of the river during the construction and impoundment of the reservoir
SNC-Lavalin	Numerical modelling of Muskrat Falls structures	Development of a digital model and testing of the Project's structures to verify satisfactory operation of the structures and optimization of the design
Hatch	Condition assessment of existing pumpwell system	Determine the suitability of the existing pumpwell system and piezometer system for a continued life of 10 years under conditions similar to existing
High Voltage Alternating Current Transmission Lines		
Hatch	Tower type selection, 735 kV	Review, optimize and select tower types for the 735 kV AC transmission lines
SNC-Lavalin	Field investigations and construction requirements - 735 kV Gull Island to Churchill Falls	Assess the required number and location of camps, marshalling yards, access routes and tote roads for the Project. Perform all necessary field investigations to design and construct this 735 kV transmission line from Gull Island to Churchill Falls
Hatch	Tower type selection, 230 kV	Review, optimize and select tower types for the 230 kV AC transmission lines
SNC-Lavalin	Field investigations and construction requirements – 230 kV Muskrat Falls to Gull Island	Assess the required number and location of camps, marshalling yards, access routes and tote roads for Muskrat Falls to Gull Island. Perform all necessary field investigations to design and construct the 230 kV transmission line for the Project
Hatch	Load control and failure containment	Review design requirements for additional dead end structures
Hatch	Conductor selection	Provide most suitable alternative for the type and size of the conductors required for the 230 kV and 735 kV AC transmission lines

3.7 Alternative Means of Carrying out the Project

3.7.1 Methods to Evaluate Alternative Means

In meeting the requirements of *CEAA*, *NLEPA* and the EIS Guidelines, this following section discusses the alternative means that were considered in Project planning. The focus of this section is thus on describing the alternative means of carrying out the Project, and identifying the ones that are technically and economically feasible. The selection of alternatives includes consideration of environmental effects, safety, capital and operating cost, reliability, energy efficiency, constructability and schedule for construction. Only those alternative means, that were found to be environmentally, technically and economically feasible and preferred were carried forward in the assessment.

This section considers alternative means of carrying out the Project for the following:

- the design and siting of typical components of a hydroelectric generation facility;
- approach to reservoir preparation;
- transmission line route selection;
- facility layout and siting;

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- generation facility optimization;
- construction sequence;
- construction labour force accommodation; and
- reservoir management during operation and maintenance.

The alternatives discussed include items identified in the EIS Guidelines (Appendix IB-E).

The preferred alternative means of carrying out the Project were selected using clearly described methods and criteria. An explanation is included of how environmental factors affect the design and consideration of alternative means of carrying out the Project.

Specific criteria for evaluation of various alternatives are dependent on the component under consideration. The presentation of the feasibility discussion aims at simple explanation. Consideration of technical and economic feasibility reflects more than 30 years of technical study and an ongoing design process. The design of the Project is relatively advanced for the permitting stage of a project and there is a high degree of confidence in technical and economical feasibility of the various Project components.

Technical feasibility includes many considerations that incorporate the principles of design. In evaluating alternative means of carrying out the Project, the engineering studies (Table 3-1) included consideration of state-of-the-art technology. New studies conducted considered developments in technology. The BOD considered several new alternatives. However, state-of-the art technology was limited to consideration of that which is proven.

While there have been advancements in technology in some aspects of the design over the past 30 years, it remains that most of the alternative means of carrying out a hydroelectric development are well established and proven by the electrical utility industry. This encompasses the proven technology principle and known experience with a particular design concept or construction technique in Arctic/sub-Arctic conditions (as per the design principles the design selected must consider local climatic/service conditions such as ambient temperature, elevation, humidity and wind). In considering the overall record of proven performance of a technology, the Project Team also considered specific experience within the organization and applications of the technology within Canada.

Consideration of economic feasibility includes capital (construction cost including interest during construction and financing) and operating cost. The BOD includes a life-cycle cost analysis approach that captures this aspect in the design process. Life-cycle cost analysis selects the most cost effective approach from a series of alternative means of carrying out the Project. This is done so that the least long term cost of ownership is achieved, where life cycle costs are total costs estimated to be incurred in the design, development, production, operation, maintenance, support and final disposition of an asset over its anticipated useful life from inception to disposal. Economic feasibility in this EIS relies upon evaluation using life-cycle cost analysis. Environmental effects were considered and compared at a preliminary level, but only for alternative means that were economically and technically feasible. The preferred alternative means are those that are carried forward in design and environmental assessment.

3.7.2 Typical Components of a Hydroelectric Generation Facility

Engineering studies considered alternative means of carrying out the Project for many of the components of the Project. To support discussion of alternative means of carrying out the Project it is useful for the reader to be familiar with the basic components of a hydroelectric facility.

A hydroelectric generation facility produces electricity by harnessing the kinetic energy of flowing water. The typical components are show in Figure 3.2.

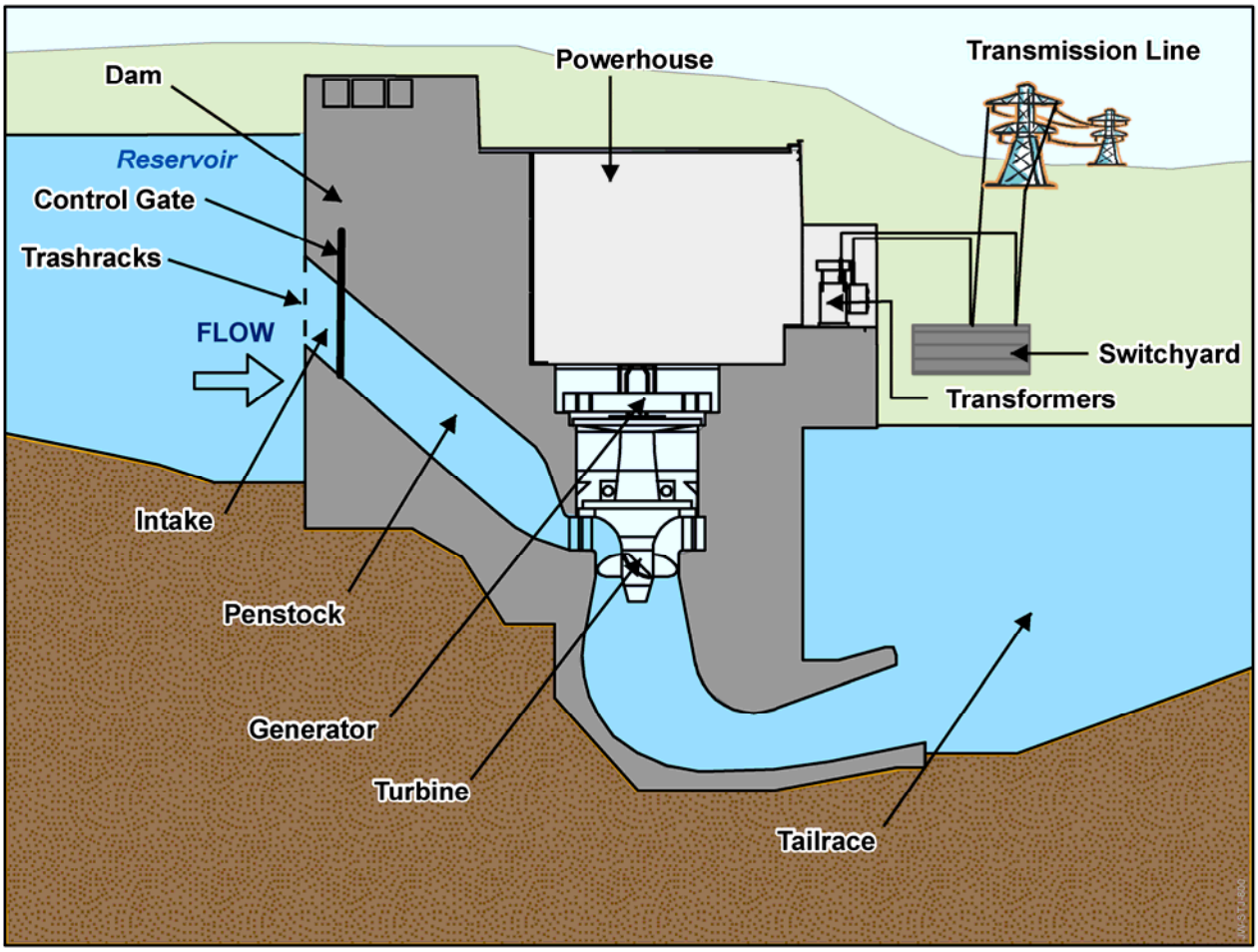


Figure 3-2 Typical Components of a Hydroelectric Generation Facility

3.7.2.1 Dam

The foundation of a hydroelectric power facility is the dam: usually an earth-filled or concrete structure that retains a reservoir. Dams block the flow of water and increase the elevation of the water to create head (the difference between water levels upstream and downstream from the generation facility) for energy production.

3.7.2.2 Reservoir

The reservoir is the body of water behind the dam. The reservoir stores potential energy in the form of water that can be replenished by runoff from within the watershed due to rain and snowmelt. Inflows, outflows, evaporation and the dam operations control the water level in a reservoir.

The storage volume of a reservoir refers to the total quantity of water upstream from a generation station or dam. Live storage capacity is the amount of water contained between the reservoir's maximum allowable level (or full supply level (FSL)) and the minimum allowable level (low supply level (LSL)). This live storage is the amount of water available for power generation.

3.7.2.3 Powerhouse

The water captured and controlled by the dam is carried through pipes (penstocks) to turbines located in the powerhouse. The powerhouse contains the turbines, generators and related equipment used to convert the flow of water into electricity. Powerhouses can be stand-alone buildings connected to the reservoir through an approach channel, intake and penstock, or they can be an integral part of the dam holding back the reservoir.

The difference between the forebay water level (immediately upstream from the generation station) and the tailrace water level (immediately downstream from the station) defines the hydraulic head. The type of turbine used for generation depends on the available hydraulic head and the planned operating regime. Currently, Francis and Kaplan are the two predominant turbine types found in Canadian hydroelectric facilities (Canadian Electricity Association 2001, Internet site).

Water flowing through the turbine causes the turbine runners to rotate, which in turn drives the generator. The water then discharges through a draft tube into the tailrace. The generator converts the mechanical energy into electric energy for delivery along conductors through a network of transmission lines.

3.7.2.4 Spillway

When heavy rain and snowmelt exceed water use, reservoirs fill up. Excess water is released during such water surpluses via a spillway (bypass facility).

3.7.3 Process for Identification and Evaluation of Alternative Means of Carrying Out the Project

A stepwise analysis protocol was used for the assessment of alternative means of carrying out the Project:

- identification of the range of alternative means of carrying out the specific components or aspects of the Project;
- evaluation of the technical feasibility of alternative means of carrying out the Project;
- evaluation of the economic feasibility of alternative means of carrying out the Project;
- consideration of the environmental effects of technically and economically feasible alternatives of carrying out the Project; and
- selection of the preferred alternative means of carrying out the Project.

A summary of the analysis that is described in subsequent sections is provided in Table 3-2. Following the protocol listed above, it is important to note that for each suite of identified alternative means of carrying out the Project, the analysis does not consider the differentiating environmental effects unless there is more than one alternative that is technically and economically feasible.

Table 3-2 Summary of Analysis of Alternative Means of Carrying Out the Project

Major Components of Analysis	Alternative Means of Carrying Out the Project that were Considered	Technically Feasibility	Economic Feasibility	Environmental Effects	Preferred Alternative
Location of the Gull Island Generation Facility	Four locations considered between Gull Island and Grizzle Rapids -represent the range of feasible options from detailed feasibility study in 1971	All four technically feasible	All four economically feasible but Grizzle Rapids optimal from cost and energy production perspective	Little differentiation	Grizzle Rapids due to optimal energy

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Table 3-2 Summary of Analysis of Alternative Means of Carrying Out the Project (cont.)

Major Components of Analysis	Alternative Means of Carrying Out the Project that were Considered	Technically Feasibility	Economic Feasibility	Environmental Effects	Preferred Alternative
Location of the Muskrat Falls Generation Facility	Muskrat Falls	Only technically feasible site due to unique geology and unstable marine sediments at other locations	Only economically feasible site due to lower costs of construction and maximization of energy production	Not applicable	Muskrat Falls
Gull Island Generation Facility components	Dam height and reservoir operating level - range of heights and operating levels considered	All heights and operating levels technically feasible	Maximum height optimal and only a slight loss of head renders Project not economically feasible	Minimal differences in environmental effects (due to flooding and habitat loss) with slightly different heads in range of economic feasibility	Maximum height and operating scenario preferred providing optimal economic feasibility
	Type of dam construction - earth and rockfill (ERD), CFRD, Multi transition vertical core (MTVC) and inclined core with upstream blanket (ICUB)	All types are technically feasible but availability of core materials and impervious filters is constraining	CFRD has slight economic advantage over ICUB and is economically feasible - MTVC and ERD would require eight and 12 months longer construction schedule and are not economically feasible	CFRD has smaller physical footprint than the ICUB. Both dams maximize the use of available material from excavations and reduce the amount of spoil areas required	CFRD preferred due to slight economic advantage and smaller footprint
	Approach channel configuration - previous alignment and optimized new configuration	Both are technically feasible	Reduction of 2 million m^3 of rock excavation and the associated reduction in capital cost favours the new configuration	New configuration has smaller footprint due to less excavation and less spoil, and produces less emissions during construction	New configuration preferred due to economic and environmental considerations
	Penstocks - concrete and steel-lined tunnel, with and without construction adit and aboveground	Both are technically feasible; the use of an adit reduces construction schedule risk	Both are economically feasible but the surface penstocks are considerably more costly	Rock excavation for tunnels can be used in dam. Surface penstocks have poorer aesthetics although surface penstocks are located in the development area	Tunnels with construction adit is most cost effective, provides rock for dam, reduces construction risk and minimizes the adverse aesthetics of surface penstocks

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Table 3-2 Summary of Analysis of Alternative Means of Carrying Out the Project (cont.)

Major Components of Analysis	Alternative Means of Carrying Out the Project that were Considered	Technically Feasibility	Economic Feasibility	Environmental Effects	Preferred Alternative
Gull Island Generation Facility components (cont.)	Powerhouse capacity and - configuration 2,000 to 2,520 MW and four to eight turbines	All are technically feasible	All are economically feasible with a wide range of economic return	Differences in environmental effects due to size of turbines, rate of reservoir drawdown and fish mortality are not substantial	The five-unit plant is the preferred alternative at 2,250 MW. This provides the optimal balance between energy production, operational flexibility, capacity and capital cost. The alternative selected increases the efficiency of the plant as a whole and the cost for additional power is lower than any other source
	Type of Turbine - Pelton, Francis, propeller, Kaplan	Francis is the only turbine that is efficient at these heads and flows	Francis is the only turbine that is an economically feasible option	Not applicable	Francis turbine due to efficiency
	Tailrace channel improvement - 30 alternatives considered	All alternatives technically feasible	Channel improvement not economic as the additional head is limited to four to five years when Muskrat Falls is constructed	Not applicable	Not proposed
	Spillway layout and design - seven or eight gates with parabolic crest	All designs technically feasible	All designs economically feasible	Differences in environmental effects are not substantial	Parabolic crest design was selected, employing eight gates and a parabolic crest
	Diversion facilities - north side and south side tunnels	Both are technically feasible but south side has less overburden and can be constructed more quickly. Slope stability is a safety issue on the north side	Both are economically feasible, although the south side diversion tunnel is preferable	Differences in environmental effects are not substantial	The preferred alternative is the south side due to schedule advantage

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Table 3-2 Summary of Analysis of Alternative Means of Carrying Out the Project (cont.)

Major Components of Analysis	Alternative Means of Carrying Out the Project that were Considered	Technically Feasibility	Economic Feasibility	Environmental Effects	Preferred Alternative
Gull Island Generation Facility components (cont.)	Switchyard location - north and south side of river	The south side has some foundation slope stability issues that can be overcome	The north side is less costly due to better foundation conditions and proximity to transmission line	More ground disturbance would occur with the south side alternative	The north side is preferred as it is most economic and has slightly less environmental effects
	Permanent access - use of existing access or development of new routes	Both are technically feasible	Both are economically feasible (although use of existing access is less expensive)	The environmental effects are reduced by using existing routes and alignments	The use of existing alignments is preferred due to lesser cost, higher certainty and lesser environmental effects
Muskrat Falls Generation Facility components	Generation Facility layout - three variants considered: Variant 7 on the north and 10 and 11 on the south	All variants are technically feasible but Variant 10 can be constructed in 9-10 months less time and with less risk	All variants are economically feasible but Variant 10 has the best rate of return due to much shorter construction period	The preferred alternative reduces the environmental effects on the culturally important rock knoll	The preferred alternative (Variant 10) has the lowest technical and economic risk and avoids tunnels through the rock knoll
	North and South Dam design - conventional concrete and roller compacted concrete (RCC)	Conventional concrete, and RCC are both technically feasible option	RCC is the only economically feasible option	Not applicable	RCC is the preferred option
	Reservoir operating level	All levels are technically feasible	Only the maximum operating level and levels very close to that are economically feasible	Environmental effects differ little at high operating levels that are economic	Maximum operating level (39 m asl) is preferred due to maximum energy production and little difference in environmental effects
	Powerhouse generation - capacity 618 to 1,236 MW with four to six turbines	All alternatives are technically feasible	Economic feasibility is achieved by only a few of the alternatives	The differences in environmental effects are not substantial although rates of drawdown in the reservoir would vary in relation to the total generation capacity	The optimal arrangement of 824 MW with four turbines was selected to optimize energy production and cost

Table 3-2 Summary of Analysis of Alternative Means of Carrying Out the Project (cont.)

Major Components of Analysis	Alternative Means of Carrying Out the Project that were Considered	Technically Feasibility	Economic Feasibility	Environmental Effects	Preferred Alternative
Muskrat Falls Generation Facility components (cont.)	Type of turbine - Kaplan and propeller	Both are technically feasible	Both are economically feasible	Environmental differences are nominal with similar fish mortality rates	Both Kaplan and propeller turbines are proposed and the number of each is yet to be determined
	Spillway layout - four alternatives considered	All are technically feasible with varying requirements for concrete and excavation - the preferred alternative is the least complex	All are economically feasible, with varying cost	There is no substantial difference in environmental effects with slight differences in excavation and concrete requirements	The preferred alternative is the lowest cost alternative and involves a four-bay gated spillway, no rubber dam, and is least complex, using the least concrete and second least excavation
	Permanent access - north and south side	Both are technically feasible	Both are economically feasible	The north side would disturb the culturally sensitive rock knoll but otherwise have similar requirements for new road and related disturbance	The south side option is preferred as it uses an existing access road and reduces disturbance over the rock knoll
Transmission line	Transmission line corridors - Alternative 1 along existing transmission line and Alternative 2 selected in previous study	Both are technically feasible but Alternative 1 has demonstrated constructability, reliability and established access	Both are economically feasible	The environmental effects of using an established right-of-way are less due to shared access and less fragmentation	Alternative 1 is preferred due to lower environmental effects and demonstrated constructability and reliability
Construction infrastructure components at Gull Island and Muskrat Falls	Access - route selection for temporary roads and bridge locations for Gull Island	All alternatives are technically feasible - the preferred Gull Island bridge location has better constructability and a better schedule	All alternatives are economically feasible, although new roads will more expensive	The route selection process for roads will reduce environmental effects. There are no substantive differences in environmental effects between the bridges at Gull Island	Routes for roads will be selected following the route selection protocol and the preferred bridge at Gull Island is 2,000 m below the dam, having improved constructability and schedule. A third alternative with a similar footprint is currently being considered

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Table 3-2 Summary of Analysis of Alternative Means of Carrying Out the Project (cont.)

Major Components of Analysis	Alternative Means of Carrying Out the Project that were Considered	Technically Feasibility	Economic Feasibility	Environmental Effects	Preferred Alternative
Construction infrastructure components at Gull Island and Muskrat Falls (cont.)	Construction accommodation - on site complexes and barracks in Happy Valley-Goose Bay for Muskrat Falls	Accommodations complex at Gull Island is the only technically feasible alternative, whereas both are technically feasible for Muskrat Falls	All alternatives are economically feasible	The socio-economic and cultural effects of Muskrat Falls accommodations complex in Happy-Valley Goose Bay would result in greater environmental effects	State-of-the-art accommodations complexes on site are preferred to attract work force and to mitigate potential environmental effects in Happy Valley-Goose Bay
	Borrow pits and quarries - various locations will be sited based on further engineering study during detailed design	Various materials are in limited supply and further study will be required to confirm locations	The selection of the final locations of borrow pits and quarries will include consideration of economic feasibility. Distance from site also a key consideration	The environmental effects will be reduced through environmental considerations in site selection	The preferred locations will be selected in consideration of material quality and requirements with due consideration to environmental constraints
Reservoir preparation	Clearing strategy - minimal, partial and full	Minimal clearing is not technically feasible as it does not meet operational needs	Partial clearing provides the most economic alternative for meeting operational needs while full clearing is not economically feasible	Not applicable	Partial clearing is the only technically and economically feasible alternative, making available wood fibre while meeting the operational requirements of the Project
	Disposal of slash and debris - burning, mechanical processing and burying	All methods are technically feasible	All methods are economically feasible to varying degrees	Burning will contribute to air emissions	The preferred alternative is not to burn A combination of mechanical processing and burying will be used to dispose of slash and debris
Reservoir management	Impoundment – immediately following completion of the civil works	Technically feasible	Economically feasible	The greatest environmental effects would occur in spring and summer, while the early fall affords the least adverse interactions	Filling between August and October is scheduled for both Gull Island (Year 6) and Muskrat Falls (Year 9)

Table 3-2 Summary of Analysis of Alternative Means of Carrying Out the Project (cont.)

Major Components of Analysis	Alternative Means of Carrying Out the Project that were Considered	Technically Feasibility	Economic Feasibility	Environmental Effects	Preferred Alternative
Sequence and pace of construction	Sequence of construction - Gull Island or Muskrat Falls constructed first	Both are technically feasible	Construction of Gull Island first has the best opportunity to create revenue stream for the support of the construction of Muskrat Falls	The environmental effects of Gull Island first are more positive with the greater amount of energy and revenue realized earlier, and the earlier opportunity to offset GHG from other sources	The preferred alternative is Gull Island first
	Pace of construction - consecutively, concurrently with the same finish date, or staged overlap	All are technically feasible although concurrently may have workforce issues	All are economically feasible with varying rates of return	The duration of biophysical effects is greatest with sequential, socio-economic effects best optimized with staged-overlap	Preferred alternative is staged overlap reducing boom and bust and maximizing Project economics
Operating philosophy	Remote operation located in St. John's or Churchill Falls; generation and transmission crews located in Churchill Falls or Happy Valley-Goose Bay	All options are technically feasible; existing ECC based in St. John's; existing transmission maintenance crew based in Churchill Falls; Happy Valley-Goose Bay is closer for generation station crew	All options are economically feasible; use of existing ECC less costly; transmission maintenance crew in Churchill Falls less costly; generation station crew less costly to be operated out of Happy Valley-Goose Bay	There are no differences except to the extent that opportunities will vary slightly in different communities	Remote operation in St. John's, transmission maintenance in Churchill Falls, and generation crew in Happy Valley-Goose Bay

3.7.4 Siting of the Gull Island Generation Facility

Alternatives Considered

In 1971, engineering studies determined the optimum plan for developing the generation facilities on the lower Churchill River. Four alternative sites between Gull Island and Grizzle Rapids were studied in detail for the Gull Island Generation Facility (Table 3-2). A range of technical and economic factors ruled out locations upstream and downstream from this area. This included implications for available head and projected economics for each site.

Technical Feasibility

For each site, the study considered the geology and scheme of development. Each alternative considered met the objective of having no effect on the future development of the undeveloped head at Muskrat Falls. Each of the locations identified was determined to be technically feasible.

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Economic Feasibility

For each site, the study considered the cost of construction, available head, generation capacity and energy output. The location at Grizzle Rapids offers the best economic optimization due to available energy and cost.

Environmental Effects

Although there are slight differences in footprint and the environment at each of sites considered, there is little difference in overall environmental effects of the Project. Important environmental effects related to impoundment and facility construction and operation are effectively the same.

Preferred Site

The preferred site at Grizzle Rapids had topographic characteristics that would support an optimal layout of Project components and thereby would maximize energy production and reduced cost. Provision of the optimal location from a cost and energy production standpoint is the best decision from a sustainable development perspective given that there is little differentiation between the sites from an environmental perspective.

3.7.5 Siting of the Muskrat Falls Generation Facility

Alternative Considered

The Muskrat Falls site is the only technically and economically feasible location for this development (Table 3-2). Located at the head of tidal influence, the site affords the use of the full available head below Gull Island, and is the only site that has both technical and economic feasibility. Feasibility studies over 30 years have confirmed these conclusions (Table 3-1).

Technical Feasibility

The natural topography of the Muskrat Falls site consists of a unique feature: the north spur and rock knoll. This north spur forms a natural dam that connects the north bank of the river valley to the rock knoll. Foundation conditions across the river at Muskrat Falls are very favourable. The length of dam required is considerably less than any other possible location. At potential locations upstream, foundation conditions are poor due to the presence of unstable marine sediments. The upstream locations would require much longer dams in uncertain or poor foundation conditions, affording less head for electrical generation and involving considerably higher capital cost.

Economic Feasibility

The presence of the north spur reduces the required construction costs for building a hydroelectric facility at Muskrat Falls. Due to the unique geology of the north spur and the requirement to maximize available energy and reduce construction cost, Muskrat Falls offers the only economically feasible site.

Environmental Effects

There is only one alternative means that is economically and technically feasible for siting of the Muskrat Falls Generation Facility; therefore, no comparison of environmental effects was conducted.

Preferred Alternative

The Muskrat Falls site is the only technically and economically feasible alternative for the Muskrat Falls Generation Facility.

3.7.6 Gull Island Generation Facility Alternatives

The previous engineering studies (Table 3-1) considered several alternatives for the layout of, and construction methods for, the components at Gull Island. Alternatives were evaluated based on field investigation and through consideration of construction cost and schedule. In the current engineering program, layout and construction alternatives have been refined from the extensive previous study. The following text describes the various alternative means of carrying out the Gull Island components of the Project and includes consideration of:

- dam height selection and associated reservoir operating levels;
- type of dam construction;
- approach channel configuration;
- penstock construction and material;
- powerhouse capacity and configuration;
- type of turbine;
- tailrace channel improvements;
- spillway layout and design;
- diversion facilities;
- switchyard location; and
- permanent access roads.

The analyses are summarized in Table 3-2.

3.7.6.1 Dam Height and Reservoir Operating Level

Alternatives Considered

Dam height and reservoir operating level is an important aspect of the Gull Island Generation Facility. It determines the available energy and involves technical and economic considerations. A full range of dam heights was considered.

Technical Feasibility

Any height of dam is technically feasible at Gull Island within the range of available head. The crest of the highest dam possible without affecting generation at Churchill Falls would be at 129 m above sea level (asl) to provide sufficient freeboard (to prevent over-topping in worst case conditions) at the maximum FSL of 125 m asl.

Economic Feasibility

Dam height was optimized in feasibility studies to provide maximum available head and energy without causing a backwater effect at the Churchill Falls Power Station. Economic analysis of capital cost and energy demonstrated that the optimal alternative was to operate the dam at a FSL of 125 m asl. Any substantive loss in

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head would render the Project not economically feasible. Decreased head results in lower economic benefit, and if sufficiently great, would render the Project not economically feasible.

Environmental Effects

The analysis showed that sub-optimal dam height scenarios from an economic perspective were technically feasible. The environmental effects for a lower reservoir are progressively lessened due to reduced habitat loss and smaller area flooded, but result in increasingly poorer economics. The relationship between available head and economic feasibility is strong. The difference in environmental effects for only slightly lower reservoir elevations (economically constrained) would result in nominal differences in environmental effects between alternative dam heights (upper reservoir levels have the steepest slope). Although the preferred alternative dam height represents the worst-case scenario for environmental effects due to flooding, the threshold for significant environmental effects for all VECs is not exceeded as demonstrated in the environmental effects assessment presented in Volume IIA and Volume IIB.

Preferred Alternative

The preferred alternative is the optimal design with a dam height of 129 m asl and a FSL of 125 m as it affords the optimal energy production for economic feasibility, with little difference in consequential environmental effects.

3.7.6.2 Type of Dam Construction

Alternatives Considered

The engineering studies for the Gull Island Generation Facility were undertaken starting around the time of the construction of the Churchill Falls Power Station. At the Churchill Falls Power Station, dams and dykes are of earth and rockfill construction. With this experience the initial dam design for the Gull Island Generation Facility included a central impervious core of glacial till, contained by gravel filters and a shell of rockfill.

In order to confirm the type of dam construction methodology appropriate for the Gull Island site, an engineering study reviewed the selection based on existing technology in dam construction and the findings of the 2007 field program.

The use of a concrete-faced rockfill dam (CFRD) with a cut off wall is a new alternative solution in recent studies. A CFRD would involve materials obtained from the required rock excavations. The upstream side of the dam would have a reinforced concrete surface. In order to account for the lack of well-graded impervious material for an earth core dam, two modified types of earth core dam that rely on filters made from materials readily available near the site were considered. These two types were a multi transition vertical core (MTVC) dam and a dam with an inclined core with upstream blanket (ICUB).

Technical Feasibility

Engineering studies took into consideration the foundation conditions at the Gull Island site, which adds complexity to the design and construction of the main dam. These conditions include alluvial and glacial deposits over the bedrock in the river. Valley sides comprise thick deposits of moraine overlain by lacustrine and marine deposits.

In addition to foundation conditions, the 2007 field investigations into potential borrow materials showed that the available deposits contain glaciofluvial material, and colluvium of silty sands and gravels, which are similar to

till and actual till. Such a mixture of materials in the same deposits, combined with the fact that these deposits are located at the base of rocky hills and ridges and have naturally high water contents, would likely result in requirements for expensive blending and partial kiln drying in order to be suitable material for construction.

The field investigations also failed to identify substantial sources of esker type deposits and well-graded sand and gravel for use as filter materials. The deposits identified are randomly stratified and their use as filter material would necessitate extensive mixing and strict methods of excavation in order to meet construction specifications.

In conclusion, all dam types are technically feasible. However, there will be technical challenges with the provision of materials for an earth and rockfill dam.

Economic Feasibility

The CFRD alternative has a slight advantage economically over the ICUB alternative. Both have reasonable economic feasibility.

The MTVC alternative was determined to require an additional eight months to construct and therefore not considered economically feasible due to additional cost and interest during construction. An earth and rockfill dam would be far more costly due to unavailability of suitable materials and the need for drying and blending to provide impervious core and filter materials. The earth and rockfill dam would likely require an extra year for construction (increasing interest during construction and total cost) and has a higher degree of relative uncertainty. It is not economically feasible.

Environmental Effects

The environmental effects assessment of alternatives includes the overall footprint of the dam, the use of material from excavations and the requirements for concrete production.

With an increase in dam footprint, the affected fish habitat would increase. It was determined that the CFRD had a smaller physical footprint than the ICUB. Both dams would maximize the use of available material from excavations and therefore reduce the amount of spoil areas required (as compared to rejected alternatives).

An increase in concrete would result in an overall increase in air emissions for the Project during the construction phase. While the ICUB alternative would require less concrete production, additional heavy equipment would be required to transport materials from borrow areas.

There would be no substantial difference in environmental effects from either of the CFRD or ICUB alternatives.

Preferred Alternative

The CFRD and ICUB would have similar construction schedules; however, based on cost estimates, the CFRD would be the most advantageous. As well, the CFRD would be less affected by the geotechnical aspects of the borrow pits and is less susceptible to adverse weather conditions.

Considering that there would be minimal differential in the anticipated environmental effects as a result of selecting either of these alternatives (CFRD has a slightly smaller footprint), the CFRD has been selected as the preferred alternative.

There are currently no CFRD constructed within the Hydro system. However, CFRD is a proven technology and in use worldwide. A CFRD constructed at Kárahnjúkar, Iceland, has similar climate and weather conditions to the Gull Island site. The Project engineering team has conducted a site visit to Kárahnjúkar and the Project engineers

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discussed their issues, lessons learned and recommendations for improvement with the Kárahnjúkar engineering team.

The CFRD will comply with the Canadian Dam Association (CDA) Dam Safety Guidelines 2007 and will comply with design standards and guidelines. Further detail on the CFRD alternative is included in Section 4.2.1.1.

3.7.6.3 Approach Channel Configuration

Alternatives Considered

The most recent engineering studies included a review of the approach channel configuration as carried forward from earlier designs. The approach channel to the spillway is an area where optimization could potentially reduce cost and excavation. This analysis considers the originally proposed approach channel layout that resulted from previous feasibility studies and a new alignment selected to consider technological advances and updated site data.

Technical Feasibility

The main technical consideration in the study of the approach channel layout was to optimize the structure location and the design concept, based on technology advances and updated site data. Both the original and new alignment are technically feasible.

Economic Feasibility

The approach channel was re-aligned, deepened and narrowed to reduce rock quantity in the channel. These revisions retained the hydraulic criteria, yet reduced the excavation by almost 2 million m^3. The reduced excavation results in a corresponding reduction in capital cost. There were no other alternatives considered for the approach channel alignment and location for the Gull Island Generation Facility as the study was an optimization process.

Environmental Effects

The re-alignment inherently reduced the footprint and excavation of the Project and related environmental effects. The lesser volume of excavated rock will reduce the use of heavy equipment and the amount of spoil and related environmental effects.

Preferred Alternative

The re-alignment is preferred for economic and environmental reasons related to footprint and the need for less excavation and spoil.

3.7.6.4 Penstocks

Alternatives Considered

Earlier concepts of the Project consisted of one concrete and steel lined tunnel per turbine, with construction access through the intake structure and powerhouse. The most recent studies revisited this design. A construction adit was included in the re-arrangement to reduce schedule risk. Although not previously considered, the alternative of surface penstocks was included.

Technical Feasibility

The revised tunnel arrangement and surface penstocks are technically feasible. Technical considerations included the geotechnical properties of the rock (such as strength and fractures) and the potential for hydro jacking. Hydro jacking is the opening of joints and fissures due to high water pressure. It can have serious consequences such as excessive tunnel leakage. There were some concerns with hydro jacking for the tunnel scheme, but following field tests it was concluded that having steel liners between the powerhouse and the lower penstock elbow would overcome this problem.

Economic Feasibility

Both alternatives are economically feasible. Surface penstocks would be considerably more expensive.

Environmental Effects

One consideration for environmental effects was that of site aesthetics. The aboveground penstocks would be visible and there is some loss of terrestrial habitat with aboveground penstocks. The aboveground penstocks will be within the existing footprint and would not result in additional areas of disturbance. Tunnels involve rock excavation for use in dam and other construction. The use of heavy equipment would be greater in tunnelling than for a surface penstock. However, rock for dam construction must be excavated somewhere. Hence, the differential in air emissions is nominal. Both alternatives will have similar environmental effects.

Preferred Alternative

The evaluation found the surface penstock arrangement to be substantially more expensive than the tunnel arrangement with the construction adit. The aesthetics of aboveground penstocks would be less desirable. Thus, the tunnel arrangement, with a construction adit was selected.

3.7.6.5 Powerhouse Capacity and Configuration

Alternatives Considered

The most recent study on the capacity and configuration of the powerhouse evaluated seven powerhouse alternatives. The alternatives ranged in generation capacity from 2,000 to 2,520 MW, and included from four to eight turbines. The powerhouse footprint varied from 188 m to 245 m long and 37 to 44 m wide. Turbine runner diameters varied from 5.7 m for the smallest turbine to 7.6 m for the largest. The number of turbines, their capacity, operational flexibility, energy production and capital cost was determined.

Technical Feasibility

All configurations were technically feasible.

Economic Feasibility

All alternatives were economically feasible but had considerable variation in rate of return.

Environmental Effects

The environmental considerations associated with the number and size of turbines relates to reservoir fluctuations and fish entrainment. More turbines would provide better control of the reservoir and generation. Fish injury and mortality is directly proportional to the size of the runner. However, all turbines considered have

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very large runners and the difference in fish related environmental effects are nominal. Total capacity and the number of turbines affect the rate of drawdown in the reservoir. The difference in rate of drawdown between the scenarios is small; the reservoir would have the same low and full supply levels. Minor differences in rate of drawdown would occur. The differences are not sufficient to be of concern in alternatives selection from an environmental effects perspective.

The different powerhouse size is not great enough to be a material consideration from an environmental effects perspective.

Preferred Alternative

The energy production, operational flexibility, capacity and capital cost of alternatives was evaluated. The five-unit plant is the preferred alternative because it provides the optimal balance between these factors. Turbine runners will be 7.2 m in diameter and each turbine will be 450 MW in capacity totalling 2,250 MW. The alternative selected increases the efficiency of the plant as a whole and the cost for additional power is lower than any other source.

3.7.6.6 Type of Turbine

Alternatives Considered

Francis turbines are the only technically and economically feasible alternatives for a project with this available head. Other turbine types such as Pelton, propeller and Kaplan, provide optimum solutions in higher and lower head scenarios than that of the Project.

Technical Feasibility

The selection of turbines considered the range of head and flow, which are determinants in the efficiency of energy generation. Francis turbines are the only turbine type at the head range and flow proposed for the Project that would efficiently generate electricity. Thus, Francis turbines are the only technically feasible alternative. Hydro operates Francis turbines at many of its facilities.

Economic Feasibility

Technical and efficiency issues would occur with other turbine types at the head range and flow rates proposed for the Project. Francis turbines are the only economically feasible alternative. The inefficient generation of electricity would not be a responsible use of the resource.

Environmental Effects

There is only one economically and technically feasible alternative for type of turbine; therefore, no comparison of environmental effects was conducted.

Preferred Alternative

The preferred alternative is Francis turbines because they are the only technically and economically feasible alternative.

3.7.6.7 Tailrace Channel Improvement

Alternatives Considered

The most recent engineering investigations evaluated 30 alternative tailrace channel improvement configurations on the south bank of the river. The channel improvement would involve additional excavation of the tailrace channel into the Churchill River between the Gull Island dam site and Gull Lake. This would reduce the water level in the tailrace at the Gull Island powerhouse. This would provide the benefit of additional head on the plant until the future development of the downstream Muskrat Falls Generation Facility. The objective of the investigations was to determine if alternatives to the preliminary tailrace channel layout to lowering the tailrace water level at Gull Island were technically and economically feasible.

Technical Feasibility

The evaluation considered energy production versus the volume of excavation of the tailrace channel for six representative alternative configurations. Technical considerations included tailrace geometry, bathymetry, sediment and specific survey data from the area between the dam site and Gull Lake. The inclusion of channel improvement was determined to be technically feasible in all cases.

Economic Feasibility

The primary economic considerations were the capital cost of the tailrace channel improvements, the level of energy production achieved and the future effect of the lower water level in the tailrace on the Muskrat Falls Generation Facility. The results of the study indicated that the tailrace channel improvement would not be economically feasible if Muskrat Falls is built within four or five years as planned. Consequently, although economically feasible without Muskrat Falls, its benefit would only be realized for four to five years until the construction of Muskrat Falls is completed.

Environmental Effects

There is only one economically and technically feasible alternative for the tailrace at the Gull Island Generation Facility; therefore, no comparison of environmental effects was conducted.

Preferred Alternative

No alternative was preferred or will be integrated into the Project due to the short term nature of the benefits.

3.7.6.8 Spillway Layout and Design

Alternatives Considered

The main features of the spillway layout and design have remained generally unchanged throughout the course of engineering studies carried out for the Gull Island Generation Facility. The design had several gated intakes on an ogee crest leading down to a sloping concrete lined chute, a flip bucket and a large plunge pool, then a short discharge channel to the river.

The spillway design capacity will pass the full probable maximum flood (PMF), increased based on recent hydrological data. The discharge capacity is 20,800 m^3/s. This design criterion assumes that no generation flow will occur during this event and the maximum allowable surcharge on the reservoir is 2 m. Because of the increase in PMF in current studies, three alternative designs and layouts were studied considering either seven

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or eight gates. The optimal design includes a parabolic crest as opposed to the earlier ogee design and eight gates.

Technical Feasibility

This optimal design is technically feasible and offers a number of operational improvements over alternatives and previous design. One alternative failed because the dimensions of the gates would be bigger than the largest gates ever used in Canada. The other two would be acceptable, but one presents more advantages, as the gate weight of that case is slightly lower than its alternative. This lower weight means savings in manufacturing, shipping and installation, as well as improved operability.

Economic Feasibility

The optimized design is economically feasible. Other designs could be economically feasible but were sub-optimal technically.

Environmental Effects

The varying design alternatives would result in no material differences in environmental effects. Both alternatives would be designed to reduce turbulence as this creates cavitation problems, which is undesirable from an engineering perspective. There would be no substantial difference in gas pressure between the alternatives. The spillway will likely be used only once annually.

Preferred Alternative

The preferred spillway is the optimal design balancing cost and other operational considerations. It will be equipped with eight fixed-wheel vertical lift gates 13 m wide and 20 m high, and discharge over a parabolic-shaped crest set at elevation 105.4 m. The parabolic crest shape replaced the ogee crest shape, and to reduce rock excavation the earlier alignment of the spillway was revised. The overall hydraulic design of the intakes, chute and plunge pool were updated.

3.7.6.9 Diversion Facilities

Alternatives Considered

Diversion of the river around the dam site for construction of the main dam at Gull Island is required. In previous reports, the proposed plan for the diversion tunnels was on the north side of the river, consisting of two tunnels side-by-side measuring 14 m wide and 17 m high. A new alternative would locate tunnels on the south side of the river and the inlet portal of the tunnels would be in the approach channel to the power intake and spillway. The tunnels would then go underneath the approach channel and intake/spillway to exit at the outlet portal located downstream of the dam, between the future locations of the powerhouse and spillway.

Technical Feasibility

Both alternative diversion schemes are technically feasible.

Economic Feasibility

Both alternatives are economically feasible.

Environmental Considerations

There is little difference in environmental effects between the alternatives under consideration.

Preferred Alternative

The south side option would be located in better quality rock and would have considerably less overburden excavation that would shorten the construction schedule and decrease the need for spoil areas, while avoiding the engineering implications of constructing the tunnels in poor quality rock. As well, slope stability is a safety concern on the north side. The south side diversion is the preferred alternative.

3.7.6.10 Switchyard Location

Since 1980, reports have shown the switchyard located on the south shore. However, the most recent engineering studies identified an alternative location on the north side of the river. The report considered technical aspects such as the transmission line configuration, requirements for foundation development and slope stabilization.

Technical Feasibility

Both alternatives are technically feasible. The south side has foundation and slope stability issues that must be overcome.

Economic Feasibility

Both alternatives are economically feasible but the north location is less expensive due to site conditions and proximity to the ultimate destination of the transmission line on the north side.

Environmental Effects

The footprint of both alternatives is similar. Better slope stability and foundation conditions at the north site reduces the potential environmental effects associated with construction (e.g., slope failure, erosion). The north alternative consequently may have some slight environmental preference.

Preferred Alternative

Considering the new transmission line configuration and extensive foundation development and slope stabilization that would be required on the south side, the alternative location on the north side was selected as the preferred alternative due to lower capital cost and fewer footprint-related environmental effects.

3.7.6.11 Permanent Access Roads

Alternatives Considered

A review of the routing of a permanent access road to the site was undertaken. Based on the design principles, the designs will assume the use of existing transportation infrastructure to the maximum extent possible, in particular, existing roads and bridges. Existing road use will be a priority. Upgrading to applicable standards will occur where required. Not considered in detail was the alternative of building a completely new road due to the obvious additional cost and environmental effects.

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Technical Feasibility

Road construction is technically feasible where engineering constraints (e.g., grade, foundation conditions, unstable slopes) are avoided. Route selection avoids such constraints. The existing routes have demonstrated technical feasibility but may require some upgrading and minor realignment.

Economic Feasibility

The use of existing roads is for the most part economically positive as compared to new construction. New construction is economically feasible where routing would avoid severe engineering constraint.

Environmental Effects

The use of the existing road would reduce environmental effects such as habitat loss and erosion and would reduce emissions due to construction.

Preferred Alternative

This principle of using existing infrastructure leads to the selection of the existing road as preferred permanent access to the site. The selection of the existing access road reduces cost, environmental effects and the amount of new road construction required.

3.7.7 Muskrat Falls Generation Facility Alternatives

In the previous engineering studies (Table 3-1), several alternatives for the layout of, and construction methods for, the components at Muskrat Falls were considered. Alternative analysis considered field investigation and construction cost and schedule. In the current engineering program, layout and construction alternatives have been refined. The following text describes the various alternative means of carrying out the Muskrat Falls components of the Project and includes consideration of generation facility layout, north and south dams, reservoir, powerhouse, type of turbine, spillway and permanent access. The analyses are summarized in Table 3-2.

3.7.7.1 Generation Facility Layout

Alternatives Considered

The layout of the Muskrat Falls Generation Facility has been the subject of a series of engineering studies. The most recent study considered early access to the south side of the river now available due to the construction of a new highway bridge downstream of the site. The recent analysis included three previously selected variants. These variants are as follows.

Variant 7 comprises a tunnel diversion through the rock knoll. An upstream cofferdam above the upper falls and a downstream cofferdam just above the lower falls would allow the entire river between the cofferdams to be dewatered. The design includes a close-coupled intake and powerhouse and an adjacent spillway in the river near the downstream cofferdam. Roller compacted concrete (RCC) dams would be constructed to the north and south of the intake, powerhouse and spillway structures. An inflatable rubber dam would be located on the top of the north dam to provide secondary spillway capacity. The south dam would be an overflow dam for additional spilling capacity.

Variant 10 would have the powerhouse and spillway structure located in the south bank of the river, allowing excavation to begin in the dry immediately after south side access is available. No river diversion would be

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necessary until Year 3 of the schedule when river flow is via the spillway sluices, temporarily without rollways. Compared to Variant 7, this variant has large rock excavations on the south bank from the approach and discharge channels, and a larger upstream cofferdam, but does not have diversion tunnels through the rock knoll.

Variant 11 in its completed state is similar to the layout of Variant 7. However, as it has no diversion tunnels, river flows would be through a channel excavated through the north side of the river, allowing the south side of the river to be coffer-dammed for construction of the powerhouse and spillway. The river closure completed during a third stage diversion when the river flows are via the spillway sluices, temporarily without rollways. The excavated channel through the north side, river channel would then be dewatered and the north dam constructed.

Technical Feasibility

Considerations for technical feasibility included requirements for cofferdams and requirements for construction infrastructure, such as a temporary bridge and the complexity of tunnel and underground arrangements. Predicted head losses were also an important technical consideration. All alternatives considered are technically feasible. However, Variant 10 has a construction schedule that is nine to ten months shorter and with relatively less technical risk.

Economic Feasibility

The primary consideration for economic feasibility was the initial capital cost. Another important consideration was the construction schedule, as the schedule would affect the date of first power and, consequently, interest accumulation during construction. A prolonged schedule would also affect the date when the Project could generate revenue. Variant 10 has the shortest construction schedule and its cost is the lowest. Each alternative is economically feasible but there is considerable variation in rate of return on investment for each.

Environmental Effects

Through the Innu Task Force, the Project Team became aware of the cultural importance of the rock knoll at Muskrat Falls. Variants that would reduce disturbance to the rock knoll would be preferred over those that would require extensive construction on the knoll. An excerpt from the ITKC Report relevant to the rock knoll at Muskrat Falls is presented below:

> *ITKC members said that uenitshikumishiteu live under the hill at Muskrat Falls called Manitu-utshu. In fact, the hill is so-named because of this animal; the toponym means 'evil creature mountain'. The hill is like a uisht (beaver lodge) and the entranceway is under the water. Uenitshikumishiteu can be very dangerous creatures and will attack people if they have been threatened or harmed in some way…*
>
> *"Like any animal that can travel through the water, uenitshikumishiteu can travel through the ground. Once two men were hunting, and one of them killed a young uenitshikumishiteu whereupon the water started to bubble. The hunters took off. They could see the ground moving like water towards them. The one who shot the uenitshikumishiteu was killed, and his buddy heard him screaming. The fellow who hadn't shot the being wasn't bothered" (P2.24.1.07). "We have all heard this story about uenitshikumishiteu from the old people. It is very dangerous" (P1.24.1.07).*
>
> (p. 95)

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> *The fact that the "uisht" (lodge, dwelling-place) of uenitshikumishiteu is in Manitu-utshu was of special concern to the ITKC members because of the construction work proposed for the location. One end of the Muskrat Falls dam will be secured to it, and an access road and diversion tunnel will be built there. Committee members are concerned that the construction work will be disrespectful to uenitshikumishiteu. "I'm afraid that they might get mad and destroy the dam," said one person (P1.24.1.07). "It was never disturbed in the past, but it will be disturbed by construction," said another person (P2, 24.1.07). The consensus seemed to be that "uenitshikumishiteu won't let the project happen. If you don't touch the hill, destroy it, uenitshikumishiteu won't get mad" (P1, P2, P3.24.1.07). When asked directly, the committee members were unwilling to contemplate, or could not think of, any mitigation measures that would prevent uenitshikumishiteu from getting angry.*
>
> (p. 96)

The requirements for new access roads and the associated access to previously inaccessible areas will increase the Project footprint.

Requirements for borrow materials and the volume of concrete required was another environmental consideration due to associated land disturbance and energy use.

Preferred Alternative

A summary of the layout alternatives analysis is provided in Table 3-3. All options are technically and economically feasible. Variant 10 is the preferred alternative based on the technical, economic and environmental considerations. It has the lowest cost and lowest technical and economic risk. Variant 10 reduces the potential cultural environmental effects at the rock knoll.

Table 3-3 Project Layout Alternatives for Muskrat Falls

Variant	Technical Feasibility	Economic Feasibility	Technically and Economically Feasible	Environmental Effect
7	Highest Risk longest duration (achieves first power in 65 months)	Lowest (highest cost)	Yes	• Rock knoll has cultural importance to the Innu. Diversion tunnels would be required through the rock knoll • Existing borrow areas along the TLH could be used
10	Lowest Risk least duration (achieving first power in 55 months)	Highest (lowest cost)	Yes	• Diversion tunnels would not be required through the rock knoll • A 5 km long access road would be required along the south bank of the river • Existing borrow areas along the TLH could be used. However, borrow areas may be required along the south side of the river • Possibility to have permanent access from the south side under this type of layout, which would further reduce disturbance to the rock knoll • 2.5 to 3 times more excavation required than the other two variants • 80 percent more concrete required than the other two variants
11	Medium Risk Intermediate Duration (achieving first power in 64 months)	Medium	Yes	• Diversion tunnels would not be required through the rock knoll • A 5 km long access road would be required along the south bank of the river • Existing borrow areas along the TLH could be used. However, borrow areas may be required along the south side of the river

3.7.7.2 North and South Dams

Alternatives Considered

The type of dam originally proposed for Muskrat Falls was conventional concrete. However, engineering studies in the past two decades have concluded that RCC construction is an economically feasible alternative. Other alternatives were limited for technical and economic reasons including, particularly, foundation conditions and the availability of suitable materials.

Technical Feasibility

Conventional concrete is technically feasible. RCC is a durable material and can develop strength that compares with conventional concrete. One consideration for the use of RCC is the requirement that the dam foundation must be constructed on bedrock as this type of construction is vulnerable to issues caused by settling. Since the Muskrat Falls site has little overburden and a lot of exposed bedrock, this type of construction is well suited to the site conditions. RCC gravity dams are technically feasible as overflow dams. Incorporated into the design, this will reduce the required spillway capacity and the cost of the spillway. RCC gravity dams are in use worldwide and are becoming more common in North America.

Economic Feasibility

Roller compacted concrete is the only economically feasible option.

Environmental Feasibility

There is only one economically and technically feasible alternative for the north and south dams at Muskrat Falls, therefore no comparison of environmental effects was conducted.

Preferred Alternative

Roller compacted concrete is the only economically feasible alternative and is thus preferred.

3.7.7.3 Reservoir Operating Level

Alternatives Considered

The alternatives considered were a range of reservoir operating levels up to the tailrace of the Gull Island facility.

Technical Feasibility

Any level of reservoir operation is technically feasible.

Economic Feasibility

Engineering studies in 1980 involved an optimization of the FSL of the Muskrat Falls Reservoir. The study based the optimization on the assumption that the Muskrat Falls and Gull Island facilities would be constructed at approximately the same time and, on this basis, showed that the optimum FSL of the reservoir would be 39 m asl, taking advantage of the full available head. This optimization takes advantage of the full available head between Lake Melville and the tailrace water level at the proposed Gull Island Generation Station. Lower FSL

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would reduce energy production and increase energy production cost on a per-unit of energy basis. Any loss of available head would compromise the economic feasibility of the Project.

Environmental Effects

The differences in environmental effects for economically feasible operating levels are nominal.

Preferred Alternative

Operation of the reservoir at an FSL of 39 m asl is the preferred alternative because it would result in the maximum energy production with little difference in environmental effects.

3.7.7.4 Powerhouse Generation Capacity

Alternatives Considered

A power and energy study was conducted to optimize the powerhouse capacity at the Muskrat Falls Generation Facility. This optimization was based on a reservoir operating level of 39 m. The Project optimization process assessed a variety of system configurations and carried out a cost/benefits analysis for each. Plant capacities considered ranged from 618 to 1,236 MW and from four to six turbines.

Technical Feasibility

All plant size alternatives are technically feasible.

Economic Feasibility

Some plant size alternatives are economically feasible, while others were not. The 824 MW alternative is optimal from an energy production and cost perspective.

Environmental Effects

The different alternatives would have varying rates of reservoir drawdown directly related to the generation capacity. The environmental effects of the different alternatives are not substantively different as they result in minor variations in footprint and emissions and discharges during construction.

Preferred Alternative

The engineering analysis concluded that the optimal plant capacity of Muskrat Falls is 824 MW. Considering operational flexibility, capital cost and other engineering factors, it was determined that four turbines was optimal.

3.7.7.5 Type of Turbine

Alternatives Considered

Both Kaplan and propeller type turbines are suitable for the head range, and flow at the Muskrat Falls Generation Facility. Hydro currently operates a Kaplan turbine at its Granite Canal generation facility. Francis and Pelton turbines do not operate efficiently at this low head and are not considered.

Technical Feasibility

Both Kaplan and propeller turbines are technically feasible offering equivalent operational efficiency at the planned head. Kaplan is technically more complex.

Economic Feasibility

Kaplan turbines would result in higher initial capital costs but can generate more energy. The Kaplan turbines have adjustable blades that can run efficiently over a larger range of river flows. Both Kaplan and propeller types are economically feasible. Final design will optimize capital cost, energy production and operational flexibility to determine the turbine type.

Environmental Effects

Large Kaplan and propeller turbines have similarly low fish mortality rates. There is effectively no difference between them environmentally. There are no other distinguishing environmental effects differences between the two turbine types.

Preferred Alternative

The additional cost of one Kaplan turbine over using all propeller-type turbines is recoverable in two years. However, replacing all propeller turbines with Kaplan turbines would result in only a small increase in total energy compared with a combination of both types. Further analysis of the optimal combination of Kaplan and propeller turbines is required in final design. The environmental assessment considers both alternatives.

3.7.7.6 Spillway Layout

The spillway facilities in the preferred layout, Variant 10, required further optimization as the gates in this scheme were larger than commonly used. A design review optimized a number of technical parameters. Ten spillway alternatives were developed and later shortlisted to four alternatives:

- Alternative 1: three-bay gated spillway, surface vertical gates 13.75 m wide by 19.4 m high, rubber dam 330 m long and fixed RCC dam crest 115 m long;
- Alternative 2: five-bay gated spillway, surface vertical gates 10.4 m wide by 21.5 m high, no rubber dam, fixed RCC dam crest 429.5 m long;
- Alternative 3: five-bay gated spillway, surface vertical gates 13.75 m wide by 17.7 m high, no rubber dam, fixed RCC dam crest 409.3 m long; and
- Alternative 4: four-bay gated spillway, submerged radial gates 12.5 m wide by 14.8 m high, no rubber dam, fixed RCC dam crest 433.2 m long.

Technical Feasibility

The four alternatives are technically feasible. Alternative 4 has the lowest complexity.

Economic Feasibility

The four alternatives are economically feasible with substantial differences in cost.

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Environmental Effects

The relative environmental concerns present are the difference in excavation, borrow and overall footprint. The preferred Alternative 4 would require about 30 percent more excavation than Alternative 1, but would require approximately the same amount of concrete. The other two alternatives would require about 40 to 43 percent more excavation and six to nine percent more concrete. Therefore, there would be little difference in the potential environmental effects of the alternatives.

Preferred Alternatives

Alternative 4 is the least expensive and it involves the least complicated arrangement for construction; no rubber dam or overhead service bridge would be required. It has lower construction and operating costs as well as constructability advantages as compared to other schemes.

3.7.7.7 Permanent Access Roads

Alternatives Considered

There are two potential alternatives for permanent access to the Muskrat Falls site. Access can be from the north bank via the existing access road off the TLH or from the south bank via Black Rock Bridge, which crosses the Churchill River 19.3 km downstream from the site. Based on discussions with the Forestry Branch of NLDNR, a new forest access road is planned as part of the harvesting plan for Forest Management District (FMD) 19A. This road will be in place before the construction of Muskrat Falls.

Under Alternative 1, the main access to the Muskrat Falls site would be located directly off the TLH. This access road would be about 28 km west of Happy Valley-Goose Bay. The road would extend approximately 4.5 km from the intersection with the TLH to the area of the main dam. Of the 4.5 km, about 3 km of existing access road would require upgrading and approximately 1 km of new road construction would be required.

Under Alternative 2, site access would be via Black Rock Bridge. To support construction, the forest access road would be upgraded and approximately 5 km of new road construction would be required.

Technical Feasibility

Both alternatives are technically feasible.

Economic Feasibility

Both alternatives are economically feasible.

Environmental Effects

Alternatives 1 and 2 would involve the creation of a similar amount of new road. However, Alternative 1 would require additional disturbance of the culturally sensitive rock knoll at Muskrat Falls. This alternative may also be more difficult to construct.

Preferred Alternative

Based on environmental and cultural considerations, the southside access road (Alternative 2) is the preferred alternative.

3.7.8 Transmission Line

Alternatives Considered

The end points of transmission lines, defined at the outset of planning by the location of the generation stations and terminal stations, have an almost infinite range of potential alternatives alignments between them. The Project Team completed studies to evaluate potential technical, economic and environment constraints and select a preferred and alternative route. These studies included constraints mapping of environmental sensitivities (AMEC Earth and Environmental Ltd. 2008). Using avoidance as the principal mitigation, the studies balanced technical and economic matters while avoiding environmental constraints.

Two potential 1 km wide corridors were selected. Alternative 1 is along the existing transmission line from Churchill Falls to Happy Valley-Goose Bay. Alternative 2 was identified in the late 1970s and evaluated in 1999. Engineering and environmental data are available for both corridors. Alternative 1 parallels an operating transmission line that has been in service for approximately 30 years. The analyses are summarized in Table 3-2.

Technical Feasibility

Both options are technically feasible. Alternative 1 has several inherent technical advantages, including operational experience and proven constructability, existing access and known foundation and terrain conditions. Over 100 km of access roads and trails were established for the construction and maintenance of the existing line.

Economic Feasibility

The cost of construction and operation of Alternative 1 is less with the use of existing access roads and trails. The co-location of the existing and proposed transmission lines with Alternative 1 will greatly reduce operational costs of both lines. Both alternatives are economically feasible.

Environmental Effects

The potential environmental effects of both alternatives would be similar due to avoidance mitigation. However, the use of the existing alignment of transmission line corridor for Alternative 1 would reduce habitat fragmentation and would result in a reduced need for additional terrain disturbance (habitat loss or degradation) and new stream crossings (erosion and sedimentation), and their attendant environmental effects, for the creation of access.

Preferred Alternative

Alternative 1 is preferred because it would result in the least environmental effects, lowest capital cost and greatest technical certainty.

3.7.9 Construction Infrastructure at Gull Island and Muskrat Falls

Alternative access roads, construction camps, and borrow pits and quarries, and diversion facilities are included in this section. The analyses are summarized in Table 3-2.

3.7.9.1 Access

Alternatives Considered

For the Gull Island and Muskrat Falls generation facilities construction roads will be required to facilitate construction at the sites. A bridge would be required for access at both sites. The location of permanent access roads has been addressed in Section 3.7.6.11 for Gull Island and Section 3.7.7.7 for Muskrat Falls. This section focuses on the process to be followed to site temporary access roads and considers a bridge at Gull Island.

Use of existing roads reduces potential for interactions with the environment. The location of new roads will take into consideration environmental constraints such as streams, rivers and water bodies, wetlands and areas sensitive for wildlife and vegetation. Stream crossings and fording sites for all watercourses and water bodies will consider habitat type and species present at each stream crossing including upstream and downstream. Erosion stabilization and effective sedimentation control practices will be employed. Stream crossings will comply with permits issued by the NLDEC and federal guidelines, including a letter of advice from DFO. When fording any watercourse during road construction, the Environmental Guidelines for Fording from NLDEC, Water Resources Division will apply in conjunction with the following criteria:

- areas of spawning habitat will be avoided;
- crossings will be restricted to a single location and crossings made at right angles to the watercourse;
- equipment activity within the watercourse will be reduced by limiting the number of crossings;
- all equipment will be mechanically sound to reduce leaks of oil, gasoline and hydraulic fluids;
- the entire fording area would be stabilized using vegetation mats, corduroy roads or coarse material (125 mm diameter or greater) when such material is available from nearby within the right-of-way, and the ford area is not natural bedrock, or is easily disturbed by fording;
- when the substrate of the ford area is not subject to easy disturbance by fording, or coarse material is not easily available within the right-of-way, fording under existing substrate conditions may occur under the direction of an Environmental Field Coordinator;
- fording activities will not decrease the depth of the watercourses to less than 20 cm; where the existing depth is less than 20 cm, that depth will be maintained; and
- fording activities will be halted during high flow periods.

Engineering studies in 2000 proposed constructing the bridge across a narrow part of the Churchill River approximately 2,000 m downstream from the Gull Island dam centreline. A new location, proposed in 2007, for the bridge would place it at approximately 1,350 m downstream from the dam. In 2008, following the completion of the alternatives analysis, on-going engineering work identified a third alternative, approximately 1,100 m upstream of the Gull Island Site.

There are two alternatives for access across the river to the Muskrat Falls site. One would involve relocating the construction bridge from the Gull Island site, placed across the river at the Upper Falls. The other would involve access across the river at the existing Black Rock Bridge, which is preferred as shown in Section 3.7.7.7.

Technical Feasibility

Roads and bridges, and fording are all technically feasible where technical engineering constraints are not limiting.

Economic Feasibility

Capital cost can be reduced using existing access roads where possible. The required roads, bridges and fording site alternatives are all economically feasible.

Environmental Effects

Environmental effects management by route selection and the employment of standard environmental construction procedures are effective tools that would be used to reduce the environmental effects of road, stream crossing and bridge alternatives. The use of existing access would reduce environmental effects.

Preferred Alternatives

A number of existing roads are preferred to access the various structures during construction. The environmental effects of new road construction would be mitigated by planning to avoid environmental constraints and good construction and maintenance practice. Temporary roads would be located within the flood zone of the reservoirs, wherever possible, and reduced above the flood zone (e.g., for transmission lines).

At Gull Island, three bridge locations are possible. Initially, the preferred location was identified as the location 1,350 m downstream from the dam which would employ readily available spans that have standard dimensions, whereas the previous alternative required a site-specific design with an impractical span. The preferred location was in a much shallower area of the river and, therefore, construction time would be shorter. The major difference from an environmental perspective between these two initial alternatives was the length of access road required (4.5 km compared to 850 m). The current alternative under consideration would not require instream work (i.e., piers). Further work is on-going to determine the technical feasibility of this alternative. The environmental assessment is based upon the initially preferred location (i.e., 1,350 m downstream of the site). The environmental footprint of the upstream location, if selected, would be equal to or less than the footprint of the downstream location.

For the Muskrat Falls site, the south side alternative is preferred (Section 3.7.7.7) because that alternative avoids the culturally sensitive rock knoll on the north side.

3.7.9.2 Accommodations Complex

Alternatives Considered

Engineering studies considered the location of worker accommodations. An accommodations complex at the Gull Island site is required to house the construction labour force. Because of the distance of the site from the nearest community, it is not feasible to locate the construction labour force off-site. During the 1975 construction start, a 30 ha site was prepared for the camp, where it remains. In order to reduce costs and additional surface disturbance, this site will house the accommodations complex. No alternatives are considered.

The Muskrat Falls site is near the Town of Happy Valley-Goose Bay and, as such, there is an alternative to having the accommodations complex on-site. The alternative location is in the Town of Happy Valley-Goose Bay, possibly in existing barracks at 5 Wing Goose Bay, which are not currently in use.

Temporary, self-contained camps will be required for the clearing of the reservoir and for transmission line construction. These camps would be much smaller and temporary in nature.

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Technical Feasibility

The Gull Island site and both Muskrat Falls alternatives are technically feasible.

Economic Feasibility

The accommodations alternatives are all economically feasible.

Environmental Effects

Accommodating the work force in the Town of Happy Valley-Goose Bay would result in adverse socio-economic effects on the community infrastructure and services. These would be difficult to mitigate despite the economic benefit to the community. As is described in this EIS, the Project as proposed will result in increased economic activity in the Upper Lake Melville area, and this will place additional demands on community infrastructure and services, including those providing recreation and entertainment to local residents. The additional demands resulting from Project workers living in the Town of Happy Valley-Goose Bay would likely exceed the capacity of these facilities and services for the duration of the Muskrat Falls construction period, precluding or limiting their use by locals. While local entertainment and recreation infrastructure and services could meet such demand with expansion, it would not be sustainable after the short construction period.

The use of the barracks may result in daily transportation of workers between Happy Valley-Goose Bay and the worksite, with associated costs of travel and of travel time. It may require a fleet of buses moving back and forth on a daily basis, resulting in additional greenhouse gas generation and an increased risk of traffic accidents. Highway closures because of weather or forest fires may prevent workers from getting to and from the worksite, disrupting Project work and the lives of the construction labour force.

Preferred Alternative

To attract the required construction labour force, the accommodations complex option will be custom designed to provide a residential environment competitive with other such facilities elsewhere in Canada. This will result in a state-of-the-art accommodations complex in terms of rooms and dining, recreation and entertainment facilities and services. The modular style of the accommodations complex would allow use at both sites.

The Muskrat Falls accommodations complex is preferred to mitigate adverse interactions between the construction labour force and the Town of Happy Valley-Goose Bay. Experience elsewhere has demonstrated that the housing of construction workers in existing communities can have a number of environmental effects, as discussed in Volume III, Section 4.6.5.3.

3.7.9.3 Borrow Pits and Quarries

Alternatives Considered

Due to the limited nature of suitable borrow sources near the construction sites for the generation facilities, the number of alternatives for the locations of borrow pits is limited as determined by the 2007 engineering study. Potential sources of fill are currently under consideration and subject to confirmation studies during final design.

The source of rock fill is primarily facility excavation. The need for new quarries is limited. Borrow pit locations will be selected based on the quality of the material required and in consideration of environmental constraints.

Borrow pits for the transmission line will be located along the right-of-way. The majority of quarry areas are existing.

Technical Feasibility

Borrow sources are limited by material characteristics (e.g., grain size distribution, moisture content). The availability of some types of borrow has constrained the technical feasibility of some types of dam construction (addressed elsewhere). Rock material supply is not greatly limited except by mineralogy and structure in certain engineering applications.

Economic Feasibility

It is economically feasible to source all borrow and quarry materials proximal to the installations for alternatives as proposed.

Environmental Effects

The potential footprint environmental effects relate to habitat loss and disturbance. Limiting the number of borrow pits and quarries would limit the environmental effects. However, there is a substantial and fixed requirement for materials. Thus, environmental considerations factor in the selection of final borrow pit and quarry locations.

Preferred Alternative

Careful selection of sites to avoid environmental constraints and the use of standard construction practices will mitigate potential environmental effects. Preferred alternatives will be selected in consideration of environmental concerns.

3.7.10 Reservoir Preparation

One important element in the consideration of alternatives is the aspect of reservoir preparation. The type of preparation selected and the methods used influence the overall effects of this Project activity. This section considers the clearing strategy, and the mechanisms for removal of wood, slash and debris. The analyses are summarized in Table 3-2.

The extent of reservoir preparation (as described throughout this EIS) may be modified due to limiting factors that will be encountered in the field. Safety and technical considerations may determine that reservoir clearing in certain areas cannot be achieved (e.g., steep slopes adjacent to Winokapau Lake). Areas not cleared because of these limiting factors will not change the results of the effects assessment. In addition, operational procedures and methods will be implemented to deal with any potential issues (e.g., trash and debris removal requirements) that could result from any area not cleared.

3.7.10.1 Clearing Strategy

Alternatives Considered

Investigations considered and assessed three alternative reservoir preparation strategies:

- minimal clearing for construction of Project components, such as dams, power houses, access roads, docking sites and administrative facilities;
- partial or selective clearing where certain areas in the reservoirs would be cleared while the vegetation in other areas would be left standing, depending upon specified operational and environmental criteria (this strategy includes minimal clearing); and

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- complete clearing that would entail the removal of all major vegetation (trees and large woody shrubs) within the reservoir below the high water level, except in areas where it is not safe to do so.

Technical Feasibility

The reservoir preparation strategy selected must reduce the risk of floating debris during the operation of the generation facilities. The design of the hydraulic structures must take into account the amount of trash and floating debris expected at these structures. For very large spillway structures, such as those planned at Gull Island and Muskrat Falls, trash and floating debris will not affect the capacity of the structures because the gate openings are sufficiently large to preclude obstruction by the debris. However, the same does not apply for the power intakes. Trash and debris can accumulate in front of the intake, create large head losses, limit the flow to turbines and even force a plant shutdown. It is therefore necessary to prevent trash and debris from accumulating. The minimal clearing alternative does not meet this Project requirement and is therefore not technically feasible.

Clearing the rim of long and narrow reservoirs is good practice, especially when their orientation and the direction of the flow coincide with that of the strongest winds. These conditions are very likely to carry debris and trash toward power intakes and other hydraulic structures. As such, both partial and full clearing meet the operational requirements of the Project and are technically feasible.

Safety is a limiting factor for the removal of forest stands in difficult terrain. The highest level of safety standards in the forest industry will apply to all aspects of reservoir clearing. Modern forest harvesting equipment can operate in steep terrain.

The removal of a large volume of wood from the reservoirs in a relatively short time makes efficiency of operation critical. The use of conventional wheeled or tracked harvesting equipment to the greatest extent possible is most time-efficient and cost-effective. Slope is a critical factor, since conventional harvesting equipment generally cannot operate on steep or unstable slopes, although other factors may come into play such as roughness of terrain, soil conditions and drainage.

Both options are technically feasible, although full clearing will extend the Project schedule to an unacceptable length of period that affects economic feasibility (discussed below).

Economic Feasibility

The cost of removing the wood from the reservoir is a consideration in the selection of the preferred clearing strategy. Removal of wood is not economic (revenue positive) for a substantial portion of the clearing that is required. However, the net cost of reservoir preparation is a Project requirement to achieve operational requirements and reliability. In that context, partial clearing is economically feasible. However, full clearing would be a substantially greater cost and would extend the construction schedule, resulting in unacceptable levels of interest during construction, and is therefore not economically feasible. The partial clearing strategy affords the best opportunity to maximize fibre removal, reduce debris and slash for operation and reduce the emissions of GHG.

Environmental Effects

There is only one economically and technically feasible alternative for reservoir clearing; therefore, no comparison of environmental effects was conducted.

Preferred Alternative

The preferred alternative, partial or selective clearing, is the only technically and economically feasible alternative that meets operational requirements. Once cleared, merchantable timber will be placed above the flood zone and made available for third party removal.

3.7.10.2 Disposal of Slash and Debris

Alternatives Considered

Three alternatives for the disposal of slash and debris were considered.

Typically, the main method used to eliminate slash and wood debris is to burn it. Machinery carries out this task; boats can be used to push debris onto the shore where cranes or backhoes equipped with grapples pile up the debris above the reservoir drawdown zone. Finally, bulldozers with rakes push debris into stacks for burning. Restrictions for burning debris due to fire hazards can be a limitation. One commonly used alternative is to bury the wood materials within the reservoir flood zone with loaders and bulldozers. A third alternative has been identified which is to mechanically process the wood.

Technical Feasibility

Each alternative is technically feasible.

Economic Feasibility

Each alternative is economically feasible but the costs vary based on a variety of access and other technical factors.

Environmental Effects

The burning of slash would contribute a greater amount of particulate emissions.

Preferred Alternative

Burning or burying of slash is not preferred from an air emissions perspective. The preferred alternative is to use a combination of mechanical processing and burying.

3.7.11 Reservoir Management

This section addresses the schedule and timing of the filling of the reservoirs for the commencement of operation. The analyses regarding impoundment are summarized in Table 3-2.

Alternative Considered

The timing of impoundment is an important consideration for the alternative analysis. Reservoir impoundment is one of the construction activities that has a substantial potential for interaction with the environment. The interactions vary among species and seasons. There is only one economically feasible time to impound the reservoirs: immediately following the completion of the civil works. In the current Project schedule, impoundment will be completed between August and October.

Technical Feasibility

The reservoir impoundment at Gull Island and Muskrat Falls cannot occur until their respective dams are complete and can withstand the hydrostatic pressure exerted by the reservoir.

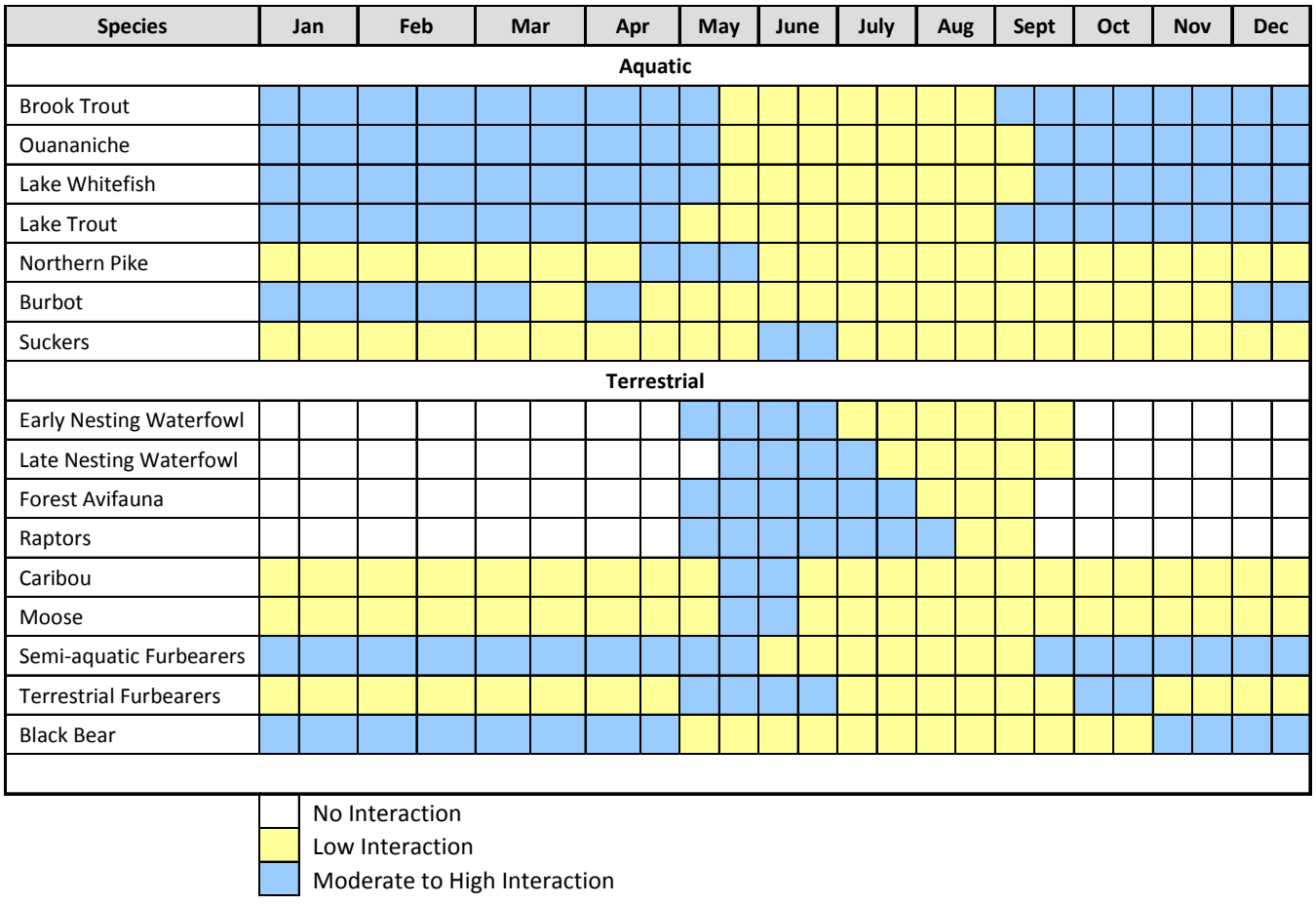
Economic Feasibility

Commissioning of the turbines requires the reservoir at the FSL. Impoundment of the reservoirs when the dams are complete is critical because commissioning of the units requires the reservoir at the FSL. A delay in impoundment and consequently commissioning and start up of the generation units would result in a delay in delivery of first commercial power and the generation of revenue. The ability to meet schedule, power purchase agreements and to avoid penalties is essential for the overall economic feasibility of the Project.

Environmental Effects

The flooding of habitat for terrestrial and aquatic species is date sensitive due to the timing of reproduction and rearing in a variety of species. The sensitive life history stages of aquatic and terrestrial fauna in relation to the timing of impoundment are provided in Table 3-4. August through October is the least sensitive period. The abundance and distribution of aquatic and terrestrial habitat differs between the reservoirs. Generally, biodiversity is lower and habitats are less productive within the Gull Island Reservoir compared to the Muskrat Falls Reservoir.

Table 3-4 Sensitive Life History Stages of Aquatic and Terrestrial Fauna for Reservoir Impoundment



Preferred Alternative

The preferred alternative for reservoir impoundment of both Gull Island (Year 6) and Muskrat Falls (Year 9) is immediately following the completion of the civil works, when the dams can withstand the hydrostatic pressure exerted by the reservoir. In the current Project schedule, impoundment is scheduled to take place between August and October for both reservoirs. In the event of changes to the Project schedule, the dams may be ready for impoundment at an alternative time. Should this situation become apparent, the environmental effects would be assessed, mitigation identified and appropriate approvals will be sought prior to commencement of impoundment.

3.7.12 Sequence and Pace of Construction

The analyses regarding the sequence and pace of construction are summarized in Table 3-2. Changes in economic conditions could potentially alter sequence and pace of construction. However, the discussion in this section reflects careful consideration of the key factors related to sequence and pace of construction, particularly the availability of workforce, cashflow, interest during construction and the sequence of revenue generation.

3.7.12.1 Sequence

Alternatives Considered

There are two alternatives for the order of construction: construct the Gull Island Generation Facility first; and construct the Muskrat Falls Generation Facility first.

Technical Feasibility

Both alternatives are technically feasible.

Economic Feasibility

The cost per unit of energy generated is the key indicator of economic feasibility. Both alternatives are economically feasible. However, Gull Island has lower cost per unit of energy and therefore is more economically attractive. Constructing Gull Island first would generate a larger revenue stream earlier that would support the economic construction of Muskrat Falls. In addition, if Muskrat Falls were constructed first, its energy output would be affected by the filling of the Gull Island Reservoir.

Environmental Effects

Given that the market is available for approximately 2,000 MW, constructing the Gull Island Generation Facility first is preferred, as it will provide more energy, income and opportunity for GHG reduction than Muskrat Falls. In addition, if Muskrat Falls were constructed first, its energy output would be affected by the filling of the Gull Island Reservoir. Environmental effects of either option are otherwise similar.

Preferred Alternative

Constructing the Gull Island Generation Facility before the Muskrat Falls Generation Facility is preferred.

3.7.12.2 Pace of Construction

Alternatives Considered

Three alternatives were identified for the construction of the Gull Island and Muskrat Falls generation facilities:

- consecutive construction;
- concurrent construction with the same finish date; and
- staged overlap.

The possibility of winter construction was also explored.

Technical Feasibility

Concurrent construction may not be technically feasible due to the availability of work force. Otherwise, there are no real technical limitations to any of the three identified alternatives if the work force is available.

Economic Feasibility

Economic feasibility depends upon cost as affected by the duration of construction and interest during construction, the cost of labour and materials and the ability to re-use infrastructure (e.g., worker accommodations). All three alternatives are economically feasible but the rate of return differs.

Environmental Effects

Biophysical considerations included the length of time of disturbance to the terrestrial, aquatic and atmospheric environment. Socio-economic considerations included the potential for and the magnitude of the boom and bust effect. The potential for and magnitude of peaks and valleys for labour and business opportunities were also considered. The staged overlap may have the best approach for the mitigation of boom and bust and management of workforce opportunity.

Preferred Alternatives

Assuming the market is readily available for the energy output of the Project, it would be beneficial to have both plants commissioned as early as possible. However, from a socio-economic and logistic viewpoint, a staged overlap is preferred to a concurrent or consecutive scheduling option. A staged overlap with construction at Gull Island beginning first would lessen the boom and bust effect on the local economy, as opposed to having a peak work force at both sites simultaneously. It will also reduce a peak and valley situation that would occur with a consecutive construction sequence. The peak and valley issue is reduced by implementing a year-round construction schedule instead of slowing the pace during the winter months. The preference for the CFRD alternative at Gull Island will further increase the potential for continued productivity during the winter. From a socio-economic standpoint, duration of employment is an important consideration for economic stability.

The preferred construction sequence is staged overlap with construction at Muskrat Falls beginning just after the peak construction period at Gull Island has passed. The latter part of construction at the Gull Island site will overlap the early part of construction at Muskrat Falls. This overlap, as opposed to starting construction concurrently or consecutively, will reduce mobilization costs and allow a better use of temporary infrastructure such as accommodations complexes, while reducing costs. This also allows for better use and optimization of the workforce and equipment, and shortens construction as compared to sequential progress to lessen the duration

of biophysical environmental effects. Staged overlap is also preferred from a financial perspective. The total value under construction in the staged approach is less than having two sites under construction simultaneously.

3.7.13 Operation

The planning of operations for the generation facilities involves balancing the power production and energy requirements to produce safe, reliable and cost-effective electricity. The analyses are summarized in Table 3-2.

3.7.13.1 Operating Regime

Alternatives for the operating regime are limited as the reservoirs have little storage capacity and operating levels are constrained. In order to maximize power and energy output, both Gull Island Reservoir and Muskrat Falls Reservoir will be operated as close to FSL as possible, while giving consideration to short term inflows and near-term production requirements. Water management (regulating the reservoir levels) is intended to maximize efficiency of the generation facilities with the effect that there will be little variations in reservoir levels. The fluctuations that occur will affect daily/weekly load swings. The reservoir level will be lowered each spring to LSL in preparation for the substantial inflows that result from melting snow. At times of extreme precipitation events, the water level may rise to the maximum flood level. The operational regime will maximize energy production through the anticipated range of river flow through the life of the Project.

Technical Feasibility

The operating regime is constrained by available water and full and low supply. The Project will operate safely within the extreme limits of river flow and the design. As such, the operating regime is technically feasible.

Economic Feasibility

The operating regime is economically feasible and designed to maximize energy production.

Environmental Effects

The environmental effects of the operating regime are assessed in the EIS.

3.7.13.2 Operating Philosophy

Alternatives Considered

A remotely operated plant from either Churchill Falls or St. John's comprises the technically and economically feasible alternatives. Maintenance staff would be located at Churchill Falls or Happy Valley-Goose Bay.

Technical Feasibility

The ECC for the system is currently located in St. John's. The location of maintenance staff at Churchill Falls or Happy Valley-Goose Bay are both technically feasible. Happy Valley-Goose Bay is closer to the generation facilities at Gull Island and Muskrat Falls. The transmission line maintenance crew is currently based in Churchill Falls.

Economic Feasibility

The remote operation staff location alternatives are economically feasible. Remote operation from the ECC in St. John's would be less costly as the facility already exists. Generation station maintenance out of Happy Valley-

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Goose Bay would be less costly due to its relative proximity to the sites. The use of the existing transmission maintenance services out of Churchill Falls would be less costly than establishing a new base and crew out of Happy Valley-Goose Bay.

Environmental Effects

The differences in environmental effects are related to employment and business opportunities afforded by different operating alternatives. The differences between alternatives are determined by where and the extent to which opportunities are provided. Adverse environmental effects are not expected.

Preferred Alternative

Operational control is preferred to be located at the ECC in St. John's due to cost and the existing facility. Location of the maintenance staff for the generation facilities in Happy Valley-Goose Bay is preferred, where response and travel times are acceptable via the TLH. With existing infrastructure in mind, transmission maintenance in Labrador is preferred to be based in Churchill Falls.

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4.0 PROJECT DESCRIPTION

4.1 Introduction

This Project Description for the Lower Churchill Hydroelectric Generation Project was prepared in accordance with the joint requirements for an EIS under the *CEAA* and the *NLEPA.* It intends to fulfill requirements as outlined in Section 4.3.3 of the EIS Guidelines (Appendix IB-E).

Since this Project's conception in the 1960s, considerable review and study of the proposed development sites have been carried out in an effort to advance and refine the Project Description. The Project Description has also benefited from, and evolved with, the advancement of technology, an improved understanding of the existing environment and enhanced industry standards for environmental protection and mitigation.

Through the continued design and optimization of the Project, as part of the iterative planning process, additional mitigation was developed. For example, in the design phase some Project components were optimized to reduce the amount of rock excavation required and thus the amount of spoil produced. Other design changes will reduce disturbance to areas of cultural importance, such as the rock knoll at Muskrat Falls.

As the Project enters the detailed design phase, the Project Description may undergo further definition to refine and optimize technical, economic and environmental features; consequently, specific descriptions of these features are approximate. Such refinements are consistent with the normal planning and design process; they will not affect the overall Project footprint or the predicted environmental effects. An overview of Project planning and associated design decisions is presented in Chapter 2 and Chapter 3.

4.2 The Project

The Project (Figure 4-1), located in central Labrador, comprises:

- the Gull Island dam, generation facility and reservoir (Figure 4-2);
- the Muskrat Falls dam, generation facility and reservoir (Figure 4-3);
- a 60 km double-circuit 230 kV transmission line connecting generation facilities at Gull Island and Muskrat Falls; and
- a 203 km single-circuit 735 kV transmission line connecting generation facilities at Gull Island and the existing Churchill Falls Power Station.

The Gull Island site is approximately 100 km southwest from the town of Happy Valley-Goose Bay, between Gull Island Rapids and Grizzle Rapids, just upstream from Gull Lake on the Churchill River. The Muskrat Falls generation site, also located on the Churchill River, is about 30 km southwest from Happy Valley-Goose Bay. The Muskrat Falls facility will be adjacent to a rock knoll connected to the north bank of the river by a natural spur of land.

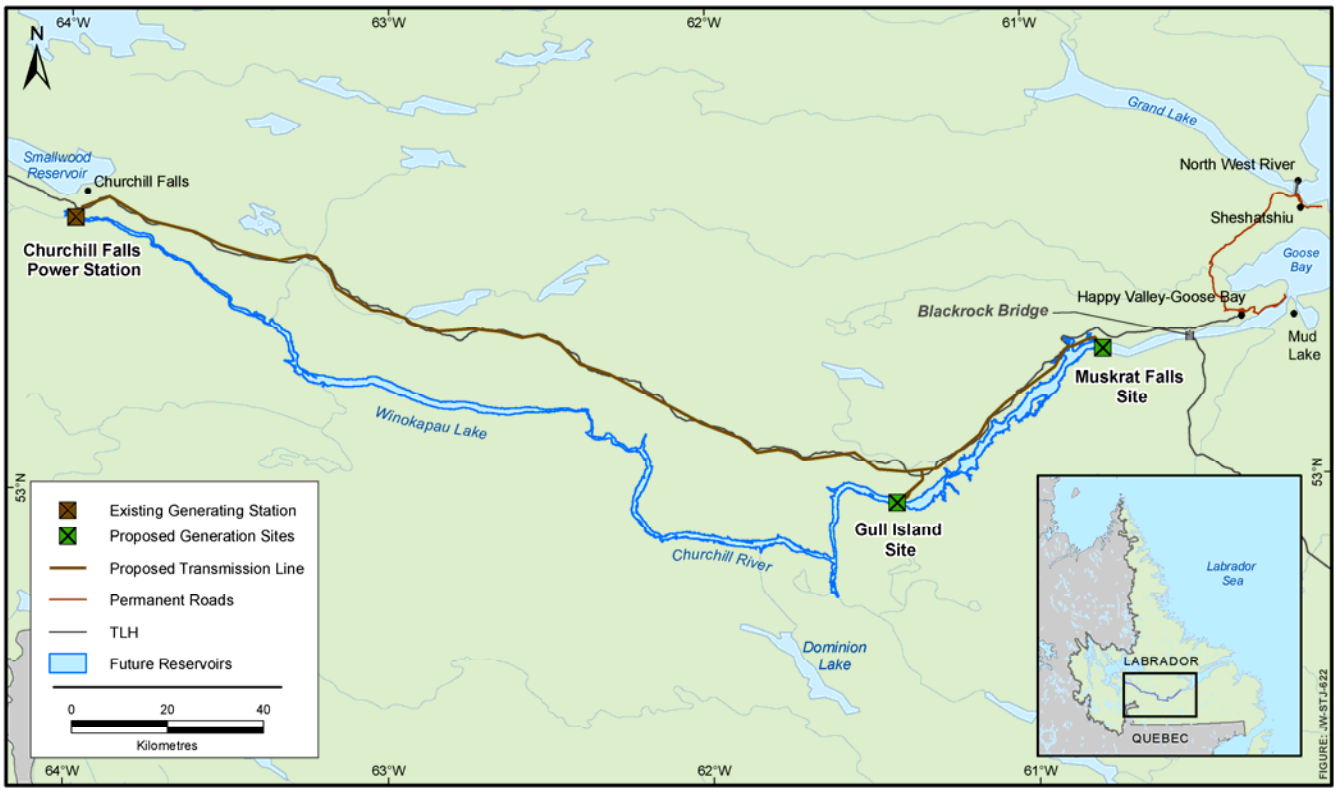


Figure 4-1 The Project

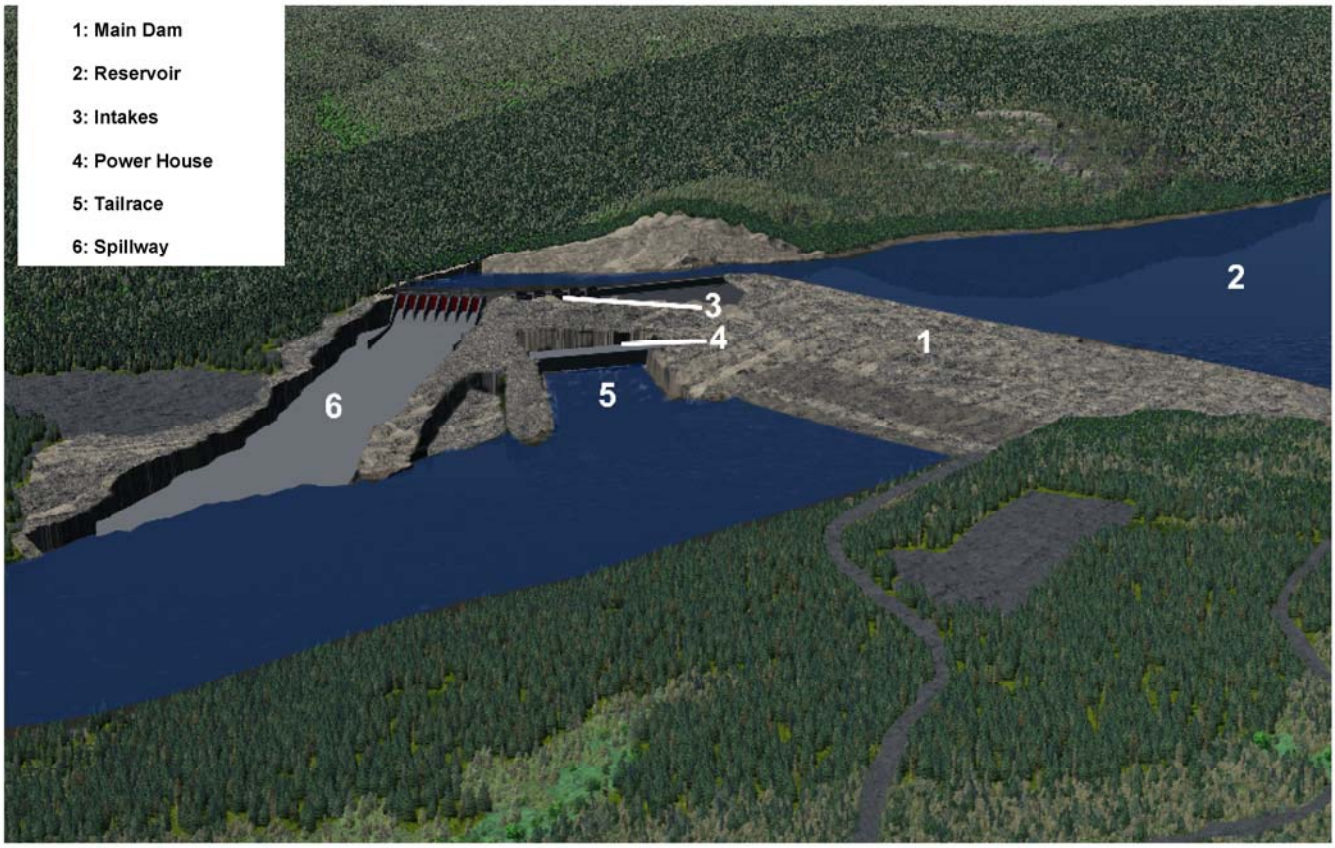


Figure 4-2 Conceptual Layout of Gull Island Generation Facility

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Figure 4-3 Conceptual Layout of Muskrat Falls Generation Facility

Nalcor Energy is seeking approval to construct a 203 km long, 735 kV transmission line from the Gull Island site to the Churchill Falls Power Station and a 60 km long, 230 kV transmission line from Muskrat Falls to Gull Island, to be located within a one km wide corridor. The actual cleared right-of-way will be approximately 80 m, in addition to the existing right-of-way and for most of its length, the right-of-way will be adjacent to the existing transmission line right-of-way.

4.2.1 Gull Island Generation Facility

Figures 4-2 and 4-4 show details of the Gull Island Generation Facility. The concept for this site is for a single dam to span the river. Both the construction bypass as well as the operations spillway will be located on the south bank. The powerhouse will be within the dam structure on the downstream side. An approach channel will direct water from the reservoir into the power intakes, which directly connect to turbines. The water will pass through the turbines and exit through the draft tubes into the tailrace. The passage of flows in excess of power generation requirements will be through the spillway.

4.2.1.1 Main Dam

At 99 m high and 1,315 m long, the main dam will be the largest structure associated with the Gull Island Generation Facility. This concrete-faced structure will be constructed to Canadian Dam Association (CDA) standards and consist mainly of rockfill obtained from local excavations. The triangular cross-section will be 9 m wide at the crest with a maximum thickness of 300 m at the bottom. The dam axis will be perpendicular to the river flow.

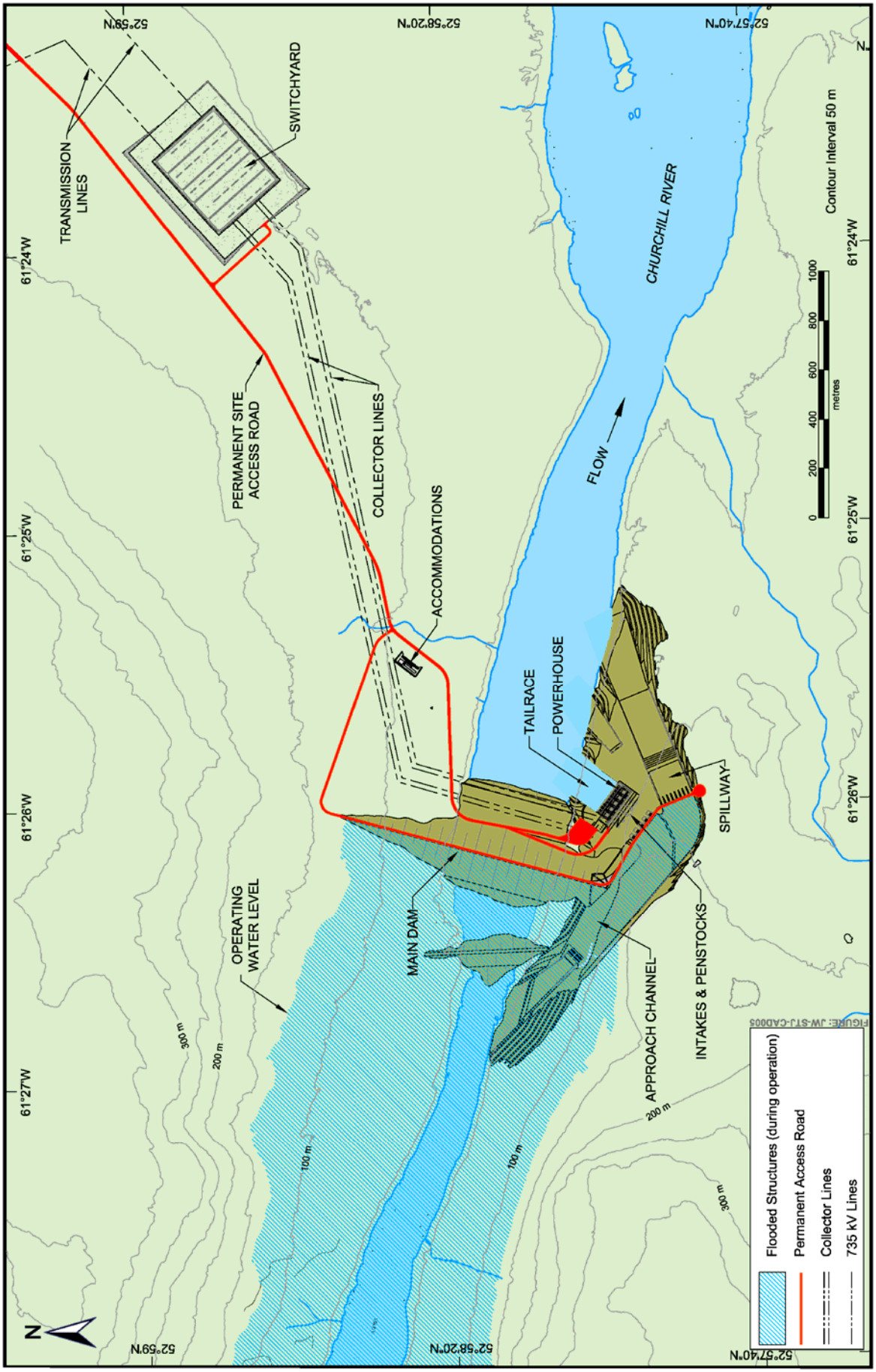


Figure 4-4 Gull Island Layout

The dam will consist of two main components: the main rockfill and an impervious upstream layer. The main rockfill provides stability to resist hydrostatic pressure forces exerted from the reservoir, while the reinforced concrete layer covering the upstream side provides an impervious layer to prevent water seepage.

A concrete cut-off wall, as well as a grout curtain, will be installed in the riverbed under the upstream side of the dam to control seepage. A cross-section of the Gull Island concrete faced rockfill dam (CFRD) is shown in Figure 4-5.

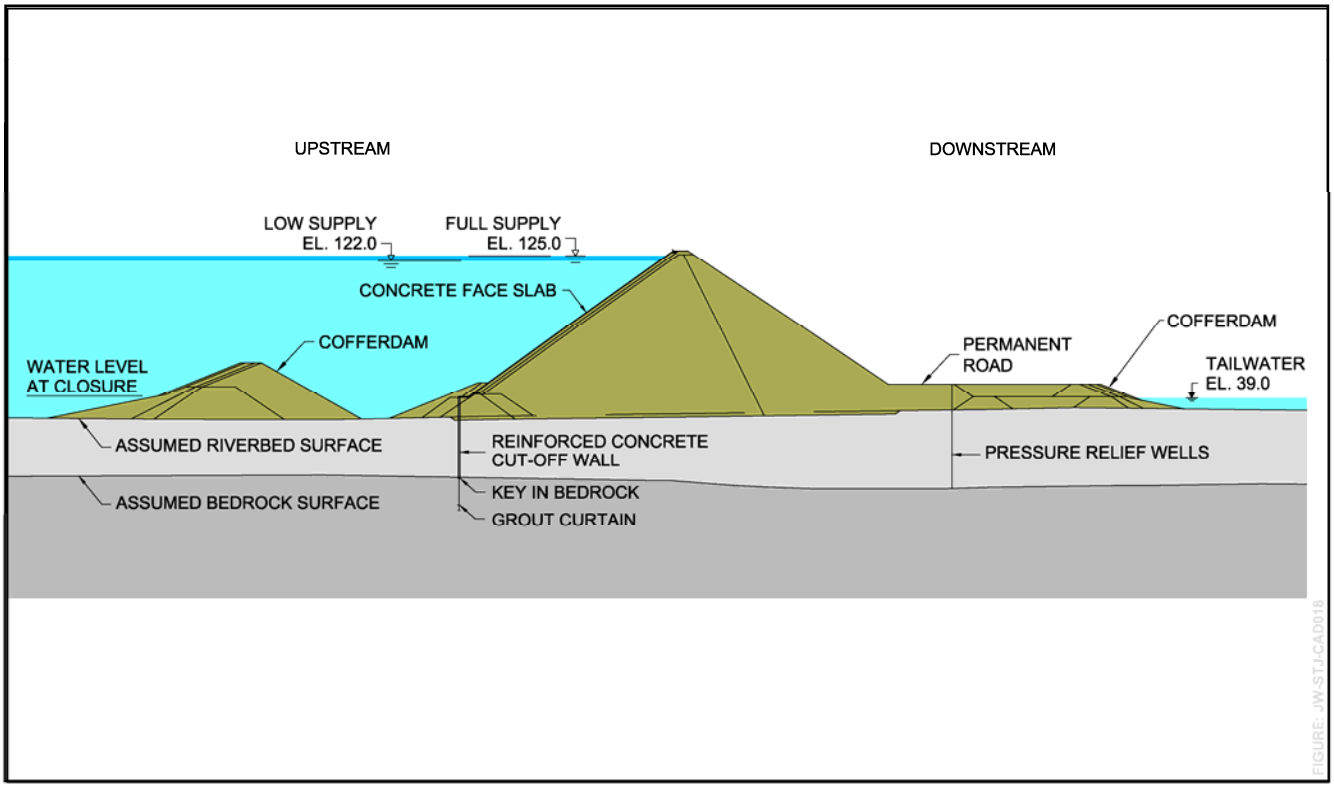


Figure 4-5 Cross-section of Gull Island Concrete Faced Rockfill Dam

4.2.1.2 Powerhouse

The 210 m long by 40 m wide powerhouse (Figure 4-6) will be anchored in bedrock on the south side of the river immediately downstream from the dam. The powerhouse will be above ground, enclosed in a metal-clad, concrete building with steel superstructure, its longitudinal axis approximately 30° to the river axis. Five turbines, each with a capacity of 450 MW, will provide a total installed capacity of 2,250 MW. The maximum discharge per turbine will be 590 m^3/s. In turn, total discharge from the powerhouse will be 2,950 m^3/s. The net head on the plant will be 86 m.

The diameter of the Francis turbine runners will be 7.2 m. The air-cooled generators will be directly coupled to the turbine shafts, with each generator connected to a power transformer via an individual isolated phase bus and generator breaker.

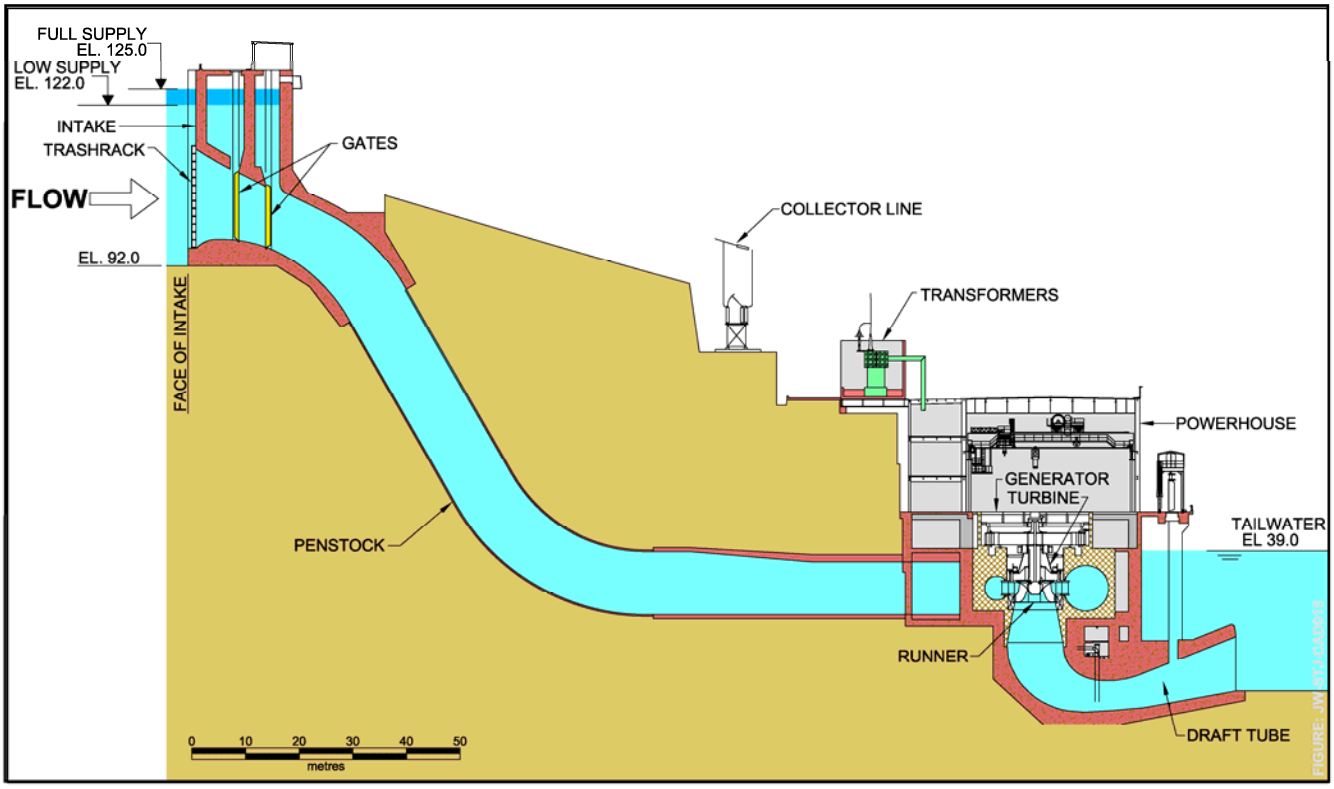


Figure 4-6 Cross-section of Gull Island Powerhouse

Auxiliary services for the powerhouse include:

- a raw water system (fed from the reservoir upstream of the turbines);
- a turbine cooling water system (discharged to the tailrace downstream of the powerhouse at approximately 100 L/s);
- a fire protection system;
- a service water system (capacity of 75 L/s);
- a potable water treatment system;
- a sewage treatment system (conventional septic tank followed by a metering tank and two circulating filter beds);
- a dewatering system for turbine water passages;
- a clearwater drainage system for powerhouse seepage, leakage from turbine seals and fire protection;
- a drainage system for dewatering intake and draft-tube gates (floor trenches drain to a sump and discharge to the tailrace); and
- an oily water drainage system (an oil interceptor will be incorporated at the entrance of the dewatering/ drainage sump to intercept any oil before it enters the sump) with an oil detection alarm.

In addition, the powerhouse design incorporates the following features to address environmental considerations for long term operations:

- energy-efficient lighting;
- a ventilation system for the distribution and/or direct exhaust of heat dissipated from the generators;
- oil separation systems for all areas where hydrocarbons are present;

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- solid waste materials and garbage collection and delivery to a licensed disposal site;
- disposal of chemicals in accordance with the waste management section of the EPP;
- use of dyked or doubled-walled tanks to store controlled products (all controlled products will be in areas where the drainage is directed to an interceptor tank); and
- monitoring devices for emissions and discharges.

Diesel generators will be installed in the powerhouse for emergency use. Associated diesel fuel storage tanks will be certified, double walled and equipped with remote monitoring systems. All oil and waste oil will be stored in double-walled tanks inside the powerhouse. Batteries will be stored in a secure (no drain) dyked area in the powerhouse.

4.2.1.3 Reservoir and Zones of Clearing

Construction of the main dam will form a 232 km long reservoir from the Gull Island Generation Facility to the tailrace for the Churchill Falls Power Station. The elevation of the reservoir will be approximately 125 m asl at FSL and 122 m at LSL. At FSL, the area of inundation will be 85 km², resulting in a total surface area of 213 km². A series of maps illustrating the area of inundation is provided in Appendix IB-C.

Preparing the area for inundation involves removal of vegetation (timber and brush) along the reservoir perimeter to 3 m below LSL (ice impact zone). This area will extend vertically from elevations of 119 m (3 m below LSL) to 128 m (3 m above FSL), for a total of 44 km^2 (i.e., about 50 percent of the vegetation within the reservoir area will be affected) (Figure 4-7). The environmental assessment has been based upon a maximum cleared width of 15 m from the shoreline at FSL. The actual cleared width will be dictated by the reservoir preparation plan that will consider safety, terrain, biophysical and access requirements. The clearing strategy will result in a reservoir with a natural shoreline and riparian zone. As a result, the reservoir will be free of impediments to movement by boats or animals (e.g., swimming caribou). Reservoir preparation, combined with the operating regime of the reservoirs, will result in the development of a stable littoral zone, shoreline and vegetated riparian zone.

4.2.1.4 Approach Channel

A 137 m wide by 600 m long approach channel (Figure 4-4) will be excavated in rock on the south bank of the river, upstream from the intake and spillway. The invert elevation of the channel will be approximately 92 m at the intake, rising to approximately 99.5 m, 200 m upstream from the spillway. The channel will provide approach conditions to the power intakes and the spillway. At LSL, the maximum velocity will be 0.7 m/s for the powerhouse flow. In the event of the probable maximum flood (PMF), the average velocity in the approach channel will be 4.1 m/s near the entrance to the spillway.

4.2.1.5 Intake and Penstocks

The approach channel will direct the flow of water to the front of the intake structure where the sill elevation is 97 m. The intakes feed water into the penstocks. There will be one intake per penstock structure, each with a set of vertical lift operating gates with individual wire rope hoists in heated enclosures. There will also be one set of steel bulkhead gates with a permanent hoist system. Removable trash racks in each inlet, at the face of the power intakes, will prevent trash from entering the penstocks and damaging the turbines. There will be one permanent trash removal system.

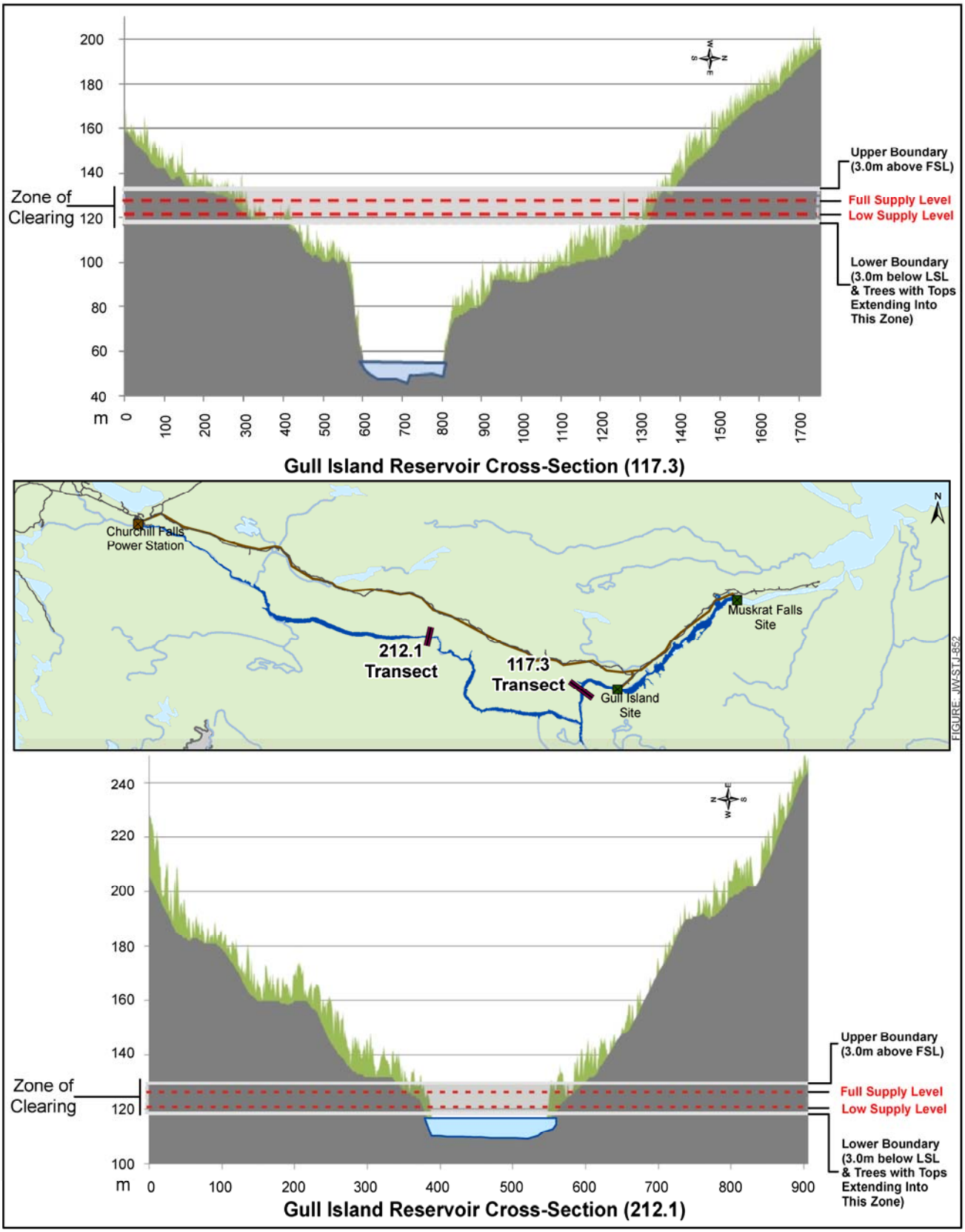


Figure 4-7 Extent of Reservoir Clearing at Gull Island

There will be one penstock per generation turbine, each consisting of a rock tunnel excavated between the intake and powerhouse and including:

- a concrete-lined section, 12 m in diameter and 80 m long; and
- a steel-lined section, 12 m to 10 m in diameter and 47 m long.

The vertical centreline of the turbine is approximately 160 m downstream from the face of the intake of the dam, as shown in Figure 4-6.

4.2.1.6 Tailrace

The tailrace channel (Figure 4-4) will direct water to the river after it passes through the turbines in the powerhouse. The 140 m wide by 200 m long tailrace channel will slope from the powerhouse draft tube to the river bottom. The tailrace water will flow at approximately 3 m/s.

4.2.1.7 Spillway

The spillway (Figure 4-8) will be used infrequently because the design flow capacity of the turbines is greater than the average flow of water into the reservoir. During spring runoff, turbine shut down for maintenance, or emergencies, the spillway will release water from the reservoir. The spillway will accommodate a probable maximum flood (PMF) of 20,800 m^3/s.

Located on the south bank, the spillway will have eight gated openings on a parabolic crest sloping down to a lined chute, a flip bucket, a large plunge pool and a short channel to the river. A cross-section of the spillway is shown in Figure 4-8.

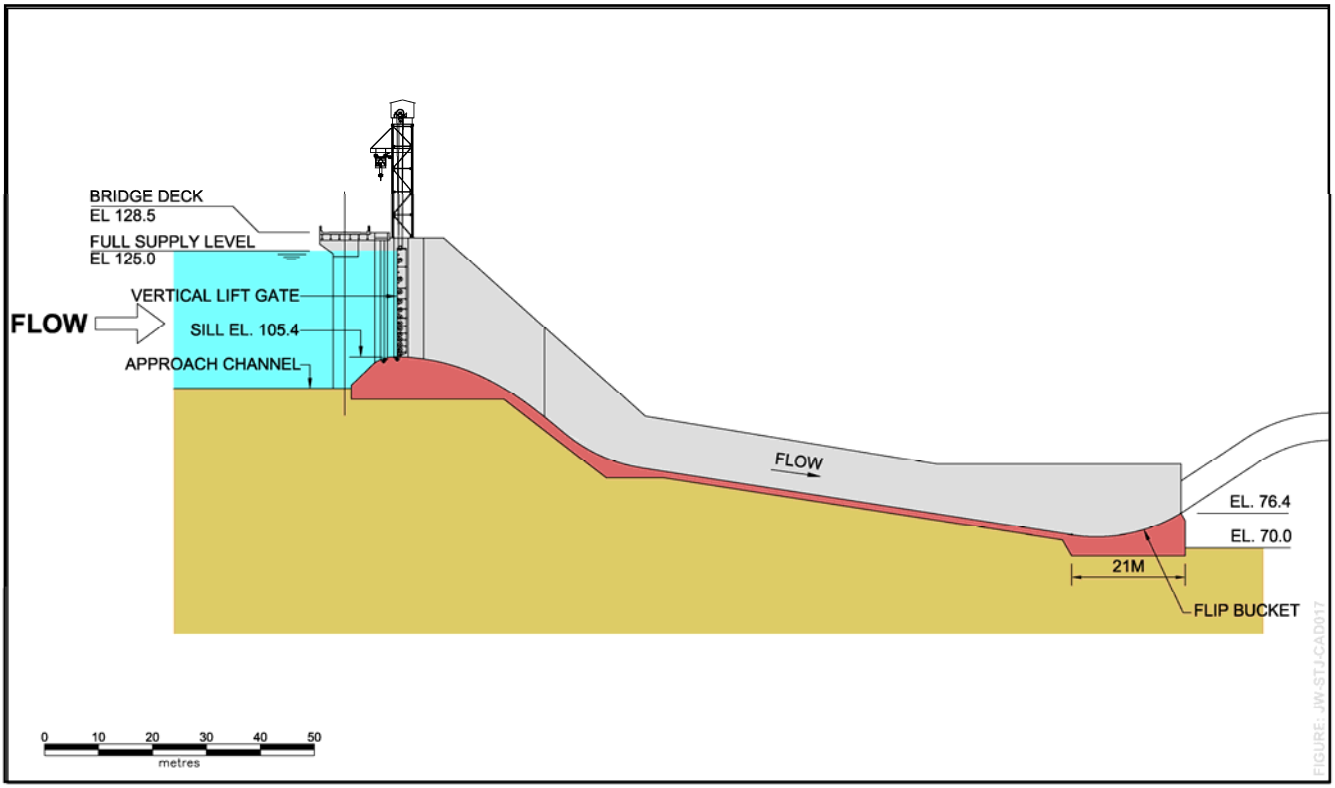


Figure 4-8 Cross-section of the Gull Island Spillway

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The spillway will be equipped with eight, fixed-wheel vertical lift gates, each 13 m wide and 20 m high. The crest will discharge spillway flows at an elevation of 105.4 m into a 130 m wide, concrete-lined chute and flip bucket. The flip bucket allows the water to plunge into the unlined stilling basin (plunge pool) for the dissipation of its energy before passing into the discharge channel and the river. The elevation at the bottom of the 255 m long and 130 m wide plunge pool will be 14 m. The discharge channel will deliver water back to the river at less than 7 m/s.

4.2.1.8 Main Power Transformers and Switchyard

The main power transformers will be upstream from the powerhouse, at the same elevation as the powerhouse roof (66.5 m). The transformers will be dyked with drainage to an interceptor tank. The power transformers will raise the generation voltage to 230 kV, with collector lines transmitting power to a 230 kV/735 kV switchyard. Five separate collector lines run from the powerhouse to the switchyard, with one circuit from each turbine. Exiting the powerhouse on the south bank of the river, the lines will pass 3.5 km across the river to the switchyard on the north bank. This passage across the river requires constructing two 230 kV double-circuit and one single-circuit 230 kV overhead transmission lines. The locations of the collector lines and switchyard are shown in Figure 4-4.

The 230 kV section of the switchyard will receive the collector lines from the Gull Island powerhouse, as well as the double circuit 230 kV line from the Muskrat Falls Generation Facility. The 735 kV section of switchyard will connect the outgoing 735 kV line(s) to Churchill Falls.

The 580 m by 550 m gravelled switchyard site is on the north side of the river, 2.5 km east of the main dam, and will be contained within a galvanized steel security fence. A control building, to house all control, monitoring and telecommunications interfaces, will be located in the switchyard.

4.2.1.9 Permanent Access

Main access to the Gull Island site will be along an existing road (Figure 4-4), off the TLH, approximately 88 km from Happy Valley-Goose Bay. A permanent access road linking the Gull Island site to the TLH will extend approximately 10 km from the TLH intersection to the north shore of the Churchill River. Of the 10 km, 7 km are existing and will require upgrading, while 3 km will be new road construction. The access road will be gravel, with a 9.5 m wide top and 2:1 side slopes.

One stream crossing on the existing road will require the installation of a new 1,200 mm culvert. Four other existing culverts on this section at stream crossings will remain as is, except for the addition of slope protection on the inlet and outlet slopes.

4.2.1.10 Permanent Accommodations

A 40 person, self-contained accommodations building will be provided for maintenance staff during major shutdowns and overhauls (Figure 4-4). The building will include potable and firewater facilities, sewage and waste treatment, and heating, ventilation and air conditioning. The facilities will also be equipped with a kitchen, sleeping quarters, recreation and laundry rooms.

4.2.1.11 Security

All areas around the structures will be fenced with locked gates. All entrances to structures and buildings will be equipped with card access. Sensitive areas will be equipped with remote cameras. The generation facility will also include warning signs as required.

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4.2.2 Muskrat Falls Generation Facility

Similar to the Gull Island Generation Facility, the construction of a dam at the Muskrat Falls site (Figures 4-3 and 4-9) will result in the formation of a reservoir. The excavation of the powerhouse will be on the south shore of the river, such that the elevation of the turbines will be below the elevation of the existing riverbed at the lower falls. The facility will not have penstocks; an approach channel will direct the water from the reservoir into the power intakes, which directly connect to turbines. The water will pass through the turbines and discharge through the draft tubes into the tailrace. The passage of flows in excess of power generation requirements will be through the spillway.

4.2.2.1 North and South Dams

The construction of two dams, one on the north and one on the south river bank, will result in the closure of the river. The north dam section will be 32 m high and 432 m long, while the south dam section will be 29 m high and 325 m long. The maximum width of the dams will be 30 m. The dams (Figure 4-10) will be constructed of roller compacted concrete (RCC), a specially proportioned, relatively dry mix zero-slump concrete, which has the strength and durability of conventional concrete.

The upstream face of the RCC dams will consist of a vertical wall, while the downstream-sloped face will be similar to a concrete staircase. To provide access across the top of the dams, a road will be built. Seepage through cracks or voids in the bedrock will be sealed by installing a grout curtain directly underneath the dams.

4.2.2.2 Powerhouse

The Muskrat Falls powerhouse will be a surface-type, concrete structure with a steel superstructure, 188 m long by 69 m wide. Four turbines each with a capacity of 206 MW will provide a total installed capacity of 824 MW. In turn, total discharge from the powerhouse will be 2,660 m^3/s. The net head will be 35 m.

The diameter of the turbine runners will be 9 m. The air-cooled generators will directly couple to the turbine shafts, with each generator connecting to a power transformer via an individual isolated phase bus and generator breaker. Generator components, such as bearings and bushings, will be self-lubricating or use biodegradable lubricants.

Mechanical equipment and environmental design aspects for the powerhouse are similar to the systems described for the Gull Island powerhouse in Section 4.2.1.2.

The location of the powerhouse is shown in Figure 4-9 and a general cross-sectional view is provided in Figure 4-11.

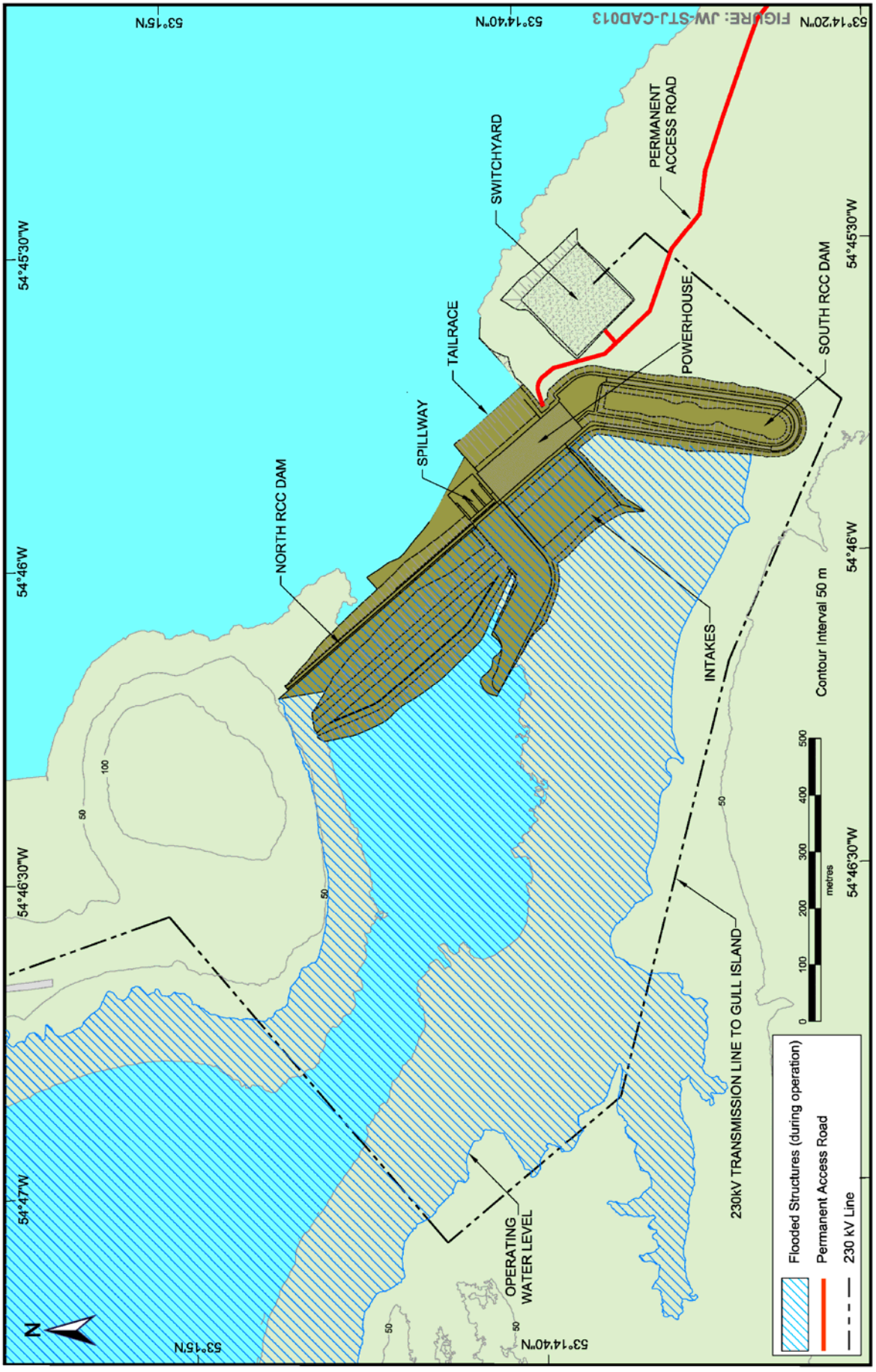


Figure 4-9 Muskrat Falls Layout

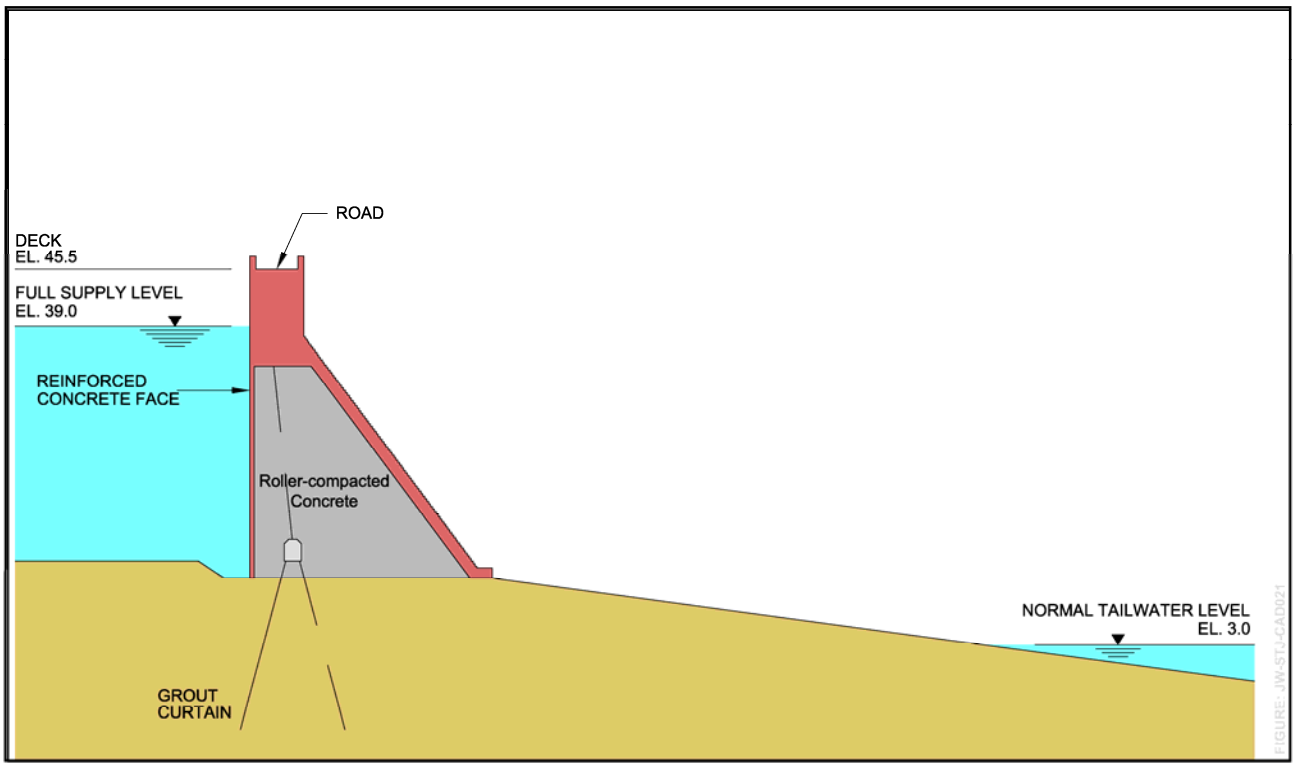


Figure 4-10 Cross-section of Muskrat Falls Roller-compacted Concrete Dam

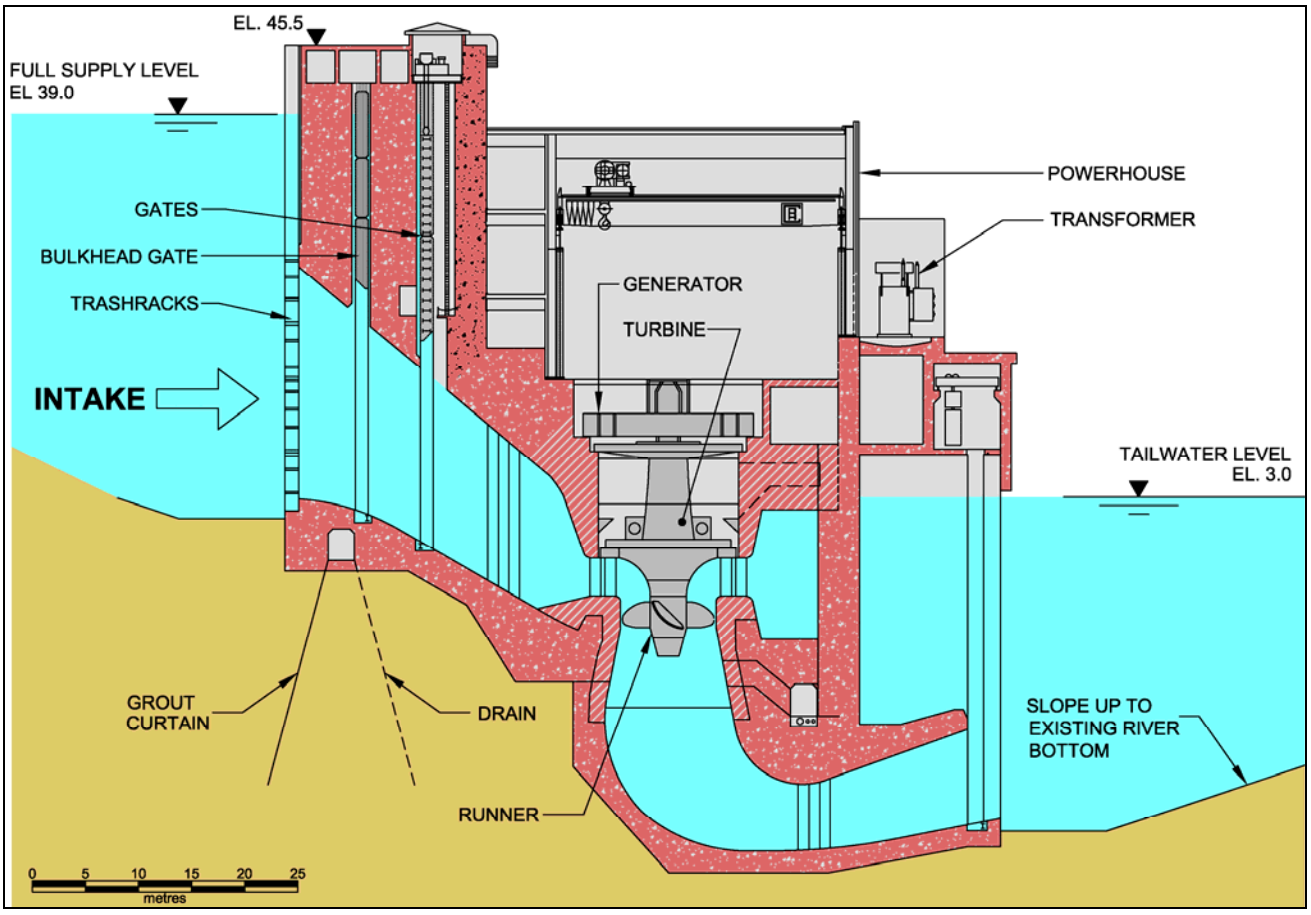


Figure 4-11 Cross-section of the Muskrat Falls Intakes and Powerhouse

4.2.2.3 Reservoir and Zones of Clearing

Construction of the north and south dams will result in the formation of a 59 km long reservoir. At FSL, the area of inundation will be 41 km², resulting in a reservoir with a total surface area of 101 km². The elevation of the reservoir will be 39 m at FSL and 38.5 m at LSL.

Preparing the reservoir area for inundation (Figure 4-12) involves removal of vegetation within a zone of elevation from 35.5 m (3.0 m below LSL) to 42 m (3.0 m above FSL). The environmental assessment has been based upon a maximum cleared width of 15 m from the shoreline at FSL. The actual cleared width will be dictated by the reservoir preparation plan that will consider safety, terrain, biophysical and access requirements. This will result in almost full clearing of the reservoir, except along existing riparian zones where only larger (taller) trees will be removed and existing shrubs left in place to provide refuge habitat until inundation.

4.2.2.4 Approach Channel

A 150 m wide by 138 m long approach channel to the power intakes will be excavated in rock on the south bank of the river. Its invert elevation will be 10 m. At normal operating levels, the maximum flow will be 0.6 m/s in the approach channel to the intakes.

4.2.2.5 Intake

The approach channel will direct the flow of water to the intake structure (Figure 4-11). The channel will have an invert elevation of 10 m sloping downwards to an elevation of 1 m at the intake entrance. The intake and powerhouse arrangement will provide a close coupling of the intake water passages to the powerhouse spiral cases. The intake structure will comprise four intakes. There will be one intake per unit, each with a set of vertical lift operating gates with individual wire rope hoists in heated enclosures. There will also be one set of steel bulkhead gates with a permanent hoist system. Removable trash racks in each inlet, at the face of the power intakes, will prevent trash from entering the intake water passages and damaging the turbines. There will be one permanent trash removal system.

4.2.2.6 Tailrace

The 138 m wide by 100 m long tailrace channel will slope upward from the powerhouse to an elevation of −10 m at the river. The water elevation at the tailrace will be approximately 3 m. The tailrace water will flow at approximately 1.5 m/s.

4.2.2.7 Spillway Channel

A spillway approach channel with an invert elevation of 5 m will be excavated in rock alongside the approach channel to the intakes. During PMF, the average velocity in the spillway channel will be 4 m/s at the entrance to the spillway.

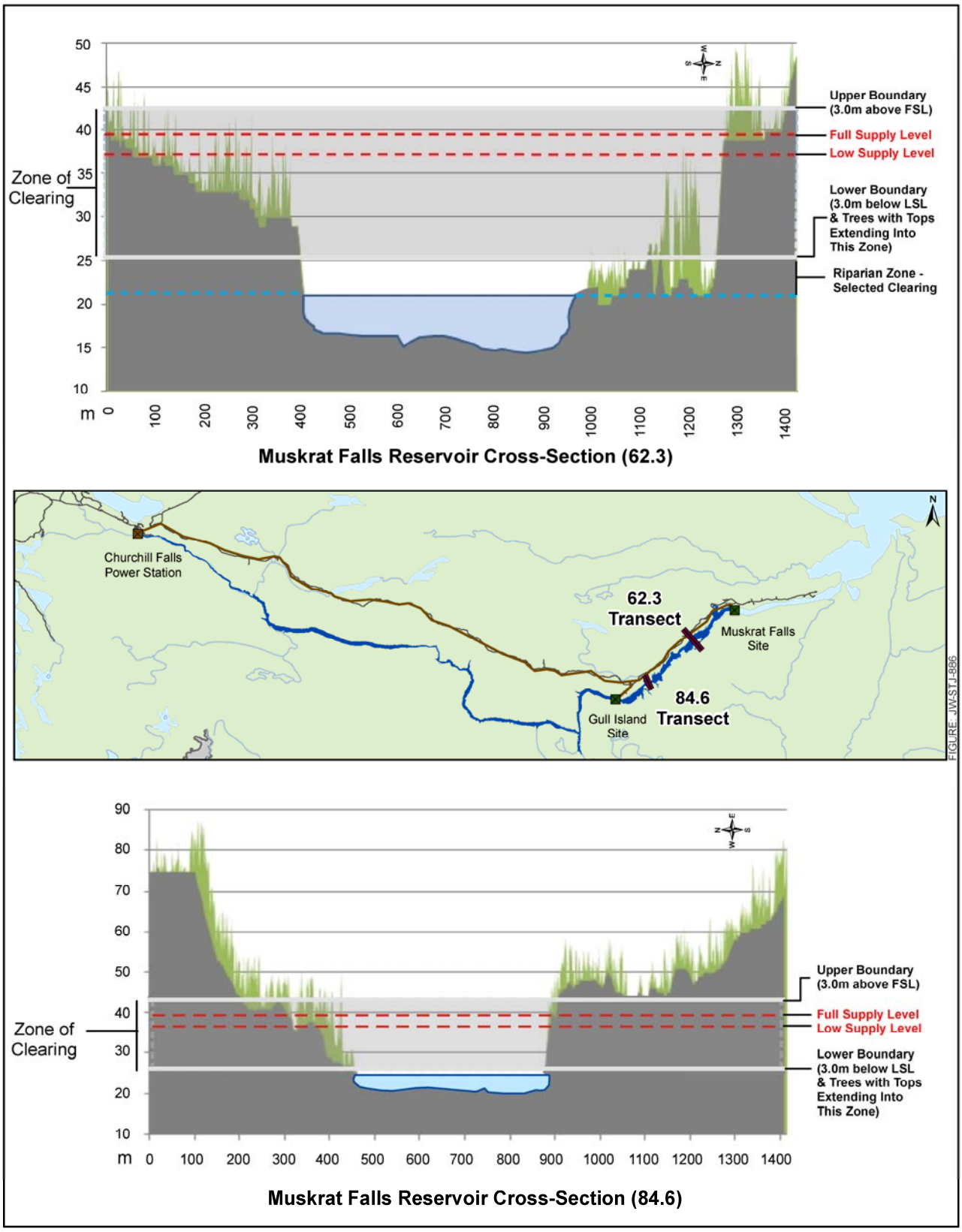


Figure 4-12 Extent of Reservoir Clearing at Muskrat Falls

4.2.2.8 Spillway

Similar to the Gull Island facility, the spillway (Figure 4-13) will be used infrequently. The spillway design has four submerged radial gates and can accommodate a full PMF flow of 22,420 m^3/s. It will be made of concrete and set into rock on the north side of the powerhouse.

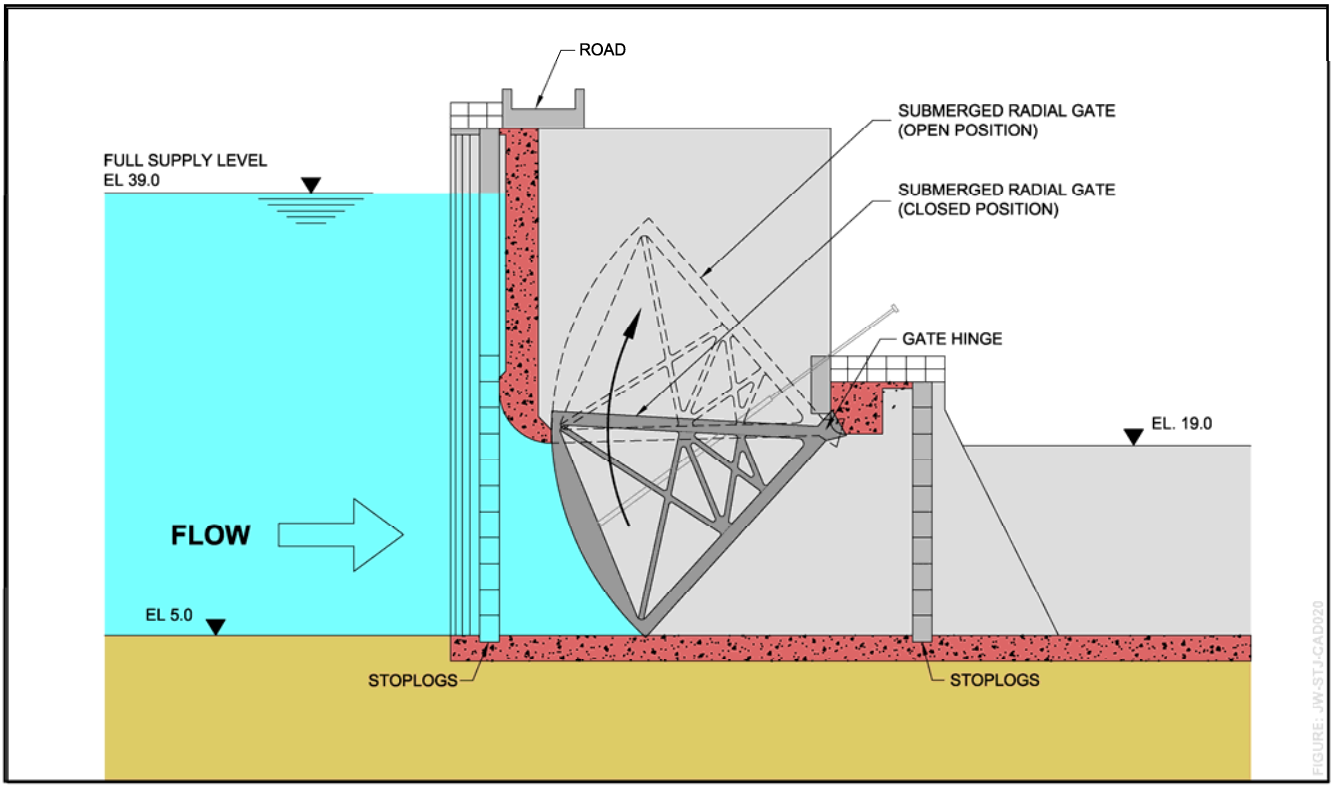


Figure 4-13 Cross-section of Muskrat Falls Spillway

The radial gates will be 12.5 m wide by 14.8 m high with sills at 5.0 m elevation, which is above the tailwater level of 3.0 m. The water will discharge directly into the river, as a high velocity jet, where a natural pool (formed by erosion from the existing falls) will dissipate the energy of the water.

4.2.2.9 Main Power Transformers and Switchyard

The main power transformers will be located on the draft tube deck of the powerhouse. The power transformers will raise the generation voltage to 230 kV. Collector lines connecting them to a 230 kV switchyard will consist of 230 kV underground cables in a 100 m long cable trench. The 230 kV switchyard will connect to an outgoing double-circuit 230 kV transmission line to Gull Island.

The switchyard will be located on the south side of the river, about 100 m east of the powerhouse (Figure 4-9). The 200 m by 200 m gravel surface switchyard area will be gated and fenced for security.

The switchyard will contain a control building to house all control, monitoring and telecommunications interfaces.

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4.2.2.10 Permanent Access

Permanent access to the Muskrat Falls site will be along the south bank of Churchill River via the planned forest access road identified as part of the Forest Management Plan for District (FMD) 19A. The forest access road will intersect with TLH south of the Black Rock Bridge and pass within about 5 km of the Muskrat Falls site. A Project access road will be constructed from that road to the site.

4.2.2.11 Permanent Accommodations

Permanent accommodations are not planned for the Muskrat Falls Generation Facility because of its proximity to Happy Valley-Goose Bay.

4.2.2.12 Security

All areas around structures will be fenced with locked gates. Sensitive areas will be equipped with remote cameras. The generation facility will also include warning signs as required.

4.2.3 Transmission Lines

The 735 kV transmission line between Gull Island and Churchill Falls will be 203 km long. The 230 kV transmission line between Muskrat Falls and Gull Island will be 60 km long.

4.2.3.1 Line Routing

The optimal line corridor was determined using the constraint mapping approach. This will enable engineering designers to reduce environmental interactions by avoiding sensitive resources and paralleling an existing right-of-way, where practical.

Both lines will follow a relatively direct corridor from the switchyards and generally parallel the existing 138 kV transmission line between Happy Valley-Goose Bay and Churchill Falls (Appendix IB-B).

4.2.3.2 Configuration

The transmission line structures from Gull Island to Churchill Falls will be lattice steel-type towers approximately 50 m high (Figure 4-14), with an average span of 500 m between towers. The conductors will have a minimum ground clearance of 18 m over roads and 14 m over other areas, in accordance with design standards for this voltage class transmission line.



Figure 4-14 Typical 735 kV Single Circuit Structure

The structures from Muskrat Falls to Gull Island will also be lattice steel-type towers, although there are two lines on one tower (i.e., a double-circuit line) (Figure 4-15). The towers will be approximately 40 m high with an average span of 380 m between towers. The conductors will have a minimum ground clearance of 7.3 m over roads and 6.7 m over other areas, in accordance with design standards for this voltage class transmission line.



Figure 4-15 Typical 230 kV Double Circuit Structure

4.3 Schedule

Provided all the prerequisite sanctions and environmental approvals are in place, construction will begin in 2010 (Year 1) at the earliest and last 10 years, with first power from the Gull Island Generation Facility scheduled for Year 6 (Figure 4-16). The Gull Island facility will be fully complete by the end of Year 8. Transmission lines will be constructed from Year 2 to Year 9. Construction of Muskrat Falls will begin in Year 5 and see completion at the end of Year 10, at which time the Project will be fully operational.

The first step of the construction programs will be to implement an EPP in accordance with the EMS. A discussion of the EMS is provided in Section 3.4. The overall construction will incorporate the principles and polices included in the EPP.

The annual sequence of construction is shown in Figures 4-17 to 4-26. The Project footprint is displayed for each year of construction and includes all major activity areas: the two generation sites, reservoir preparation and transmission line.

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Figure 4-16 Project Summary Schedule

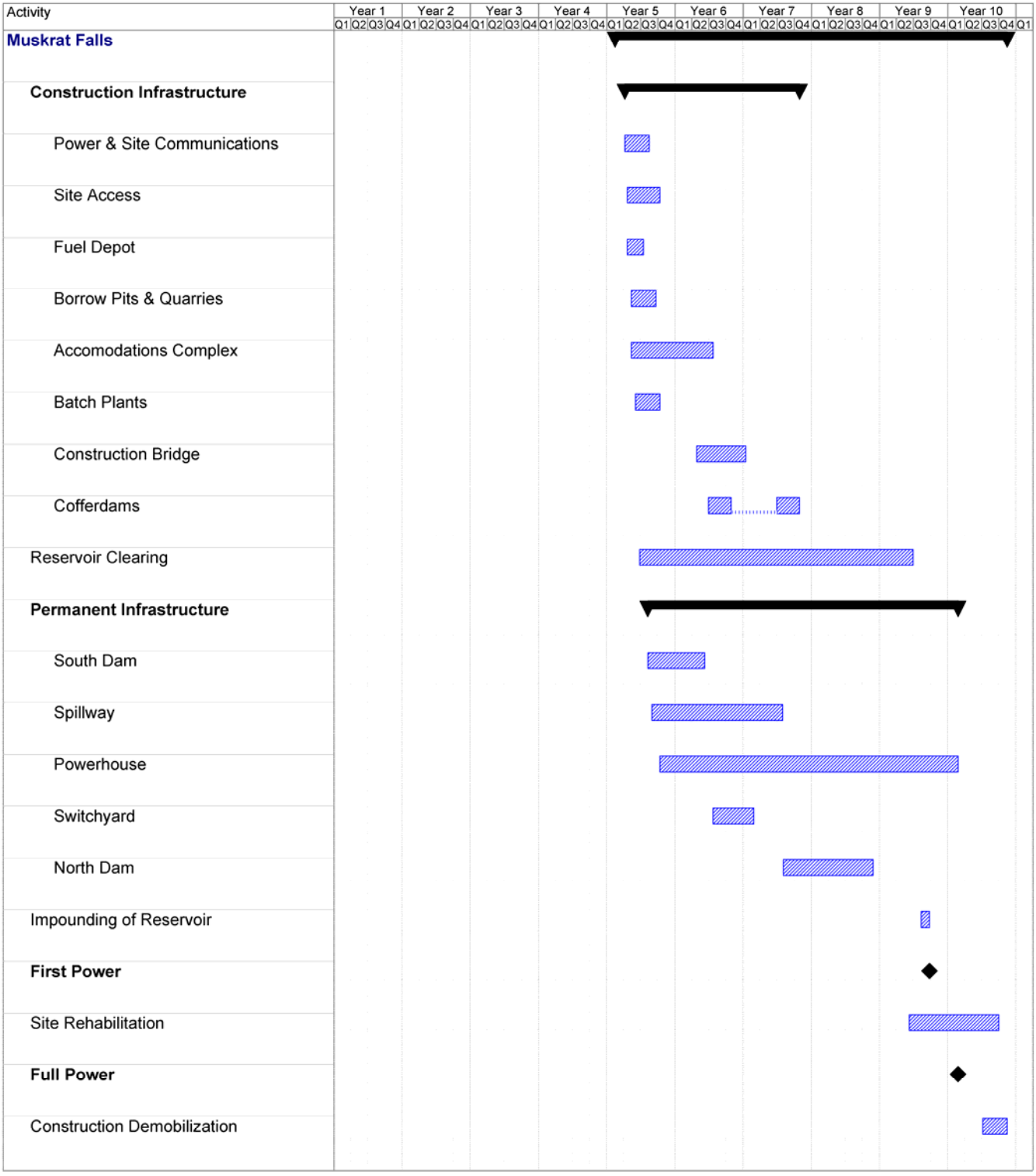


Figure 4-16 Project Summary Schedule (cont.)

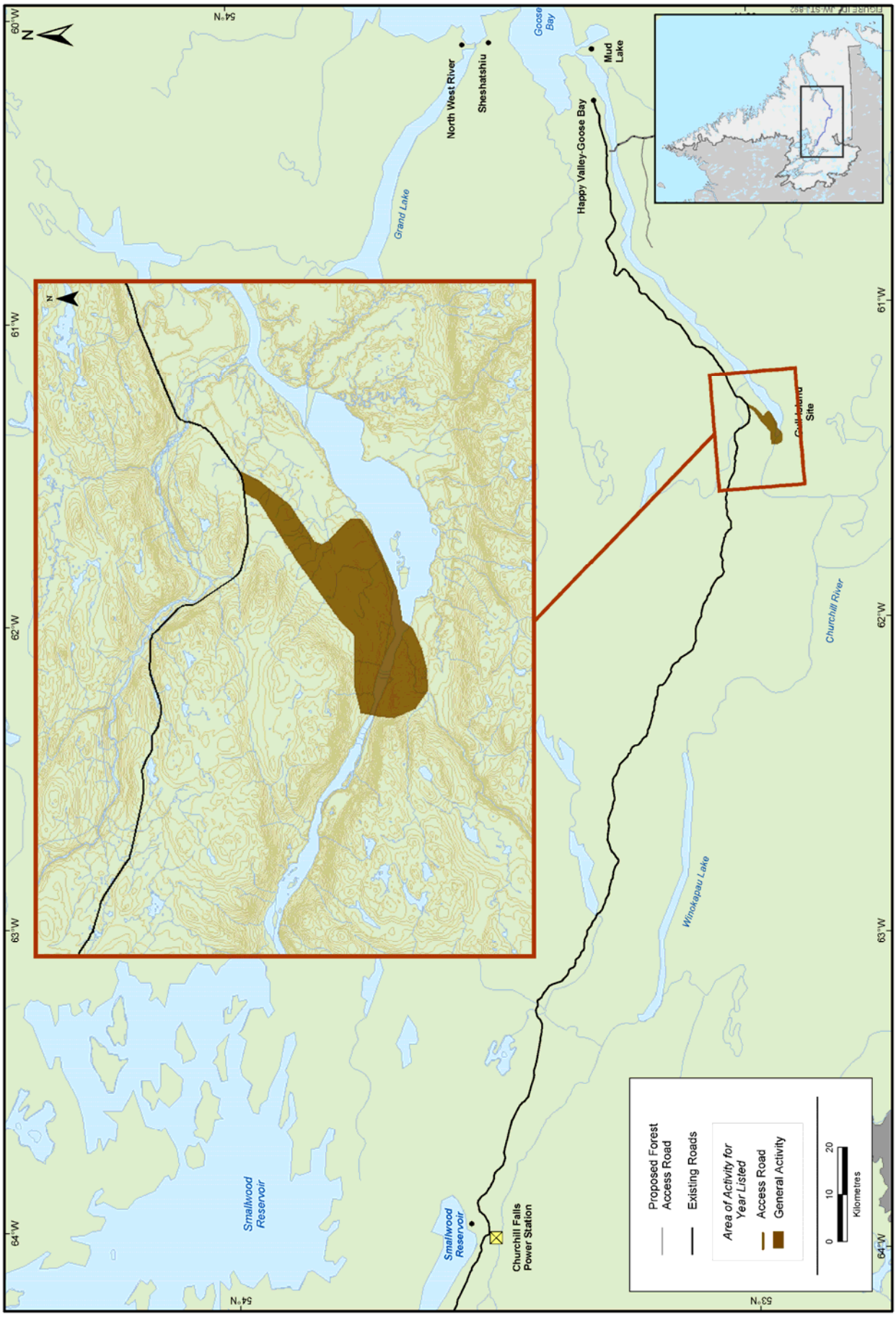


Figure 4-17 Construction Sequence Year 1

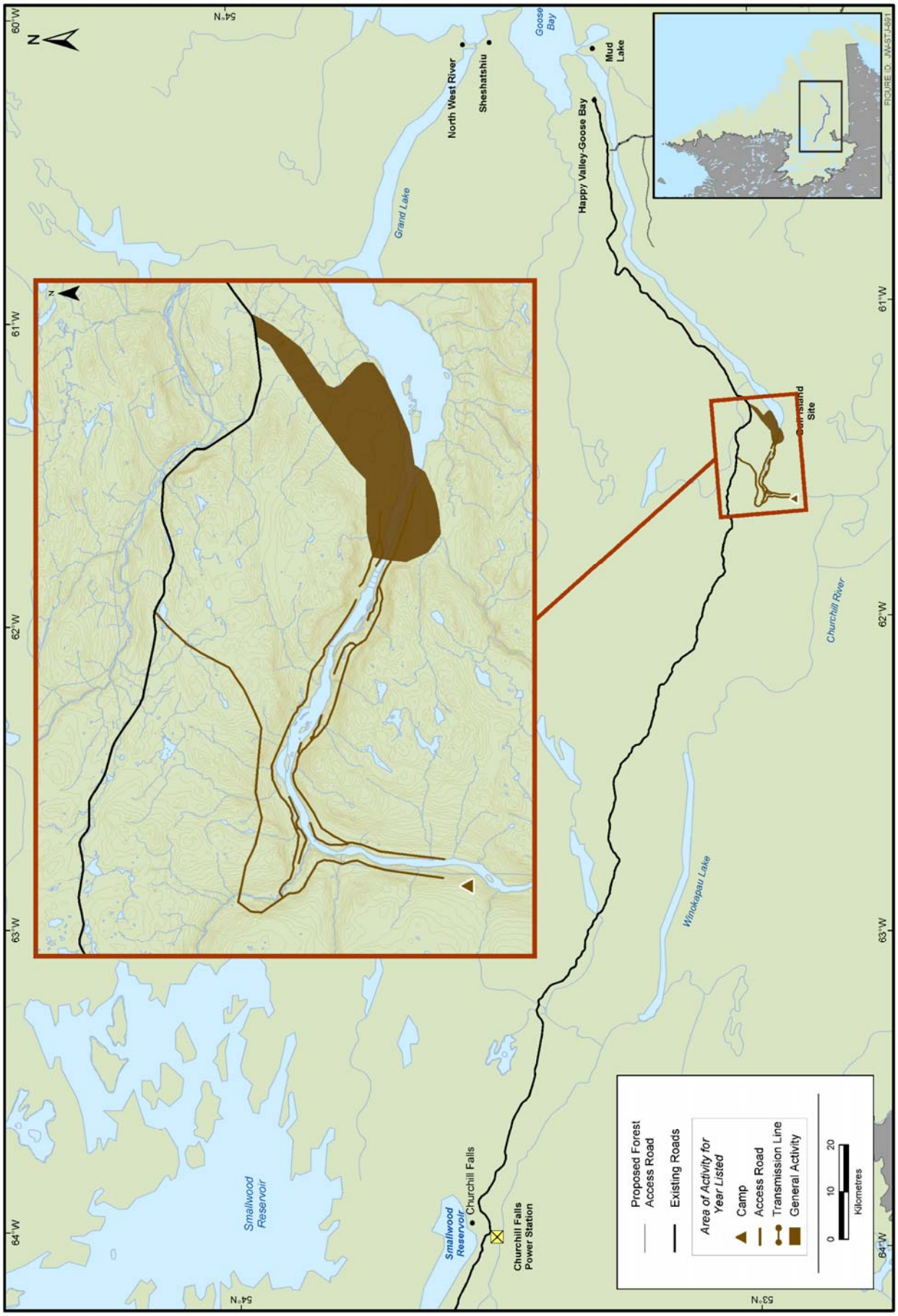


Figure 4-18 Construction Sequence Year 2

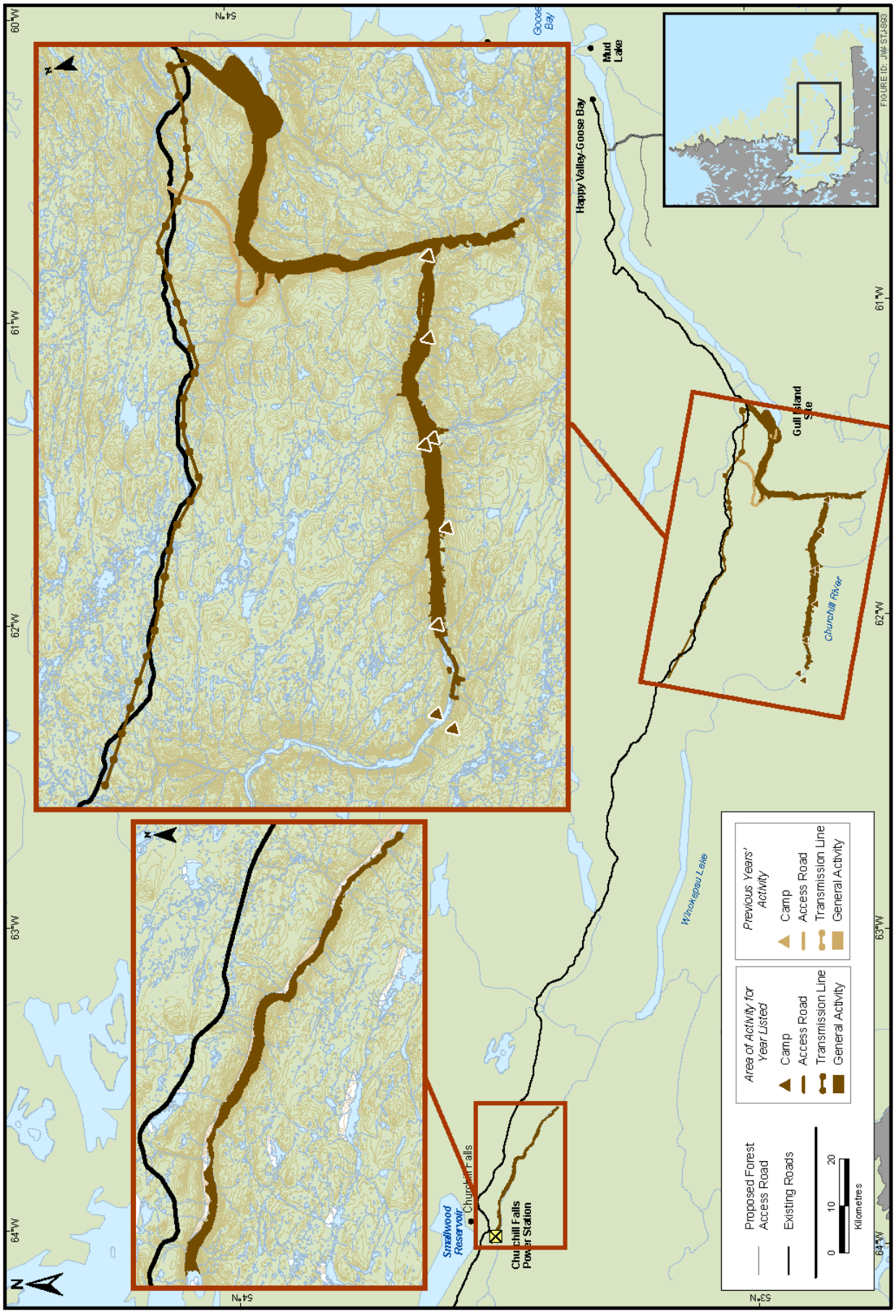


Figure 4-19 Construction Sequence Year 3

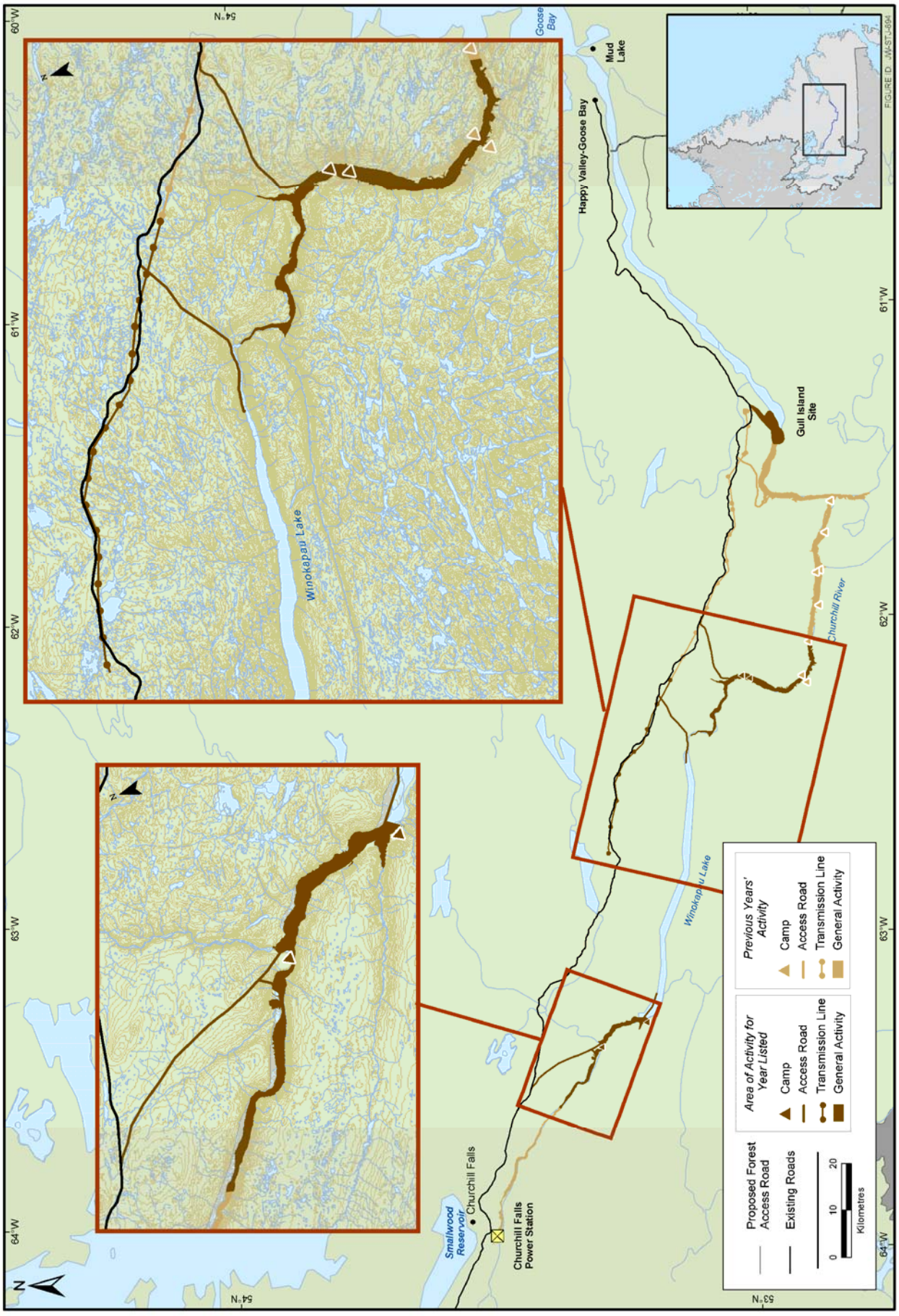


Figure 4-20 Construction Sequence Year 4

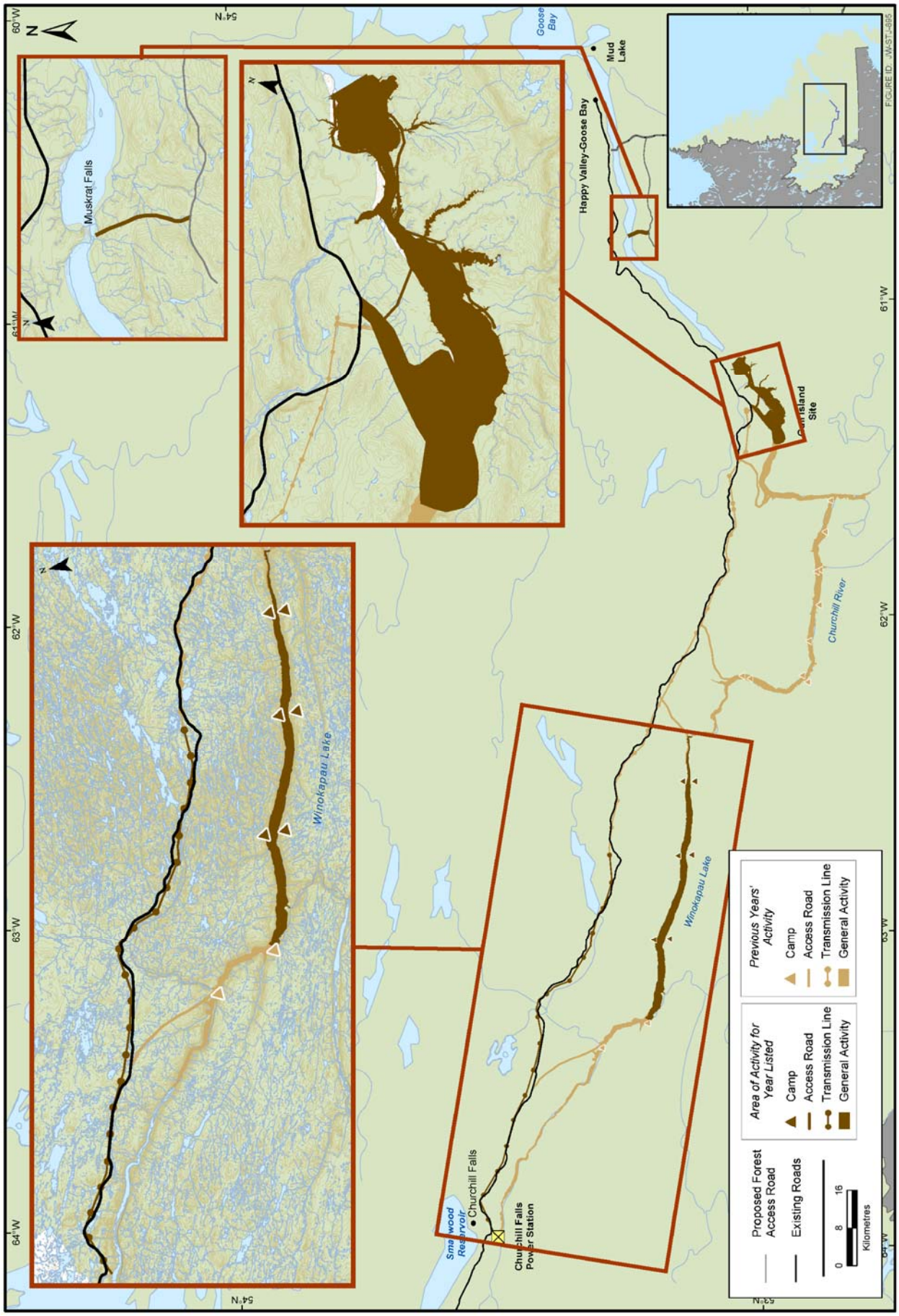


Figure 4-21 Construction Sequence Year 5

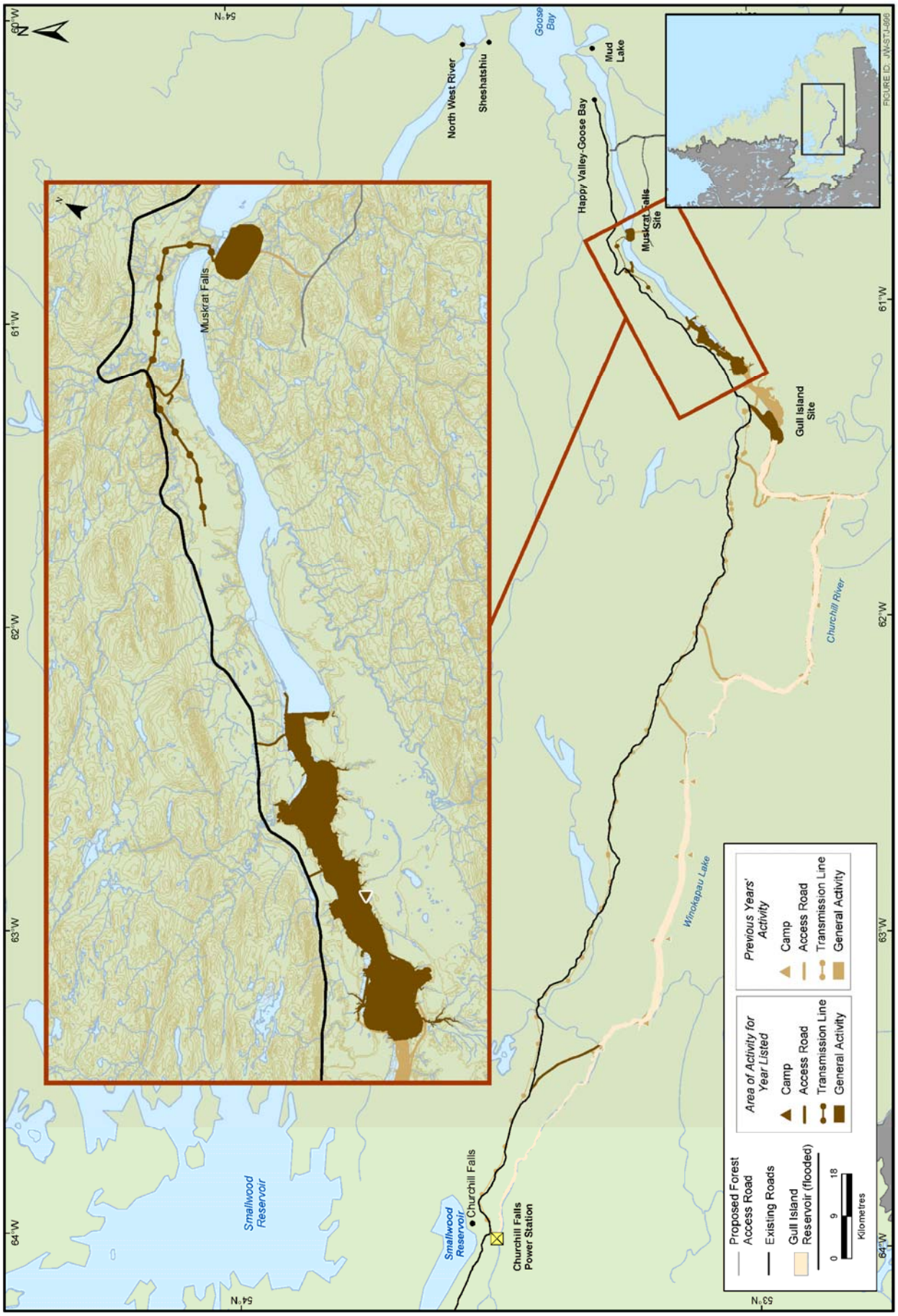


Figure 4-22 Construction Sequence Year 6

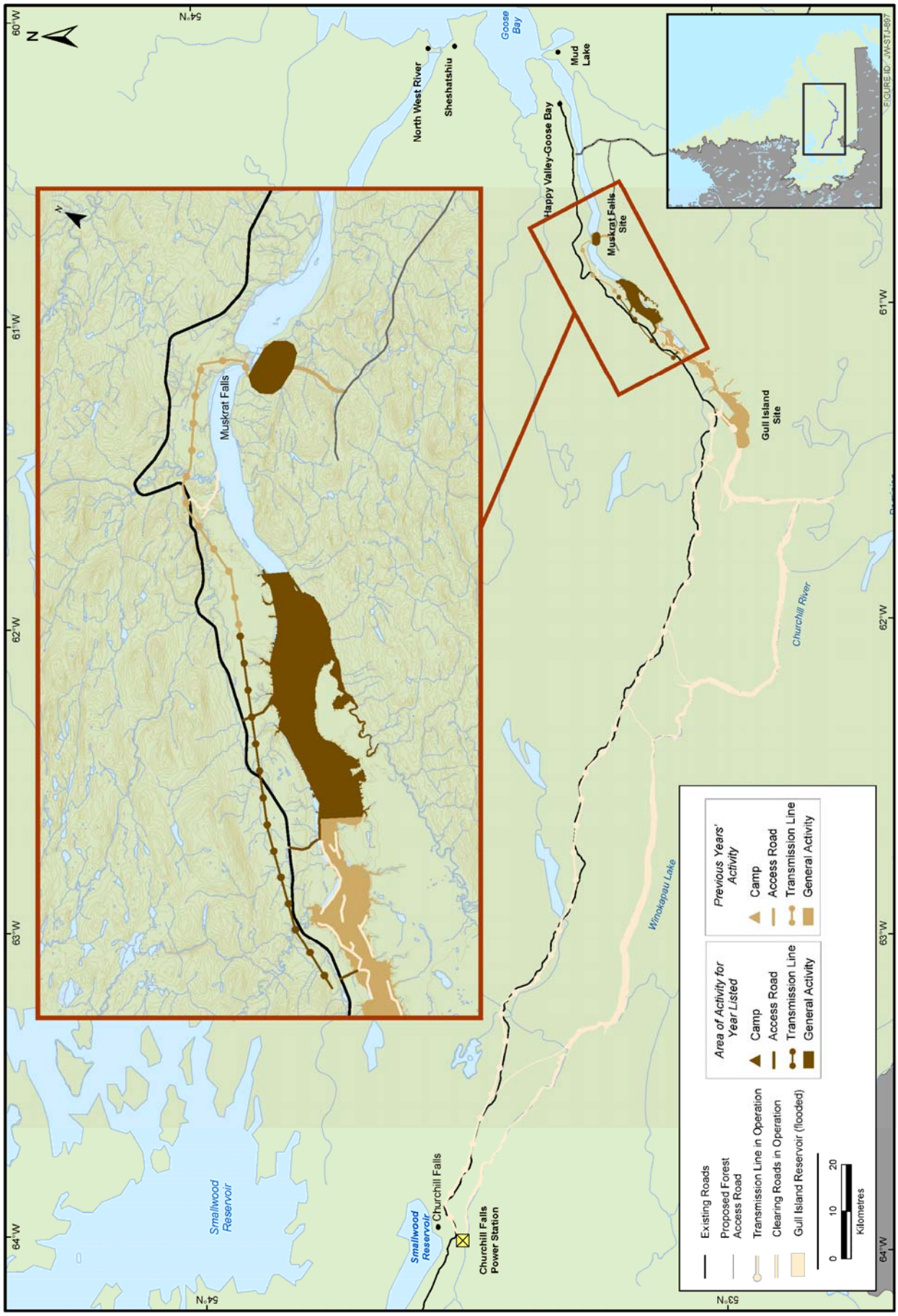


Figure 4-23 Construction Sequence Year 7

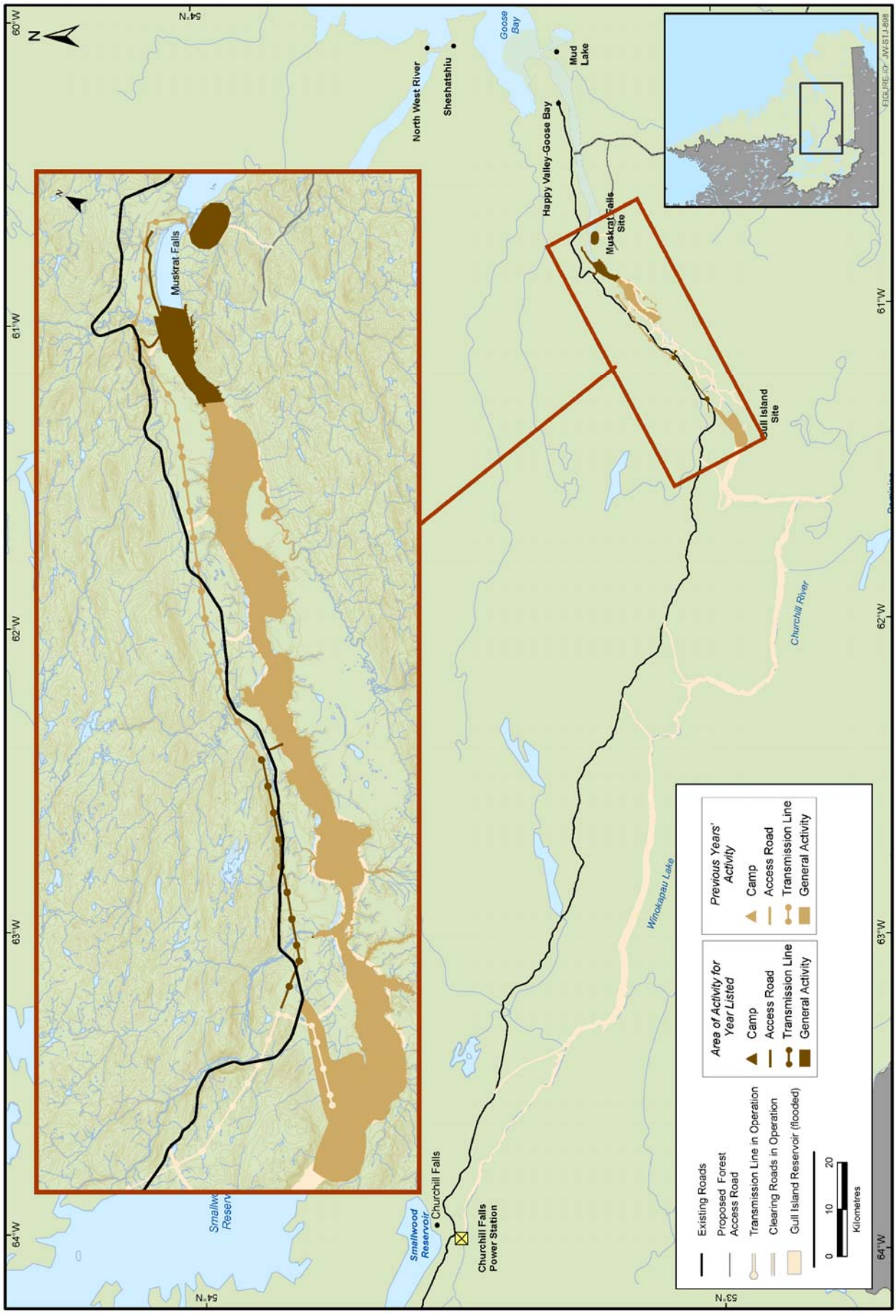


Figure 4-24 Construction Sequence Year 8

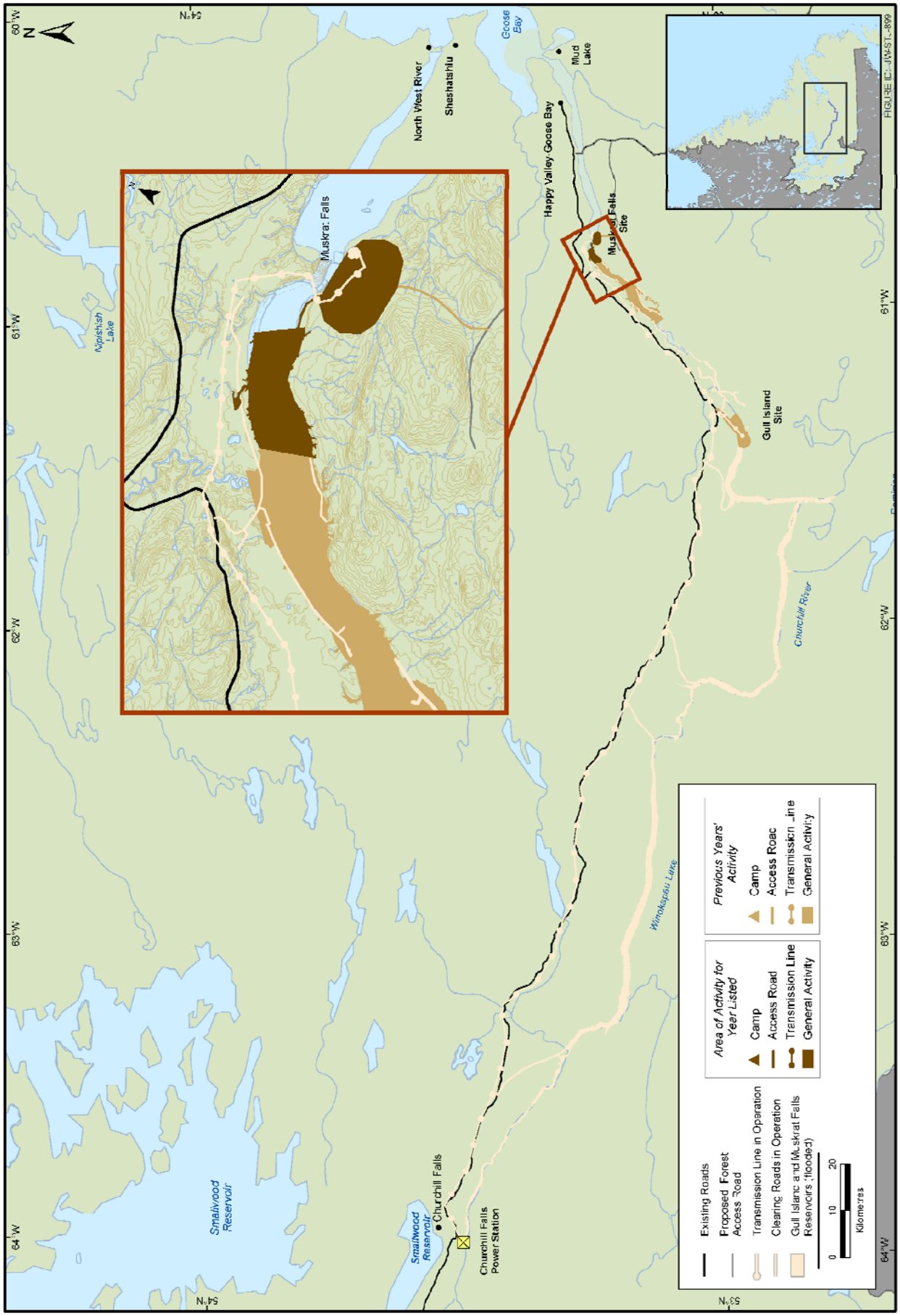


Figure 4-25 Construction Sequence Year 9

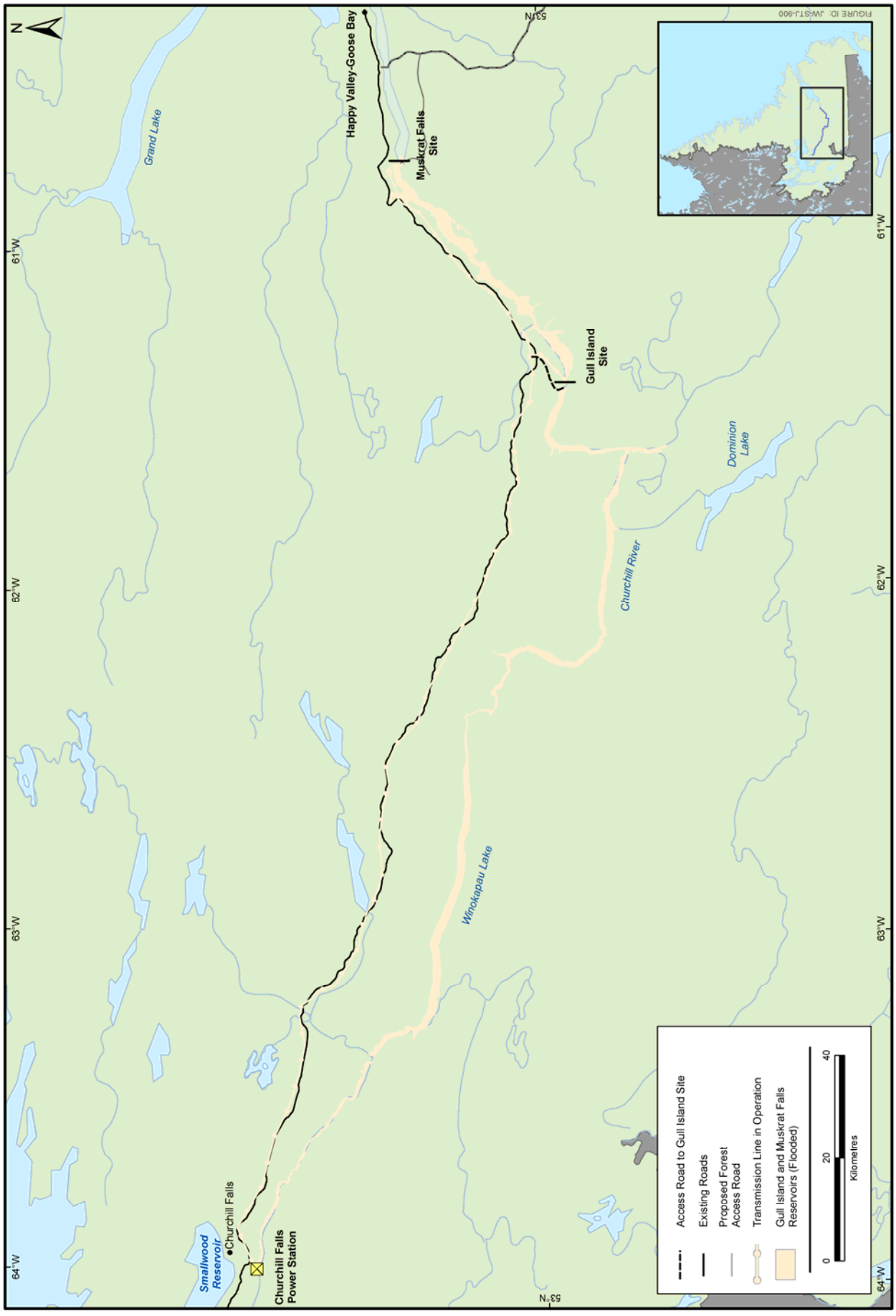


Figure 4-26 Construction Sequence Year 10

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4.4 Construction

The construction of the Project and its associated components will be a major undertaking, which will require substantial quantities of material, support infrastructure and equipment (Tables 4-1 and 4-2). The construction phase will have the greatest potential for interactions with the existing environment.

Table 4-1 Construction Equipment for Gull Island and Muskrat Falls Sites

Activity	Estimated Quantity	Anticipated Types of Equipment
Gull Island Site		
Diversion Tunnels and five Penstocks	3	3-Boom Jumbo
	2	Cat 988 Loader
	5	Cat 773 Trucks
	1	Cat 14 or 16 Graders
	2	Cat D8 Tractors
	6	Crawler Drillers
	3	High Lift Platforms
Spillway Excavation and Dam Rock Shell	2	O&K RH120E Face Shovels
	1	Cat 385 Backhoe
	1	Cat 345 Backhoe
	15	Cat 777 Trucks
	3	Cat D8 Tractors
	5	Cat CS-573 E Vibratory Rollers
	1	Cat 16 Grader
	6	Crawler Drillers
	3	High Lift Platforms
Dam, Filters and Transitions	3	Cat 345 Backhoe
	3	Cat D8 Tractors
	3	Cat D6 Tractors
	5	Cat CS-533 E Vibratory Compactors
	2	50 t Towed Compactors
	1	Cat 14 Grader
	30	Dump Trucks
Common Excavation	3	Cat 385 Backhoes
	10	Cat 773 Trucks
	3	Cat D8 Tractors
	1	Cat 14 Grader
Powerhouse and Spillway Concreting	2	150 m^3 wet mix concrete plant
	1	Rotec Creter Crane
	2	250 t Manitowoc Model 999 Crawler Crane
	1	Aggregate Preparation Plant – crushers, screens, conveyors, stackers and loading equipment
Muskrat Falls Site		
Spillway Excavation	1	O&K RH120E Face Shovels
	1	Cat 385 Backhoe
	1	Cat 345 Backhoe
	7	Cat 777 Trucks
	2	Cat D8 Tractors
	2	Cat CS-573 E Vibratory Rollers

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Table 4-1 Construction Equipment for Gull Island and Muskrat Falls Sites (cont.)

Activity	Estimated Quantity	Estimated Types of Equipment
Muskrat Falls Site (cont.)		
Spillway Excavation (cont.)	1	Cat 16 Grader
	3	Crawler Drillers
	2	High Lift Platforms
Dam (RCC)	2	Cat 345 Backhoe
	5	Cat CS-573 E Vibratory Rollers
	2	Cat D8 Tractors
	2	Cat D6 Tractors
	2	Cat CS-533 E Vibratory Compactors
	1	50 t Towed Compactors
	1	Cat 14 Grader
	15	Dump Trucks
Common Excavation	3	Cat 385 Backhoes
	5	Cat 773 Trucks
	2	Cat D8 Tractors
	1	Cat 14 Grader
Powerhouse and Spillway Concreting	1	150 m^3 wet mix concrete plant
	1	Rotec Creter Crane
	1	250 t Manitowoc Model 999 Crawler Crane
	1	Aggregate Preparation Plant – crushers, screens, conveyors, stackers and loading equipment

Notes:
Type and quantity of equipment preliminary
All estimates are approximate based on:
- experience with other large projects
- estimated quantities
- estimated schedule

Based on a rockfill dam with inclined core
Equipment is assumed to be from Caterpillar; however, the actual equipment used during construction may be from other manufacturers
Includes equipment used to haul rock, aggregate and borrow materials

Table 4-2 Construction Equipment for Reservoir Preparation and Transmission Lines

Activity	Quantity (Gull Island)	Quantity (Muskrat Falls)	Type of Equipment
Reservoir Clearing	6	6	Feller Buncher
	5	5	Skidder/Forwarder
	4	4	Delimber
	4	2	Excavator
	4	4	Slasher
	9	6	Trucks
	5	5	Chippers

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Table 4-2 Construction Equipment for Reservoir Preparation and Transmission Lines (cont.)

Activity	Quantity (Gull Island)	Quantity (Muskrat Falls)	Type of Equipment
Transmission Line Construction	30	20	4x4 Pickup Truck
	1	1	Crane
	2	2	Bull Dozer
	10	7	Boom Truck
	20	17	Muskeg
	1	1	Crawler Crane – 150 t
	10	8	Quad
	15	10	Excavator
	5	3	Nodwell
	1	1	Grader
	4	3	Dump Truck
	4	3	Float

The following sections detail the construction infrastructure required and the construction sequence for each of the Project components, as well as a discussion of material requirements, labour demands and the overall construction schedule.

4.4.1 Gull Island

Gull Island will be constructed first, as it is the more economically attractive generation site, the larger Project element and has the longest construction schedule.

4.4.1.1 Construction Infrastructure

Support infrastructure includes access to the Gull Island Site for material delivery (some of which will be heavy loads), camps and laydown areas, borrow and quarry areas and associated access roads. Much of the supporting infrastructure will be temporary and will be removed following completion of construction activities. Integrated into contracts will be progressive implementation of rehabilitation and restoration measures; for example, once a location is no longer required, it will be rehabilitated as part of the ongoing work program. An overview of the various structures and facilities required to support the construction phase of the Project are provided in Figures 4-27A and 4-27B. An alternative construction bridge location currently under consideration is also shown (Figure 4-28).

Access

Temporary access roads are required both within the construction site and to access off-site quarry and borrow areas. Temporary roads will be gravel surfaced, with 8 m wide tops and 2:1 side slopes. Roads constructed on the north side include access to the temporary construction bridge, switchyard and main dam. Roads on the south side include access to the diversion structures, power facility and laydown area. The access roads to the switchyard, main dam and powerhouse will become permanent roads. Approximately 4 km of road will be required to access these facilities. Roads will also be required to access other areas on site and off site, including borrow areas. Approximately 12 km of construction access will be required around the site and 11 km will be required to access borrow areas. All temporary road stream crossings will be designed and installed such that they can be removed following construction (Figure 4-27A and Chapter 5, Figure 5-7). A temporary construction bridge is also required to gain access to the south side of the river to facilitate early construction of the power facility and associated structures. The structure will be removed at the end of construction.

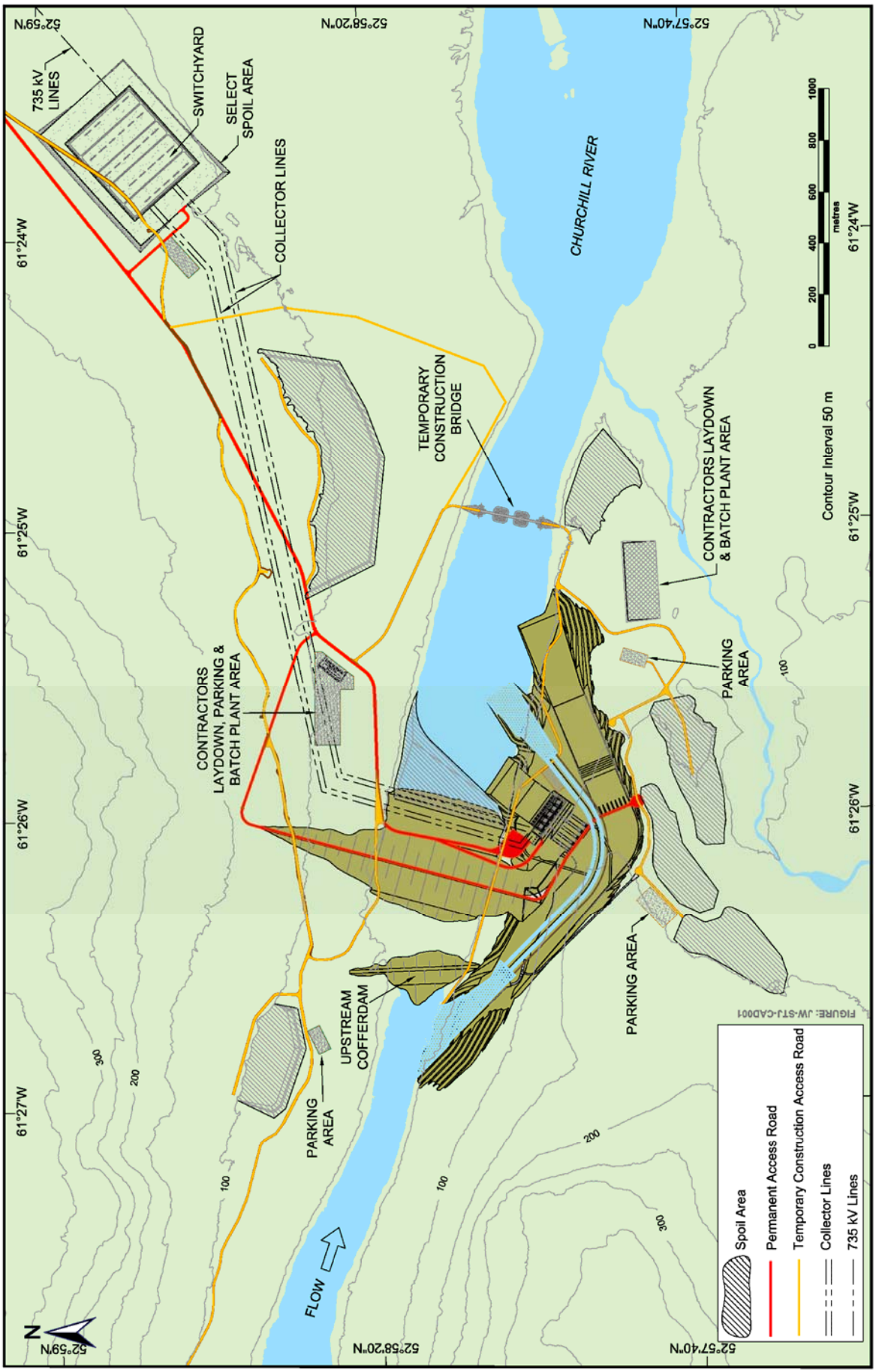


Figure 4-27A Gull Island Construction Infrastructure - Construction Site to Switchyard

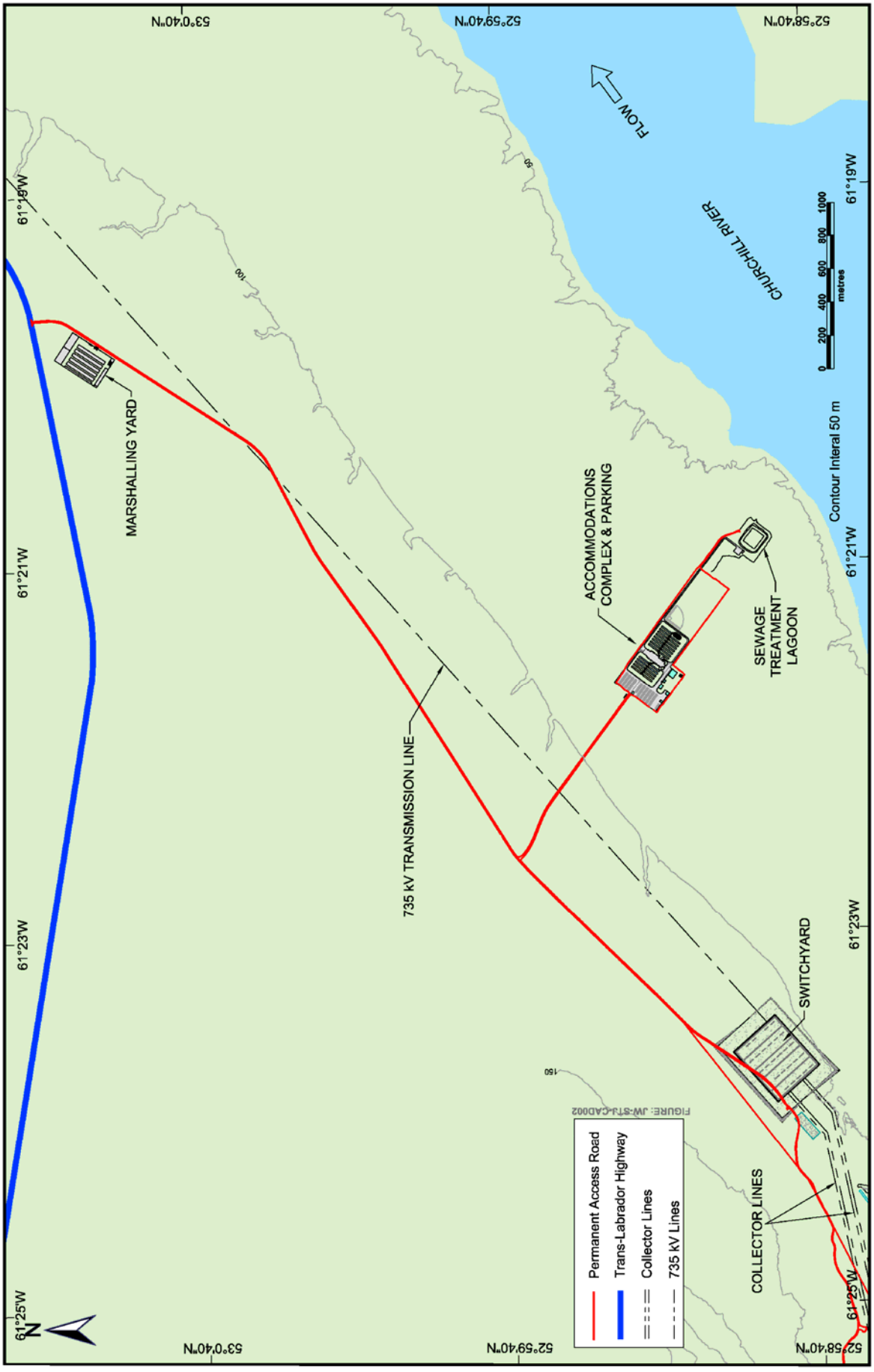


Figure 4-27B Gull Island Construction Infrastructure - Switchyard to Trans Labrador Highway

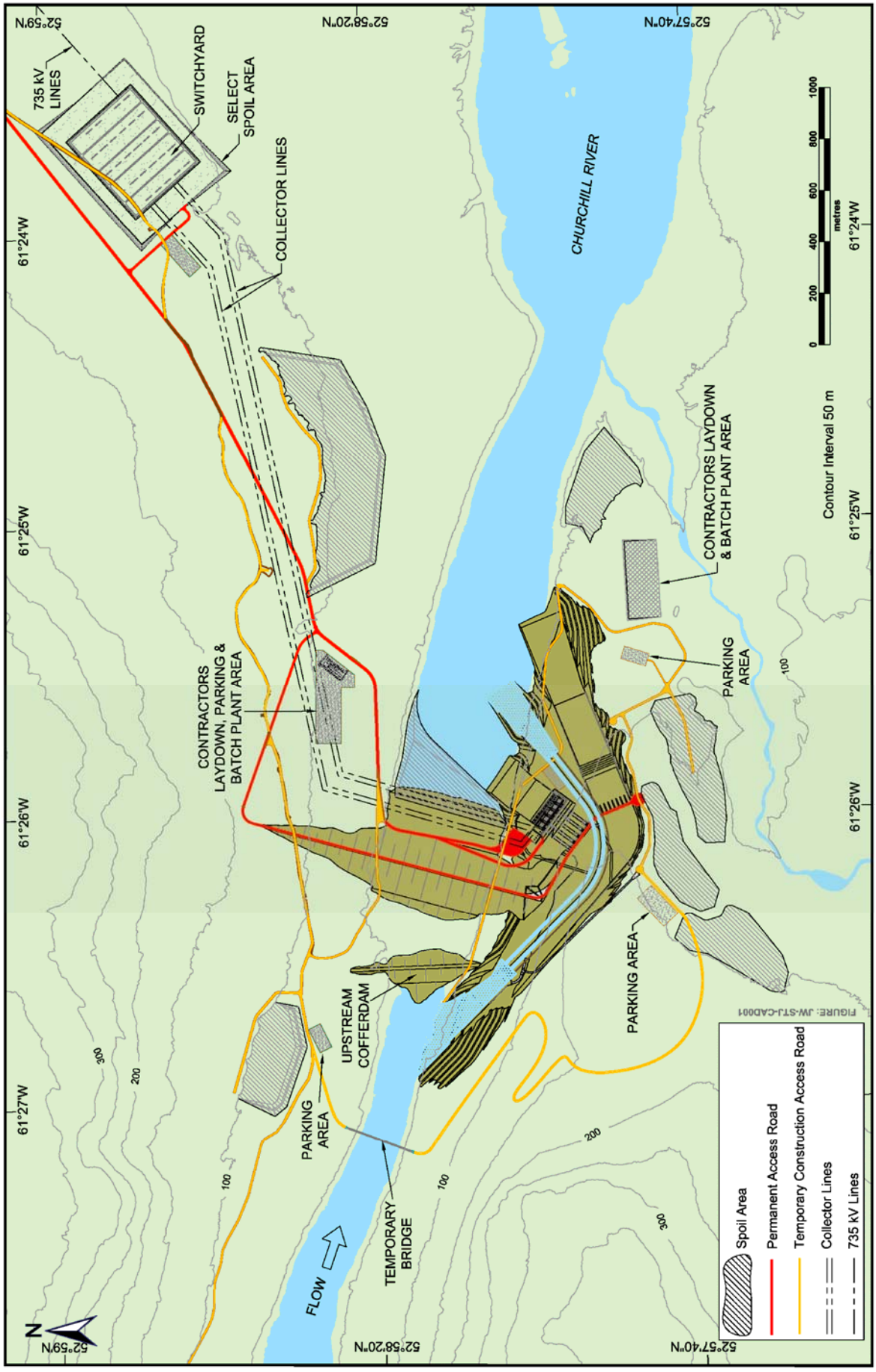


Figure 4-28 Alternative Location – Gull Island Temporary Construction Bridge

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Road access is also required for reservoir preparation (Appendix IB-D). A network of access roads totalling 231 km will be constructed in the eastern section of Gull Island Reservoir. As a general principle, construction roads required for reservoir clearing will be routed to lie within the reservoir flood zones, and will be temporary.

Temporary access roads will be gated or restricted for public use.

Main Accommodations Complex

During the 1975 construction start at Gull Island, a 30 ha site was cleared and grubbed for a construction camp. The accommodations complex for the construction of the Gull Island development will be in the same location. The complex will have a peak capacity of 2,000 workers.

In addition to the site facilities, the Project may utilize family accommodations in Happy Valley-Goose Bay for some Project management staff, vendors and specialists.

The accommodations complex will be comprised of mainly single rooms for both male and female occupancy. Short term workers will have access to double occupancy rooms. The accommodations will comprise a two-storey configuration using modular trailer units. The complex will have a dining room with approximately 600 person seating capacity and a kitchen designed to service 2,000. The complex may also have a coffee shop, bank machines, commissary, recreation facilities, satellite TV and security systems. The site will also house a medical clinic, post office and administrative offices.

Water will be available from groundwater wells. The water supply system will consist of deep well submersible pumps and will be treated as required.

A sewage treatment system, designed in accordance with guidelines as set out by the Province, will provide a sewage effluent acceptable for discharge.

Solid waste will be stored in bear-proof containers and regularly transported to a licensed landfill, e.g., at Happy Valley-Goose Bay (subject to the approval of the appropriate authority). Alternatively, Nalcor Energy would apply for and develop its own facility. A recycling program will be implemented at the complex to reduce the amount of solid waste generated, provided recycling services are available.

The existing transmission line between Churchill Falls and Happy-Valley Goose Bay will be the main power supply for the site and accommodations complex (the complex will require 4 MW to operate). A 2.5 MW backup generator will be available.

Communications will be provided between the site and Happy Valley-Goose Bay, in addition to high-speed internet access for the complex facilities.

The accommodations complex also includes:

- a laboratory/water treatment facility;
- a maintenance workshop;
- a fire station and ambulance shelter; and
- a communications building.

Five construction parking areas will be required at the site, along with a main parking area at the campsite.

Warehouses will also be required at site, including a 300 m^2 maintenance workshop for vehicles and a 9,000 m^2 warehouse for equipment storage.

Reservoir Clearing Camps

Temporary, self-contained reservoir clearing camps will be constructed for the reservoir clearing crews. Camps will have their own on-site water and electrical power as well as facilities for sewage treatment and garbage disposal. Medical facilities will also be available. An estimated 20 campsites will be required to complete the clearing of the reservoir. Approximate locations for the temporary reservoir clearing camps are identified in Figure 4-29 (see also Appendix IB-D). These camps, sized for 30 or 10 persons, will be demobilized and moved as required to support reservoir clearing.

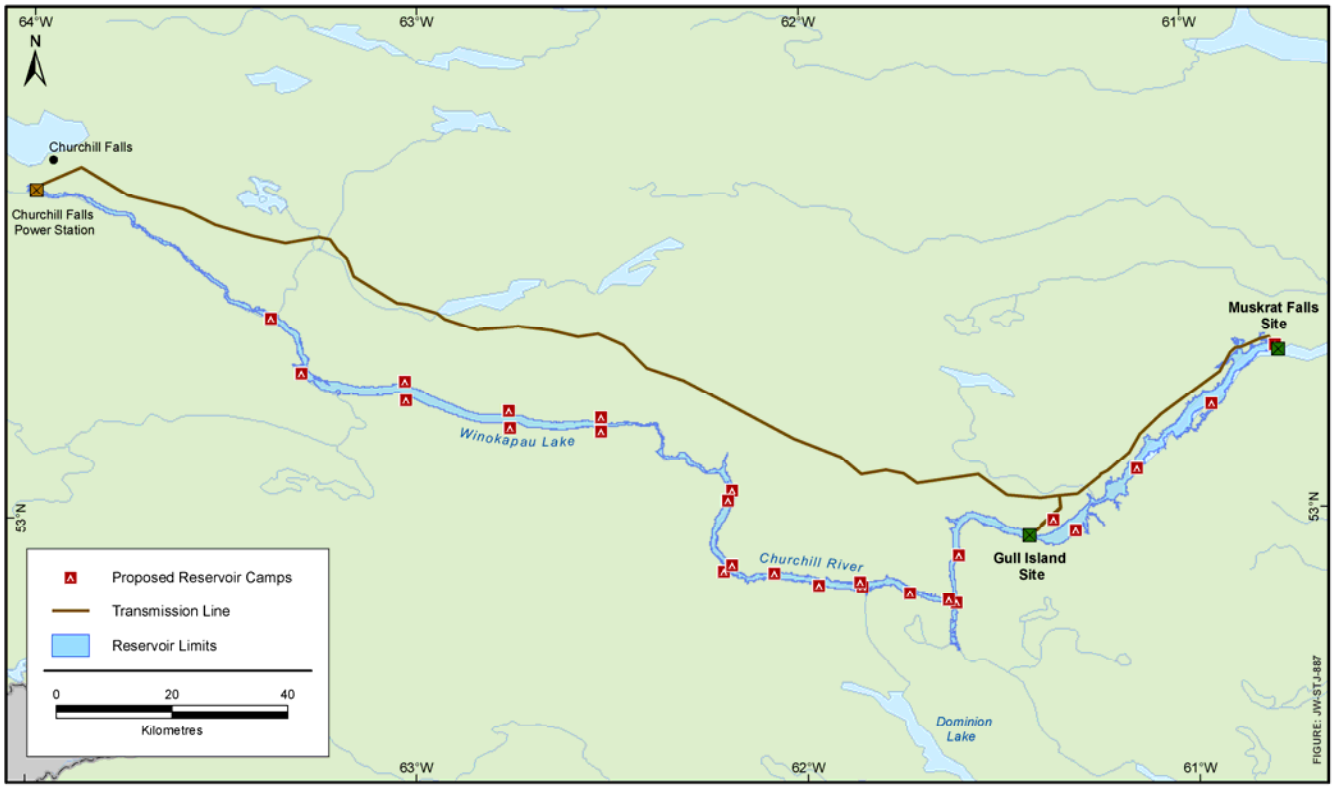


Figure 4-29 Location of Temporary Reservoir Clearing Camps

The 30 person camp will be self-contained with diesel power, communications and road and/or water access. Minimum site preparation will be required for these modular units. Water and sewer facilities will consist of dug wells and septic tanks with field disposal. Each camp will reflect current labour standards, including separate quarters for men and women and recreational/lifestyle services. To reduce the amount of land required, campsites and material and fuel storage yards will be together.

The 10 person camps will be accessible by air or water transport only. These temporary facilities will have power and communications, water by way of a dug well, and pit privy-type sewage disposal.

Material Storage and Laydown Areas

A total of 110,000 m^2 has been identified as laydown areas for materials on both sides of the river; however, scheduling of deliveries could reduce the amount of area required as this provision assumes that all materials and equipment will be stored on site at the same time.

A laydown/storage area is also required at the port in Happy Valley-Goose Bay, for which the Project Team is investigating suitable locations. Also, new warehouse space is required at the dock in Happy Valley-Goose Bay to

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meet the needs of the Project. Fabrication and assembly areas are part of the total area identified for material laydown areas.

Fuelling and Fuel Storage

On-site fuelling facilities will be required during the construction phase. Anticipated fuel requirements include diesel for heavy equipment (trucks, excavators, dozers, cranes, and generators), aviation fuel for helicopters and gasoline for light trucks and other vehicles. Construction and operation of all fuelling facilities will be in accordance with the *Storage and Handling of Gasoline and Associated Products Regulations* CNR 775/96. All necessary approvals will be obtained from the Newfoundland and Labrador Department of Government Services (NLDGS).

Supply, delivery and dispensing of fuels (diesel and gasoline) will be contracted out so that there is a one-point responsibility for on-site fuel transport and handling. Tanker trucks will transport fuel from bulk storage locations in Happy Valley-Goose Bay. On-site bulk storage tanks will provide enough fuel to operate the fleet of construction equipment. Fuels will be dispensed from one location on the north side of the river. Smaller tanker trucks will deliver fuel to stationary equipment at the various work locations on both sides of the river. Equipment and procedures for on-site bulk storage, transportation and dispensing of the fuels will be in accordance with applicable safety and environmental regulations.

Explosives

The supply, delivery and dispensing of explosive materials to the Gull Island site will be contracted out so that there is a one-point responsibility for explosives onsite. Explosives will be stored and dispensed in accordance with applicable safety regulations.

Concrete and Crushing Plant

The main concrete batch plant as well as a smaller secondary plant will be on the south side of the river. Aggregates will be crushed at source and trucked to stockpiles near the batch plant. The footprint of each batch plant will be approximately 200 m by 300 m.

Borrow Pits and Quarries

Most of the rockfill and rock aggregate required for the Project will come from the site excavations; however, additional rock, as well as impervious and granular materials, will be accessed through development of nearby borrow pits or quarries, see Figure 4-30. Standard mitigation measures will apply to the operation of all quarries and borrow areas as per the Project EPP. Where practical, such features will be located within the reservoir perimeter to reduce the overall Project footprint.

Diversion Facilities

An upstream cofferdam will close the river for construction of the main dam. (Figure 4-31). The cofferdam will divert the natural flow of the river through diversion tunnels on the south side of the river. Construction of a downstream cofferdam allows for the main dam construction to commence in the dry.

The upstream cofferdam will be constructed of rock and glacial till. It will have a crest elevation of 60 m and be 500 m long. The downstream cofferdam construction (also made of rock and glacial till) will have a crest elevation of 48 m and be 470 m in length.

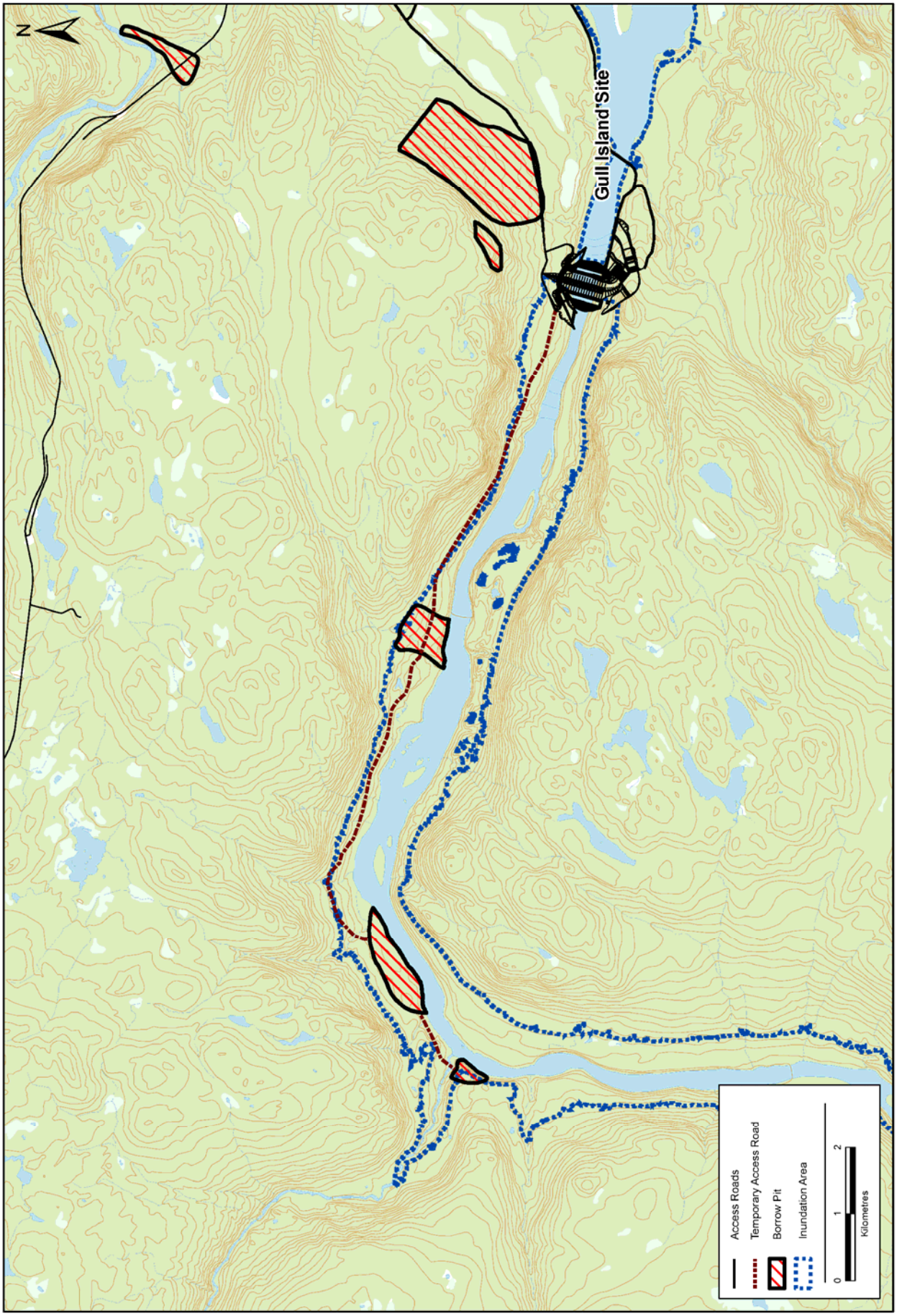


Figure 4-30 Candidate Sources of Borrow Material for Gull Island Site

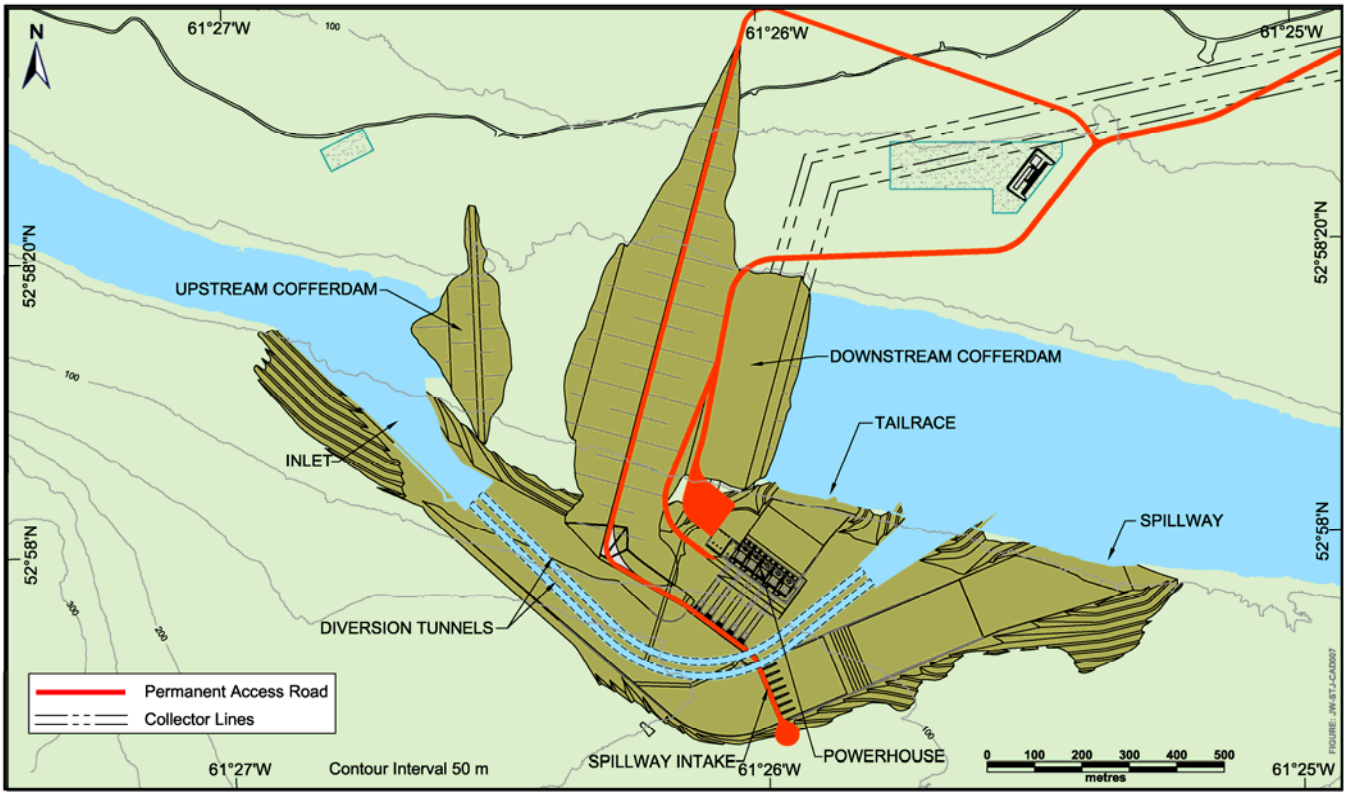


Figure 4-31 Gull Island Diversion Facilities

There will be two (1,000 m and 1,050 m long) diversion tunnels on the south side of the river. Both tunnels will be 14 m wide by 20 m high and excavated in rock. The diversion tunnels will be designed to pass a flood of 4,800 m^3/s. The Churchill Falls Power Station will provide additional flood control if required. The inlet to the diversion tunnels will be located upstream of the start of the approach channel, at elevation 30 m, sloping down to elevation 16 m at the tunnel entrance. The diversion tunnel alignment passes under the approach channel, then below an interface dam between the intake and spillway and between the spillway plunge pool and powerhouse to the exit portal and outlets.

Spoil Material

Spoil (i.e., overburden and rock) generated during site clearing and excavation will be stockpiled and used for site construction and rehabilitation. The majority of this rock will be used for constructing the cofferdams and the main dam.

The spoil areas will be located close to the construction site in flat dry areas and will stay away from streams and steep hills.

As part of the 2007 engineering field program, acid-base accounting was conducted on rock samples in order to evaluate the risk of acid rock drainage associated with the exposure of rock spoil to air and water. Tests were performed on composite samples produced from cores retrieved in boreholes drilled at the excavation sites. The modified acid/base accounting was determined by the Sobek method and yielded a Neutralizing Potential to Acid Potential ratio of less than 0.2 for the composite samples tested, indicating that the rock material is not a net acid producer.

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4.4.1.2 Construction Activities and Sequence

This section details the sequence of construction activities associated with the Gull Island site. The sequence of construction from Year 1 to 10 is detailed in Figures 4-17 to 4-26 and include areas of past activity.

As stated in Section 3.7.10, the extent of reservoir preparation (as described throughout this EIS) may be modified due to limiting factors that will be encountered in the field. Safety and technical considerations may determine that reservoir clearing in certain areas cannot be achieved (e.g., steep slopes adjacent to Winokapau Lake). Areas not cleared because of these limiting factors will not change the results of the effects assessment. In addition, operational procedures and methods will be implemented to deal with any potential issues (e.g., trash and debris removal requirements) that could result from any area not cleared.

Preliminary Activities

During year one construction, work will focus on developing and improving road access and installing a temporary bridge.

The main access to the site is via the TLH and the existing access road to the construction site. Upgrading of this existing access road will include clearing, ditching, installing culverts, supplying and laying road material, stabilizing road embankments and installing guard rails. New permanent and temporary access roads are also required for the Project. These routes will be cleared, grubbed and graded as required.

Access roads will be constructed using standard construction practices, including industry standard and regulator approved mitigation measures. Work on the construction bridge will start as soon as access to the location is established.

The construction camp, scheduled to be built in Year 1, is a key component of the preliminary construction. The existing cleared site will be covered with granular material for vehicle passage and the remaining exposed sand area will be covered.

Reservoir Preparation

This section presents the plan for preparing the Gull Island and Muskrat Falls reservoirs prior to flooding. It also describes all activities associated with the clearing, cleaning and removal of vegetation in the reservoirs, as well as estimates of the volumes of wood products of potential commercial value that will be generated; however, the marketability of these products is not addressed. Further details on the reservoir preparation strategy are found in Sikumiut (2008).

The extensive work program associated with removing vegetation from the two reservoirs addresses several objectives, including:

- supporting hydroelectric plant operations by reducing the occurrence of floating debris at intakes;
- rendering the reservoirs navigable for existing and anticipated boat traffic;
- improving shoreline and riparian zone habitat quality;
- improving fish habitat quality, especially for shallow water and nearshore areas; and
- making the merchantable timber resource available to other users.

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In addition to the general work program described below, specific mitigation measures to be implemented during reservoir preparation, include:

- removing vegetation above the flood zone to encourage succession of shore zone plant species typical of riparian habitats;
- retaining riparian zone refuge habitat, especially in Muskrat Falls Reservoir;
- developing riparian habitat that meets the requirements for certain species/groups that occupy specific habitat types (e.g., ruffed grouse and wetland sparrows); and
- developing delta (outwash plain) features at the mouth of some inflow tributaries.

Specific mitigation measures associated with reservoir preparation are described in detail in the relevant VEC sections of Volume IIA and Volume IIB.

Forest Land Inventory

Aerial photography was used to classify the land base into productive forest, non-productive forest and other land classes. Productive forest was delineated into stand types based on tree species, stand age, tree height, density of crown closure and site capability. The height and diameter by species was emphasized, as these are the main factors affecting wood volume. Stand and stock data were calculated to determine the estimated total and gross merchantable volumes (m^3) within the reservoirs. The information gathered was used in conjunction with Geographic Information System (GIS) software for mapping, area determination, volume calculations and other types of analysis.

The distribution of land classes in the proposed impoundment areas is summarized in Table 4-3. Forest vegetation covers 12,610 ha of the total 33,740 ha, or just over 37 percent of the area to be flooded.

Table 4-3 Distribution of Land Classes in the Reservoirs

Land Class	Gull Island (percent)	Muskrat Falls (percent)	Total (percent)
Commercial Forest	30.5	30.0	30.3
Non-commercial Softwood Forest	3.6	2.7	3.3
Non-commercial Hardwood Forest	3.2	4.7	3.7
Bog	0.1	1.5	0.6
Rock and Soil Barren	6.7	5.3	6.2
Lakes and Ponds	0.3	0.4	0.4
Rivers and Streams	55.6	55.4	55.5
Total	100.0	100.0	100.0

Commercial forest predominates the Churchill River valley, of which black spruce stands account for 60 percent of the total forest area. The remainder is non-commercial softwood and hardwood stands. The forest stands in most areas are in generally good condition with the exception of small, scattered patches of blow down. There has been essentially no cutting, with the exception of a very small area at Gull Island Rapids. The area has been free from fire since the 1967 burn west of Beaver Brook. Recent government surveys confirm infestation of hemlock looper and to a lesser degree spruce budworm, in the eastern reaches of the lower Churchill River valley. The Provincial Government has begun a spray program to control this outbreak that is concentrated along lower slopes (where balsam fir occurs) in the area downstream of Minipi River, Gull Island, and on the

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south side of the river east of Muskrat Falls. Damaged areas are being monitored and mapped by the Forest Resources Branch of the Department of Natural Resources in Labrador.

Reservoir Access

The Gull Island and Muskrat Falls reservoirs will flood a 284 km long, generally narrow band of forest vegetation. The south side of the Churchill River is inaccessible by road, and most of the north side is a considerable distance from the TLH. Primary access routes to the river are proposed at several points along the north side of the river from the TLH. These will be linked to a secondary network of temporary haul roads on either side of the river, most of which will be below the flood level. Where temporary haul roads are impractical, the movement of machinery and materials will be facilitated by barges. The road network for both reservoirs is approximately 316 km (Appendix IB-D).

Two crossings may be required between the Gull Island dam site and the eastern end of Winokapau Lake. A Bailey-type bridge could be moved as required and removed after clearing. Power boats with a capacity of eight to 10 persons will provide transport if barges are required.

Clearing Methods

Mechanical full-tree harvesting/clearing systems will be the primary means for removing the large quantity of timber and disposing of the logging slash and other forest biomass. Full-tree systems will extract merchantable trees, with branches and tops attached, from the cleared areas to collection sites via road or river transport. Feller bunchers will be used for a major portion of the cutting, including units equipped with operator-cab levelling capability for working on steep slopes. Manual clearing systems will be used to a lesser extent, mainly in areas where machinery cannot safely operate. Virtually all of the merchantable and sub-merchantable trees will be removed as full trees (tops and branches intact) from the clearing areas.

At the collection sites, merchantable size full trees will be delimbed, slashed (cut into shorter lengths) as required, and placed for removal from the reservoir. The brush resulting from the processing operation, and other sub- and non-merchantable material, will be mechanically processed. Burning of brush and slash, a practice sometimes used in reservoir clearing, will not be employed for this Project.

Schedule

Clearing of the Gull Island Reservoir will begin in Year 2 and is expected to take up to five years. Clearing of the Muskrat Falls Reservoir will follow the completion of the Gull Island clearing work, using the same personnel and equipment. This requires three to four more years, with perhaps some overlap in timing. Based on this, very little time for mobilization will be required for Muskrat Falls. Scheduling for clearing is based on a 250 day work year, or less, depending on the clearing system used. Clearing activities from Winokapau Lake west to the Churchill Falls tailrace are restricted to spring, summer and fall.

Recoverable Resource

As summarized in Table 4-4, the total cleared area will be 8,570 ha. This involves removing about 1.55 million m^3 of wood. Allowing for cull and other losses, the total net marketable volume is about 1.04 million m^3. The area and wood volume are divided almost equally between the two reservoirs. The total biomass available from clearing both reservoirs is 2,356,000 green tonnes.

Table 4-4 Area, Wood Volume and Biomass Cleared for Reservoirs

Reservoir	ha	TMV[A] (m^3)	Biomass (green tonnes)
Muskrat Falls	4,201	756,800	1,150,000
Gull Island	4,369	794,600	1,206,000
Total	8,570	1,551,400	2,356,000

[A] TMV – Total Merchantable Volume

Diversion Facilities

River diversion facilities at Gull Island are the first major site components to be constructed. Work will begin in Year 2 and continue into Year 3, with the clearing and excavation of the overburden material at the inlet and outlet of the diversion tunnels. Diversion tunnels will require the removal of approximately 1.85 million m^3 of overburden. During their excavation, the worksite will be isolated from the river with temporary cofferdams in the inlet and outlet channels. Overburden material will be stockpiled for use in rehabilitating the site, spoiling or for incorporation into the main cofferdams. Over 900,000 m^3 of rock will be excavated for the inlet and outlet channels, followed by conventional drilling and blasting techniques. About 530,000 m^3 of rock will be excavated for the diversion tunnels.

Work will commence on the main cofferdams in Year 2. The main cofferdams (upstream and downstream) will advance mainly from the south bank of the river. In stage one, rockfill from a quarry or structure excavations will be used to construct two rockfill groins into the river, one at each cofferdam location. During this initial phase of construction, the cofferdams will extend to about the midpoint in the river. This work will commence during the diversion tunnel construction, but after the spring flood in Year 2. Transition material will be placed on the upstream and downstream face of the rockfilled groins to an elevation of 47 m (upstream cofferdam), and 40 m (downstream cofferdam) during the first phase. Borrow pits will supply the transition material.

Once the spring flood subsides and the diversion tunnels are complete, the temporary diversion cofferdams will be breached in Year 3. Extending both of the rockfill groins at the upstream and downstream cofferdam locations will divert the water around the construction site and through the diversion tunnels.

Following closure, rock transition material will be placed upstream and downstream of the groins to seal voids in the closure section. The contractor will then place sand and gravel as required between the two rockfill groins. This will be followed by the placement of till seal material (about one week to complete).

The second phase of the cofferdam construction will be completed in September and October of Year 3. During this phase, the crest elevation of the upstream cofferdam will increase to 60 m and the crest elevation of the downstream cofferdam will increase to 48 m.

Dewatering of the area between the upstream and downstream cofferdam will begin after the first stage of the cofferdam construction. Surface pumping and deep wells in the riverbed will keep the dam foundation dry.

Main Dam

Work on the main dam will begin in Year 2 and continue until the end of Year 6. Overburden will be removed at the abutments until bedrock is fully exposed, followed by foundation preparation and grouting. Work on a concrete cut-off wall will begin once the site has been dewatered.

Materials from the rock excavations for other Project components will comprise the majority of the materials for the main dam. The contractor will complete construction work for the main dam by the end of Year 6.

Spillway

The spillway will be excavated in Year 3 and completed in Year 5. Although the spillway excavation is not on the critical path for the construction of the facility, it is the main source of rock fill for the main dam. The schedule for rock excavation allows for the supply of rockfill to meet the placement needs of the dam schedule, while reducing the need to re-handle material. Each section of the spillway will be completed sequentially, including concreting and installing of the spillway gates.

Intake, Penstocks and Powerhouse

Excavation of overburden and rock in the powerhouse and tailrace will begin in Year 2. The objective of the first stage of excavation is to expose the rock face to facilitate the excavation of the penstocks. Horizontal excavation of the penstocks will begin in Year 3, once the face of the penstocks has been exposed. After the penstocks are excavated, the lower elbow of each penstock will be lined with concrete and, later, steel.

The work on the intakes will begin in Year 3 and finish in Year 5. The work includes installing intake gates and trashracks.

The excavation of the powerhouse will be complete in Year 3. Concreting will then start for the powerhouse structure and the associated service bay. Once this stage is complete, the powerhouse structure (steel, exterior metal cladding and roof) will be erected and the crane installed. Additional concrete and structural work will continue in preparation for the delivery and installation of the turbines and generators. Finally, the turbines will be installed.

Switchyard

The switchyard consists of a transformer yard and a substation. Work will begin on the substation in Year 3, with construction of the platform. Equipment foundations will be complete in Year 5. Work on the transformer yard will start after the structural steel for the powerhouse has been erected. Equipment installation will start in Year 5.

Grading of the switchyard location will be required. The contractor will remove topsoil/organic material, leaving a level-graded surface (the yard requires 200 mm to 250 mm of clean gravel to keep vegetation from growing). To prevent erosion, the ground will be stabilized and sandy slopes will be at least 2:1. In silt/clay, the slopes will be 3:1 with surface stabilization. A small, intermittent-flow drainage will require diversion and erosion protection.

Impoundment

The final construction steps involve removing a small cofferdam at the tailrace exit of the powerhouse and closing the diversion tunnel gates. With this, impoundment of the reservoir will begin. The timing for impoundment is currently scheduled for August to October, Year 6.

It will take 33 to 37 days to fill the reservoir to the full supply level, at which time normal downstream flows will recommence down river.

Concreting of the diversion tunnel plugs will commence once the reservoir level has reached the spillway sill elevation.

Seismic activities will be monitored before the reservoir impoundment, so as to highlight any seismic event that may occur early on during the impoundment. This will allow the rate of reservoir impoundment to be regulated

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to minimize the possibility of further induced seismic activity. An earthquake hazard analysis study concluded that given the Gull Island site conditions, it is unlikely that the reservoir could trigger an induced earthquake comparable to a M3 or M4 event on the Richter scale.

Site Rehabilitation

Progressive rehabilitation of work areas will be integrated into construction contracts. An overall Project Construction Restoration Plan will be developed and applied as well as site-specific rehabilitation plans for work areas, quarries and borrow pits. More detail is provided in Section 4.6.1.

Commissioning

Commissioning at Gull Island will occur after installation and prior to release for commercial operation; it is a means of verifying and documenting that each component, system and assembly of a facility is built, installed and tested as planned and designed to meet Project requirements.

It will take about three months to commission each turbine at the generation facility. This includes physical inspections, comparing as-built components to original design drawings and specifications, and testing in a de-energized state and energized state, in isolation, and connected to the transmission line grid, for various operating conditions. Commissioning of the first turbine is to be completed in Year 6, with the final commissioning in Year 7. Power will start up as each turbine is commissioned.

4.4.2 Muskrat Falls

4.4.2.1 Construction Infrastructure

Similar to Gull Island, facilities are required (Figure 4-32) to provide access, materials and support for the construction activities at the Muskrat Falls site.

The construction sequence is generally more straightforward for Muskrat Falls than Gull Island. There will not be a need for major diversion works and the scale of structures is modest compared to the Gull Island site. Consequently, both the area and duration of construction infrastructure is relatively reduced. The construction contracts will include provision for site rehabilitation and restoration to be implemented progressively.

Transportation and Access

Access roads are shown in Figures 4-23 and 4-31. Early access to the south bank of the river is available via a 5 km long construction road extending from a forest access road. Temporary roads are also required to access work sites, including access to the cofferdam and switchyard. The temporary roads will be gravel with 8 m wide tops and 2:1 side slopes. Temporary roads will also be required to access borrow areas. The contractor will install temporary bridges at stream crossings as required.

Road access will be required for the reservoir preparation operation. Access and haul roads, built on both the north and south sides of the river, have a total length of 86 km. Potential locations for access roads for reservoir clearing are identified in Appendix IB-D. Most of these roads will be temporary.

Public use of temporary access roads will be restricted during construction for safety and security reasons.

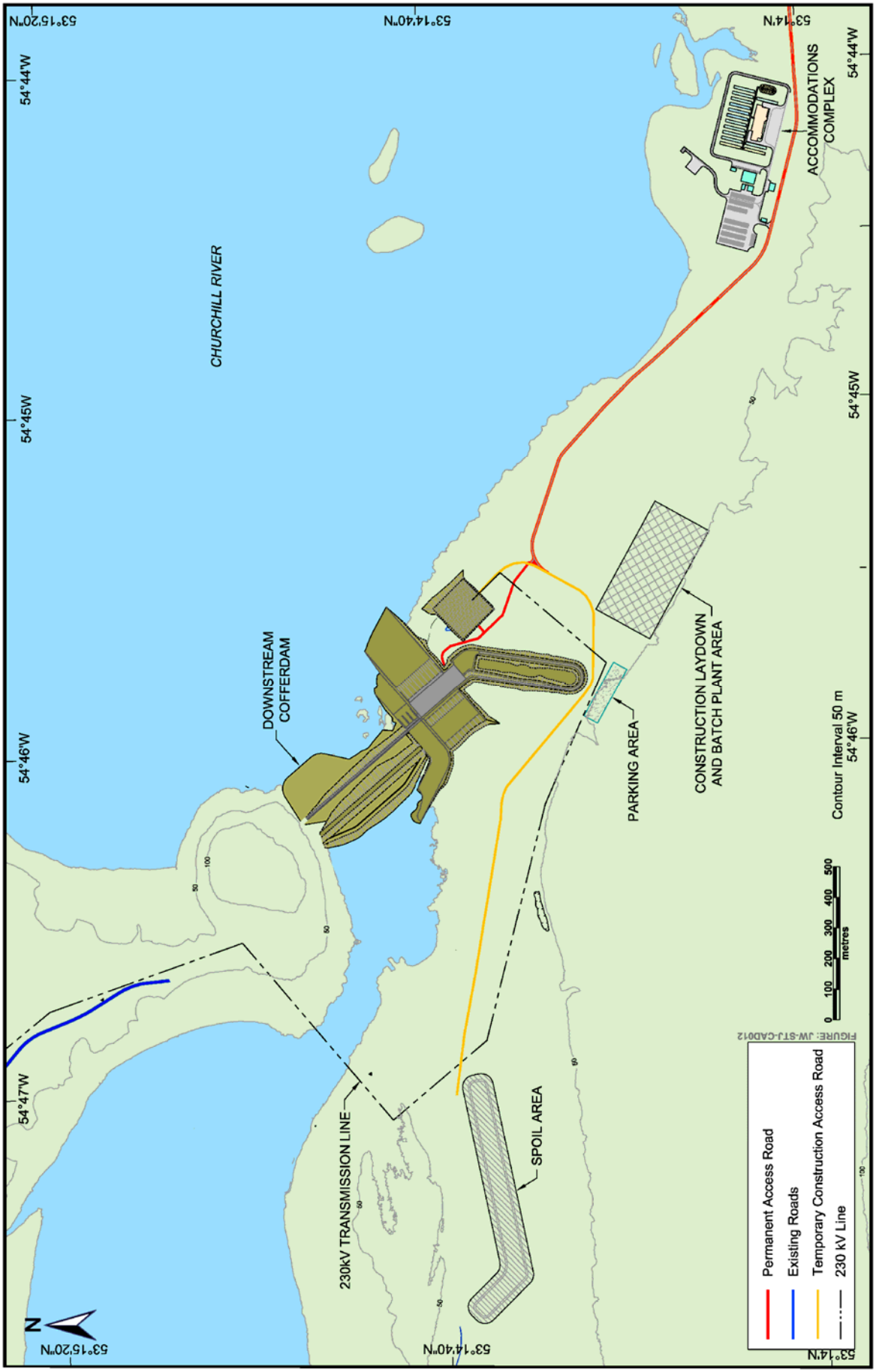


Figure 4-32 Muskrat Falls Construction Infrastructure

Accommodation Complex

The accommodation complex will be located on the south side of Churchill River near the work site. Occupancy will range from 500 persons in the first year of construction to a planned peak of 1,000.

In addition to the site accommodation facilities, available housing in Happy Valley-Goose Bay may be used for long term Project personnel.

The accommodations facility will mainly be comprised of single rooms for both male and female occupancy. Short term workers will use double occupancy rooms. The accommodations will be a two-storey configuration constructed of modular trailer units. The camp will have a dining room with a 350 person seating capacity and a kitchen designed to service up to 1,000. In addition to these facilities, the camp will also have a coffee shop, bank machines, commissary, recreation facilities, satellite TV and security systems. The site will also have a medical clinic, a post office and administrative offices. Where possible, components of the Gull Island accommodations complex will be used at Muskrat Falls.

Potable water will be supplied from groundwater wells. The water supply system will consist of deep well submersible pumps and may include treatment. An aerated sewage treatment lagoon will produce a sewage effluent to a standard suitable for discharge.

Solid waste will be stored in bear-proof containers and, pending approval from the appropriate authorities, will be regularly transported to the landfill at Happy Valley-Goose Bay or to an alternate licensed facility. A recycling program will be implemented at the camp to reduce the amount of solid waste generated.

The existing transmission line will be the main power for the site and camp. The power requirement for the camp is 2.5 MW. A backup generator will provide 1.5 MW of power.

Fuel storage on site will be similar to the fuel storage at the Gull Island Generation Facility as outlined in Section 4.4.1.1.

Communication will be available between the site and Happy Valley-Goose Bay. In addition, the camp facilities will have high-speed internet access.

Other buildings at the accommodations complex will include:

- a laboratory/water treatment facility;
- a maintenance workshop;
- a fire station and ambulance shelter; and
- a communications building.

Construction parking areas will be established at the campsite and at selected locations around the site.

Warehouses include a 195 m^2 maintenance workshop for vehicles and a 9,290 m^2 equipment inventory/storage building.

Reservoir Clearing Camps

Five temporary, self-contained reservoir clearing camps will be required for the clearing of the reservoir. The approximate locations for the temporary reservoir clearing camps are provided in Figure 4-29 (and Appendix IB-D).

Material Storage and Laydown Areas

Laydown areas for materials will occupy up to 69,100 m^2. Scheduling of deliveries will govern the amount of space utilized. The marshalling yard and warehouse space in Happy Valley-Goose Bay used in Gull Island site construction will also be available for Muskrat Falls construction. Fabrication and assembly areas are part of the total area identified for material laydown areas. Fuel and explosive storage will follow the same procedure as that described for Gull Island.

Concrete and Crushing Plant

A concrete batch plant will be located on the south side of the river. Aggregates will be crushed at source and trucked to stockpiles near the batch plant.

Borrow Pits and Quarries

Much of the rockfill and rock aggregate required for the Project will come from the structure excavations. The contractor will obtain additional rock from local sources and will excavate impervious and granular materials from suitable nearby locations. Where practical, quarries and borrow pits will be located within the future reservoir flood zone to reduce the footprint of the Project.

Standard mitigation measures will be applied and permits obtained for all quarries and borrow areas, as described in the Project EPP and Rehabilitation Plans.

Diversion Facilities

The cofferdams will be constructed of rock fill, with glacial till providing an impervious layer. Rock-filled groins will become part of the main cofferdams and will enable final closure of the river. The upstream cofferdam will have a crest length of 575 m; the downstream cofferdam will have a crest length of 300 m. Impoundment will inundate the upstream cofferdam. The contractor will remove the downstream cofferdam prior to tailrace flooding.

Spoil Areas

Spoil (i.e., overburden and rock) generated during site clearing and excavation will be stockpiled and used for site rehabilitation (Figure 4-32). The majority of this rock will be used for construction of the cofferdams. The remaining spoil will be disposed of in designated spoil areas.

As part of the 2007 field program, an acid-base accounting was performed on rock samples in order to evaluate the risk of acid rock drainage associated to the exposure of rock spoil to air and water. Tests were completed on composite samples produced from cores retrieved from boreholes. The Sobek method yielded a neutralizing potential to acid potential ratio of 2.3, indicating that the rock material is not a net acid producer.

4.4.2.2 Construction Activities and Sequence

As outlined in Section 3.7.12.2, the timing and sequencing of the construction of the sites has been designed to reduce peaks and valleys in labour demands, facilitate labour retention and increase the ability to reuse construction infrastructure. Construction of the Muskrat Falls facility commences in Year 5.

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Preliminary Activities

Similar to the construction sequence at Gull Island, the first activity will be to establish access to the site. Access will be available within three months of the start of construction, by extending the forest access road along the south side of the river.

Road access will also be integral to reservoir preparation (Appendix IB-D). Access and haul roads are required on both the north and south sides of the reservoir, totalling 86 km. As practical, the construction roads required for reservoir clearing will be located within the flood zone.

Access roads will be constructed using standard construction practices and subject to application of approved mitigation measures.

Accommodations Complex

The site selected for the accommodations complex location will require clearing and grubbing, grading and the placement of granular driving surfaces.

Spur Stabilization

Since the mid-1970s, an active system of pumped groundwater wells has been maintained along the neck of land (spur) connecting the Muskrat Falls rock knoll to the north bank of the river. This neck of land comprises erodible sand/silt/clay material. Although rendered stable through the control of groundwater elevation, the site requires additional measures prior to reservoir formation, including:

- installation of additional pumpwells to complement the existing system;
- provision of downstream erosion protection and fill;
- local topcutting of the spur and removal of high, steep slopes to improve local stability; and
- provision of upstream erosion protection and a stabilizing berm for wave protection.

Reservoir Preparation

A detailed description of the reservoir preparation strategy for Muskrat Falls and Gull Island is presented in Sections 4.2.1.3 and 4.4.1.2. An overview of the activities at Muskrat Falls is provided here.

A reservoir preparation strategy has been developed whereby 4,200 ha will be cleared of vegetation. All brush and debris will be mechanically processed. All merchantable timber will be removed from the reservoir limits via road or river transport. The removed wood fibre will be made available for use.

Mitigation measures will be integrated into vegetation removal. For example, the existing riparian zone will be protected to provide habitat refuge up until inundation. Within this zone, selective clearing will occur (i.e., only tall trees will be removed and smaller vegetation (e.g., willow shrubbery) will be left in place). As well, in selected areas, additional measures will be taken to prepare the soil surface and encourage re-growth suitable for specific habitat types.

The clearing of the Muskrat Falls Reservoir will begin in Year 5 and be completed in Year 9 and timed such that operations in the Gull Island Reservoir can relocate to the area. The first stage of reservoir clearing involves the construction of access roads and this activity will be ongoing throughout the duration of the clearing program. Work crews will start downstream and advance up the reservoir towards the Gull Island Generation Facility, they will construct additional access roads and extend existing access roads to facilitate access to the clearing areas.

Portable accommodations camps will be relocated as crews progress towards Gull Island.

Similar to the clearing for the Gull Island Reservoir, feller bunchers will complete the major portion of the cutting and will follow the same methodology as outlined in Sections 4.2.1.3 and 4.4.1.2. Manual clearing may be required but to a much lesser extent than mechanical clearing. The clearing strategy will result in the removal of an estimated 756,000 m^3 of merchantable timber from the reservoir.

Spillway

Unlike the construction sequence for Gull Island (with diversion tunnels representing a major feature of the construction), the Muskrat Falls spillway is the main diversion structure. Once the contractor has established access, construction will begin with the excavation of the spillway on the south bank of the river. In Year 7, excavation on the south bank will be completed and the civil works for the spillway will be finished. The spillway excavation will result in the removal of approximately 25,000 m^3 of overburden and 200,000 m^3 of rock. The contractor will stockpile overburden for use in site rehabilitation. Excavated rock will be used for cofferdam construction or sent to spoil areas.

In Year 7, the intakes will be completed and gates will be installed in the spillway structure.

Cofferdams

The spillway and power facilities will be constructed in the dry on the south bank of the river. The natural high ground on the south bank may be sufficient to protect the construction works from flooding; however, a low cofferdam will be installed as a precaution. During winter, ice damming may cause high tailwater levels, which also may require a low cofferdam on the downstream side of the excavations. Once the spillway is complete, it will pass all river flows during the remaining construction period.

Concurrently with the construction of the spillway, construction will commence on the main cofferdam associated with works to the north side of the facility. The contractor will advance the main cofferdam (upstream of the north dam construction site) from the north bank of the river. The contractor will remove approximately 50,000 m^3 of overburden from the north and south banks of the river for the construction of the cofferdams. In stage one of the cofferdam construction, the contractor will use rockfill from quarries or from stockpiles of materials from the spillway. Excavation will be used to construct two rockfill groins, which will partially close the river. Once the spillway is complete and the river diverted, the contractor will extend the groins across the river to complete closure. Filter material and impervious glacial till material will then be dumped between the two rock groins, sealing the cofferdam.

The downstream cofferdam (downstream of the north dam) will be a smaller rockfill berm advanced from the north side of the river. Filter material and impervious glacial till, placed on its downstream side, will seal the dam from water infiltration during periods of high tailwater levels. The two cofferdams will be constructed from materials obtained from stockpiles and from borrow pits. The contractor will then raise the cofferdams to their final elevations of 25 m (upstream cofferdam) and 7 m (downstream cofferdam). The cofferdams will be complete in Year 7. Dewatering of the area between the upstream and downstream cofferdams will commence after the first stage of the cofferdam construction. Surface pumping and deep wells in the riverbed will keep the dam foundation dry.

North and South Dam Sections

The construction of the north and south dams will require removal of overburden on the north and south banks of the river. The excavation of overburden will commence in Year 5. The contractor will strip the dam foundation

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of all overburden material to expose the underlying bedrock. A grout curtain directly underneath the dam will control seepage through any cracks or voids in the bedrock. The grout curtain will consist of boreholes drilled into the bedrock at predefined intervals and injected with impermeable grout. The grout will seal any cracks or fissures in the rock.

The on-site plant will mix the roller compacted concrete and haul trucks and conveyor belts will deliver the RCC to the placement area. Bulldozers or front-end loaders will spread the RCC into a horizontal layer, typically called a lift. The concrete will be placed in a series of successive horizontal layers, with each layer approximately 0.3 m thick. Once a lift has been compacted, it can immediately support the equipment to place the next layer. Unlike conventional concrete, RCC requires no forms, finishing or sealing. These unique properties allow rapid construction of RCC dams. The completion of the construction work for the north and south dams will be in Year 8.

Intake and Powerhouse

The intakes and powerhouse excavation will commence on the south bank of the river at the same time as the spillway excavation, in Year 5. The contractor will clear the intakes and the powerhouse site and excavate the overburden to bedrock. Rock excavation will begin in Year 6.

Rock excavation for the intakes will be completed in Year 7. Concreting the intakes will then commence. The contractor will then install the intake gates and trashracks. The intakes will be completed in Year 7.

Completion of the first phase of the powerhouse excavation will be in Year 7. The contractor will excavate approximately 150,000 m^3 of overburden and 1.2 million m^3 of rock from the powerhouse and intake locations. Much of the excavated rock material will be used in other civil works at the site. Concrete work for the units and associated service bays will then commence. As soon as the upstream and downstream walls in each turbine have been completed, the contractor will commence structural steel erection of the actual powerhouse superstructure. The contractor will then install the powerhouse crane. Steel erection will continue, as the concrete in each turbine bay is complete. The contractor will enclose the powerhouse in Year 7 and ready it for the installation of the turbines and generators.

Switchyard

Construction of the switchyard will begin with excavation and grading in Year 6. The contractor will complete the equipment foundations and equipment erection in Year 7.

Topsoil and organic material will be stripped to produce a surface area clear of soil during site preparation. The whole yard will require 200 mm to 250 mm of clean gravel to keep vegetation from growing. All slopes will be cut to at least 2:1 and the ground surface will be stabilized to prevent erosion.

Impoundment

Once the north and south dams have been constructed, impoundment will begin. Since the spillway will be the diversion structure, the spillway gates can regulate flow in order to provide for minimum downstream flow during impoundment, if required.

It will take 10 to 12 days to fill the reservoir to FSL, at which time normal downstream flows will re-commence in the river. Impoundment is currently scheduled to take place between August and October of Year 9.

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Seismic activities will be monitored before the reservoir impoundment, so as to highlight any seismic event that may occur early on during the impoundment. This will allow the rate of reservoir impoundment to be regulated to minimize the possibility of further induced seismic activity.

Site Rehabilitation

Progressive rehabilitation of work areas will be integrated into construction contracts. An overall Project Construction Restoration Plan will be developed and applied, as well as site-specific rehabilitation plans for work areas, quarries and borrow pits. More details are provided in Section 4.6.1.

Commissioning

It will take about three months to commission each turbine at the generation facility. This includes physical inspections, comparing as-built components to the original design drawings and specifications, testing in a de-energized state and energized state, in isolation, and connected to the transmission line grid, for various operating conditions. Commissioning of the first turbine is expected to be completed in Year 9, with the final turbine commissioned in Year 10. Power will start up as each turbine is commissioned.

4.4.3 Transmission Lines

The availability of site power during construction means that the transmission line construction is not a critical path item for the overall Project Schedule. The equipment and construction methods will employ proven technology and techniques with standard, proven mitigation measures available for implementation. The main challenge relates to route selection; however, the presence of existing linear facilities make the choices reasonably obvious.

4.4.3.1 Construction Infrastructure

The presence of the TLH and an existing transmission line right-of-way facilitate construction of the Project transmission lines because existing access is generally available, thus reducing the need for construction infrastructure.

Access Roads and Tote Roads

There is excellent access from the TLH throughout the proposed transmission line route from Muskrat Falls to Gull Island and to Churchill Falls. The construction of the existing 138 kV transmission line established tote roads, or access trails, from the TLH that are suitable for the proposed transmission line. The number of access trails, with the exception of one additional track at Edward's Brook will be adequate to construct the 230 kV line. Two new access trails will be required to access the 735 kV line. The access trails will be similar to the temporary construction access roads and will have an 8 m wide top and 2:1 side slopes.

As part of the 2007 engineering studies, seven stream/river crossings were identified between Muskrat Falls and Gull Island as no-fording crossings. Four of these crossings are major rivers; namely, Lower Brook, Upper Brook, Edward's River and Pena's River. Access points exist on either side of these river crossings so bridges will not be required. Another sixteen stream/river crossings were identified between Gull Island and Churchill Falls. Five of these are major rivers: Bob's Brook, Cache River, West Wilson, East Metchin and West Metchin and four crossings on a meandering section of East Wilson. Access exists on either side of these river crossings so bridges will not be required. For smaller crossing locations, the method of crossing will be determined by consultation with the regulatory authorities and the crossing method will comply with applicable standards.

The locations of access trails and fording sites are provided in Appendix IB-B.

Construction Camps

Space will be provided at the Generation Site accommodations complex for the crews that will construct the 230 kV transmission line.

For the 735 kV transmission line construction, two additional separate 150 person camps will be required: one 49 km west of Gull Island and the second 54 km east of Churchill Falls. The locations of the campsites are provided in Appendix IB-B. Both sites were used during upgrading of the TLH.

At both camp sites, a suitable water supply is available. Each will be equipped with a sewage treatment system. Solid waste will be stored in bear proof containers and trucked to the nearest waste disposal site, either Happy Valley-Goose Bay or Churchill Falls.

Marshalling Yards

Approximately 1.5 ha is required to store materials for the 230 kV transmission line. The marshalling yard will be part of the laydown area for construction of the Muskrat Falls development. Approximately 6 ha of storage space will be required for materials required for the 735 kV transmission line. The marshalling yard site is in a burnt over area near the intersection of the TLH and the access road to Gull Island. Both marshalling yards will have a Class A or gravel base and a perimeter chain link fence.

Borrow and Quarries

Construction of the lines and associated structures will require materials for fill and aggregates. Clean, acceptable fill is present over most of the line route for the 735 kV transmission line. Several existing quarries and borrow pits also exist along the line route for the 230 kV transmission line and are accessible from the nearby TLH.

4.4.3.2 Construction Activities and Sequence

Transmission lines are linear projects, which allow a contractor to commence construction activities concurrently. The start of each activity will be staggered to allow crews to move sequentially down the transmission line route completing each phase of construction. The following paragraphs detail these construction activities. Construction of the transmission line is scheduled from Year 2 to Year 9.

Clearing and Access

The right-of-way clearing involves removal of all vegetation that exceeds 1 m in height at maturity. Clearing will consist of cutting trees within 15 cm of the ground and properly disposing of all standing trees, as well as removing of shrubs and slash from the area. The contractor will cut all trees into consistent lengths for neat piling, along the side of the right-of-way. Approximately 250,000 m^3 of wood will be cleared along the right-of-way. The contractor will use chain saws, hand-held equipment or mechanical harvesters, as appropriate.

The contractor will pile brush and slash along the side of the right-of-way. Brush piles will not be higher than 3 m. Along the right-of-way, there will be a 6.5 m break in slash piles at least every 200 m to allow for lateral drainage and wildlife access.

The right-of-way clearing will take into account:

- location and identification of watercourse crossings along the right-of-way;

- widths of watercourses;
- location of wetlands;
- areas of commercially valuable timber and the method of cutting and storing;
- required buffer zones along watercourses and at sensitive areas;
- special clearing requirements; and
- locations of roads required to bypass zones of difficult access in the right-of-way.

Effort will be made to minimize the unnecessary removal of low growing vegetation with due consideration for the safety, reliability and maintenance of the transmission lines.

An access trail will be constructed along the cleared right-of-way. The trail will be routed to stay away from sensitive areas such as small wetlands. All relevant EPP measures will apply to construction and maintenance of the trail.

Material Distribution

Distribution of materials along the route is essential for the construction of transmission lines. An offroad tracked machine or helicopter (as appropriate) will distribute materials.

Foundation Installation

Foundation installation requires excavating overburden at each of the tower locations. Tower foundations may be on bedrock, requiring the installation of rock anchors or in some cases blasting and excavation. In order to prepare foundations, fill materials from borrow pits may be required.

Tower Assembly and Erection

Once the materials have been distributed along the right-of-way and the foundations put in place, the steel members will be bolted together to form the lattice structure. An off-road crane will lift the tower and place it on the foundation. The contractor will then bolt the tower to the foundation. Some towers will be free-standing and not require guy wires; for others, tensioned guy wires will be installed to anchor the tower.

The contractor will then install hardware on the towers in preparation for the conductor.

Conductor Stringing

The final stage in transmission line construction is stringing the conductor and attaching the conductor to the steel structure. The contractor rolls the conductor onto the line using stringing blocks, which are pulleys used to facilitate stringing from structure to structure.

Commissioning

Commissioning the proposed transmission line is related to mechanical acceptance so that all hardware is in place and properly installed.

4.4.4 Material Requirements and Delivery

The construction activities outlined in the preceding sections require large volumes of materials and equipment. These materials will be procured from various sources and delivered to the sites. Some material such as rock and aggregate will be accessed from local quarry and borrow pits.

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Large volumes of cement are required for concrete work for both sites. Approximately 300,000 tonnes will be required and will be trucked to the site from Goose Bay, as needed.

The Project requires other materials such as 22,000 tonnes of explosives for rock excavation and 30,000 tonnes of reinforcing steel. Gates, hoists and other parts are required, as well as mechanical and electrical equipment and generators, weighing over 12,000 tonnes. Camp supplies will also be required.

There will be some heavy load items (defined as items weighing over 100 tonnes), the heaviest being the power transformers, each weighing 250 tonnes. All heavy loads will be on special floats with axle loads in accordance with highway load limits.

Two options are available for transporting of heavy/wide loads to the Project sites. The first is by marine transport to the port of Happy Valley-Goose Bay, then by road via the TLH to the generation facility sites. The second option is marine transport to Sept-Îles and then rail via the Quebec North Shore and Labrador Railway (QNSLR) to Emeril Siding and by the TLH to the generation facility sites (Chapter 5, Figure 5-7).

The ability of the port in Happy Valley-Goose Bay to handle the heavy loads will be investigated and confirmed. As designed, the facility can meet Project requirements; because of its age however, the Project Team will conduct assessments (diving inspection and structural analysis) to determine whether repairs or upgrades will be required. If it is determined that such work is required, a request will be submitted to the Newfoundland and Labrador Department of Transportation and Works (NLDTW).

There are no other major issues associated with access from the port of Happy Valley-Goose Bay to the Project sites for the transport of heavy/wide loads and materials. A structural analysis of the four bridges on the TLH between Happy Valley-Goose Bay and the Project sites (Lower Brook, Upper Brook, Edwards Brook and Pena's River) indicated that bridges could accommodate the 250 tonne transformer load. The road between the Gull Island site and Happy Valley-Goose Bay is due to be paved. Widening is currently ongoing and will continue for the next three to four years. Additionally, there are plans to chip seal the remaining 450 km between Gull Island and Wabush over the next four years. Consequently, the highway will provide an adequate level of access for the Project.

Black Rock Bridge was evaluated as part of the 2007 field studies. This bridge provides access to the south side of the river for the construction at Muskrat Falls, including the delivery of heavy loads such as the transformers. This structure will require upgrading or alternate measures to accommodate the 250 tonne load. These requirements are the subject of discussion with the NLDTW.

The alternate route from Sept-Îles was examined and confirmed viable. The QNSLR services the Churchill Falls Power Station and can support heavy loads. As well, as part of the TLH upgrading project, NLDTW indicated that all bridges on the TLH between Labrador West and the Project sites would accommodate heavy loads.

An estimated 22,000 tonnes of material is required to construct the transmission line. The delivery of these materials will also be by marine transport to Happy Valley-Goose Bay and by road to marshalling yards at Gull Island or Muskrat Falls.

Some manufacturers will also choose to transport loads by road to the Project sites or by road to Sept-Îles and then by rail.

The total volume of fuel needed for the Project is estimated to be 165 million L.

4.4.5 Traffic

The construction activities and delivery of materials outlined above will result in increased traffic around and in transit to the Project sites.

As part of the 2007 engineering studies, an estimate was developed of the total amount of materials moving through Happy Valley-Goose Bay. Approximately 184,500 tonnes will be required over the construction phase of the Project. For the basis of estimating traffic through Happy Valley-Goose Bay, it is assumed that all material delivery for the Project, with the exception of camp supplies, equipment supplies and miscellaneous items, will be through Happy Valley-Goose Bay. Distribution of the materials will not be the same over the life of the Project, and will peak at 60,000 tonnes per year, exclusive of fuel. Based on an average of 30 tonnes per trailer load, there will be 2,000 trips per year. With a shipping season of five months, the number of truck trips is 14 per day. Adding fuel trips and camp supplies, the truck traffic on the TLH will be approximately 16 round trips per day for material delivery. This traffic volume is well within design capacity of the public roads.

Given the size of the workforce, the Project will provide transportation from defined points in Labrador and the Island to the work site. Traffic will result from the requirement to transport personnel between the sites and Happy Valley-Goose Bay. There will be a regularly scheduled bus service operating to transport workers to the site, including local residents. All workers will be urged to use the bus system, and there will be limited parking on-site for private vehicles, the use of which will be discouraged for safety reasons. There will be approximately five bus trips per day to transport personnel.

In addition to personnel and materials, trucks may also use the TLH to transport up to 1,700,000 m^3 of fill and granular materials from borrow areas within hauling distance of the sites. The majority of these trips will be within each site and along construction roads. Transport of these materials will use 40 tonne semi-dump trailers or equivalent. This activity will produce 25 to 40 trips per day to transport rock and aggregate to the sites.

At present (2009) Hamilton River Road in Happy Valley-Goose Bay does experience peak-hour traffic congestion. The construction phase of the Project could add marginally to this. Alternatives will be examined to minimize congestion. The scheduling of traffic may be one simple solution. Alternately, road widening may reduce traffic congestion. An alternative access from the port to the TLH could be achieved along an upgraded South Branch Road or by extending an existing road around the west side of the airport to the TLH. As detailed planning continues, these various alternatives will be considered and discussed with the municipality.

4.5 Operation and Maintenance

The Gull Island and Muskrat Falls generation facilities will be operated remotely using the Hydro Energy Management System. This system operates the network for efficient delivery of electricity. For safe operation and protection of the environment, remote monitoring systems will be installed to monitor:

- weather conditions, including wind, rainfall and temperature;
- reservoir, intake, sump and tailrace water levels;
- trash rack differentials;
- ice conditions;
- fuel levels and flows of the emergency diesel storage system;
- presence of oil in interceptor tanks; and
- oil levels in equipment including main transformers, power transformers, turbine and generator bearings, governor sumps and accumulator tanks and any major oil storage tanks.

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4.5.1 Gull Island

The Gull Island Generation Facility will be operated from the ECC in St. John's. The ECC will continuously monitor all critical points, including water levels and loading. The generation facility will also have the flexibility to be controlled locally from a control room at site.

4.5.1.1 Operating Regime

In order to maximize power and energy output, Gull Island Reservoir will be operated as close to FSL (125 m) as possible, while giving consideration to short term inflows and near-term production requirements, with minimum fluctuations in water level. The fluctuations will reflect daily/weekly load swings. The site will be operated primarily as a base/intermediate load plant; daily fluctuations will be in the order of a few centimetres and weekly fluctuations could be up to 1 m. These fluctuations will result from hydraulic and production imbalances, which will be minimized. Over the course of the year, there may be periods of time when the reservoir level will change. For example, in preparation for the substantial inflows that result from melting snow in the spring, the reservoir could be drawn down to LSL at 122 m and could rise in a few days to FSL at 125 m. The reservoir has the capacity for additional storage in order to handle extreme flood events up to a maximum flood elevation of 127 m.

Water management agreements are standard on rivers with more than one operator. The provincial government is currently moving to regulate the coordination of water management on provincial rivers so that hydroelectric facilities operating on the same river work together. This optimizes the value of the resource, and therefore benefits both the Province and power generators. As a result of this legislation, the reservoir level of the Gull Island facility will operate as close to the 125 FSL as possible to maximize the efficiency of the facility. The amendment to the *Electrical Control Power Act* (ECPA) provides a framework for the Public Utilities Board (PUB) to regulate the coordination of water management agreements. The amendment allows for the delivery commitments under existing power contracts to be honoured, including the 1969 power contract for the Upper Churchill. The amendment provides hydroelectric operators sharing a river system, as will be the case on the Churchill River with the Upper Churchill and the Project, with certainty over the coordination of water flow. Through this amendment, the needs of both the Churchill Falls Power Station and the Project will be accommodated.

4.5.1.2 Monitoring and Maintenance

Maintenance personnel will reside in the town of Happy Valley-Goose Bay. The normal work schedule requires that workers commute to site five days a week to conduct routine maintenance. Other ongoing activities include worker protection, minor preventative maintenance, operational checks, environmental checks and safety checks. General housekeeping and condition monitoring and analysis of the generation facility will also be required.

The maintenance crews will also assist other maintenance crews and contractors for major inspections and overhauls and will complete daily checks of instrumentation and equipment. The plant engineer(s) will perform frequent engineering analysis of any readings (data collected). If the engineer(s) observe any data changes or inconsistencies, the issue will be flagged for further investigation. Instrumentation will continuously monitor water, diesel fuel and oil systems.

Weekly checks will include dam surveillance to inspect for erosion, rainfall damage and sloughing. Each week, personnel will conduct a reconciliation of fuel tanks as well as tests on fire pumps and emergency diesels. On a monthly basis, personnel will inspect the domestic water system.

Personnel will also conduct semi-annual surveys of the dam to check for movement of the dam or elevation changes. There will be semi-annual operational checks of the spillway gates.

Each year, personnel will conduct a vegetation management program to remove vegetation from the dam and an annual calibration chart for the water level monitoring system. Personnel will also remove trash from the trash racks. An inspection of the spillway (including hoists, heating systems and gates) will determine if the spillway is functioning properly and whether components are corroded. Annual road and access road maintenance will also be required. Fire protection systems, generators, transformers and the powerhouse will be inspected annually, including the turbines and auxiliary equipment (pumps, compressors, air conditioning systems, overhead cranes). Personnel will also inspect transformers and switch gear.

4.5.1.3 Accommodations

As noted, maintenance personnel will reside in Happy Valley-Goose Bay; however, a small accommodation building will be provided at site for crews and contractors performing major inspections and overhauls.

4.5.2 Muskrat Falls

4.5.2.1 Operating Regime

The Muskrat Falls Generation Facility will be operated remotely using a system and maintenance schedule similar to that outlined in for the Gull Island Generation Facility in Section 4.5.1. The generation facility also has the flexibility to be controlled locally at site. Monitoring and maintenance will be completed by crews based in Happy Valley-Goose Bay.

As with Gull Island, Muskrat Falls will be operated as close to FSL (39 m) as possible, with minimum fluctuations in water level. These fluctuations will reflect daily load swings due to hydraulic and production imbalances, which will be minimized. The plant will operate as a base load plant; daily fluctuations will be in the order of a few centimetres and weekly fluctuations will be to a maximum of 0.5 m.

The reservoir is designed for additional storage in order to handle extreme flood events. Muskrat Falls Reservoir has a maximum flood elevation of 44 m.

It is not anticipated that ice, including frazil ice, will be an issue for plant operations. The reservoir will form a stable ice cover upstream of the dam; therefore, frazil ice generation will not be an issue. The intake gates will be located below this stable ice cover.

4.5.2.2 Monitoring and Maintenance

The operation and maintenance of the Muskrat Falls Generation Facility will be similar to the details outlined for the Gull Island Generation Facility in Section 4.5.1.2.

4.5.2.3 Accommodations

Given the proximity of the Gull Island Generation Facility to Happy-Valley-Goose Bay, there will be no accommodations at site.

4.5.3 Transmission Line

Line maintenance activities include regular inspection, repair of the line and the management of vegetation along the right-of-way. Line maintenance crews will be based in Labrador.

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4.5.3.1 Inspection and Maintenance

The transmission line and right-of-way will be inspected and maintained via tracked vehicle or helicopter. General surveillance surveys are usually conducted by helicopter to establish condition of conductors, insulators and tower structures. Raptor nesting sites will be mapped and a no-fly zone will be applied. In winter, snowmobiles will be employed for closer inspection of the structures. Scheduled maintenance will be completed from tracked vehicles in summer. Only approved routes will be followed to access the right-of-way and environmental protection measures (as per the Operational EPP) will be applied.

4.5.3.2 Vegetation Management

Vegetation growth along rights-of-way can be a safety concern to maintenance crews and the public. Trees are very good conductors of electricity, and the presence of dense vegetation can prevent crews from responding promptly to emergency situations and outages.

Vegetation management encourages the development of plants compatible with utility operations, encouraging natural biological control of vegetation, and providing a safe environment for people and wildlife.

In Labrador, re-growth is slow with the result that following the initial right-of-way clearing, infrequent maintenance is required. As well, given the time scale for the Project, it can be expected that new and improved vegetation management practices will evolve. Nalcor Energy will stay current with such developments and implement changes as appropriate. The description below reflects current vegetation management practices and protocols.

The integrated vegetation management program employs several methods including the use of herbicides. The selective use of herbicides on rights-of-way, following cutting produces a low, dense plant cover that discourages the invasion of nuisance vegetation while encouraging the growth of compatible vegetation.

Cutting is often sufficient to control softwood such as spruce and balsam fir, but only provides short term control for hardwood such as birch, maple and aspen because of multiple sprouting from undisturbed roots. The selective use of herbicides, following cutting, offers long term control of tall trees. Only problem trees are selected for treatment, leaving a diversity of desirable species such as shrubs and wildflowers.

Vegetation management commences three to four years after construction is completed. Crews will use approved herbicides (e.g., Tordon 101), as per current standard operating practices, mixed with a surfactant such as Sylgard 300, which will be sprayed using a tracked vehicle with a 1,500 or 2,000 L tank. The quantities of chemicals used will depend largely on terrain, as well as quantity and type of vegetation. A detailed survey will be necessary prior to beginning each vegetation management program.

The herbicide will be sprayed directly so that application is confined to areas requiring treatment (i.e., tall-growing species). Shrubs and bushes will not be sprayed. This vegetation management program will be carried out every eight to 10 years. The management schedule varies with the type of vegetation, the extent of ground disturbance during construction, and terrain and experience gained in operations.

Cut and stump applications may also be used and involve cutting the vegetation and applying herbicide to the freshly cut stumps to control re-sprouting of woody species. This vegetation control method will use such products as Tordon 101, Garlon 4 and glyphosate products.

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4.5.3.3 Electromagnetic Fields

Electromagnetic fields are associated with all transmission lines and their strength diminishes with distance from the transmission lines. In the design of high voltage transmission facilities, the conductor lines are suspended in the air and isolated from the tower structures such that large distances separate the transmission lines from the ground. As a result, measurable electromagnetic fields at ground level are within acceptable (low) levels and generally not detectable beyond the right-of-way.

4.6 Decommissioning and Restoration

There are no plans to decommission the Project and therefore, it is not part of the environmental assessment. Any future decommissioning/abandonment activities will be subject to future examination under the *NLEPA* and *CEAA* or other legislation as applicable at the time of decommissioning.

At the conclusion of construction, temporary infrastructure will be removed and restoration of sites will be conducted. These activities are described below.

4.6.1 Construction Site Restoration

During construction, areas of disturbance will be created by the works, storage and waste disposal areas. Areas of disturbance will also be created by borrow pits and quarries and both temporary and permanent access roads.

The restoration of work sites, including the transmission line and removal of construction infrastructure will be incorporated into the contract technical design specifications. This will assist in the progressive restoration at the work sites, quarries and borrow pits. All such activities will be in accordance with Restoration Plans and the Project EPP. An overall Project Construction Restoration Plan as well as site-specific rehabilitation plans will be developed and implemented. Standard, proven techniques are available and will be employed to return work sites to an environmentally appropriate state. Site restoration planning will apply from the start of construction. For example, during initial site clearing, the topsoil or organic layer will be stripped and stored separately for subsequent access and use in site rehabilitation. Removal of the temporary construction infrastructure and site rehabilitation is discussed in the following paragraphs.

4.6.1.1 Primary Construction Sites

All temporary surface infrastructure associated with the construction sites will be dismantled and removed. This includes the accommodation complexes, workshops, warehouses, material storage and laydown areas, marshalling yards and the concrete plants. Permanent drainage patterns will be established at the sites through grading, which will also reduce erosion.

Natural revegetation of disturbed surfaces will be encouraged where applicable and where required (e.g., by scarifying, then grading, contouring and spreading of stockpiled organics). Appropriate active revegetation (seeding or planting) will be conducted (soil and terrain conditions permitting).

Periodic inspections subsequent to rehabilitation and abandonment of the construction sites will be conducted to measure the success of the restoration measures and to apply adaptive management techniques if needed. Benchmarks for success will relate to the establishment of stable surface areas (e.g., with vegetative growth), and staying away from erosion/slumping phenomena. Surveyed areas will be re-treated and appropriate remediation measures applied to address any anticipated or observed failures of restoration measures.

4.6.1.2 Dewatering and Sediment Control Structures

Silt fences and other siltation control structures will be removed when no longer required. The settling basins will be stabilized and any impermeable liners, such as plastic, will be removed and properly disposed of. The settling basin will then be filled in, graded and landscaped as required. Ditches and surface water interception will be filled in and stabilized.

4.6.1.3 Temporary Access

Following completion of construction activities, the temporary construction bridge at the Gull Island Generation Facility will be removed.

Bridges and culverts at stream crossings along all temporary access roads will be removed as these structures are designed to be temporary in nature. Road surfaces will be scarified to promote natural regeneration of a productive forest. Roadside ditches along temporary access roads will be backfilled using existing road surface or other suitable material. Stream banks around disturbed areas will be stabilized to provide erosion protection.

4.6.1.4 Borrow Pits and Quarries

Rehabilitation of borrow areas will include restoration of natural drainage and re-establishment of stable gradients. Where land is compacted, the contractor will be responsible for loosening up the ground to make it suitable for introduction of tree or shrub plants. Permanent drainage patterns will be established through grading, which will also reduce erosion.

4.6.1.5 Spoil Areas

Any remaining spoil areas will be graded to a natural slope and capped with stockpiled organic material in order to encourage revegetation.

4.7 Potential Future Modifications

There are no plans for potential future modifications. Any future modifications, if proposed, will be subject to examination and approval under legislation applicable at that time.

4.8 Environmental Management

The Project, in all its phases, will be designed, constructed and managed in accordance with the Hydro's EMS. The EMS provides a framework for the design and implementation of environmental protection planning and monitoring

4.8.1 Environmental Management System

Environmental protection measures and mitigations will be managed and controlled through the EMS. An EMS monitors environmental performance and integrates environmental management into a company's daily operations, long term planning and other quality management systems.

Currently, Nalcor Energy has an overall corporate EMS, which comprises:

- an **Environmental Policy:** this is a statement of what is intended to be achieved from an EMS. It determines if all environmental activities are consistent with objectives.

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- **Environmental Risk Identification:** identification and documentation of the actual and potential environmental effects of operations. This is achieved through undertaking an environmental audit. A similar process will be undertaken as part of the planning process for the Project. All planned activities will be audited and the potential environmental risks identified.
- **Objectives and Targets:** the environmental audit forms the basis for environmental objectives and targets. To continually improve, targets will be regularly reviewed. Project-specific objectives and targets will be set.
- **Consultation:** staff and community consultation were carried out before, during and after establishment of the EMS. This was necessary to obtain the compliance of all staff to be involved in, and committed to, the EMS.
- **Operational and Emergency Procedures:** all procedures are reviewed for compatibility with environmental objectives and targets. Any changes are included with the documentation.
- **Environmental Management Plan:** this details the methods and procedures to be used to meet objectives and targets.
- **Documentation:** all objectives, targets, policies, responsibilities and procedures are documented along with information on environmental performance.
- **Responsibilities and Reporting Structure:** responsibilities are allocated to staff and management so that the EMS is implemented effectively.
- **Training:** staff has undergone and continues to undergo environmental awareness training to familiarize them with their responsibilities for implementing the EMS and with the overall environmental policy and objectives.
- **Review Audits and Monitoring Compliance:** review audits are undertaken regularly to determine if the EMS is achieving its objectives and to refine operational procedures to meet this goal. In order to determine if regulatory and other requirements are being met, regular environmental monitoring is conducted as necessary.
- **Continual Improvement:** an important component is continual improvement. An EMS comes into its best use when used to review progress towards the targets and objectives set by a company to protect the environment. The procedures set in place to meet these objectives will be constantly examined to see if they can be improved or if systems that are more effective can be introduced.

To develop the corporate EMS, Nalcor Energy has assessed its environmental influence, set targets to reduce negative effects and has set a plan in place to achieve these targets.

As part of the development of its EMS, Hydro is ISO 14001 compliant. The ISO 14000 series is a collection of voluntary standards that assists organizations to achieve environmental and financial gains through the implementation of effective environmental management. The standards provide both a model for streamlining environmental management, and guidelines to determine if environmental issues are considered within decision making practices. ISO 14001 is the standard for EMS.

The Project will build upon the existing EMS system in place while implementing Project-specific objectives and targets based on the identification of potential environmental effects.

4.8.2 Environmental Protection and Mitigation

In addition to the concept of mitigation through design, the Project itself incorporates standard environmental protection measures that have been developed and proven through the extensive experience of the Project Team and contractors.

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The Project will be constructed in accordance with the principle of environmental mitigation systems. It will include aspects of the Project, such as siltation and erosion control, in the design and will provide these design details as technical specifications in contracts. This allows the Project to meet the guidelines and standards set out in the EPP in a practical and efficient manner.

4.8.2.1 Environmental Protection Plan

Environmental protection is an important component of overall Project planning and implementation. EPPs are commonly required as part of a project approval by governments following the environmental assessment stage of project planning and before construction development occurs. EPPs provide a practical way in which proponents can demonstrate their understanding of environmental regulations, practices and procedures required to reduce or eliminate potential negative environmental effects.

Nalcor Energy is committed to the development and application of a comprehensive EPP to help achieve a high level of environmental protection throughout its work areas and activities associated with the Project. An EPP is a working document for use in the field for both Project personnel and contractors. As well, at the corporate level the EPP provides a means to assign responsibility and an important means to translate policy statements into action. EPPs provide a quick reference for Project personnel and regulators to monitor compliance and to make suggestions for improvements.

In addition to the Project EPP, site-specific EPPs will be completed to address key Project components. The plans will address site-specific environmental concerns.

The purpose of the EPPs will be to:

- identify environmental concerns and general protection measures to be considered in the development of mitigation measures;
- provide a reference document for the development of site-specific mitigation measures;
- provide expectations with regards to orientation and awareness; and
- communicate changes to the program through the revision process and provide a reference to the applicable legislative requirements and suggested reference material for the development of mitigation measures.

The Project EPP outlines the context of the document, the environmental and planning aspects of the Project and provides a list of Project policies. The Project EPP outlines general environmental protection procedures used to guide the plans for specific work areas. The site EPPs address site-specific conditions and the construction/design requirements of the Project and identify environmentally sensitive areas and periods, as well as other key environmental concerns associated with the work. Site EPPs also detail site-specific environmental protection measures, rehabilitation measures, waste management and contingency plans for accidental events and malfunctions.

The Project EPP will be updated and modified as required according to the Project phase and as determined by site-specific conditions and monitoring results. A table of contents is provided in Appendix IB-G.

4.8.2.2 Environmental Orientation

Nalcor Energy is committed to an active orientation and ongoing environmental awareness program throughout the Project construction and operation phases. All workers will receive environmental orientation prior to initiating work at the Project sites. A detailed worker orientation plan will form part of the site-specific EPP.

4.8.2.3 Development of Specific Environmental Protection Plans

Site-specific environmental protection measures will be developed for key Project components. The EPPs will address:

- temporary and permanent access roads (upgrading and construction);
- campsite development;
- diversion structures (including cofferdams);
- main dam construction;
- intake, penstock and powerhouse;
- tailrace;
- spillway;
- de-watering operations;
- reservoir preparation; and
- transmission line construction.

A thorough analysis of all planned activities will be conducted prior to the start of construction to identify activities that will require an EPP. Each plan will identify potential effects of the planned activity, the consequences of the effect, what will be done to mitigate the effect, adaptive management provisions, contingency measures and responsibilities for implementation and compliance monitoring.

Specific EPPs will include the following:

- a description of the anticipated construction sequence and work methods;
- a description of environmentally sensitive areas or periods relating to fisheries, wildlife, vegetation, other land use and historic resources as appropriate for the context of developing site-specific environmental protection procedures, contingency plans and site rehabilitation measures;
- site-specific environmental protection measures with appropriate use of illustrations;
- compliance policies, procedures and rules for contractor and subcontractor personnel;
- environmental awareness training for contractor and subcontractor personnel;
- a description of surveillance monitoring, compliance monitoring and integration of ongoing wildlife monitoring, if applicable;
- permit control and management including all permits, authorizations and approvals;
- document control and maintenance appropriate for the mitigation plan;
- identification and contact list of key personnel including regulators and resource managers, appropriate for the mitigation plan; and
- detailed contingency or environmental emergency response plans.

Contingency plans will be developed for:

- spills of fuel and other hazardous material on land;
- spills of fuel and other hazardous material in water bodies;
- wildlife presence and nuisance wildlife;
- fires;

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- discovery of historic resources; and
- floods.

4.8.2.4 Standard Environmental Protection Procedures

The Project EPP contains general environmental protection procedures outlined in the following sections. Additional procedures will be developed as required for the Project.

Clearing of Vegetation

Vegetation clearing will be required in advance of road construction, surveying, building construction and other site preparation activities. Concerns related to clearing include the piling of slash in or near watercourses and encounters with historic resources.

Standard environmental protection procedures will include the removal of vegetation in such a manner that will accommodate salvage of merchantable timber. Measures will be implemented that will reduce the potential environmental effect of vegetation removal. Clearing activities will be limited to those areas that are required for Project development and site infrastructure and will comply with the requirements of all applicable permits, including the Commercial Cutting Permit.

Areas to be cleared of vegetation will be identified in drawings accompanying the site-specific mitigation plans. Only those areas designated on the drawings will be cleared. Trees will be clearly marked at intervals in advance of clearing to demarcate the limits of the work.

Slash and any other debris will not be permitted to enter any watercourse. A buffer zone of 15 m from the highwater mark of water bodies will be established in areas where clearing of vegetation is to be undertaken near a water body.

Timber will be felled inward towards the work area so that standing trees within the immediate work area will not be damaged. Measures will be implemented so that workers do not destroy or disturb any features indicative of a cultural or archaeological site. Such sites will be isolated until the Historic Resources Division of the Newfoundland and Labrador Department of Tourism, Culture and Recreation is notified and clearance to proceed has been received.

Temporary and Permanent Access Roads

Temporary and permanent access roads have the potential to interact with the environment at various stages of development; such Project activities include clearing of vegetation and establishing the temporary/permanent access roads and associated water crossings. Procedures to mitigate these interactions are outlined in the relevant sections for various construction activities such as clearing of vegetation and stream crossings. As well, there is the potential for interaction when the roads are built through run-off and erosion areas, and when vehicular traffic interferes with wildlife.

In order to limit potential Project interactions, existing access roads will be used wherever possible.

Open drainage ditches will be used for drainage, combined with galvanized steel culverts where required to provide cross-grade drainage. The drainage ditches will have check dams, combined with ditching, in erosion prone areas and they will consist of well-graded blast rock as per DFO's *Guidelines for the Protection of Freshwater Fish Habitat*.

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Cut areas through silts and clays will have erosion prevention measures such as soil stabilization blankets and matting. A combination of seeding and mulching will also be used as required and as appropriate to help prevent erosion of material during high water flows. The use of seeding will depend on the design life of the access road, as vegetation will require time to become effective.

Only essential vehicular activity will be permitted on the construction sites and access roads to the construction sites and speed limits will be posted to reduce the potential for vehicle collisions with wildlife.

Grubbing and Disposal of Related Debris

The principal concerns associated with grubbing and disposal of related debris are the potential adverse effects on freshwater ecosystems and water quality through the release of sediments into water bodies and disturbance of wildlife by heavy equipment. The work will be undertaken in such a way that disturbance to the environment is reduced.

Grubbing will be done so that, wherever possible, the organic vegetation mat and upper soil horizons will not be left in place. During any grubbing activities, special precautions will be taken to divert surface runoff and control sediment laden water (e.g., by use of settlement basins). Where grubbed materials are re-spread or stockpiled, as many stumps and roots as possible will be left on the ground surface to maintain soil cohesion, to dissipate energy from runoff, and promote natural revegetation. Erosion control measures will be implemented in areas prone to soil loss; these measures include brush cover, stone rip rap, wire mesh, settling ponds and drainage channels. Appropriate practices for specific sites will be developed and outlined. The length of time that grubbed areas are left exposed to natural elements will be reduced to prevent unnecessary erosion.

Overburden and topsoil from grubbing activities will be stored for the purpose of site rehabilitation.

Storage, Handling and Transfer of Fuel and Other Hazardous Material

Fuel and hazardous materials can damage vegetation, soil, surface water, groundwater, wildlife, aquatic organisms, historic resources and human safety and health.

All necessary precautions will be taken to prevent and reduce spillage, misplacement or loss of fuels and other hazardous materials. These precautions will include but are not limited to:

- All fuel storage and handling will be in accordance with the *Storage and Handling of Gasoline and Associated Products Regulations* CNR 775/96. Necessary approvals will be obtained from the Newfoundland and Labrador Department of Government Services.
- Fuels and other hazardous materials will be handled by trained and qualified persons in accordance with the manufacturer's instructions and government laws and regulations. Operators will be in attendance for the duration of the refuelling operation.
- Oils, grease, gasoline, diesel or other fuels will be stored at least 100 m from any surface water.
- Fuel caches of helicopter fuels stored in 205 L drums will be established within the Project area as required. All fuel caches will be operated as per conditions of approvals from the government services centre. All helicopter refuelling will be done at these locations.
- Gasoline for chainsaws and water pumps will be stored in approved 20 L storage containers.
- Regular inspections of hydraulic and fuel systems on machinery will be performed by Project personnel, and leaks will be repaired immediately upon detection. Servicing of mobile equipment on land will not be performed within 50 m of a watercourse.

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- Water pumps used within 50 m of a watercourse will be equipped with a drip pan and lined with absorbent material to collect any leaks or spills that may occur.
- Bulk fuel storage will be established at least 100 m from any surface water.
- Handling and fuelling procedures will comply with the *Storage and Handling of Gasoline and Associated Products Regulations* (CNR 775/96) and any additional requirements of forth by the NLDEC to limit potential contamination of soil or water.
- Any above-ground container, with the exception of those exempted under *Newfoundland and Labrador Regulation* 775/96, will be placed on an impervious mat and will be surrounded by an impervious dyke of sufficient height (minimum height 0.6 m) to contain a specified amount of fuel. Fuel storage areas and non-potable transfer lines will be clearly marked or barricaded so that they will not be damaged by moving vehicles. The markers will be visible under all weather conditions and barriers will be constructed in compliance with the *Storage and Handling of Gasoline and Associated Products Regulations* (CNR 775/96).
- Waste oils, lubricants and other used oil will be disposed of at an approved disposal site. Waste oil will be stored in drums (clearly marked waste oil) inside of a dyked area and will be shipped for disposal on a monthly basis.
- All storage tank systems will be inspected on a regular basis as per Sections 18, 20 and 21 of the *Storage and Handling of Gasoline and Associated Products Regulations* (CNR 775/96).
- Any soil contaminated by leaks or spills of any petroleum product from equipment will be excavated, stored in an approved container and disposed of off-site at a licensed disposal site.
- A supply of absorbent material and a spill kit will be kept on board each piece of heavy equipment and at every fuel storage location.
- Smoking will be prohibited within 10 m of a fuel storage area.

In the event of a fuel or hazardous material spill, the procedures outlined in Section 4.11.2 will apply.

Sewage Disposal

The release of untreated sewage is a concern to human health, drinking water quality and freshwater and marine ecosystems.

The Project will comply with all the requirements of the *Health and Community Services Act* (SN1997, plus amendments). Approval will be obtained for water and sewer systems, grey water systems, food dispensing systems and potable water systems to be used at permanent and temporary facilities and remote sites. For water and sewage systems with a capacity of less than 4,500 L/day, approval will be obtained from the Government Services Centre regional office. For water and sewage systems with a capacity greater than 4,500 L/day, approval will be obtained from NLDEC.

The sewage disposal system will comply with the Newfoundland and Labrador Department of Health and Community Services guidelines and the *Department of Environment and Lands Act* (RSN1990, Chapter D-11, plus amendments), *Environmental Control Water and Sewage Regulations* (Consolidated Newfoundland Regulations 1078/96 under the *Environment Act* (O.C. 96-254)).

The tile field at the sewage treatment facility will be clearly marked and vehicular traffic will not be permitted to operate within this defined boundary.

Solid Waste Disposal

Solid waste (i.e., domestic waste, food, paper, cardboard, wood) if not properly controlled and disposed of, can affect aesthetics and may cause human safety and health concerns and could result in conflict with wildlife. Disposable wastes will be stored in a leak proof container and disposed of at an existing approved municipal landfill site. Recyclable materials will be collected separately and provided to an approved recycling facility.

All waste produced will be collected and disposed of at an approved waste disposal facility. No waste material will be deposited in any watercourse.

Prior to mobilization, a Waste Management Plan will be developed for the Project. The Waste Management Plan will include methods for waste stream separation, collection, storage, transport and disposal, and associated schedules.

Waste streams will be separated and appropriate receptacles will be provided for the collection of recyclable materials; aluminum, glass, paper, cardboard and plastic. Construction scrap and debris will be separated into disposable and salvageable materials.

Waste accumulated on site prior to disposal will be confined in animal-resistant containers so that it does not pose an environmental or health hazard or cause conflict with wildlife. Waste material disposal will not be permitted within the Project sites.

Borrow Areas and Quarries

Principal concerns for quarry and borrow area development include the potential for sedimentation of freshwater ecosystems, loss of terrestrial habitat, land use and disturbance to wildlife.

The number of borrow pits and quarries opened during construction will be controlled and existing areas will be used wherever possible. These areas will comply with all applicable regulations and guidelines and a permit from the NLDNR will be obtained.

The development of borrow areas will be controlled and will not be located within 150 m of any watercourse. In exceptional cases where no suitable alternative exists, sites within the 150 m buffer will be evaluated on an individual basis and a decision will be made on seeking permission to use the area, including the identification of additional mitigation measures.

The processing of aggregates, whether in the borrow area or at the Project sites, will be planned in advanced. There will be a plan implemented for sediment and run-off control associated with any aggregate washing operations. This may include, but will not be limited to, use of a closed system washing operation or a multiple-tiered settling basin system. Water will control dust from aggregate storage and handling as required.

Borrow and quarry areas will be developed in the following sequence:

- removal of organic layer and topsoil and stockpile separate from mineral soil;
- excavation of pit;
- replacement of unused excavated material;
- replacement of topsoil and organic layer; and
- grading of the area.

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Quarry and borrow areas will be developed in a controlled manner to reduce potential environmental effects. The following procedures will be implemented to reduce disturbance and facilitate rehabilitation:

- the development area, stockpile area and limits of clearing will be staked and/or flagged to prevent over-extension of the development, thereby minimizing the extent of the operation;
- the area to be excavated will be clear-cut of all vegetation prior to any grubbing, excavation or removal of any material;
- all stumps, organic material and topsoil will be stripped from the area to be excavated and stockpiled at least 5 m from uncleared areas; stockpiled strippings will be placed a minimum of 10 m away from the area of excavation; separate overburden piles will be developed for topsoil and underlying overburden;
- settling ponds will be established and if required, cleaned on a regular basis so that the retention capacity is maintained at all times;
- dust from aggregate storage and handling will be controlled with water as required;
- quarries will be developed with clear closure/rehabilitation objectives for aspects such as cliff face or bench height and the use of available material to reduce slopes, face heights and to rehabilitate the quarry at closure; and
- following sloping, the topsoil and any organic material will be re-spread over the disturbed area to promote natural revegetation by adjacent seed sources.

Excavation, Embankments and Grading

Environmental concerns associated with excavation, embankments and grading involve the potential effects on freshwater ecosystems and water quality due to runoff of sediment-laden water and disturbance to wildlife.

Work will be conducted in a manner that reduces the amount of disturbance. All works near water bodies will be carried out in strict compliance with the required watercourse alteration approvals from NLDEC and with authorization from DFO. Work will be conducted in a manner that controls potential sedimentation of watercourses and water bodies in or adjacent to the work area.

Work will be done only upon completion of grubbing and striping. Excavation and grading near stream crossings will be completed so that erosion and sedimentation of watercourses and water bodies is controlled. Where possible a buffer zone of undisturbed vegetation will be maintained between construction areas and all watercourses. The recommended minimum buffer zone will be fifteen meters but will be increased dependant on slope and soil stability.

Dust Control

The environmental concerns associated with dust include human health effects and potential environmental effects on aquatic ecosystems and vegetation.

Dust from construction activities will be controlled using water, whenever practical. Other approved dust control agents, such as calcium chloride, may be used with the approval of regulatory agencies. Waste oil will not be used for dust control under any circumstances.

Noise Control

A variety of noises associated with heavy construction activity can cause negative effects on wildlife resources in terms of their distribution and abundance. Noises associated with blasting and heavy equipment use are temporary in nature and noises associated with drilling are considered long term, but localized.

The Project will implement measures wherever possible to reduce potential effects arising from a variety of noise sources. Exhaust systems on all vehicles and generators will be regularly inspected and mufflers will be in good operating condition. The contractor(s) will also take measures so that workers are not exposed to noise levels above 85 dBA as per Occupational Health and Safety Guidelines. Workers will wear proper personal protective equipment for hearing protection.

Blasting

Blasting on land has different considerations than blasting adjacent to or in water. All blasting will comply with the appropriate permits and approvals. All blasters will have a Blasters Safety Certificate from the Newfoundland and Labrador Department of Labour. The handling, transportation, storage and use of explosives and all other hazardous materials will comply with all applicable laws, regulations, orders of the Newfoundland and Labrador Department of Human Resources, Labour and Employment and the Mining and Energy branches of NLDNR, and the *Dangerous Goods Transportation Act* (RSN1990, Chapter D-1, plus amendments).

On-land blasting concerns include:

- the destruction of vegetation outside quarry limits;
- noise disturbance to wildlife; and
- disturbance of archaeological resources.

Blasting in or near water can affect fish and other aquatic organisms as well as other aquatic mammals and waterfowl. Care will be exercised at all times when carrying out blasting operations. Blasting mats will be used in environmentally sensitive areas.

Explosives will be used in a manner that will minimize damage or defacement of landscape features, trees and other surrounding objects by controlling through the best methods possible the scatter of blast material beyond the limits of the work site. Blasting patterns and procedures will reduce shock or instantaneous peak noise levels.

Time delay blasting cycles will be used if necessary, to control the scatter of blasted material. Blasting will not occur near any fuel storage facilities. When blasting operations are within 200 m of a water body occupied by fish the operations will be carried out in accordance with DFO guidelines.

Underwater blasting activities will require review and authorization from DFO and the DFO Area Habitat Coordinator will be notified 24 hours before the start of blasting operations. Downstream areas will be monitored after each blast for evidence of fish kills and if any are evident, blasting operations will cease and DFO will be contacted. Blasting underwater will comply with the required water resources permits from NLDEC and a Letter of Advice from DFO. Three hours prior to any blasting near water bodies, a visual reconnaissance of the area will be undertaken to establish the presence of any waterfowl or aquatic mammals. Blasting may be delayed in such circumstances until wildlife have been allowed to leave the area of their own accord.

Drilling and blasting activities will be undertaken so that the magnitude of explosions is limited. Blasting plans will be provided as part of the mitigation plans.

Accommodation Complexes and Construction Camps

Environmental concerns associated with the development of the accommodation complexes and construction camps include the clearing of vegetation and soil disturbances that may cause erosion and the introduction of sediments into nearby streams. Development activities may result in habitat loss and noise disturbance to wildlife in the area.

Camp plans will be reviewed prior to the commencement of construction so that:

- buffer zones are flagged prior to any disturbance activities;
- natural vegetation is left in place where possible;
- drainage from areas of exposed fill is controlled by grade or ditching and directed away from watercourses, whenever possible;
- surface water is directed away from work areas by ditching and runoff from these areas have silt removed by filtration or other suitable treatment;
- the requirements for ditch blocks/check dams or sediment traps to intercept runoff are determined in the field;
- check dams are used, as required, to reduce runoff velocity from work areas where there is exposed soil;
- natural terrain exposed/disturbed is reduced to what is required and disturbed areas are graded to level grades and compacted. If required, erosion control matting may be required on exposed slopes prone to erosion;
- in areas where natural vegetation is to be removed, the vegetation layer will be stored for possible used as erosion control material on exposed slopes; and
- diesel generators at the construction camp will meet the requirements of the *Air Pollution Control Regulations* (Consolidated Newfoundland Regulations 956-96, under the *Environment Act* (O.C. 96-246).

Concrete Production

The effects of released wastewater are a major concern relating to concrete production activities. Liquid wastes may contain potential contaminants that can harm the environment, such as cement, concrete additives and form oil.

Cement is very alkaline, and washwater from spoiled concrete or from the cleaning of the batch plant mixers and mixer trucks, conveyors and pipe delivery systems can be expected to have a high pH. Similarly, spoiled concrete or washwater could contain concrete additives and agents, which may be toxic to aquatic species. Aggregates, particularly the finer fractions, are expected to be washed from spoiled concrete or discharged in washwater. Uncontrolled release of such washwater, chemicals and sediments can adversely affect aquatic life and aquatic habitat.

Approval will be obtained from NLDEC to establish the required concrete batch plants at each site. Plant operations will comply with the conditions outlined in the approvals and batch plant operations will meet the requirements under the *Air Pollution Control Regulations* and the *Environmental Control Water and Sewage Regulations*.

Washwater from the cleaning of mixers, mixer trucks and concrete delivery systems will be directed to a closed system aggregate rinsing settling basin(s). In the event that water from the closed settling system is intended for release, it will first be tested (prior to release) for parameters related to any concrete additives to be used in the production of concrete, pH, total suspended solids. It will also meet the limits specified by NLDEC, and will

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adhere to those portions of the *Fisheries Act* (SN1995 F-12.1) that relate to fish habitat protection and pollution prevention.

Protection of Fish Habitat and Water Quality

Activities near streams and other water bodies, such as grubbing and dewatering operations, can cause excessive siltation and may result in harm to fish or damage to fish habitat. Disturbances will be reduced to the extent possible by using buffer zones and erosion prevention measures as well as for dewatering work areas.

Approval will be obtained from the Provincial Water Resources Division, NLDEC for all activities within 15 m of a water body and authorization from the DFO for all activities with the potential to alter, disrupt or destroy fish habitat or introduce deleterious substance into fish-bearing waters. Work will be performed in such a way that deleterious substances including, but not limited to, materials such as sediment, hydrocarbon products and hazardous materials do not enter water bodies.

Approval will be obtained from the Provincial Water Resources Division, NLDEC and authorization from the DFO for all temporary and permanent dewatering operations. Fish entrained during dewatering will be live trapped and relocated to an adjacent part of the system. Fish trapping, temporary storage and release will be such that fish are not unduly stressed or harmed. Prior to relocation, the fish entrained as a result of dewatering operations will be counted and identified. A dewatering plan will be developed prior to dewatering activities.

When stabilization measures are required to protect aquatic habitat from sedimentation, appropriate erosion control techniques will be implemented to mitigate the problem. These may include, but are not limited to:

- the placement of corduroy and/or spreading brush or slash over disturbed areas;
- the installation of baffles or sediment traps at appropriate intervals within the area of disturbance;
- the installation of drainage collectors across disturbed areas to channel drainage into vegetated areas;
- the re-routing of drainage around the disturbance and re-directing it into its natural course; and
- the stabilization of exposed soils with appropriate rip-rap, filter fabric or any other erosion control techniques deemed appropriate.

Sediment control plans will be developed prior to the start of construction.

Where possible, a buffer zone of undisturbed natural vegetation will be maintained between the construction area and water bodies. Sediment runoff control devices will be constructed at the toe of the slope outside the buffer zone when required to control runoff from areas of exposed soils towards water bodies. Silt fences and buffer strips will be inspected on a daily basis, and more frequently, where conditions dictate (high rainfall event). Any accumulations of silt will be removed and disposed of in an area where it will not re-enter any water body.

Erosion control is an important component of protecting fish habitat and water quality. The primary means of erosion control is not doing activities that contribute to erosion. All areas of exposed erodible soil will be stabilized by back-blading or grading to meet engineering slope requirements. Where slope erosion is a potential concern, and there is less than a 15 m buffer of natural vegetation between the area and natural water bodies, an alternate means of erosion control such as a silt fence will be established. Mitigation plans will take into account factors such as drainage/surface area of exposed soils and time of year that erosion control is to be employed.

No servicing or washing of heavy equipment will occur adjacent to a watercourse. Temporary servicing or washing of equipment will not be allowed within 30 m of a watercourse.

Stream Crossings

A key element of protecting fish habitat and water quality is the proper implementation of stream crossing procedures. Streams will not be crossed where possible, but some crossings will be needed for the construction of site roads and infrastructure, reservoir clearing and transmission line construction. When fording a watercourse, the environmental guidelines for fording from NLDEC, Water Resources Division, will be applied. An authorization and letter of advice will be obtained from DFO, which will be used to develop mitigation strategies to reduce the effect of in-stream work during sensitive periods. Work will be performed in such a way that deleterious substances, including but not limited to material such as sediment, fuel and oil do not enter water bodies.

Culverts will be installed in accordance with good engineering and environmental practices, which include but are not limited to the following:

- culvert installations in streams deemed to be fish habitat will be designed to allow the passage of fish and preserve habitat;
- unless otherwise indicated, all work will take place in dry conditions, either by use of cofferdams or by diverting the stream;
- cylindrical culverts will be counter sunk only where necessary to protect fish habitat;
- at multiple culvert installations, one culvert will be set at an elevation lower than the others;
- culvert installations will be designed so that the natural flow regime of the river is not altered;
- culverts will not be installed until site-specific information such as localized stream gradient, fish habitat type and species present has been evaluated;
- rip-rap outlets and inlets will be used to prevent erosion of fill slopes;
- culverts of sufficient length will be used to extend a short distance beyond the toe of the fill material;
- backfilling material will be used to support the culvert and limit seepage and subsequent washing out;
- fill and construction debris will be removed from the culvert area to a location above the peak flow level to prevent its entry into the stream;
- construction activity will be confined to the immediate area of the culvert;
- fill material will not be removed from streambeds or banks, except when installing a culvert and removal is necessary for establishing a flat foundation;
- the use of heavy equipment will be restricted in and near water courses, an excavator will be used from shore rather than a bulldozer in the watercourse;
- as required, cofferdams of non-erodible material will be used to separate work areas from the watercourse when excavating for culverts and footings; and
- cofferdams will be removed upon completion of construction and the streambed returned as closely as possible to its original condition.

When fording any watercourse, the Environmental Guidelines for Fording from NLDEC, Water Resources Division, will be applied in conjunction with the following guidelines:

- areas of spawning habitat will be left avoided;
- crossings will be restricted to a single location and crossings will be at right angles to streams where possible;
- equipment activity within the watercourse will be reduced by limiting the number of crossings;

- equipment will be mechanically sound to minimize leaks of oil, gasoline and hydraulic fluids;
- approaches to all stream crossings will use erosion resistant materials such as rock or clean gravel;
- any materials placed in the stream to improve the crossing site will be clean, non-erodible and non-toxic to aquatic life;
- fording will not decrease the depth of the watercourse to less than 200 mm. Where the existing depth is less than 200 mm, that depth will be maintained; and
- fording activities will be halted during high flow periods.

Wildlife Protection

Disturbances associated with development activities (i.e., noise, human presence) have the potential to affect wildlife species and their habitat.

Work activities will be undertaken in a manner that does not harass wildlife. Harassment is usually defined as any activity that would disrupt the normal behaviour of an animal. Any incidents that involve harassment of wildlife will be reported to Site Management. Investigation of such incidents will be completed and a report provided. All recommendations will then be addressed as follow-up.

Only essential vehicular activity, including helicopter flights, will be permitted on the construction sites and access roads.

The following conditions apply to active raptor nests during the critical stages of the bird's life, which is normally between May 15 and August 15:

- all activities within 200 m of an active Raptor nest will be reviewed and documented prior to entering the area;
- when work activities fall within 200 m of an active raptor nest, activity at the nest site will be monitored. Where work activity creates a disturbance at the nest site for more than two hours, work will cease and move a minimum of 200 m from the nest. Work will not resume until activity at the nest site has returned to normal for a period of two hours;
- while working within 200 m of an active raptor nest, only machinery necessary will be operated. When not required for use, all equipment and machinery will be shut down;
- work crews will not take a lunch break within 200 m of an active raptor's nest; and
- a permanent or temporary work camp will not be established with 800 m of an active raptor's nest.

No firearms will be permitted on the construction sites, unless authorized for use in control of nuisance animals. A firearm permit will be required for this purpose. A policy of no hunting or fishing will be in force for all personnel on the Project site.

Historic Resources

Ground disturbances could result in the disturbance and/or destruction of historic resources. As provided for in the *Historic Resources Act*, Revised Statues of Newfoundland, 1990, Chapter 4-H, as amended, all fossils, articles of value of antiquity, and other remains, or things of geological or archaeological interest or value, discovered on the construction sites will be the property of the Crown. All reasonable precautions will be taken to prevent employees or other persons from removing or damaging any such articles or things.

A designated individual will be notified immediately upon discovery and before disturbance and removal of any historic resources. In the event of the discovery of an historic resource, all work will cease in the immediate area

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of the discovery until the proper authorities have been consulted. Work will not resume until the proper authorities have provided advice on the disposition of the discovery and have authorized a resumption of the work.

All personnel will be informed of the historic resources potential of the Project area and of their responsibility to report any unusual findings and to leave such findings undisturbed. In the event of an archaeological discovery, personnel working in the vicinity will be advised of the find and the area will be flagged for protection.

While working in areas with a high potential for historic resources, site-specific work procedures will be developed to reduce the potential for inadvertent damage to undiscovered historic resources.

Marshalling Yards and Laydown Areas

Marshalling yard and laydown areas are important to consider based on the types of activities associated with such areas. Areas for temporary storage of materials and equipment will require approval prior to use. Equipment and material storage yards will be located at least 30 m from any watercourse.

These areas will be used only for the amount of time necessary for construction activities in the area. Following use, marshalling yards will be rehabilitated.

Spoil Areas

Where possible, spoil areas will be located within the flood plain of the reservoir. Spoil areas will be designed such that all slopes, grades and surface material do not impede wildlife movement through the area. Spoil areas near the tailrace and other water bodies will be lined with filter fabric screens, such that fines cannot migrate into adjacent waters.

Abandoned borrow areas may also be used for spoil. The spoil material will be graded to a natural grade to minimize erosion.

Site Water Management

Sediment control systems reduce the potential for silt-laden water to enter a water body. The approach to dewatering and sediment control involves reducing the amount of water entering the work site, handling and treatment of water once present in excavations, and reducing the sediment in the water that is released back into the river system.

It will be necessary to reduce the amount of surface water entering the work sites by infiltration through the cofferdams and groundwater seepage. This will in turn reduce the amount of water that will require siltation treatment. Trenches (ditches) will intercept surface water and divert it around the areas of construction. Infiltration through cofferdams and groundwater seepage will be reduced by the installation of a pump well system that will draw down the groundwater table.

A system of ditches and drains, incorporated with a well and pump system and settling basins, will handle water that enters the excavations. The ditches, drains and sumps will be located along the lower boundaries of the construction site to intercept and contain silty or muddy surface water. Silt fences or straw/rock check dams will slow the flow of water in the ditches, allowing some sediment to settle out prior to reaching the settling basins.

A properly designed and constructed settling basin is the preferred method of silt removal. The design of the settling basins will consider the loading of suspended solids in the water, particle size and gradation, the volume of water to be treated, the rate of inflow, rate of outflow and the contributing surface area. The basins will be

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located in low-lying areas where they will not contribute to high groundwater conditions and where the system can return the water to a body of water or recharge the water table. The selected area will be accessible by heavy equipment for removal and disposal of silt.

The contractor may also use other low-lying areas or wetlands for treating lightly silted water or smaller quantities of water. Mechanical processes (hydrodynamic separators), flocculating agents or filtration may also be required to help precipitate very fine or colloidal particles for smaller quantities of water.

The level of total suspended solids (TSS) in the released water will comply with provincial *Environmental Control Water and Sewage Regulations* under the Newfoundland and Labrador *Environment Act*.

It is recognized that certain site activities (such as the placement of cofferdams in the river) will result in the generation of silt in the water column and that the water containing elevated levels of TSS will be difficult to contain and treat. Such activities were included in a plume modelling exercise, which is described in Section 9.1.3.

4.8.3 Environmental Compliance Monitoring

Ongoing monitoring for compliance with regulatory requirements will be conducted throughout the life of the Project. Dedicated Project environmental monitors will be present at the construction sites. The construction contractor(s) will also be responsible for environmental performance and reporting, as required by provisions of any permits, authorizations or approvals. The results of surveillance compliance monitoring will be integrated into the EPP, as appropriate through a revision control process.

As one example of compliance monitoring, Hydro has entered into an agreement with the Water Resources Division of NLDEC for the operation of Real Time Water Quality Monitoring (RTWQM) network on the Churchill River. Four stations were established in 2008 and additional stations will be installed following Project approval. Monitoring data will establish background pre-construction conditions, water quality during construction and water quality during operation. Water quality parameters will include hourly measurements of conductance, dissolved oxygen, pH, and turbidity. Water quality data will then be displayed on a publicly available website.

In addition to the RTWQM network, water quality monitoring will be undertaken during construction at specific work locations and during sensate periods of activity. Sampling parameters will reflect regulated standards as well as the issue of concern (e.g., TSS, total dissolved solids, turbidity and pH).

4.9 Workforce

The Project will employ the greatest number of people during the construction phase. The operational labour force will consist of Nalcor Energy employees integrated into the Labrador part of the organization.

4.9.1 Construction

The total workforce for the Project is illustrated in Figure 4-33. A detailed breakdown by National Occupational Classification (NOC) Code/month/year is presented in a component study (Newfoundland and Labrador Hydro 2008). At peak, during Year 6, over 2,000 personnel will be employed in construction.

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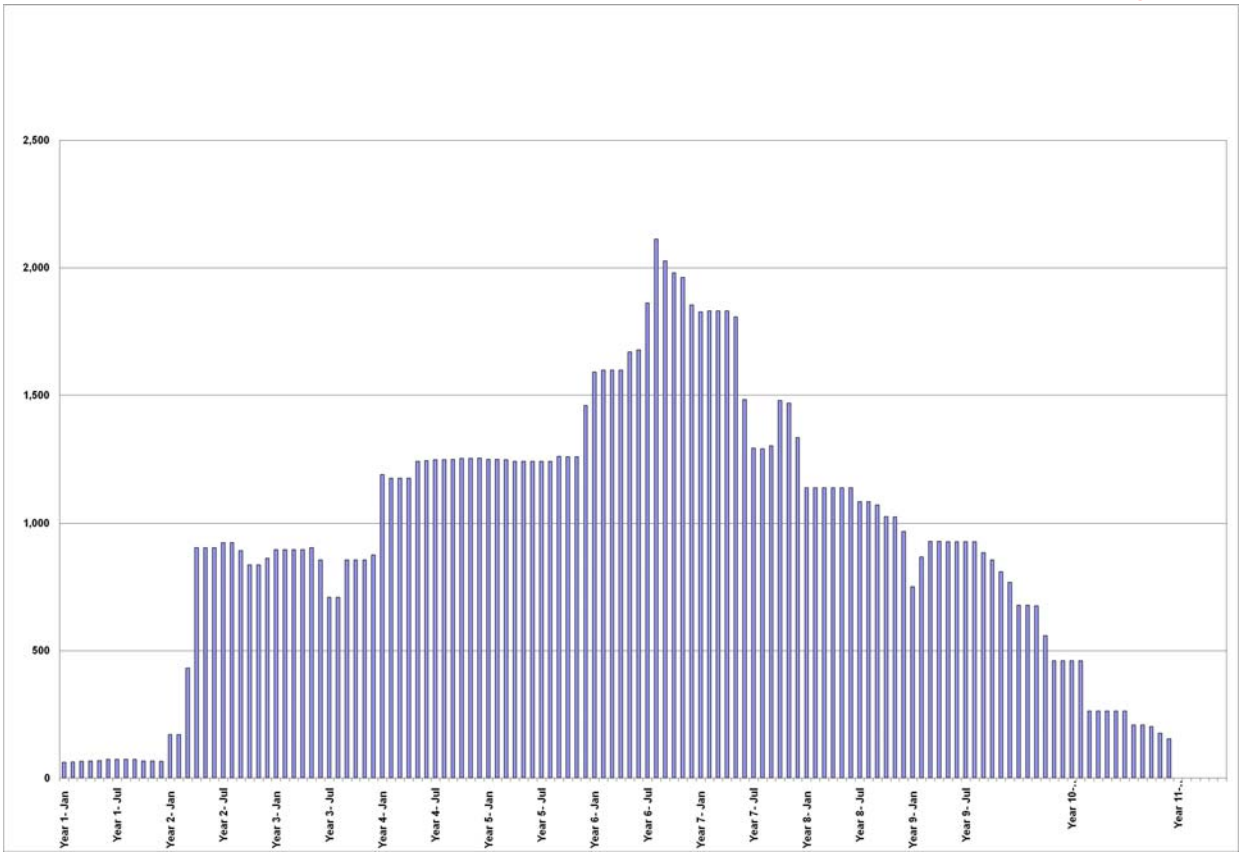


Figure 4-33 Total Construction Workforce, Gull Island and Muskrat Falls

4.9.2 Operation

4.9.2.1 Generation Sites

Employees living in the Happy Valley-Goose Bay area will perform the day-to-day administration, engineering and maintenance at the two generation facilities. Staff will visit the generation facility on a daily basis. All employees will commute from Happy Valley-Goose Bay on a predetermined schedule to facilitate this requirement. The location of staff at Happy Valley-Goose Bay will allow for acceptable response times to investigate equipment failures and to address emergencies 24 hours a day.

The proposed 31 staff will consist of the positions listed in Tables 4-5 and 4-6. Seven additional staff will be required for the ECC in St. John's as listed in Table 4-7.

Table 4-5 Workforce Requirements – Gull Island Operations – Happy Valley-Goose Bay

Position	Qty	Classification/Expertise
Plant Manager	1	Electrical/Mechanical Engineer
Plant Engineer	1	Electrical/Mechanical Engineer
Technical Supervisors	2	P&C Operations/Mechanical/Electrical
Technical Operators	8	P&C/Communications Operations/Millwrights/Electricians-Trades and Technologists
Utility	4	Building Maintenance
Asset Specialist	1	Electrical/Mechanical Engineer/Technologist
Civil Technologist	1	Civil Technology
Planner	1	Mechanical/Electrical Trade or Technology

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Table 4-5 Workforce Requirements – Gull Island Operations – Happy Valley-Goose Bay (cont.)

Position	Qty	Classification/Expertise
Area Office Clerk	1	Administration, Management Systems
Accounting Clerk	1	Clerical/Document Control
HSE/Security Administrator	1	Safety and Environment Technology
Storekeeper/Tool Crib	1	Warehousing Attendant

Table 4-6 Workforce Requirements – Muskrat Fall Operations – Happy Valley-Goose Bay

Position	Qty	Classification/Expertise
Technical Supervisors	1	P&C Operations/Mechanical/Electrical
Technical Operators	4	P&C/Communications Operations Millwrights/Electricians-Trades and Technologists
Utility	2	Building Maintenance
Clerk	1	Document Control/Management Systems

Table 4-7 Workforce Requirements – Remote Control – St. John's

Position	Qty	Classification/Expertise
System Operators	5	Electrical Technology
Marketing Analyst	1	Marketing/Engineering
System Operations Engineer	1	Electrical Engineer

4.9.2.2 Transmission Line

An additional workforce of 10 persons will be required to maintain the Project transmission lines are listed in Table 4-8.

Table 4-8 Workforce Requirements – Transmission Line Operations – Churchill Falls

Position	Qty	Classification/Expertise
Line Workers	3	Trades
P&C Technologist	2	Electrical Technology
Communication Technologist	1	Communication Technology
Asset Specialist	1	Electrical Engineer/Technologist
Electricians	3	Trades

4.10 Expenditures

The estimated capital cost for Gull Island including the transmission line to Churchill Falls is approximately $4.3 billion in 2008 Canadian dollars. Muskrat Falls and the associated transmission line to Gull Island is estimated at $2.2 billion in 2008 Canadian dollars. These estimated amounts cover all costs up to the point of full commissioning of each plant, excluding interest during construction.

These cost estimates are based on the total engineering and construction planning investigations completed to-date; however, as engineering progresses and Project definition improves, more precise estimates will evolve.

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4.10.1 Construction

Approximately 30 to 35 percent of the total capital cost will be spent on Project labour including Project management, engineering and trade labour. The balance of the capital cost will be spent on permanent equipment, construction materials and construction equipment.

For each of Gull Island and Muskrat Falls, expenditures will vary year by year commensurate with the level of engineering and construction activity. For Gull Island and as the Project approaches sanction in Year 1, financial commitments will be incurred for long lead items including turbines, generators and transmission line hardware. In spring of Year 1 mobilization for site infrastructure will commence in order to construct the on-site accommodations complexes, utilities and other support infrastructure including warehouses, maintenance shops, access roads and bridges. Main civil works will occur in Years 2 through 6, with installation and commissioning of the turbines in Years 4 through 7. Activity levels and expenditures for permanent equipment, construction material, construction equipment and labour will vary over and throughout each of these years consistent with the planned activity indicated in the Project Schedule. Average peak annual expenditures for Gull Island during the construction phase are estimated to be approximately $700 to $800 million during Years 2 through 5. For Muskrat Falls the construction sequence will lag Gull Island by some four years and the expenditures will be proportionately smaller.

4.10.2 Operation

Annual operating costs are anticipated to be constant over the life of the generation plants due in part to the implementation of routine and preventive maintenance plans. The estimated annual operating cost for Gull Island and the associated transmission is approximately $13 million to $14 million annually in constant (2008) Canadian dollars; the estimated operating cost for Muskrat Falls is approximately $8 million to $9 million per year.

4.11 Accidents and Prevention

Nalcor Energy has a goal of zero accidents. This requires that accident prevention be assigned priority attention within corporate management systems. Indeed, safety is the number one priority and the focus is on prevention. As well, a high level of response capability is maintained throughout all operations and projects, so that any failures in prevention can be dealt with efficiently and their effects reduced.

For the Project, all personnel will be expected to maintain a high level of vigilance, undergo regular safety training, and be thoroughly familiar with all Emergency Response Plans, the EPPs and the Occupational Health and Safety Plan. Third-party contractors will be screened for compatibility with policies and procedures.

This section identifies and describes the potential accidents and malfunctions related to the Project, as well as potential consequences. Countermeasures indicate how Nalcor Energy approaches accident prevention and establishes a state of preparedness to deal with these events, should they occur.

The candidate accidents identified in the EIS Guidelines (Appendix IB-E) are waste management and disposal, hazardous material spill, dam failure and fires. The Guidelines also call for a consideration of any other type of accident or malfunction that could adversely affect the natural environment. The Nalcor Energy review indicates that the Guidelines list is inclusive; hence, no additional scenarios are proposed for consideration.

The following sections present a series of potential accident scenarios, including a consideration of their likelihood of occurrence. A selection of these scenarios is described in greater detail in Volume IIB, Chapter 6 and Volume III, Chapter 7.

4.11.1 Waste Management

The Project will result in several waste streams, especially during construction. These will include domestic garbage, treated sewage and wastewater, and construction wastes. Domestic garbage will be generated at the accommodations complexes, the largest of which will be at Gull Island and Muskrat Falls. The waste will be held in bear-proof containers and trucked on a daily basis to a licensed landfill, likely at Happy Valley-Goose Bay. Sewage and wastewater will also be generated at the construction campsites, each of which will be equipped with approved sewage treatment plants. Discharges will be required to meet effluent standards and will be monitored as per permit requirements. Construction wastes include scrap, wood packaging, tires and various non-hazardous materials. With the implementation of waste stream separation, recycling will be possible for much of this material. A temporary storage area will be used during construction. Following the removal of all recyclables, the residual material will be removed for disposal in an approved landfill.

There will be a minimum of waste produced during operation and maintenance. Domestic garbage will be trucked to Happy Valley-Goose Bay. Sewage and wastewater will be treated and released at site. During maintenance operations, some industrial wastes (packaging, worn out parts) will be generated. All such material will be removed from site and properly disposed of.

4.11.1.1 Type of Accident

A vehicle accident could result in the discharge of garbage. A line break could result in release of untreated sewage. In each case, the total quantity of release will be relatively small and emergency response procedures would apply to reduce the extent of any damage. The loss of garbage would be limited to the total capacity of one vehicle. The loss of untreated sewage would be limited to the pipe size and response time to detect and halt flow.

4.11.1.2 Countermeasures/Prevention

The construction EPP will address the applicable standard operating procedures associated with handling and disposal of wastes, as well as the associated training, equipment requirements and emergency response capabilities. Standard environmental protection procedures for solid waste and sewage disposal are described in Section 4.8.2. The severity of consequences of a spill occurring as a result of a collision will depend on location (e.g., near a water body) and time of year (e.g., fish spawning). Only essential vehicular activity will be permitted on the construction sites and access roads to the construction sites, and speed limits will be posted to reduce the potential for vehicle collisions.

4.11.1.3 Likelihood

There will be the equivalent of approximately 2,000 trips per year of truck traffic on the TLH. With a shipping season of five months, the number of truck trips will be 14 trips per day. Adding fuel trips and camp supplies, the truck traffic on the TLH will be approximately 16 trips per day to and from the sites for material delivery.

In Newfoundland and Labrador, trucks carrying waste for disposal have an accident occurrence frequency of once every 4,782 years. During the 10 year construction schedule, an estimated 2,000 two-way trips will be carried out between the Gull Island and Muskrat Falls construction sites and the Happy Valley-Goose Bay landfill. Based on these figures, there is a 0.04 percent probability that an accident involving a garbage truck will occur during Project construction. An accident does not automatically result in loss of cargo, so this figure is conservative as an estimate of the likelihood of an uncontrolled release of garbage to the environment.

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The likelihood of a release of untreated sewage is more challenging to estimate. There are no statistics available on pipeline breakage or other events that would result in an unplanned release (e.g., lagoon breach); however, the likelihood is low and the quantity lost would be small—any loss would be quickly detected, contained and repaired.

4.11.2 Spill of Hazardous Materials

Hazardous material will generally be limited to hydrocarbon products during both construction and operation and maintenance. Other hazardous material could include battery acid, concrete preparation fluids, alkaline materials (Portland cement) and similar materials. There will not be an explosives plant on site, but explosives will be stored and dispensed on-site by the contracted supplier from one location and both will be in accordance with applicable safety and environmental requirements and regulations.

The hazardous materials will be identified as part of the WHMIS protocol and handling procedures specified in the applicable EPP. Concrete production will occur in temporary batch plants, which have specific requirements for planning, layout and design, operation, tracking control, materials storage, equipment maintenance and inspection and maintenance. Standard environmental protection procedures are described in Section 4.8.2.

The greatest quantity of hazardous material to be transported, stored, transferred and consumed will be fuel, both diesel and gasoline. Other hydrocarbon products include lubricants, hydraulic fluids and transformer oils.

During construction, hydrocarbon supplies will be transported by tanker trucks and in drums or other approved containers. Fuelling stations will be established at each site, with self-dyked steel storage tanks; the largest fuel storage tank on site will hold 125,000 L. The filling stations will include concrete pads and drainage controls to retain drainage in a sump where any hydrocarbons can be captured and separated prior to release of the runoff. For stationary equipment, a tanker truck will deliver fuel to each piece of equipment. All fuel transfers will follow safety procedures to minimize even minor leaks and drips. Waste oils, lubricants and other used oil will be disposed of at an approved disposal site. Waste oil will be stored in drums (clearly marked waste oil) inside of a dyked area and will be shipped for disposal on a monthly basis.

4.11.2.1 Type of Accident

Fuel spills represent the type of accident most likely to affect the receiving environment. Spills generally occur during transport, storage and, most often, during transfer.

4.11.2.2 Countermeasures/Prevention

Both the construction and the operation and maintenance EPPs will include specific instructions on procedures to minimize spills as well as preparedness to respond in the event of a loss. Spill response kits will be maintained at all activity sites, with the contents of kits geared to the volume of fluids in use, the type of fluid, proximity to water and other relevant factors. All personnel involved in hydrocarbon transport and transfer will be trained in spill response. A Response Team will be formed, trained and receive regular practice in mock responses for incidents that require coordinated action.

All storage tanks will meet regulations; larger tanks will include dyking to contain the contents in the event of failure of the primary liner. Inventories will be maintained of all storage tanks to reconcile quantities as a check against any undetected leakage. All transport vehicles will be licensed and maintained according to safety requirements.

All necessary precautions will be taken to prevent and reduce spillage, misplacement or loss of fuels and other hazardous materials as outlined in Section 4.8.2.

In the event of a fuel or hazardous material spill, the following procedures will apply:

- the individual who discovers the leak or spill will make a reasonable attempt to immediately stop the leakage and contain the flow if it is safe to do so;
- any spill or leak of fuel will be reported immediately; and
- the field team leader or supervisor on site will take immediate action as the on-scene-commander for the purposes of containing and/or cleaning up a fuel or hazardous materials spill.

The following cleanup equipment will be available:

- 205 L drum spill kits at large fuel caches (greater than six drums);
- a fibre drum spill kit at small fuel cache (less than six drums); and
- portable kits for each piece of heavy equipment.

In reaching decisions on containment and clean-up procedures, the following criteria will be applied:

- reduce danger to persons;
- protect water supplies;
- reduce pollution of watercourses;
- reduce area affected by spill; and
- reduce the degree of disturbance to the area and watercourses during clean-up.

The on-scene-commander will consult with regulating authorities to:

- assess site conditions and environmental effects of cleanup procedures;
- assess potential for fuel recovery versus burning;
- deploy on-site staff to mobilize pumps and empty 205 L drums or other appropriate storage containers to the spill site;
- deploy on-site staff to build containment dykes and commence pumping contaminant into drums;
- apply absorbent as necessary;
- dispose of all contaminated debris, cleaning materials and absorbent by burning, if appropriate, or by placing it in an approved land-fill site; and
- take all necessary precautions so that the incident does not reoccur.

Handling and fuelling procedures will comply with the *Storage and Handling of Gasoline and Associated Products Regulations* (CNR 775/96) and any additional requirements of forth by the NLDEC. Standard environmental protection procedures for storage, transfer and handling of fuel and other hazardous materials are described in Section 4.8.2.

4.11.2.3 Likelihood

The likelihood of a spill is in proportion to the size of spill. Small leaks and drips will be more likely to occur than a spill involving the full contents of the largest container on site.

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4.11.3 Dam Failure

Dam failure is defined as the uncontrolled release of the contents of the reservoir.

4.11.3.1 Type of Accident

There are two modes of failure: overtopping and dam breach. In the first case, water inflows would reach a level such that the dam face is overtopped and water flows freely over the entire structure. In the second case, the dam structure fails and the reservoir contents discharge with the water flow further expanding the breech. The causes of a dam breech could include overtopping (i.e., high water levels).

Overtopping is a result of water flows over the top of the dam. In general, hazards that have the potential to lead to overtopping include:

- meteorological events, such as extreme floods that exceed the flow capacity of the dam's discharge facilities;
- extreme wave action, such as that caused by windstorms or landslides;
- flooding due to a failure of another dam upstream;
- blockage of discharge facilities, due to ice or debris;
- failure or mis-operation of discharge facilities; and
- settlement of the dam crest.

The other mode is a dam breach or collapse, in which the dam is unable to resist applied forces. In general, hazards that have the potential to lead to collapse include:

- earthquakes, either natural, caused by industrial activity such as mining, or by reservoir-induced pressures;
- excessive seepage, leading to piping (flow and internal erosion through or under the dam);
- applied loads such as reservoir surcharge and ice forces; and
- defects in design, construction, operation and maintenance.

At the Muskrat Falls site, the spur connecting the rock knoll to the north bank also represents a potential vulnerability that could conceivably lead to uncontrolled release of the contents of the Muskrat Falls Reservoir.

The outflow from a dam failure may result in emptying the reservoir and take the form of a large, fast-moving wave or surge that travels downstream.

A dam breach inundation analysis evaluates the potential consequences of a dam failure in detail. The analysis incorporates hydraulic modelling to determine the ultimate discharge from a hypothetical dam breach, and mapping of the potentially inundated area. This analysis was completed as part of the engineering studies for the Project. The analysis indicated all areas that could possibility be flooded in the unlikely event of a dam failure.

It should be noted, if dam failure is related to an event with natural causes such as an extreme flood, the consequences attributable to the dam failure are the incremental consequences; for example, the flooding in excess of the flooding that would have happened even if the dam had not failed. In this section, the consequences of failure refer to the incremental consequences.

The potential consequences of a dam failure at one or both of the sites were subject to verification by a dam break study and would include:

- flooding of low-lying areas along the Churchill River downstream of the failed dam(s) (flooding due to a dam failure is unlikely to extend beyond the mouth of the Churchill River);
- flooding of inhabited areas downstream of the failed dam(s), including portions of the Town of Happy Valley-Goose Bay and Mud Lake;
- loss of life and injury when there is no warning, loss of homes, loss of infrastructure and loss of transmission facilities in Happy Valley-Goose Bay and Mud Lake;
- flooding of portions of the TLH and loss of transmission lines downstream of the dam near Pena's River and Edwards Brook;
- flooding of the Black Rock Bridge, which connects the north and south shores of the river near Happy Valley-Goose Bay;
- erosion and transport of material and debris from the failed dam(s) and inundated areas;
- disruption of aquatic habitat along the Churchill River downstream of the failed dam(s);
- disruption of aquatic habitat in the reservoir of the failed dam(s), due to release of the reservoir contents;
- slope instability along the reservoir rim upstream of the failed dam(s), due to rapid drawdown of the reservoir; and
- disruption of ice cover in the reservoir and downstream of the failed dam(s), in the event of failure in winter.

Additionally, a flood wave resulting from failure of the Gull Island dam may be sufficient to overtop and cause the failure of the Muskrat Falls dam. This is referred to as a cascade failure.

Failure of the cofferdams or uncompleted main dams during the construction phase (prior to reservoir filling) is not expected to flood inhabited areas downstream. There could be disruption of aquatic habitat for some distance downstream of the construction site, but not to the extent or severity expected for failure of the completed main dam. Consequences at the construction site could include worker life safety and economic losses to the Project.

4.11.3.2 Countermeasures/Prevention

The Project will be designed and operated in accordance with the Dam Safety Guidelines of the Canadian Dam Association (CDA 2007). The Dam Safety Guidelines address requirements for management, operation, maintenance, surveillance, emergency preparedness, review, analysis and assessment of safe dams. The Dam Safety Guidelines hold the dam owner responsible for the safe management of a dam. They also require that the public and the environment be protected from the effects of a dam failure by managing the risks associated with dams, such that the risks are kept as low as reasonably practicable, and consistent with society's expectations.

It should be noted that a dam failure for any reason is extremely unlikely, and the dams will be designed not to fail. However, dam safety management calls for the identification of hazards that have the potential to lead to failure, and identification of the potential consequences of failure, regardless of how remote the probability.

The Dam Safety Guidelines classify dams based on the consequence of failure. The classification takes into consideration the potential for loss of life, and environmental, cultural, infrastructure and economic losses. The classification is in turn a direct input to technical standards such as flood and seismic design criteria, and requirements for inspection, surveillance and emergency preparedness planning. The proposed Gull Island and

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Muskrat Falls dams are classified as Extreme, which requires the most rigorous of dam designs. Based on this classification, the proposed dams will be designed to pass the PMF. The CDA Dam Safety Guidelines define the PMF as "*An estimate of a hypothetical flood (peak flow, volume and hydrograph shape) that is considered the most severe that is reasonably possible at a particular location and time of year. The estimate is based on a fairly comprehensive hydrometeorological analysis of critical runoff-producing precipitation (snowmelt if pertinent) and hydrologic factors favourable for maximum flood runoff*". Statistically, this flood represents an extremely remote event and is the largest possible flood that could reasonably occur in the basin, given the basin's hydrological characteristics.

In accordance with the Dam Safety Guidelines, an Emergency Preparedness Plan will be prepared and in place for the full life cycle of the Project, including the construction phase. An Emergency Preparedness Plan is a formal written plan developed by the dam owner for external use that identifies the hazards posed by the dam, the roles and responsibilities of all parties, and the notifications to be made in the event of an emergency at the dam. An Emergency Preparedness Plan generally includes the following sections.

- Project description and effects of inundation;
- overview of emergency response structure;
- notification procedures;
- inundation maps; and
- procedures for administration and maintenance of the Emergency Preparedness Plan.

The Emergency Preparedness Plan will form part of an overall emergency response structure (referred to as the SHERP and described in Section 3.4.1.3) that also includes:

- the owner's internal Emergency Response Plan, outlining actions that the dam owner will take in response to unusual or emergency conditions;
- the plans of responding public authorities (e.g., Emergency Measures Organization) for warning and evacuating residents within the potentially flooded area; and
- a maintenance, testing and training program for effectively integrating processes and keeping the processes updated.

4.11.3.3 Likelihood

Given that the Project dams are designed to the highest CDA standards (Extreme classification, which includes the requirement to withstand the PMF), the likelihood of a catastrophic dam failure at either Gull Island or Muskrat Falls is considered to be extremely low.

4.11.4 Forest Fire

Fire prevention is an important priority at any construction site.

4.11.4.1 Type of Accident

Many activities involve use of heat, flame and sparks, all of which can, if uncontrolled, result in a fire. Forest fires could occur naturally due to a lightning strike, or as a result of accidental ignition, result of vehicle collisions, clearing vegetation in reservoir and along the transmission line, electrical/equipment malfunction or due to human error.

Meteorological conditions, terrain and success of a response effort will determine the extent and duration of a forest fire. A fire may release emissions, particulate matter and other contaminants into the atmosphere, as well as alter/ destroy wildlife habitat.

4.11.4.2 Countermeasures/Prevention

The fire prevention and fire-fighting procedures described below will be followed.

A plan for preventing and combating forest fires will be incorporated into the Emergency Preparedness Plan. The plan will include measures such as:

- flammable waste disposal on a regular basis;
- in the event of a forest fire, steps taken to contain or extinguish the fire to the extent practical and safe; and
- fires will be reported immediately to the nearest forest management unit office.

Sufficient firefighting equipment, in proper operating condition to suit the labour force and fire hazards, will be provided. Firefighting equipment will be provided and will include shovels, back tanks and axes. Such equipment will comply with and be maintained to the manufacturer's standards. Personnel will be trained in the use of such equipment and will be available to respond immediately to an emergency.

4.11.4.3 Likelihood

During reservoir preparation, both the clearing activity as well as the associated temporary camps will represent potential sources of fire. Forest fires in Labrador are relatively low in frequency, nevertheless an average of 42 fires have occurred each year over the past decade. The average size of fire has been 800 ha. Generally, the size of burn is less near communities both because of the proximity of response equipment and the priority given to protection of these areas. Although unlikely to occur, a plan has been prepared for preventing and combating forest fires that will incorporate the appropriate measures in the Emergency Preparedness Plan. The plan will assist in minimizing the occurrence and limiting the area burned by a forest fire.

4.11.5 Worst-case Scenario

In order to provide a basis for effects assessment, a set of accidental events has been selected and for each a worst case scenario defined. These scenarios will be used for the purpose of environmental effects analysis and prediction. Every reasonable measure will be taken to prevent accidents and will maintain a high level of preparedness to respond to any such unplanned events so as to minimize their consequences.

4.11.5.1 Dam Failure

The worst case scenario for a dam failure would occur during operation when the two reservoirs are full. The scenario would involve a combination of PMF exceedance and an associated structural failure of the dam itself. Such a condition occurring at Gull Island could lead to a similar cascade failure at Muskrat Falls due to overtopping at Muskrat Falls. In this scenario, the two reservoirs would be breached and cause downstream flooding. This would result in an incremental increase in the peak water level from that which would be reached during a natural flood event (greater than the Gull Island dam could withstand) without the Gull Island and Muskrat Falls facilities in place.

The natural peak flow occurs in spring, hence, for the scenario, a June failure is credible and occurs during operation and maintenance. Based on the dam break study (Hatch 2008), the following parameters apply:

- there will be two to three hours warning time from initiation of breach at Gull Island;

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- flooding will affect approximately 380 homes in the Happy Valley-Goose Bay and Mud Lake area. Access and transportation routes and transmission line infrastructure in and around Happy Valley Goose Bay will be lost;
- maximum flows will reach Happy Valley-Goose Bay in 12 hours with a peak elevation of 6.7 m asl; and
- maximum flows will reach Mud Lake in 12.1 hours with a peak elevation of 6.2 m asl.

An Emergency Response Plan will have been developed and put in place cooperatively between Nalcor Energy and the communities of Happy Valley-Goose Bay, Sheshatshiu, North West River, Rigolet and Mud Lake. The plan will provide a mechanism to provide notice of a failure event.

Given a warning time of more than two to three hours, populations (Happy Valley-Goose Bay, Sheshatshiu, North West River, Rigolet, Mud Lake) would not be in great danger, assuming evacuation orders are issued at the time of initial dam breach and the population at risk has a coordinated emergency preparedness plan. In this scenario, it will take two to three hours until water starts to rise at Happy Valley-Goose Bay; however, it will take a further 12 hours to rise to its maximum level.

4.11.5.2 Forest Fire

The worst case scenario for a fire would occur during construction when activities will include reservoir clearing and site construction. The scenario would involve a brush fire that spread quickly so that it was not contained by the Site Response Team.

The most likely time of year for a fire associated with the Project is June. The prevailing winds are from the northeast (April to June), shifting to westerly (July to March). Given the availability of response resources, especially from Happy Valley-Goose Bay, it is considered unlikely that the fire would exceed the 800 ha average size, consequently, the worst case scenario is based on a fire that covers an area 20 percent greater in size than the average (i.e., 1,000 ha (10 km^2)). The source of fire is assumed to be within the Muskrat Falls Reservoir and the maximum extent would reach up to 10 km from the source, generally extending to the southwest.

5.0 REGIONAL ENVIRONMENTAL SETTING AND CONTEXT

The following overview of the ecological, socio-cultural and economic setting of central Labrador (Figure 5-1) provides a regional context for the entire environmental impact statement (EIS). It also includes a brief consideration of information gaps as well as a perspective on the future setting in the absence of the Project. Additional details on the biophysical and socio-economic environments can be found in Volume IIA, Volume IIB and Volume III.

Labrador, often referred to as The Big Land, encompasses an area of approximately 295,000 km^2. This is larger than the combined total area of the Maritime provinces. The Project will be located in central Labrador, with generation facilities at Gull Island and Muskrat Falls on the Churchill River, and a transmission line from the Churchill Falls Power Station to Muskrat Falls, near Upper Lake Melville. The Project is situated within the lower Churchill River watershed.

The Churchill River watershed covers an area of 92,355 km^2 in central Labrador, extending from Lake Melville in the east to beyond the Smallwood Reservoir in the west. The upper and lower Churchill River watersheds are illustrated in Figure 5-1. The Churchill River flows into Lake Melville, a large estuary that, in turn, flows into the Labrador Sea. The area is described by Innu in the ITKC Report (Appendix IB-H).

> *The entire length of Mishta-shipu is situated within the geographic entity know as nutshimit ('the interior, hunting territory'). Its shatshu ('mouth, estuary') is at unipek^u ('the sea, salt water, ocean'), a grammatical building block for the Innu place name for Lake Melville which is Atatshi-uinipek^u, meaning 'cut-off sea'. The headwaters of Mishta-shipu are on the interior plateau (takutauat – 'on the plateau').*
>
> (p. 37)
>
> *In nutshimit there's lots of things Innu can do, but I know less about uinepek^u". Atashi-uinipek^u (Lake Melville) is part of the ocean. The west end is more like nutshimit, but tshishue-uinipek^u ('the real ocean') is out at Uinuat (Rigolet). Along the coast is called uinipek^u, but salty, ocean water is also called shiuapui. The naneu ('shoreline, edge of water') is the dividing line between uinipek^u and nutshimit....taukam refers to deep water on a lake or at sea. The inland barren areas, the inland lakes, mountains, marshes, forests, everything named with Innu place names is part of nutshimit (P3.8.2.07).*
>
> (p. 36)

5.1 Previous Developments

Major industrial activities in central Labrador include the Menihek and Twin Falls power stations, the Churchill Falls Power Station, military training in the Military Training Area (conducted out of 5 Wing Goose Bay) and construction of the TLH (Figure 5-2). With the exception of the Menihek and Twin Falls power stations, these projects have been either subject to environmental assessment, to follow-up monitoring programs or both. These assessments and associated studies provide information relevant for characterizing the area and understanding the extent of human activity in the Churchill River watershed.

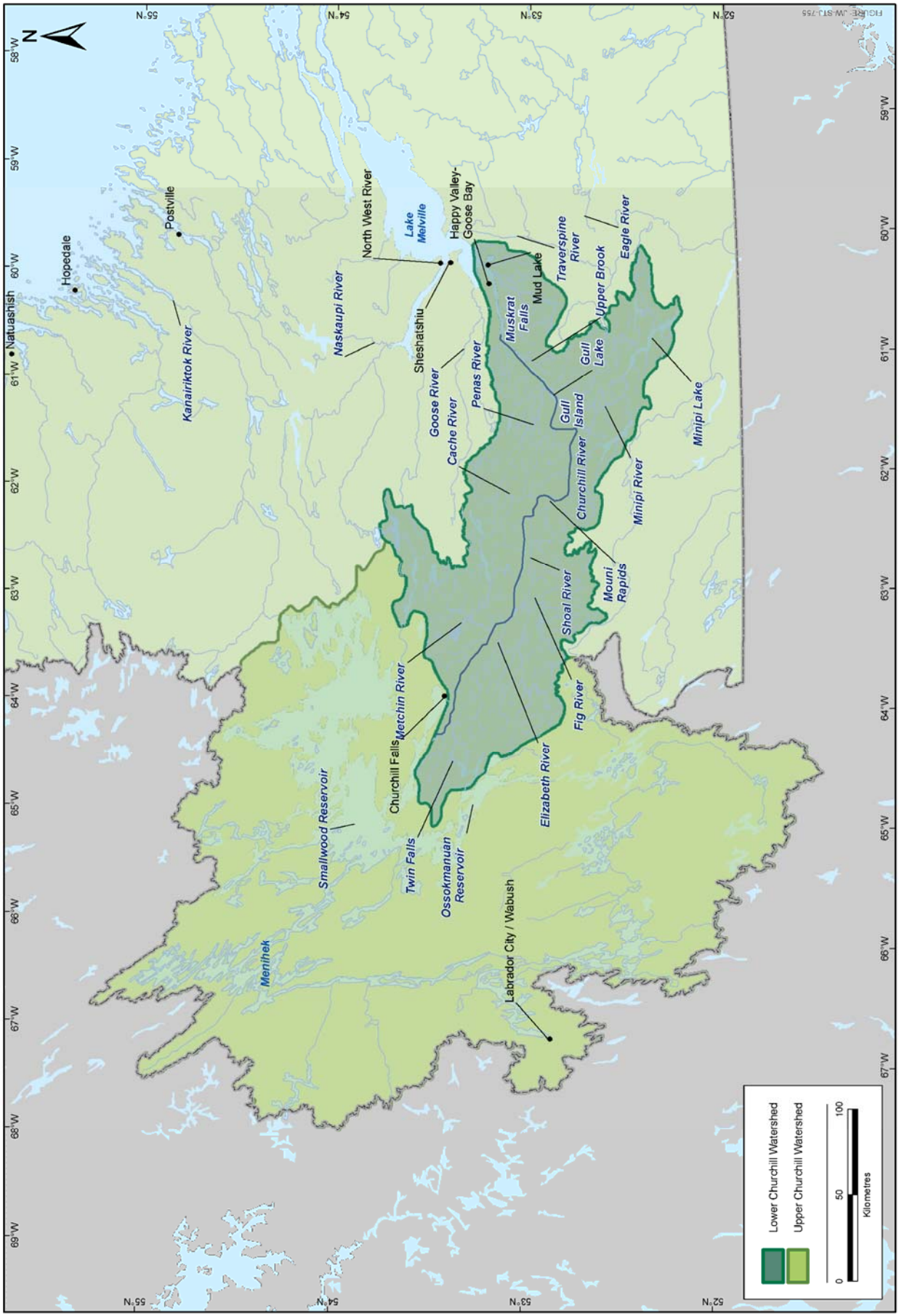


Figure 5-1 Central Labrador and the Churchill River Watershed

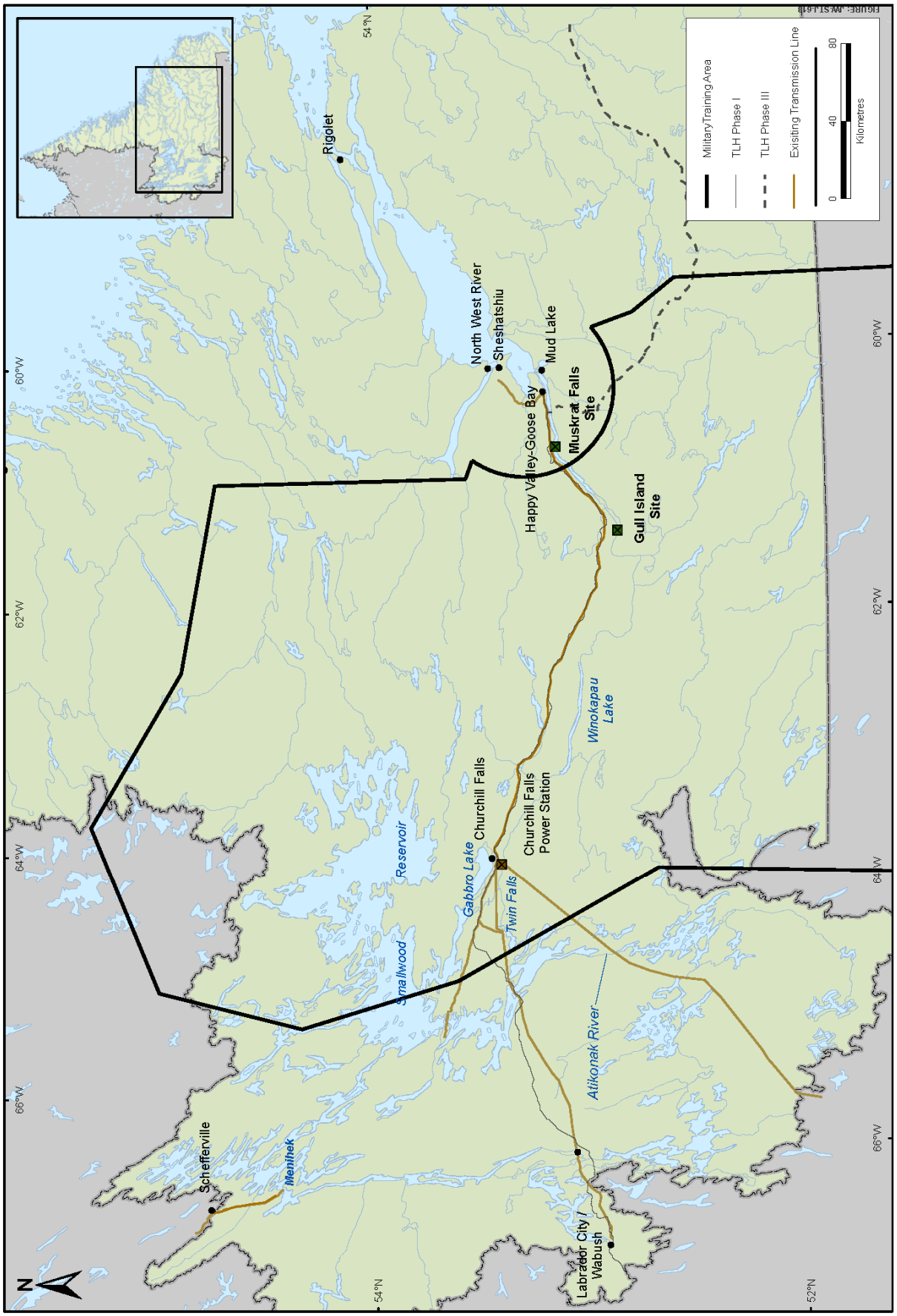


Figure 5-2 Selected Infrastructure and Activities in Central Labrador

5.1.1 Menihek and Twin Falls

The first hydroelectric generation station in Labrador was built in 1954 on Menihek Lake to meet the needs of the Iron Ore Company of Canada at its Shefferville, Quebec mine. Labrador's second hydroelectric generation station was built on the Unknown River at Twin Falls. Construction was started on the 225 MW Twin Falls Project in 1960 in order to provide power for the mining customers, Iron Ore Company of Canada and Wabush Iron Company Limited, located in the Wabush Lake area in western Labrador. The Ossokmanuan Reservoir was created by the construction of a dam at the north end of Gabbro Lake, at the outlet of the Atikonak River and another dam on the eastern edge of Ossokmanuan Lake at the outlet of the Unknown River.

Two 230 kV transmission lines were constructed to transmit power to Wabush and Labrador City. Throughout the construction of Churchill Falls, power was supplied from Twin Falls over a 69 kV line built in 1968.

With the completion of the Upper Churchill Development in 1974, generation ceased at Twin Falls because the energy generated from a unit volume of water is about 3.4 times more at Churchill Falls, than at Twin Falls. Flows were diverted away from the Twin Falls Plant to Churchill Falls by the Ossokmanuan Control Structure. The Twin Falls Spillway gates were permanently opened, releasing flows into the Unknown River.

The Twin Falls Plant was not dismantled or decommissioned due to a condition of the sub-lease agreement between TWINCO and CF(L)Co. that requires the plant to be maintained and kept in a state of readiness. The Menihek Plant is still in operation and now owned by Nalcor Energy.

5.1.2 Churchill Falls Power Station

The Churchill Falls Power Station began operating in December 1971, after a five-year construction period. It is located in the approximate centre of the Churchill River watershed and contains 11 turbines in one of the largest underground powerhouses in the world, with a generation capacity of 5,428 MW. Water is stored in the Smallwood Reservoir by a series of 88 dykes. The Smallwood Reservoir covers 6,988 km², and has a drainage area of approximately 71,700 km²; this includes the upper Churchill River as well as portions of the Naskaupi and Kanatriktok rivers. The addition of water from the latter two watersheds has increased the overall flows to the lower Churchill River by approximately 15 percent.

The Churchill Falls Power Station has affected the existing aquatic habitat within the lower Churchill River by regulating seasonal flows. Inflows in the upper basin are stored and released from the Smallwood and Ossokmanuan reservoirs for hydroelectric generation as needed.

> *The damming of Mishta-shipu and other rivers in the territory and the flooding of Meshikamau (Michikamau Lake) and other lakes frequently evokes a number of political issues for older Innu including members of the ITKC. These include the physical damage to the Meshikamau area, the lack of consultation with the Innu and lack of compensation.*
>
> (p. 83)

The Churchill Falls Power Station regulates the drainage from over 75 percent of the total watershed area and, consequently, this has reduced the natural flow variability of the Churchill River (Figure 5-3). The current flow through the Churchill Falls Power Station is kept generally steady at approximately 1,400 m^3/s. All water is discharged back into the Churchill River once passed through the turbines. As a result, compared to natural conditions, flows in the Churchill River are now higher in winter and lower in late spring and summer. As an illustration of downstream flow effects, the highest average monthly flows at Muskrat Falls have decreased (in June) and the lowest monthly flows (in April) have increased, compared to flows before the Churchill Falls Power

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Station became operational. This has resulted in a less variable flow regime over the course of the year, both seasonally and monthly. Based on water velocity and water level measurements, made at a series of transects across the lower Churchill River, the existing range in water level fluctuations is estimated to be 2.5 m.

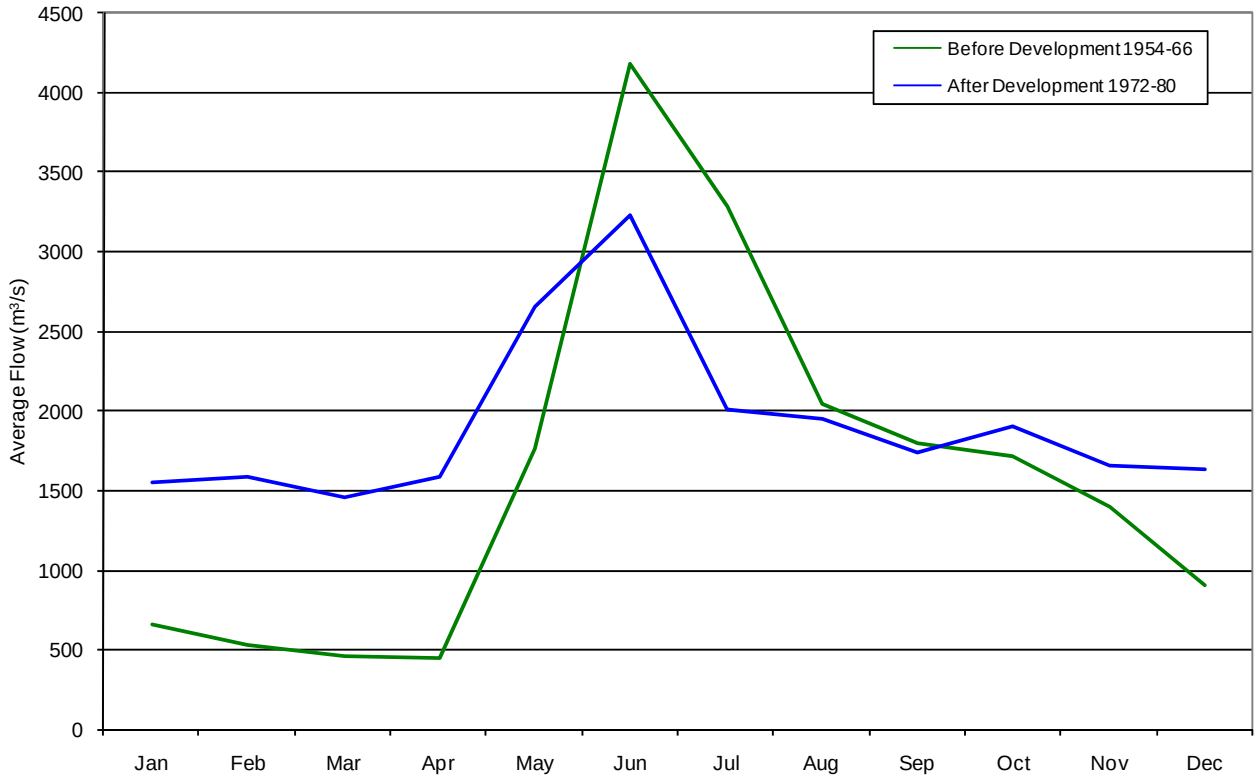


Figure 5-3 Average Monthly Flow at Muskrat Falls - Before and After Churchill Falls Power Station Operation

This change in flow regime in the lower Churchill River has affected aspects of the aquatic environment within the main stem, including water velocity, ice processes and saltwater intrusion. The operating regime of the Churchill Falls Power Station has reduced the peak high flows associated with the spring freshet, while greatly adding to the typical low-flow period through mid-winter. Fish populations, therefore, experience a lower range of velocity and a less variable area of habitat than before. Reduced variability in water level fluctuation would also have enhanced riverbank stability.

The portion of the lower Churchill River near the Churchill Falls Power Station tailrace now remains ice-free long into the winter months. Prior to the existing development, an ice cover would form on Winokapau Lake, initiating the progression of the ice cover upstream towards (and perhaps past) the present tailrace location. With the Churchill Falls dam in place, the progression of ice cover development is slower, likely delayed due to the thermal retention of the Smallwood Reservoir. In addition, as the water flows through the power station itself, it is warmed slightly, which also contributes to the maintenance of a small open water area at the tailrace.

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The changes in water flow as a result of the Churchill Falls project have been identified by Innu:

> *All of the ITKC members either participated in the commercial whitefish fishery at Lobstick Lake or visited the location post-flooding and were therefore in a position to witness some of the environmental effects of Smallwood Reservoir creation. In fact, no one in Sheshatshiu has to travel very far to observe these effects. With the damming of Meshikamau-shipu (Naskaupi River) at its headwaters, Upatauatshetshuan (North West River) now routinely freezes over whereas it never used to do so in the days before damming. Furthermore, one can sometimes taste salt water just above the Rapids at the end of Kakatshu-utshishtun (Grand Lake) at high tide.*
>
> (p. 12)
>
> *"In the past, before Meshikamau was flooded, Upatauatshetshun (North West River) never froze over. There was strong current there before Meshikamau was flooded. But there is hardly any current there now, and one can taste salt water right up to Katatshu-utshishtun (Grand Lake) when the tide comes in. Two years ago in the spring, when I was going over the small portage at Katatshu-utshishtun [between Grand Lake and Little Lake], I could see the current running back in to Katatshu-utshistun" (P1.5.2.07).*
>
> *"Everything changed after the flooding of Meshikamau. I can now walk along the shore on land I used to paddle over in the past" (P1.5.2.07).*
>
> *"After Meshikamau was flooded, I was driving around in a boat to set nets. We didn't know we were on top of old forest, and we wrecked our nets. When the water receded, we could see where the land was, the soil came up, and trees floated. It was a very messy place. Very messy along the shore" (P1.7.02.07).*
>
> *"Where we had our camp close to the shore [of Mishta-shipu near Ushkanshipiss] there were hardly any alders. Nowadays, there are a lot more alders" (P8.22.11.06).*
>
> (pp. 83-84)
>
> *"When working at the Meshikamau [Lobstick] fishery, we got our water from some kind of a well. We didn't drink water from the reservoir because there were too many insects. It was dirty. We took water from brooks when we were hunting."*
>
> *"In the past, before flooding, you could see all the hills, but after flooding, the hills where they traveled are under water, and the animals that were there died" (P9.7.12.06).*
>
> (p. 84)

The inundation of the upper Churchill River watershed as a result of the Churchill Falls Power Station caused increases in methylmercury concentrations in fish within the reservoir and downstream in the lower Churchill River. Sampling has been conducted over the last 35 years and the results show that methylmercury concentrations in fish have declined over time and recent sampling shows that methylmercury concentrations are approaching background levels. Therefore, Smallwood Reservoir is no longer causing increases in fish mercury concentrations.

The changes in fish and wildlife have been noted by Innu:

> *"The fish have been affected already from previous damming. One can only eat fish from brooks that don't flow from Meshikamau"(P2.17.11.2006).*
>
> *"When we were at Lobstick we could still eat fish from rivers that do not connect to Mishta-shipu" (P2.29.11.06).*
>
> *Tshaukuesh told us we cannot eat fish from Mishta-shipu because they are contaminated" (P.2.29.11.06).*
>
> (p. 84)

> *"The fish were good to eat before the roads and dams were built, and now the fish are no good to eat" (P2.7.12.06).*
>
> *"In the past, where we fished, there, there were a lot of fish, and we didn't have to worry about what we ate. But after Meshikamau, we were told that they fish were no good, and we were afraid to eat the fish. We had all kinds of fish up Mishtashipu except utshashumek^{u} (Atlantic salmon)" (P2.7.12.06).*
>
> (p. 84)
>
> *"There used to be a lot of nutshipaushtikueshish (Harlequin ducks) at Kakuetipapukunanut in the old days before damming and flooding of Meshikamau" (P1.25.1.07).*
>
> (p. 84)

5.1.3 Military Training Area

The military base in Happy Valley-Goose Bay, established by Canadian and American forces during World War II, was the main employer in Upper Lake Melville for decades. Now known as 5 Wing Goose Bay, its use has declined over the past decade. 5 Wing currently employs 400 civilians and 100 military personnel (CLEDB 2006). The base has been used since the 1980s by Canada and allies to conduct jet and propeller-driven low-level (100 ft or 30 m above ground level) military flight training.

In 1994, the Department of National Defence (DND) released an environmental assessment of flight training activities, including 16 technical reports characterizing the baseline environment. During normal operations, areas known to have sensitive wildlife species are to be left alone. The Institute for Environmental Monitoring and Research (IEMR) was created in 1996 to evaluate the effectiveness of mitigation measures and to conduct environmental effects monitoring of military flight training and related activities of 5 Wing. Contractors working for the DND or IEMR over this period have conducted several behavioural, physiological and population-based studies examining the effects of noise and visual stimuli associated with these aircraft (with and without the mitigation in place) for several species of wildlife. While some behavioural reactions to aircraft events have been noted, no effects on reproduction or survival at the individual or population level have been documented (L. LaPierre, pers. comm.).

Social and economic effects on the Upper Lake Melville economy have also been studied by the IEMR and underline the importance of 5 Wing to the region. The recent decline in activity has had a direct effect on economic activity in the adjacent community. The federal government has identified a growth strategy for the facility that includes a proposed battalion, unmanned aerial vehicle squadron and support to the ongoing foreign military training program, but has yet to implement these initiatives.

Since 2003, the number of flights in the area has decreased from thousands of flights per year to only 57 military flights in 2007, of which 12 were considered low-level flights (M. Mealey, pers. comm.).

5.1.4 Trans Labrador Highway

The TLH has been planned and built in phases. It is now in the third phase and, when completed, the road will link Wabush/Labrador City to the Strait of Belle Isle. Each of the three phases of the TLH has been subject to environmental assessment. Phase I and Phase III of the highway intersect the Churchill River valley. TLH Phase II between Red Bay and Cartwright is outside the Project area. TLH Phase I (Labrador City/Wabush to Happy Valley-Goose Bay) is an approximately 520 km, all-season, gravel surface highway. Field studies for the region between Gull Island and Muskrat Falls (including terrain sensitivity, vegetation and moose wintering studies) were done in support of the *Trans Labrador Highway Muskrat Falls to Gull Island Environmental Preview Report* (Northland Associates Ltd 1980). Construction of Phase I was completed in 1992, but it was not an all-season

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highway until the late 1990s. Completion of Phase I of the TLH effectively provided the first year-round access between Upper Lake Melville and the rest of Canada.

Construction of the TLH Phase III (Happy Valley-Goose Bay to Cartwright) began in 2003 and is scheduled for completion in 2009. It will be a two-lane, all-season gravel highway, approximately 250 km in length. TLH Phase III includes Black Rock Bridge and causeway, completed in 2007, which crosses the Churchill River approximately 8 km upstream of Happy Valley-Goose Bay. The environmental assessment of TLH Phase III, submitted in 2003 (NLDWST 2003), included baseline studies for historic resources, caribou, raptor, waterfowl, fish and fish habitat, community life, employment and business, Labrador Innu land use, tourism and recreation and land and resource use. The geographic extent of these studies included Upper Lake Melville and the eastern portion of the Churchill River valley. Monitoring and follow-up studies have included archaeology and rare plant surveys along the right-of-way.

5.2 Ecological Setting

Extending from its southernmost point on the Strait of Belle Isle (approximately 51°30'N) to its northern tip at Cape Chidley, Labrador spans more than 10 degrees of latitude and a range of physiographic zones with distinct ecological characteristics.

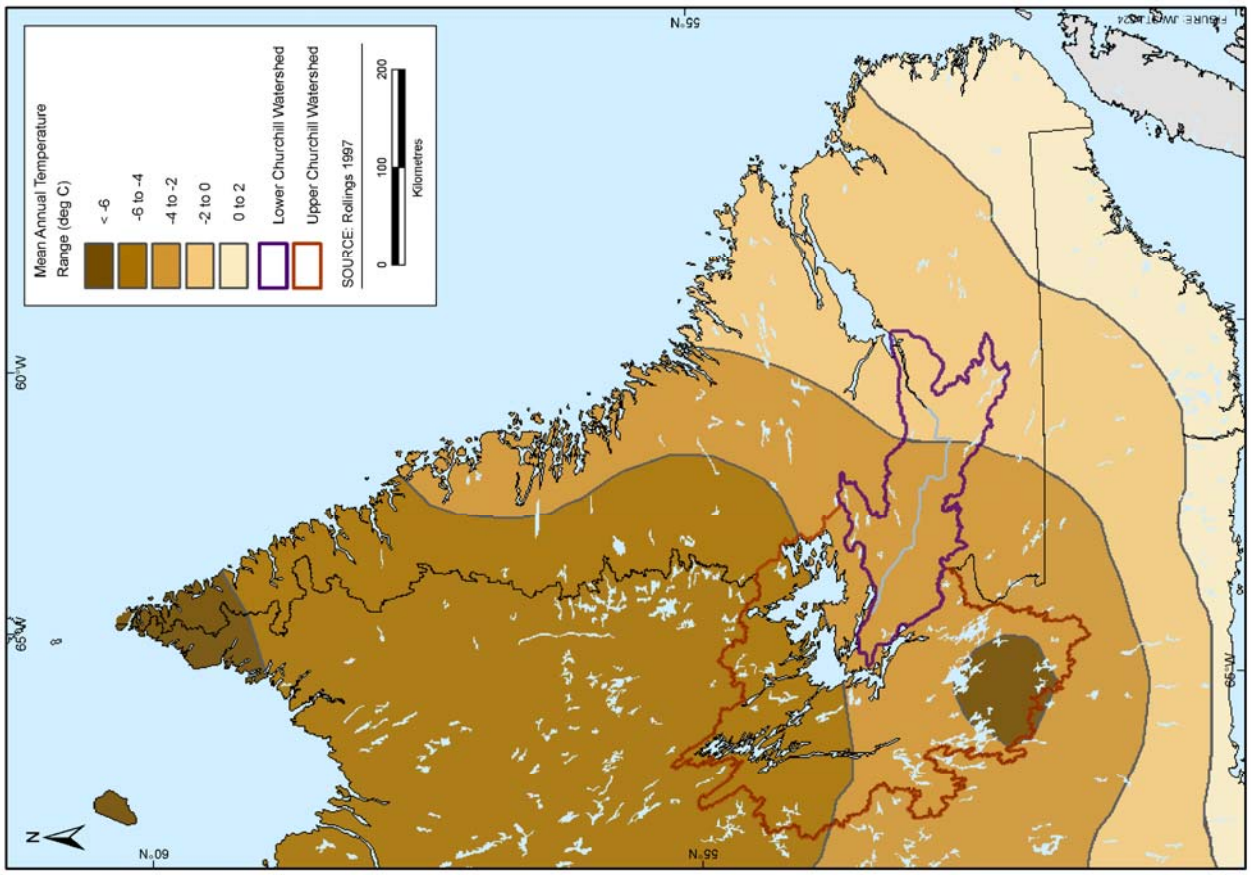
5.2.1 Climate

The Labrador Current strongly influences the climate of Labrador, primarily in the summer, when there is no sea-ice cover. This current, originating off Cape Chidley at the northern tip of Labrador, is the most southerly extension of waters of Arctic origin in the western Atlantic Ocean. The water temperature of the Labrador Current ranges from -1.7°C to 3.0°C.

The Labrador coast is deeply indented with many fjords, which funnel near-surface winds towards the coast (Lancaster et al. 1993) and sea breezes inland. Intense, low-pressure weather systems characterize the fall, winter and early spring seasons, with strong winds and heavy snowfall and rainfall common along the Churchill River valley. Occurrences of fog and strong winds decrease with distance inland from the coast. Because of the generally east-west orientation of the Churchill River valley, the topographic features influence the micro-climate, particularly at lower elevations. The Churchill River valley exhibits a boreal eco-climatic regime, in contrast to the taiga (sub-Arctic) regime at higher elevations within the same watershed. The lower Churchill River valley and associated watershed is an area of transition between Arctic and sub-Arctic climates.

The mean annual precipitation (all types) in Labrador varies from 600 mm in the north to more than 1,200 mm in the south, with a range of 800 to 1,200 mm across the lower Churchill River watershed (Figure 5-4). Approximately 50 percent of precipitation in Upper Lake Melville and at Churchill Falls occurs as snow, whereas snowfall comprises only 40 percent of the precipitation in the area of Gull Island.

The coldest month at Happy Valley-Goose Bay Airport is January, with average daily temperature of -18°C (Environment Canada 2008, Internet site). The warmest month is July, with an average daily temperature of 15°C. Temperatures on the coast are modified by marine influences and are not as extreme as those in the inland continental area (Rollings 1997). Mean annual temperatures, approximately 1°C near the coast and approximately -6°C near Churchill Falls, are illustrated in Figure 5-4. Discontinuous permafrost may occur in areas adjacent to the Churchill River valley such as the Red Wine Mountains. Permafrost does not occur in the Churchill River valley.



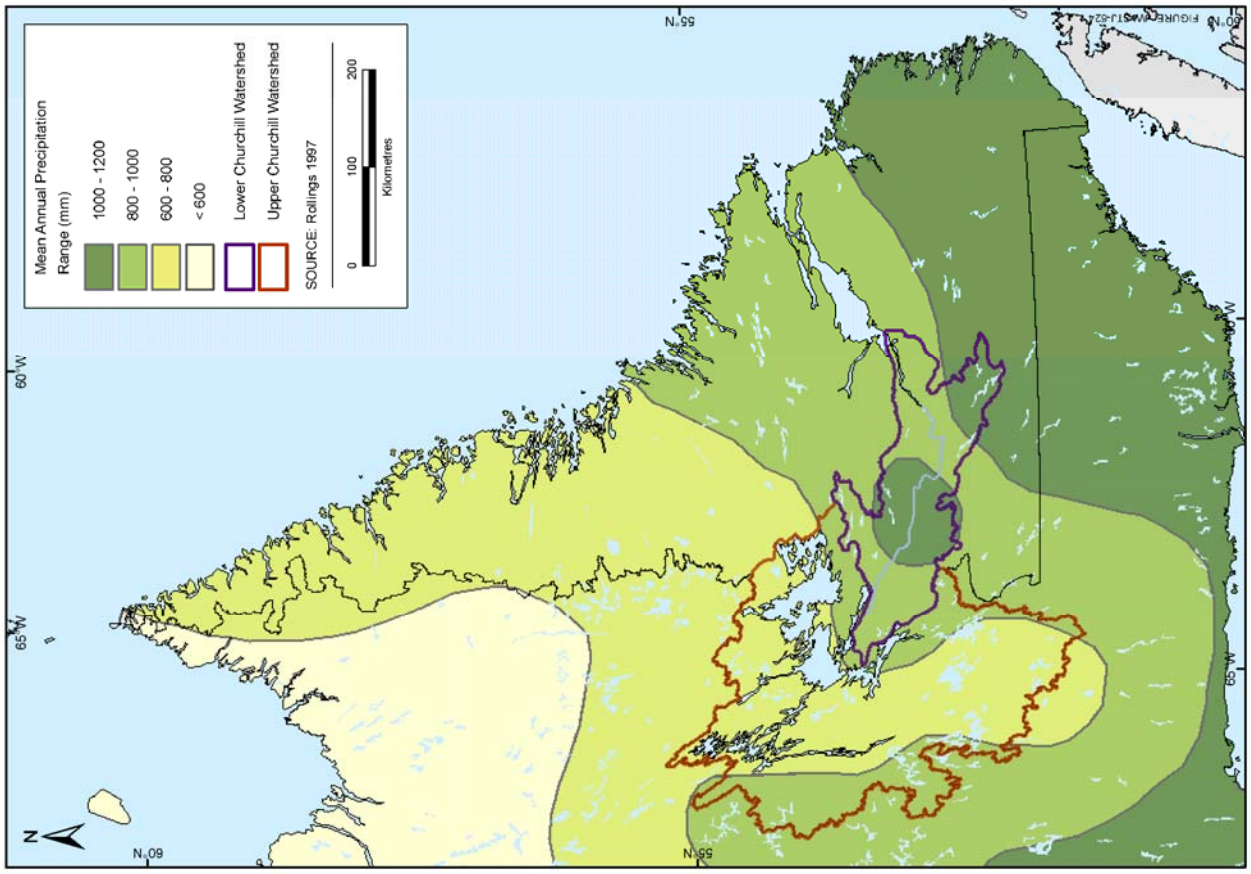


Figure 5-4 Mean Annual Precipitation and Temperature

The topography of Labrador is variable, the result of geological uplift, folding, inundation, glaciation and erosion that have modified the configuration of the original, two billion-year-old Precambrian plateau. The most recent period of glaciation, which ended approximately 10,000 years ago, imparted the most visible present-day features to the landscape. Glaciers eroded mountain tops, incised deep river valleys and fjords and deposited expansive amounts of till and moraine throughout the region. An extensive network of rivers, lakes and bogs then formed in depressions throughout this landscape.

5.2.2 Regional Landscape

Podzolic soils are found throughout the Churchill River watershed, having developed from the mostly well-drained, acidic glacial tills and moraines that blanket the area. Organic soils are widely found where poor drainage and cool temperatures have slowed the decomposition of surface vegetation, resulting in the accumulation of humus layers in some areas.

The local climate, in combination with the landscape and soil described above, has resulted in vegetative cover typical of Boreal and Taiga ecosystems that is adapted to nutrient-poor conditions and extremes in weather. Black spruce coniferous forest is by far the most common habitat in the watershed; in some areas, it is intermixed with balsam fir, tamarack and hardwood species, most notably trembling aspen, white birch and heartleaf birch. Feathermoss, sphagnum moss and Cladina lichen are the most common ground cover in these forests. The landscape also includes extensive bogs and fens.

The Innu have their own approach to describing ecosystems:

> *In order to make sense of my organization of the Mishta-shipu species inventory, let us review briefly some of the basics concerning Innu taxonomic concepts as described by the aforementioned authors (Bouchard and Mailhot, 1973; Clément, 1991, 1995). According to Clément (1990:26-27), at the most abstract level, traditionally-minded Innu divide the universe into three domains – assi (vegetation), aueshish (fauna), and innu (human being), the first two being the principal focus of this report. As far as fauna are concerned, Bouchard's and Mailhot's (1973) data from Ekuanitshu (Mingan) and Matamekush (Schefferville) indicate that the Innu have at least four parallel systems for classifying these species: (1) taxonomic; (2) hierarchical on the basis of whether the fauna have maleficent power; (3) a three-way division that associates fauna with particular seasons, namely pipun-aueshish (winter animal), nipin-aueshish (summer animal), and those that fall in neither of these categories; and (4) realms – tipenitamun - controlled by animal masters.*
>
> (pp. 25-26)
>
> *As far as the domain assi (vegetation) is concerned, Clément (1990:27) argues for two primary subdivisions, based upon his work with Ekuanitshu (Mingan) Innu. The first I have already spoken of, namely, assit nete kanitautshiki or assit nete kanitautshisht, "that which grows in the ground" (animate and inanimate variants). These are generally plants with roots including mishtik[u] (tree), shakau (shrub, bush), atishi (small shrub, bush), and mashkushu (herbaceous plant, grass, fern, etc.). The second subdivision is assi, vegetation that covers the earth, rootless "plants," as in the case of moss, certain lichens, rotten wood, and even ashissu (mud).) A number of generic taxa could not be placed in either of these two categories including rock tripe, puff-ball, old man's beard, and mushrooms.*
>
> (p. 27)

> *According to Mailhot (1975:314), "physical geography, in the conceptual universe of the Montagnais [Innu], constitutes a broad semantic system that is directly related to botany and various branches of physics." Geographical entities are designated by two parallel terminological complexes: (1) a "nominal paradigm covering twenty or more generic terms such as shipu (river), meshkanau (route, path), shipek^{u} (ocean), and pakatakan (portage) that effects a relatively simple delineation of geographic features" (ibid.:317, my translation); and (2) a richer paradigm consisting of a large number of verbs based on the structure – root + medial + final. A simple example of a geographic verb paradigm is mishikamau ('it is a big lake'), parsed as mish (big) + kam (liquid) + a (referring to the "qualities of spatially extended inanimate subjects") (Denny and Mailhot, 1976:42).*
>
> (p. 36)
>
> *Nutshimit encompasses numerous geographic entities that fit both the nominal and verb paradigms mentioned above. These include utshu (mountains), shipu ('river'), nipi ('lake'), minashkuat ('in the forest'), minishtik^{u} (island), mushuau ('it is a place without trees, it is barren ground'), massek^{u} ('marsh, wetland'), massekupi ('peat bog pond'), etc. Nutshimit is a part of assi which in certain contexts means 'land' or 'territory' in the geopolitical senses of these terms. However, assi also constitutes a taxonomic category comprising rock, sand, mud, lichen, moss, and other such vegetation (Clément, 1998:29). Another geographic entity, little known to younger Innu, is Tshishtashkamik^{u}, the land of Mishtapeu and other non-human beings who populate the traditional narratives known as atanukan (mentioned previously), and who were encountered routinely in the shaking tent ceremony.*
>
> (p. 37)

An Ecological Land Classification (ELC) was undertaken (Minaskuat Inc. 2008a) to provide the regional ecological context for the Project. This hierarchical framework of ecological land classification for Canada provides a context within which ecosystems, at various levels of generalization, can be described and monitored.

Ecozones are at the top of the ELC hierarchy; they are defined based on generalized characteristics and global and continental climate. There are two ecozones within the Churchill River watershed (Environment Canada 2005).

More than 75 percent of the Churchill River watershed falls within the Eastern Taiga Shield Ecozone, which extends across the Canadian sub-Arctic at the northern edge of the boreal coniferous forest and encompasses an area of approximately 1.3 million km^2. Cool temperatures, a short growing season and thin, acidic soils are the main limitations to plant growth. The open forests of the Taiga Shield are dominated by a few highly adaptable tree species such as black spruce.

The Churchill River falls primarily within the Boreal Shield Ecozone (although less than 25 percent of the Churchill River watershed falls within this ecozone), which extends across six provinces, from Newfoundland and Labrador to Alberta, encompassing an area of 1.8 million km^2, or approximately 20 percent of Canada's land mass. Similar to the Eastern Taiga Shield Ecozone, cool temperatures, a short growing season and acidic soils limit plant growth. Almost 88 percent of this ecozone is forested by a few highly adaptable trees, such as black spruce, white spruce and balsam fir. The remainder is composed primarily of bogs, marshes and other wetlands.

Each ecoregion is described in Table 5-1. The two ecozones are subdivided into 10 ecoregions (Figure 5-5).

Table 5-1 Ecoregions in the Churchill River Watershed

Ecoregion	Description	Percent of Watershed
Region J Mistastin Lake	The rolling topography is composed of rock, till and glaciofluvial material, vegetated by abundant lichens and sparse coniferous tree cover. Thick lichen carpets common to this area are mixed with scattered ericaceous shrubs, mosses and sedges	6.0
Region K Harp Lake	The region is an upland area dominated by exposed bedrock. A few deeply incised valleys are characteristic. Colluvial fans, talus slopes, scattered rock debris and some glaciofluvial deposits cover much of the landscape	0.7
Region M Smallwood Reservoir	This region is characterized by esker and drumlin ridges composed of deep till and glaciofluvial deposits. Organic terrain, string bogs, and fens are prominent in southern and eastern areas. The region is dominated by open-lichen woodlands	30.3
Region O Nipishish Lake	A plateau region characterized by lower-lying areas occupied by bogs and stunted spruce. Lichens with scattered tree growth typify the region, as do bedrock outcrops	6.5
Region P McPhayden River	The region is an upland of faulted and fractured bedrock. A stunted and sparse tree cover occurs over a more abundant layer of lichens. Valleys that contain deeper soils support sense forest stands	8.3
Region Q Seahorse	The region contains deep, well-drained glacial deposits characterized by black spruce-lichen woodlands. Poorly drained terrain is dominated by bogs. The region boasts productive caribou and waterfowl habitats	14.8
Region R Domagaya Lake	This region is characterized by numerous lakes that occupy the undulating uplands. Thin soils are interspersed with bedrock outcrops. Lichens are prevalent and forest cover is stunted and scattered	7.9
Region S Churchill Falls	A forested region of plains and wide valleys. Black spruce dominated the forests of the plains; white spruce may occur in more moist sites. Lichens are established on the rock outcrops and bogs are prevalent wherever drainage is impeded	10.9
Region T Lake Melville	Hummocky terrain consisting of deep glacial deposits is common. Bogs have developed extensively on the poorly drained coastal plain. The deep river valley soils support mixtures of deciduous and coniferous forests. Lichen woodlands dominate the dry sites; elsewhere, balsam fir and spruce are prevalent	4.5
Region V Eagle Plateau	Bogs are interspersed with a stunted open forest, lichen woodland and exposed bedrock. Various glacial meltwater deposits occur and are conspicuous among the expanses of bogs	0.1
Open Water		10.0

Specific landscape features are defined by Innu using terms relevant to dominant features:

> *The Innu language contains lexemes that reference landscape features in relation to concentrations of animal and plant species, but these terms do not translate neatly into western scientific terms such as habitat. The term ashkui is a case in point. It refers to a 'clearwater area', an area of open water surrounded by ice in the spring or fall. Some ashkui may be open all year round due to the strong current there (e.g. off Netauakau [Sandy Point] near Sheshatshiu), while others only form at river junctions (takuatuepan), lake outlets (kupitan), or river and brook estuaries (shatshu) during fall freeze-up and spring break-up. Ashkui can be dangerous places due to the hazards they pose to travel across ice, and so for reasons of safety, people with experience in country living are knowledgeable about the locations of ashkui and how they change shape according to fluctuations in temperature, wind velocity, and precipitation. Moreover, Innu associate ashkui with amishk^{u} (beaver), utshashk^{u} (muskrat), nitshik^{u} (otter), namesh (fish), mitshishu (bald eagle), and shiship (migratory waterfowl), and as a result they established their spring camps near ashkui in order to take advantage of the species abundance there.*
>
> (p. 44)

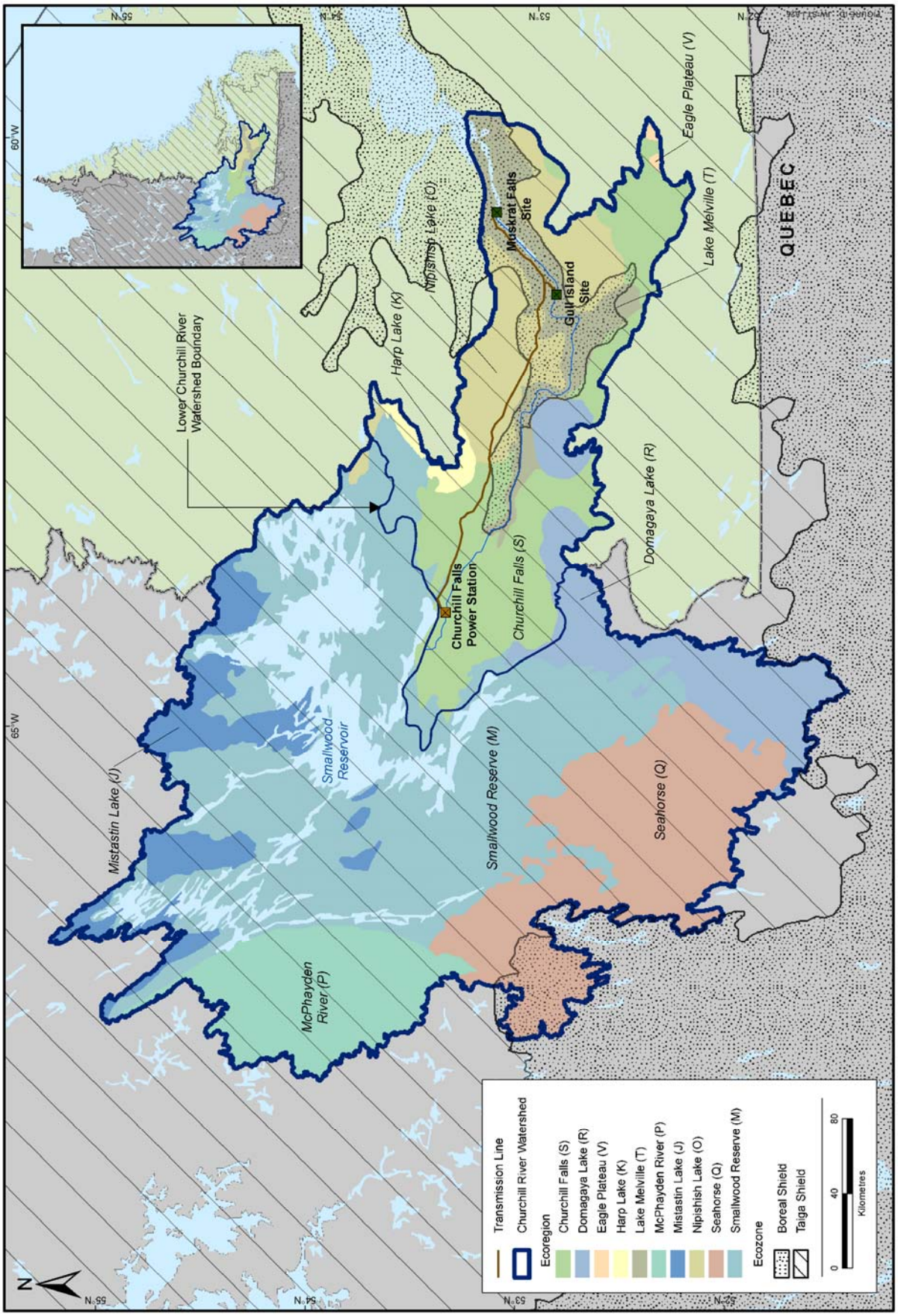


Figure 5-5 Distribution of Ecoregions in the Churchill River Watershed

> *Members of the ITKC noted that the mouths of rivers and brooks along the length of Mishta-shipu are, generally speaking, productive places for various animal and fish species, not just when ashkui form, but at other times of the year as well. Frequent mention was made of large numbers of ducks and geese at the mouths of brooks in the spring. Lots of utshashkᵘ (muskrat) were known to frequent marshes near the mouths of these brooks (P1.19.11.06).*
>
> (p. 44)

5.2.3 Terrestrial Wildlife

Large mammals and other wildlife are organized by Innu into groupings:

> *As far as aueshish (four-legged animal) is concerned, Innu distinguish between Innu-aueshish (Innu "wild" animal), and domestic ones (Bouchard and Mailhot, 1973; Clément, 1995:462). There appears to be no lexical item for "domestic animal" per se in Ekuanitshu (Mingan), but the concept is expressed as kakanuenimakanit aueshish ('animal that one takes care of'). The Innu in Matamekush (Schefferville), on the other hand, use the term kakusseshiu-aueshish ('White person animal'). According to Bouchard and Mailhot (1973), the taxon Innu-aueshish is divided into six suprageneric taxa including:*
>
> 1. *aueshish (four-legged animals, including black bear, caribou, beaver, wolf, etc.*
> 2. *missip (waterfowl, including ducks, geese, loons, etc.*
> 3. *pineshish ("birds", including eagles, gulls, owls, etc.)*
> 4. *namesh (fish, including cod, trout, tadpoles, crabs, etc.)*
> 5. *shatshimeu (insects, including midges, dragon flies, domestic flies, mosquitos, etc.)*
> 6. *manitush (creatures with maleficent power, including toads, spiders, snakes, etc.).*
>
> (pp. 26-27)
>
> *However, Clément (1995:443-444) proposes a different classification, with aueshish distinguished from manitush as branches of an unnamed domain, on the basis of whether an animal is edible (aueshish) or inedible or harmful in some way (manitush). At this level, Sheshatshiu ITKC members appear to share the same binary classification aueshish and manitush on the basis of whether a species is edible or inedible (P4, P6.6.2.07). Beyond that, Clément's informants divide aueshish into two classes – aueshish (animals having uaiash – meat) and namesh (animals having namesh – flesh). "Meat" animals are further divided into five orders in Clément's study – aueshish (four-legged animals), missip (waterfowl), pineu (Tetraonidae), pineshish (small birds), and raptors (no Innu lexeme).*
>
> (p. 27)
>
> *Of course, some of the taxa in the Innu taxonomic system appear similar to Linnaean ones, for example, the taxon aueshish (four-legged animals) comprises nothing but mammals. The significant differences in the two taxonomic systems are immediately apparent, however, when we see that the Innu include mishtamekᵘ (whales) in the category namesh along with matamekᵘ (brook trout), utshashumekᵘ (Atlantic salmon), makatsheu/mikuashai (suckers), and other fish species. In the Linnaean system, all birds are considered Aves whereas Innu divide them among separate orders, namely, missip (shiship) (waterfowl), pineu (grouse), pineshish (small birds), and an unnamed raptor category.*
>
> (pp.27-28)

5.2.3.1 Mammals

The mammals in the Churchill River watershed include caribou, moose, black bear, furbearers and other species such as porcupine, rodents and bats.

Ungulates

Caribou is the most abundant ungulate in Labrador, supplying an important hunting resource for residents and prey for wildlife. The George River (GR) Caribou Herd, estimated at 296,000 individuals (Couturier et al. 2004), is part of the barren ground population that ranges over northern Quebec and Labrador. In recent years, part of the Herd has wintered near Winokapau Lake. Much smaller populations of woodland caribou, considered Threatened under Schedule 1 of the *Species at Risk Act* (*SARA*), also occur in the lower Churchill River watershed. Of greatest concern is the Red Wine Mountains (RWM) Caribou Herd that was considered stable in the 1980s but declined dramatically to 151 animals in 1997 (Schaefer et al. 1999) with a further decrease to 97 animals by 2001 (Chubbs et al. 2001; Schmelzer et al. 2004). Other woodland caribou in Labrador and northeastern Quebec include the Joir River, Mealy Mountains and Lac Joseph herds, ranging in size from a few dozen to several hundred individuals; all are outside the physical footprint of the Project.

Moose in Labrador is at the northern limit of its range, having expanded into the region from Quebec in the 1950s as well as from an introduction in the southeast at the same time (Mercer and Kitchen 1968). During winter, this species browses primarily on young balsam fir and deciduous shrubs in areas sheltered from heavy snow. The lower Churchill River valley is one area where moose is known to congregate in winter. In summer, moose feeds largely on aquatic vegetation and nearby deciduous shrubs and trees that occur near coniferous forest adjacent to wetlands.

Black Bear

Black bear is an omnivore, consuming mostly plant matter. Its diet varies according to season, geographic location (Holcroft and Herrero 1991) and human activity (Jacques Whitford 1997a). It is the largest predator in the lower Churchill River valley (Kolenosky and Strathearn 1987). River valleys in Labrador provide the mixed forest habitat preferred by bears, with a variety of tree and shrub species that provide forage directly or habitat for prey. Males tend to range over much larger areas than females; both overwinter in dens from November to April.

Furbearers

Three canids occur in the lower Churchill River valley. Wolf, a wide-ranging species, preys primarily on moose and caribou (Ballard et al. 1981). The coyote has a generalist diet, ranging from ungulates to small mammals, birds, amphibians and even berries. It was first documented in Labrador in 1995 by a specimen trapped on the Churchill River (Chubbs and Phillips 2002) and remains uncommon, although the population is expanding (Chubbs and Phillips 2005). Red fox is the most widely distributed carnivore in the world (Voigt 1987) and has an omnivorous diet that includes a variety of plants and berries. In the boreal forest, including within Labrador, it is most often associated with mixed and riparian forest habitat types.

Lynx prefers old growth boreal forest, usually with thick cover. The abundance of lynx is linked to snowshoe hare populations. When prey is scarce in forested areas, lynx will venture onto the tundra for food (Quinn and Parker 1987), but large prey such as moose and caribou calves are only rarely attacked.

Six members of the weasel family (Mustelidae) have been recorded in Labrador. Marten is one of the most widespread furbearers in Labrador. It prefers mature conifer or mixed forests, selecting dense canopy forest patches where available (Smith and Schaefer 2002). Home ranges for marten in Labrador are larger than elsewhere, reflecting a limited availability of ideal habitat and prey (Smith and Schaefer 2002). Both the least weasel and ermine occur throughout Labrador, exploiting a wide variety of habitat and food sources. Wolverine was formerly distributed throughout Labrador (Bangs 1898), including near Muskrat Falls (Knox 1994), but its

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present distribution in eastern Canada is unclear. As of 1990, there were no recent observations to suggest the existence of wolverine in Quebec or Labrador (Northcott 1990). As of 2007, there have been no further confirmed reports of wolverine in Labrador, although speculation persists about its presence. The wolverine is provincially listed as Endangered for Newfoundland and Labrador (Government of Newfoundland and Labrador 2002, Internet site); the eastern population, found in Quebec and Newfoundland and Labrador, is also federally listed as Endangered by *SARA* (2003) and by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (SAR Public Registry 2003, Internet site). Mink and river otter, aquatic members of the weasel family (Melquist and Dronkert 1987), are distributed widely along rivers, lakes and coasts throughout North America. Both species feed on fish, insects, molluscs, crustaceans, small mammals and waterfowl (Reid et al. 1994) and regularly travel long distances within their home range.

The snowshoe hare is a widely distributed boreal forest herbivore found in coniferous, deciduous or mixed habitat (Keith 1963). It is a major prey item for carnivores and considered crucial to the functioning of the ecosystem. In spring and summer, snowshoe hare feeds primarily in open areas on grasses and herbaceous plants. In winter, it strips bark from young trees or the new growth of woody plants. The population is cyclic, typically peaking every 9 to 10 years over most of its range (Boutin 1995), but approximately every seven years in central and southern Labrador (Krebs et al. 1986; Boutin 1995). Arctic hare is believed to occur in the northern periphery of the lower Churchill River valley, but its presence was not confirmed during either the wildlife habitat surveys or the winter furbearer surveys conducted as part of this environmental assessment.

Red squirrel is one of the most common, widespread and well known mammals in North America (Klugh 1927). It is generally associated with coniferous forest, but also regularly uses mixed forest (Kemp and Keith 1970). An omnivore, it stores large quantities of seeds and other food for winter beginning in late summer (Klugh 1927). It is important to the ecosystem as a prey item for many animals such as hawks, owls, coyote, marten and lynx.

Beaver occupies rivers, streams, marshes, lakes and ponds. It has considerable localized effects on the physical and biological components of riparian ecosystems (Sigourney et al. 2006) by damming small streams, which leads to increased species richness of plants and animals (Snodgrass 1997). This rodent feeds mainly on bark and twigs, but will also eat leaves, grasses, herbs, berries and aquatic plants. The species is most often found in association with riparian and wetland habitat types.

The muskrat also inhabits marshes, pond and lake edges and streams, feeding primarily on the roots and stems of aquatic vegetation and sometimes on clams, frogs and fish.

Other Mammals

The number of porcupine is increasing in Labrador after several decades of apparent scarcity. This species is active year-round and displays seasonal shifts in foraging (Sweitzer 1996), favouring grasses, forbs, fruit and other riparian vegetation in spring and summer, and arboreal foraging on bark, needles and buds of trees during fall and winter (Woods 1973; Banfield 1974). Habitat selection by porcupine is influenced by feeding, predator presence and resting (Sweitzer and Berger 1992; Stricklan et al. 1995).

Several species of microtine rodents occur within the Churchill River valley. The red-backed vole is the most frequently encountered, particularly during population peaks. This species tends to cycle every four to five years in Labrador, with similar influences upon dependent predators such as marten (Trimper 1989). Other small mammals known to occur include meadow vole, masked shrew and meadow jumping mouse.

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The little brown bat and northern long-eared bat are known to occur in Labrador. They roost in buildings or trees in summer and hibernate in frost-free locations such as caves, mineshafts, cellars, tunnels or unoccupied buildings in winter. These bats feed on insects such as moths, beetles, mosquitoes and flies.

5.2.3.2 Herpetiles

Several species of amphibians have been documented in Labrador, including American toad, mink frog, wood frog, northern leopard frog, blue-spotted salamander, northern two-lined salamander (Chubbs and Phillips 1998) and spring peeper (Bergman 1999). Hypothetical reports of red-backed salamander have also been recorded (Maunder 1983, 1997). No reptiles are known to occur in Labrador.

5.2.3.3 Birds

The main groups of birds include raptors, waterfowl, forest songbirds as well as shorebirds and upland game birds that may be resident year round or migrate seasonally. Small numbers of other species occur in low to moderate densities, including waterbirds (gulls, terns, sandpipers) and woodpeckers.

Raptors

Osprey in Labrador tend to nest within 3 km of a water body, at the top of dominant or co-dominant white or black spruce, adjacent to smaller tributary streams (where the trees are usually taller), or on islands if suitable habitat exists (Jacques Whitford 1995). Osprey feeds primarily on fish (Poole 1989). Artificial nesting sites, such as transmission line poles, are particularly attractive for Osprey in Labrador (Jacques Whitford 1998, 1999a). Bald eagle typically builds its nests in large, mature trees but, in Labrador, it also uses rock pinnacles for nest sites (Laing et al. 2005). In Labrador, the highest densities are found near the Smallwood Reservoir and Eagle River Plateau (Jacques Whitford 1997b). This raptor feeds primarily on fish and scavenges most of its food (Godfrey 1986; Stalmaster 1987). Golden eagle typically nests under a rock overhang on the upper one-third of a prominent cliff face (Jacques Whitford 1997b), near suitable hunting grounds (open and semi-open areas) and where weather is suitable (Camenzind 1969; Morneau et al. 1994; Kochert et al. 2002). The majority of nests documented in Labrador during the 1990s are north of 55˚N, where there is an abundance of cliffs suitable for nesting (Jacques Whitford 2000). This raptor feeds on snowshoe hare and ptarmigan.

Several other raptor species occur in the lower Churchill River valley, preying on a variety of species ranging from small birds and rodents to waterfowl and medium-sized mammals such as hares. Cliff-nesting species include red-tailed hawk, rough-legged hawk, merlin, peregrine falcon, gyrfalcon and great horned owl. Red-tailed hawk, merlin and great horned owl also nest at or near the tops of trees, as does sharp-shinned hawk and northern goshawk.

Waterfowl

Large numbers of waterfowl breed in Labrador, contributing substantially to the fall flight along the Atlantic Flyway (Erskine 1987; Goudie and Whitman 1987). Waterfowl in central Labrador can be subdivided into an early-nesting group, comprising dabbling ducks and geese, and a late-nesting group, comprising sea ducks and diving ducks.

The most common of the early-nesting waterfowl in the watershed are Canada Goose, American Black Duck and American Green-winged Teal. Smaller numbers of Northern Shoveler and Northern Pintail also occur. These species are primarily herbivores and are associated with marshes and other well-vegetated wetlands. They may stage briefly in spring, usually at intertidal estuarine wetlands, but quickly move on to breeding sites.

The watershed supports a variety of late-nesting waterfowl. Species most commonly found breeding along the lower Churchill River are Common Goldeneye and Common and Red-breasted Merganser. Several tributaries of the lower Churchill River support Harlequin Duck. The eastern population found in Nunavut, Quebec and Atlantic Canada is designated as a species of Special Concern (SAR Public Registry 2001, Internet site). Other species commonly found breeding in the watershed are Lesser and Greater Scaup, Ring-necked Duck and Surf Scoter. The status of Barrow's Goldeneye, designated as a species of Special Concern (SAR Public Registry 2000, Internet site) is unclear in the watershed. All these species prey on molluscs, crustaceans and/or fish, and are typically associated with relatively deep open waters, although many nest among vegetation in relatively shallow wetlands. Most of these species stage along open parts of the lower Churchill River in spring prior to dispersing to breeding sites, especially in the case of species nesting primarily in upland areas where the thaw may be delayed (Chaulk and Turner 2002). The duration of the spring staging period is highly variable, depending on the progress of the thaw.

Songbirds

Songbirds in the watershed comprise a diverse assemblage of several dozen species, including members of the flycatcher (Tyrannidae), corvid (Corvidae), thrush (Turdidae), warbler (Parulidae), finch (Fringillidae) and sparrow (Emberizidae) families. Collectively, they occupy the full range of terrestrial habitat from riparian areas to burns to mature forest. The most abundant and widespread species include Ruby-crowned Kinglet, Swainson's Thrush and White-throated Sparrow, habitat generalists which occupy a variety of coniferous and mixed forest types. Other species are particularly dominant in selected habitats, such as Dark-eyed Junco in dry spruce forests, Black-throated Green Warbler in mixed hardwood forests and Yellow Warbler in riparian and wetland habitat. Species of special status include Rusty Blackbird (species of Special Concern according to COSEWIC), Olive-sided Flycatcher (Threatened according to COSEWIC) and Gray-cheeked Thrush (Vulnerable according to *NLESA*).

Upland Game Birds

This group of avifauna includes four species that occupy a wide variety of habitats throughout Labrador. The Spruce Grouse may have the greatest distribution in this region, occurring in close association with coniferous forest, particularly spruce and balsam fir. Ruffed Grouse is limited in distribution, primarily in areas of deciduous forest such as the eastern end of the lower Churchill River valley. Both grouse species are year-round residents.

There are two species of ptarmigan in Labrador. The Willow Ptarmigan tends to be associated with scrub vegetation, although it may occupy any habitat during seasonal migratory movements throughout the region. Rock Ptarmigan is most often associated with barren areas such as coastal bluffs and above the treeline. Upland game birds often undergo population fluctuations, which cause similar fluctuations in predator populations that depend on them. All these species are hunted by residents who often refer to them as partridge, with little distinction.

5.2.4 Aquatic Ecosystems

At 856 km, the Churchill River is the largest river in Labrador, from its headwaters at the western Labrador boundary, running in a general west to east orientation to Lake Melville, which flows into the Labrador Sea (Figure 5-1).

5.2.4.1 Hydrology

The average annual flow at Churchill Falls is 1,365 m^3/s; it is 1,780 m^3/s at Gull Island and 1,840 m^3/s at Muskrat Falls. The hydrology of the Churchill River drainage basin reflects the regional climate: runoff is seasonal, with

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inflows being highest in the spring (typically peaking in May or June) and lowest in late winter. Flow is moderated by the operation of the Churchill Falls Power Station.

Inflows in the remaining 23,088 km² of the lower Churchill River drainage basin below Churchill Falls are not controlled, and follow the natural runoff pattern. The portion of the lower Churchill basin upstream of Gull Island is 19,832 km^2 and the portion between Gull Island and Muskrat Falls is 3,256 km^2. The lower Churchill drainage basin has a well-defined drainage pattern, steep tributary slopes and few natural storage areas such as lakes and bogs, as compared to the upper basin.

From the Churchill Falls Power Station to Gull Lake, the Churchill River flows through a single, straight channel. For approximately 40 km downstream of the Churchill Falls Power Station, the channel width ranges from 110 to 700 m, passing through a narrow valley approximately 300 m below the surrounding uplands, with no major tributary rivers. Upstream of Winokapau Lake, the valley widens and is characterized by broad slopes, terraces, sandbars and deltas, with the major tributaries being the Metchin, Elizabeth and Fig rivers. Winokapau Lake is approximately 45 km long and 1.5 km wide with a depth greater than 200 m. From the outlet of Winokapau Lake, the river abruptly narrows at Mouni Rapids and descends over the next 100 km to Gull Island Rapids, joined by several major tributaries, including Shoal River, Cache River, Beaver Brook and Minipi River.

From Gull Island to Muskrat Falls, the river is slightly more winding, with an increasing number of sandbars and shoals, with wide sections at Gull Lake and Sandy Island Lake. Major tributaries in this area include Pena's River, Edwards Brook, Upper Brook and Lower Brook. Downstream of Muskrat Falls, the riverbed is mobile and, in some areas, there are multiple channels braided among the shoals and sandbars. At the foot of Muskrat Falls, there is a 50 m deep scour hole caused by winter ice conditions. Between Muskrat Falls and the river outlet at Goose Bay, the river is typically one to 2 km wide but has been narrowed to 360 m between the abutments of Black Rock Bridge.

Below Muskrat Falls, the shoreline and river bottom are characterized by a predominance of sand (Jacques Whitford 1999b). With the exception of Winokapau Lake, the river upstream of Gull Island flows rapidly over a rocky bottom. Winokapau Lake is characterized by a steep, rocky shoreline, a maximum depth of approximately 240 m and low water velocity (AMEC 2001). Previous investigations (Jacques Whitford 1999b) have shown that the water quality of the Churchill River and its tributaries is oligotrophic (i.e., it has low productivity).

The most complex ice processes in the Churchill River occur between Gull Island and Goose Bay, where the river is fast flowing and typically remains open all winter, except for border ice and stationary ice cover at the slow-flowing stretches at Sandy Island Lake and Gull Lake. The open fast-flowing water generates large amounts of slush and pan ice, which are then carried downstream. Below Muskrat Falls, the drifting ice becomes trapped under the edge of the stationary ice cover that forms between Muskrat Falls and Goose Bay, typically by the end of November. This causes a massive ice jam, backing up the river flow, raising the upstream water level and decreasing the velocity. In some years, this condition allows ice cover to develop and progress upstream. The ice cover does not usually progress across the rapids because of the turbulent flow conditions of the falls, although this did occur in 1978 and 1979, when the water level and ice surface rose to as much as 17 m over normal water levels (SNC-Lavalin Newfoundland Ltd. 1980). On average, the ice is completely broken up by the end of May.

Some open water also persists through the winter between Winokapau Lake and Gull Lake. Ice pans are transported as far as Gull Lake, where they become trapped at another ice jam formed at the stationary ice cover. Winokapau Lake is normally covered by a stationary ice cover from November until melting in place from mid-April through to the end of May. Upstream of Winokapau Lake, the river is mostly ice covered from

November to April. Open water patches have been observed in the upper end of the reach closest to the Churchill Falls Power Station, likely due to residual heat in the generation station discharge (Hatch 2007).

Innu characterization of hydrology and related features of the lower Churchill River include these specific observations:

> *Little in the way of descriptive physical information was elicited from the ITKC members, who focused more on landscape features associated with animal, fish, and plant concentrations. However, a few points of interest were mentioned. For example, Uinukapau (Winokapau Lake) is a difficult place to live in the fall because the prevailing high winds jumble the ice, producing large, protruding chunks, which are hard to travel across (P4.30.11.07).*
>
> *One person noted an ice jamming problem on Mishta-shipu near Mud Lake. On occasion, ice jams on a shoal near the outlet of the channel flowing from Mud Lake which blocks Mishta-shipu and causes the water to rise in the area, including at Mud Lake. Such ice jamming normally occurs in the spring, so the blockage that occurred in the fall of 2006, as reported in television news reports, was considered to be quite unusual (P2.7.12.06).*
>
> *It was noted that the cove on the north side of Mishta-shipu below the rapids, and from where the portage commenced when traveling upstream, can be a very dangerous place in the spring (Map 5). The ice is packed on the south side of the rapids at Muskrat Falls, and as a result the current can be very strong in the cove near the portage. Innu avoided this area in the spring because one could easily be capsized by the current or crushed in ice. The late Etuat Rich once saw some military men capsize in this area, with all hands lost except one.*
>
> (pp. 42-43)

5.2.4.2 Fish and Fish Habitat

Anderson (1985) lists 22 species that use freshwater habitat in the Lake Melville area for at least a portion of their life history. This includes species captured in the Churchill River upstream of Muskrat Falls, as well as those recorded from other rivers draining into Lake Melville. Four species (lake chub, longnose dace, pearl dace and mottled sculpin) are restricted in Labrador to the Hamilton Inlet region (Anderson 1985). The northern redhorse (not confirmed), American eel, Atlantic sturgeon and rainbow smelt are of particular note as being recorded in Lake Melville, exclusively below Muskrat Falls. The potential for anadromous Atlantic salmon in the region is excellent, but reports from both the commercial and recreational fisheries indicate a small salmon migration, which is probably related to lack of good spawning areas, low winter discharges, high turbidity (which reduces the quality of parr-rearing habitat) and the effect of past fisheries (Anderson 1985). The distance from the narrow outlet of Lake Melville to its western shore, approximately 160 km, might also limit production because it could disrupt the homing response of salmon. It also provides habitat for predators (e.g., seals).

Seventeen fish species have been recorded in the Churchill River above Muskrat Falls. The dominant species in the main stem above Muskrat Falls are longnose sucker, white sucker, lake whitefish (normal and dwarf form), brook trout, ouananiche and northern pike. Other species present are longnose dace, lake trout, round whitefish, lake chub and burbot. Species in the tributaries, but not in the main stem, are slimy sculpin, threespine stickleback and pearl dace (AGRA 1999, 2000). The standing stock levels of fish in the tributaries of the lower Churchill River are low but typical of northern watersheds (Beak Associates Ltd. 1980; Ryan 1980). Arctic char has been recorded in lakes on the plateau (e.g., Minipi and Dominion Lakes) but have not been recorded in the main stem of the Churchill River or in any tributary below obstructions (e.g., falls) (Beak Associates Ltd. 1980). Anadromous Atlantic salmon do not occur above Muskrat Falls.

Innu knowledge about fish species presence reflects their use of this resource:

> *Ushakamesh – 'where there is always fish'. In general, these are located at the mouths of brooks and at points, but they may also be found in deep water, just off-shore. ITKC members said that they used to fish kukamess (lake trout), atikamek[u] (whitefish), tshinusheu (pike), makatsheu/mikuashai (suckers), minai (burbot), and matamek[u] (brook trout) at the mouths of the brooks along Mishta-shipu (ITKC, 22.11.06). Wherever there is lake trout, there is also burbot (P9, 22.11.06). They noted that there are hardly any ponds in the Mishta-shipu valley, and so they would travel up the brooks away from the river to ponds at higher elevations where fish were known to be plentiful (P2, 17.11.06). They would identify new ushakamesh through experimentation – "Sometimes when you don't find fish, you keep checking in different places, leaving the hooks out over night to see what you get" (P6.26.1.07).*
>
> (p. 45)

In general, total standing stock and productivity are low and typical of northern watersheds, reflecting low nutrient input, as well as the key limiting conditions imposed (on stream systems in particular) by winter freezing temperatures and reduced surface flow.

5.3 Socio-Cultural and Economic Setting

Labrador has a rich cultural history and a diverse socio-economic environment, ranging from small coastal communities, to the centre of government services in the Upper Lake Melville area, to areas of mining activity in western Labrador and at Voisey's Bay.

5.3.1 Human History

The human history of Labrador and Quebec can be divided into three broad time periods:

- Pre-contact Period (circa 8,000 years before present (BP) to circa 1500 AD);
- the Historic Period (circa 1500 AD to the early 1940s); and
- the Recent Period (1940s to present).

During the Pre-contact Period (defined as the time before the arrival of Europeans in North America and contact with Aboriginal people dated at approximately 1500), Labrador was occupied by a number of different Amerindian and Arctic-adapted cultural traditions (Figure 5-6), including the pre-contact antecedents of both the Quebec-Labrador Innu, as well as the Inuit of Nunatsiavut and Nunavik. During the Historic Period, the region was used by European whalers, fishers and fur traders (e.g., Basque, French and English), as well as by Labrador Innu, Inuit, and the Settler (generally European-Inuit family units) population. The early 1940s marks the beginning of the Recent Period when the military base was established at Goose Bay.

5.3.2 The Recent Period

In contemporary times, a number of development projects have taken place in Labrador, resulting in substantial changes to the traditional ways of life of its people. This began as early as 1915 with the establishment of a hospital in North West River, providing health care and schooling to the local population, including boarding school facilities for Inuit children. The construction of the military base at Goose Bay in the early 1940s marked a major turning point in existing land and resource use and settlement and subsistence patterns, by offering steady, wage employment to many Aboriginal and non-Aboriginal residents of the Upper Lake Melville area and beyond (Wadden 1991). As a result of the shift to wage employment, fewer people travelled to the interior to partake in traditional activities, such as hunting and trapping, and those who did, did so for shorter periods of time (Minaskuat Inc. 2008b). Similar effects were noted in other aspects of the economy, such as the fishery. By

1951, the civilian payroll resulting from operations at the base exceeded $4 million (Plaice 2002). Currently, it is the largest employer in the region, but has been declining for the past decade.

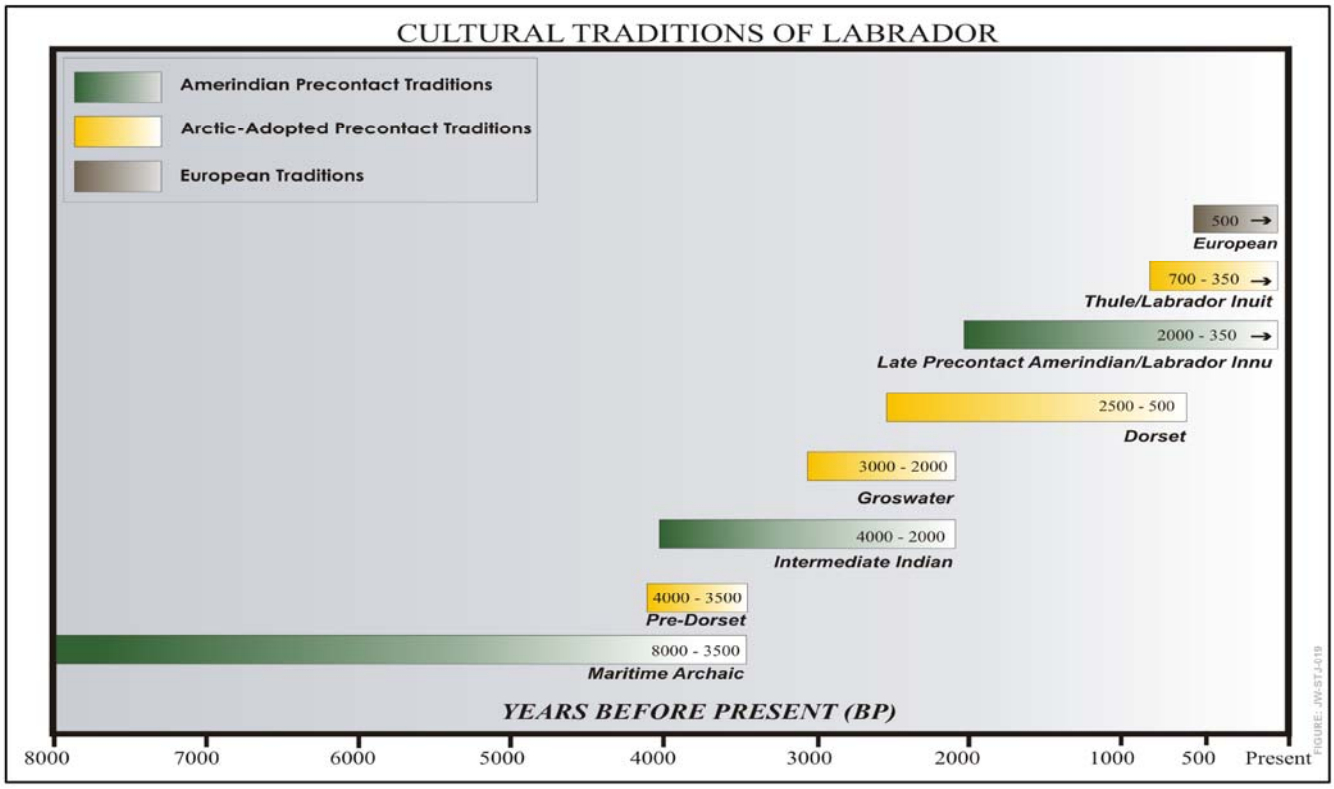


Figure 5-6 Labrador Cultural Traditions Timeline

A second key event that occurred in the Recent Period and resulted in substantial changes to existing cultural and social patterns was the settlement of Innu in the communities of Sheshatshiu and Utshimassits (Davis Inlet) in the 1960s. This change, put in place by the Government of Newfoundland and Labrador, resulted in less use of the interior and an alteration of traditional Innu harvesting patterns (Armitage 1990). Sheshatshiu is an Innu community with Federal Reserve status. After settling in these communities, land use patterns among Sheshatshiu Innu began to change as more families, particularly women and children, stayed in the communities so that children could attend school. During this period, the pattern of establishing summer camps on Hamilton Inlet (Lake Melville) ended. The Mushuau Innu resettled from Davis Inlet to Natuashish in 2002 and 2003.

Other recent developments in the region include construction of the Churchill Falls Power Station and production of mining deposits at Labrador City. Both these projects have brought substantial economic benefits to the region and the Province. TLH Phase I improved access to the interior, which has further affected the nature and intensity of land and resource use in the lower Churchill River area by Labrador residents (DND 1994). Further, recent developments include the establishment of the Regional Government Service Centre in Happy Valley-Goose Bay in 1996, serving as a hub for administration of government services in central and along the northern coast of Labrador. Happy Valley-Goose Bay serves as a regional centre for medical, retail and industrial services.

Most recently, the Voisey's Bay Mine/Mill Project on the Labrador north coast near Nain has resulted in considerable business and employment opportunities in Labrador. Happy Valley-Goose Bay serves as a pick-up area and administration centre for mine/mill. Since the start of operations, the majority of employees have been from Labrador and most of these are Inuit or Innu.

5.3.3 Innu Perspectives

5.3.3.1 Innu Place Names

The naming of places is an important part of the use, occupation, history and meaning of a landscape. Innu toponyms are further described by the ITKC and a listing along with a map are provided in Volume IB, Appendix I-A.

> *The Innu imagination organizes physical space with the aid of these geographic concepts and the generic terms that label them. Place names organize this space in a parallel way, placing a social-cultural map upon the geographic, geological, and biological world encountered by the Innu. Such names often encode descriptive environmental and geographic information that remind people of locations rich in wildlife resources. Other place names reference historical and religious events. Although they are archived in rapidly shrinking oral traditions, they continue to provide portals to vast quantities of memory about particular places on the landscape. Travel across the landscape, way-finding, and the communication of travel routes are greatly facilitated by place names because they are linked to shared narratives about, and cognitive maps of, landmarks and other geographic entities along the routes (see Jett, 1997:491). Some place names record significant life events such as births, deaths and burial locations, where people camped, or places where canoe-making, salmon spearing, trapping, porcupine singeing and other forms of "economic behaviour" transpired.*
>
> (p. 37)
>
> *Table 6 presents Innu place names along Mishta-shipu in consecutive order starting at Atatshi-uinipek^{u} (Lake Melville) in the east and moving upstream until we reach Patshishetshuanau (Churchill Falls) (see Maps 2 and 3). Two place names were collected during the ITKC work: (1) Manitu-utshu-shipiss, a tributary of Mishta-shipu located just upstream of Muskrat Falls; and (2) Kaishipanikau, a sandy terrace located just upstream of Tepiteu-shipu, between Tshiashku-nipi (Gull Lake) and Manitu-utshu. Another name, Mushumin-assi, just above Tshiashku-nipi was replaced with the preferred name, Assiuashiku-minishtik^{u} ('Canadian yew island').*
>
> (pp. 37-38)
>
> *Some of these names encode descriptive geographical information as in Kamashkushiut ('grassy place') and Kamitinishkau ('muddy place, small'), while others reference biota in the area as in Utshashku-minishtik^{u} ('muskrat island'), or refer to historical figures and non-human beings. For example, the name Uapushkakamau-shipu ('burnt area lake river') encodes information about the land surrounding the lake at its headwaters called Uapushkakamau, in this case a past forest fire, the traces of which may no longer be obvious to the eye. Etuat-shipiss takes its name from the late Edward Rich (aka Manitesh), the progenitor of the Rich family in Sheshatshiu and Natuashish who was employed at the Hudson's Bay Company (HBC) post in Sheshatshiu between 1869 and 1876. Pienshak-shipiss is named after the late Peter Jack, the father of one of the ITKC members. The late Tenesh Pastitshi, the mother-in-law of another of the ITKC members, is responsible for naming Katshakanupatau-shipiss, which means 'where an animal ran with its tail standing upright river (small)'. Tenesh saw a fox running across this river with its tail in the air. Manitu-utshu is the name given to the hill on the north side of Muskrat Falls, which the Innu believe to be the dwelling place of the giant, otter or seal-like beings known as uenitshikumishiteu, mentioned previously.*
>
> (p. 38)
>
> *Uinukupau (Winokapau Lake) appears relatively early in the historic record for Labrador as "Lake Waminikapou" in Holme's 1888 account of his travels on Mishta-shipu (Holme, 1888). Henry Bryant (1893:38) recorded the name "Pat-ses-che-wan" in his 1893 account of his journey to the "Grand Falls" (Churchill Falls) of Labrador. Pat-ses-che-wan is a corruption of Patshishetshuanau meaning 'where the current makes clouds of vapour'. Minai-nipiu-shipu, which flows from Minai-nipi (Minipi Lake), also appears early in the fledging Labrador cartography as "Minipi River" (Eaton, 1896).*
>
> (p. 38)

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5.3.3.2 Innu Beliefs

The report on ITK (Appendix IB-H) makes the point that over the past 50 years, since Innu settled in communities, there has been considerable erosion of Innu religious beliefs. Nonetheless, these traditional beliefs provide an important context for Project planning and assessment.

Excerpts from the ITKC Report relevant to the regional setting are presented below.

> *The religious ideology of traditionally-minded Innu is discussed at length toward the end of this report, but in the meantime remember that older Innu hold a special relationship between humans and animals, where animals are considered to be "persons," and where there is not the division between culture and nature that informs so much of the thinking of people of European ancestry.[7] With respect to Innu epistemology, the culturally-based reasoning (inductive analogy, generalization, association, speculation, extrapolation, etc.) of the ITKC members was explored in order to understand the manner in which propositions are advanced concerning the predicted impacts of the Project on the environment.*
>
> (pp. 8-9)
>
> *In talking about Innu religion, it is important to note that traditionally-minded Innu make no distinction between religious and non-religious ideas and practices; they are not compartmentalized realms of experience and rationality. We will return to this matter at greater length later in the report. In the meantime, we need only consider the point that for the ITKC members, animal masters are able to convey important information about their whereabouts and willingness to be hunted or fished through a number of communications media including dreams, the shaking tent ceremony, drumming, scapulimancy, oracles and other signs (Armitage, 1990; Speck, 1977[1935], Tanner, 1979).*
>
> (p. 17)
>
> *As we shall see shortly, Innu religious ideology is a source of many environmental values, and provides building blocks in the Innu knowledge system as it relates to Mishta-shipu.*
>
> (p. 89)
>
> *The best place to start is with the animal masters. As noted elsewhere (Bouchard and Mailhot, 1973), traditionally-minded Innu possess a well-developed taxonomic system that divides animals into different categories. However, various animal species are also organized in a parallel classification based on kingdoms (tipenitamun). Here, each animal kingdom is controlled by an animal being called utshimau (chief or master) or katipenitak (controller) (ibid.:61-62).*
>
> (p. 89)
>
> *One encounters small variations in beliefs about the animal masters as one travels from one part of the Innu territory to another. For example, in Unaman-shipu (La Romaine) on the Quebec North Shore, many animal species are thought to have their own animal master. Papakashtshishk^{u} is the master of caribou, Kakuapeu, the master of porcupine, Uapineu-napeu, the master of partridge, etc. At the same time, individual species are represented by a single master on the basis of certain shared traits. Thus, Missinak^{u} is the master of aquatic species including fish and beavers. The master of caribou is the most powerful of all of these masters and hence controls all terrestrial species, including most mammals, and birds (Clément. 1995:440-441).*
>
> (p. 89)
>
> *Innu living in Labrador do not use the term Papakashtshishk^{u} to refer to the caribou master, preferring instead Kanipinikassikueu. In general, they believe that the caribou master is more powerful than any of the other masters, however, this too is open to question as Henriksen discovered in conversation with the late Kaniuekutet (1977:6-7).*
>
> (p. 89)

Traditionally-minded Innu live in a perpetual cycle of exchange with the animal masters. In return for following certain rules of respect, the animal masters provide animals under their control to the Innu. The rules of respect include sharing meat and other animal products, disposing the uneaten remains in the fire, in trees or on scaffolds, handling the caribou marrow with extreme care during the ritual feast known as makushan, not wasting meat or over harvesting, making prestations to the masters in the form of decorated clothing and hunting equipment, and using deferential language when referring to or communicating with the masters. The need for respect is paramount,) and people who do not show respect run the risk of offending the animal masters, and starvation at least in the pre-settlement days.

The idea of respect for animals was mentioned on several occasions by ITKC members. For example, one person said, "You don't leave bones around for dogs to eat. If we let a dog eat a partridge head, we won't get any partridge again because the partridge boss will be mad. The younger generation doesn't know what it's doing; leaving caribou bones outside the house, disrespecting the bones. Things have changed so much" (P2.22.11.06). Another committee member said, "The most respected places were Akamiuapishk^{u} (Mealy Mountains) and Penipuapishk^{u} (Red Wine Mountains) because these are the places where caribou always were. They are like a super market. If someone breaks into the store, we'd get mad. If you don't respect the caribou, perhaps they won't go there. Nowadays, the government always seems to look after Innu animals, but in the past, the old Innu did this, from one generation to the next. We have been doing this long before government started to"

(p. 90)

Many more elements of the natural world were respected in the old days than now, and even objects that non-Innu consider inanimate had to be respected, such as rocks. In explaining this practice, one of the ITKC members referred to an atanukan dealing with the infamous trickster character, Kuekuatsheu (wolverine), who conversed with a boulder that followed him around. The rock ended up rolling on top of him, and would not budge. So Kuekuatsheu had to call on nanimissu (thunder and lightening) to help him, by striking the rock, and splitting it in two. This story was related in order to explain why Innu believe that rocks are "living things" (P1.5.2.07). Having heard this account, another member of the committee remembered his grandfather chastising him for rolling a rock off a cliff. This was viewed as disrespectful towards the rock (P6.5.2.07).

(pp. 90-91)

Respect is clearly at the core of the traditional Innu moral code, as noted by Henriksen.

Man and nature are part of one spiritual world. Hence, [Barren Ground Innu] behaviour is guided not merely by what White people call 'rational principles', but also by the spiritual and moral principles which exist in nature of which Man is an integral part. They believe that a hunter does not kill an animal against its will, but with its consent. Hunters and hunted are alike part of nature. As long as the [Barren Ground Innu] follow the customs of their people, as handed down from their fore-fathers, and they do not offend the animals and their spiritual masters, they will continue to live in peace with each other and with nature" (1977:8).

(pp. 90-91)

It is important to note, here, that not only are "other-than-human" beings such as animal masters considered sentient, intelligent beings, the animals controlled by these masters are also considered to be sentient, although in varying degrees. At the top of the list is mashk^{u} (black bear), followed by maikan (wolf), atik^{u} (caribou), matsheshu (fox), amishk^{u} (beaver) and other species that share human attributes in various ways or which are given important roles in the atanukan narratives. Even pîtshêpən (grasshopper) has some level of sentience. "You can talk to them. If you give some molasses to them, they will spit something brown" (P2. 22.11.06). I have provided examples previously of Innu thinking with respect to the intelligence (innishu) of certain animals; the tricky mashk^{u}, for example, that undertakes various deceptive manoeuvres in order to deflect hunters from his den. Mashk^{u} understands human speech, even when the latter are not within earshot.

(pp. 92-93)

In addition to the animal masters, traditionally-minded Innu say that their territory was populated at one time or another with a variety of other beings including Mishtapeu, cannibals such as Atshen and Meminteu, giant beavers and eagles, various large, malevolent creatures in the manitush category, sneaking creatures like Katshimaitsheshu (aka Uapanatsheu), cave/rock creatures like Memekueshu, and Tshiuetinishu. Mishtapeu is the attending, guardian spirit, a resident of tshishtashkamik[u], mentioned previously, who comes to the assistance of a shaman and assists him in his "negotiations" with animal masters and battles with malevolent beings and hostile shamans. Tshiuetinishu is a weather control being associated with the northwest winds. In addition to these non-human entities, Innu have also encountered spirit beings such as atshak[u] (ghosts, souls) and Kameshtashtaniuniss, a humanoid being found at Kameshtashtan.

Communication with the animal masters, Mishtapeu, and other beings is possible through dreams, the shaking tent, steam tent, scapulimancy (shoulder blade divination), oracles, omens, and other media (see Armitage, 1992; Savard, 2004:97-105; Vincent, 1973). However, only people with power can communicate with these beings, and in this regard the shamans were the most powerful. Known as miteu or kamanitushit (or its euphemism kamataukatshiut) to the Innu, the shaman could be kakushapatak or kamushtatet, the former term referring to the person who conducted a shaking tent ceremony, the latter to someone with power but who did not do the shaking tent. Shamans played a key role in reminding people of the rules of respect, in maintaining relations with the animal masters and other beings, and in rectifying problems when people had committed transgressions.

(pp. 92-93)

Moreover, shamans had frequent encounters with non-human and spirit beings. They played a leading role in interpreting daily events in terms of the bigger world of religious meaning available to the Innu. Thus, when members of the hunting group heard mysterious singing or drumming or saw a human-like being in the mist while hunting, the shaman would make sense of such phenomena.

(p. 94)

As noted elsewhere in this report, the last shaking tent ceremony in Innu territory was held at the mouth of Ushkan-shipiss in November 1969 by Uatshitshish, the father of the one of the ITKC members. She and three other members of the committee were witnesses to this ceremony. Uatshitshish had also conducted a shaking tent ceremony on the portage by Manitu-utshu. In both cases, he had been asked to ascertain the whereabouts of caribou, and other animals. Given the importance of the shaking tent to the older Innu, it is not surprising that the Ushkan-shipiss area should figure prominently in the memories of the people who witnessed the last one ever conducted - in that spot. This was made clear at the ITKC meeting with the NLH and Innu Nation Task Force in February 2007, when the shaking tent ceremony was explained to the NLH representatives. "My grandfather did his last shaking tent at Ushkan-shipiss. This will be under water. That's why we have to protect the land, because our grandfathers used this area" (P7.7.2.07).

(p. 94)

Nonetheless, despite profound changes in traditional beliefs, there are many Innu people in both Sheshatshiu and Natuashish who continue to have religious experiences of one kind or another both on the land and in their villages, including omens and encounters with spirit beings and other entities. This demonstrates that Innu religious expression is not a static, ossified lore, but a body of beliefs that continues to inspire the Innu imagination and inform behaviour, and will continue to evolve in the future.

(p. 94)

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There are many examples of the influence of Innu religious ideology in Innu discourses about Mishta-shipu and the potential impacts of hydro-electric development on the river. One of the most important ones relates to the nutshimiu-natukun (country medicine) found in plants and animals in the Mishta-shipu valley. A deeply rooted idea that healthy food, and healthy living depend on the consumption of medicine-containing animals and plants appears to permeate the thinking of older Innu, and this makes sense of their concerns about the "wasting" of the medicine in the Mishta-shipu valley through flooding. The idea that the power of nutshimiu-natukun may be weakened through industrial development, including "contamination" of water by methyl-mercury, is a correlate of this concern about wasting. Furthermore, the strong possibility that animals will drown or in some other way be hurt as a result of hydro development may well offend the core values of traditionally-minded Innu related to respecting animal masters and the animals they control.

(p. 94)

In conclusion, it is important to remember that the knowledge shared by ITKC members concerning the biota of Mishta-shipu as well as their propositions concerning the potential impacts of the hydro project are embedded within a knowledge structure and value system that is itself embedded or overlaps with their religious ideology. Tanner (2007) has noted the same with respect to the James Bay Cree. "Alongside pragmatic empirically-based knowledge about animals, explanations of environmental events can involve prophecies, divination, and the actions of spirits." Thus, core values of respect for animal masters and the species they control, belief in the sentience of various animal species, and concerns about "wasting" nutshimiu-natukun ('country medicine') all derive from a broader, religious worldview. Taking these values and beliefs into account in planning and building the Project, for example, by attempting to design the project in a "respectful" way, according to Innu ideas of respect, or by mitigating project impacts in a way that is meaningful to the Innu in a framework of "respect," could help some Innu comes to terms with what is currently an unacceptable, yet inevitable project in their minds

(p. 99)

5.3.4 Current Socio-economic Environment

Labrador is divided into five economic zones (established by the Government of Newfoundland and Labrador starting in 1995). These regions are central Labrador (including the communities of Upper Lake Melville), western Labrador, northern Labrador, southeastern Labrador and the Labrador Straits. Communities comprising Upper Lake Melville are Happy Valley-Goose Bay, Mud Lake, North West River and Sheshatshiu. Given the location of the Project, and the communities and people most likely to be affected by it, this description of the socio-economic setting for the Project focuses on the Upper Lake Melville area, the community of Churchill Falls, and the land and resource use of the residents of these communities. Upper Lake Melville is the economic and administrative hub of Labrador and is home to about one third of its population.

5.3.4.1 Demography

Labrador has a low population density, with clusters in coastal areas, around the mining communities of western Labrador and in and around the administrative centre of Upper Lake Melville. The 2006 population of Labrador is 26,364 (Statistics Canada 2006), of whom 9,660 are in western Labrador and 9,176 are in central Labrador. These two regions comprise 71.5 percent of the total population of Labrador. In central Labrador, the communities of Happy Valley-Goose Bay, Mud Lake, Sheshatshiu and North West River have 9,176 residents (Table 5-2) (Statistics Canada 2006). The remaining population of Labrador is distributed in the northern (with 3,120 residents), southeastern (with 2,615 residents) and Labrador Straits (with 1,825 residents) regions (Newfoundland and Labrador Statistics Agency/Community Accounts 2008, Internet site).

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Table 5-2 Population of Communities in Upper Lake Melville

Community	Population
Happy Valley-Goose Bay	7,572
Sheshatshiu/Mud Lake	1,112
North West River	492
Total	**9,176**
Source: Statistics Canada 2006	

Labrador's population has declined slightly since 2001. However, central, northern and southeastern Labrador have all had growth in some age groups, particularly in the age group 20 to 24 years (Newfoundland and Labrador Statistics Agency/Community Accounts 2008, Internet site). Both western Labrador and the Labrador Straits have experienced a slightly larger decline and, unlike other Labrador regions, there is no growth among the younger population.

Approximately 35 percent of the people living in Labrador are of Aboriginal identity. Within central Labrador, over 40 percent of the population is Aboriginal, including Innu, Inuit and Métis. The Aboriginal population in Labrador generally tends to be younger and is increasing at a faster rate than the general population (Newfoundland and Labrador Statistics Agency/Community Accounts 2008, Internet site).

The Innu (previously known as Montagnais and Naskapi Indians) are indigenous inhabitants of an area they refer to as Nitassinan, which comprises much of the Quebec-Labrador peninsula. The Innu of Labrador currently number approximately 2,100 and reside primarily in two communities: Sheshatshiu in central Labrador and Natuashish on the North Coast. Small numbers of Innu also reside in Happy Valley-Goose Bay, Labrador West, St. John's and elsewhere. The Sheshatshiu Innu and the Mushuau Innu of Natuashish comprise separate Bands, with each community currently a Reserve with an elected Chief and Council. Both are represented by Innu Nation in land claims negotiations and on other matters of common interest. The Innu of Labrador claim Aboriginal rights and title to much of Labrador. The Labrador Innu land claim area overlaps the proposed Project area, and is the only such claim that has been accepted for negotiation by both the federal and provincial governments. Innu Rights Agreement negotiations are ongoing between Innu Nation and the governments of Newfoundland and Labrador and Canada.

On September 26, 2008, the Government of Newfoundland and Labrador and Innu Nation announced the signing of the Tshash Petapen Agreement (which translated as the New Dawn Agreement). This agreement resolved key issues relating to matters between the Province and Innu Nation surrounding the Innu Rights Agreement, the Lower Churchill Impacts and Benefits Agreement (IBA) and Innu redress for the Upper Churchill Hydroelectric Development. Final agreements based on the Tshash Petapen Agreement are being negotiated and will be subject to ratification by the Innu people.

The Inuit of Labrador are primarily resident on the Labrador North Coast in the communities of Nain, Hopedale, Makkovik, Postville and Rigolet, and in the central Labrador communities of North West River and Happy Valley-Goose Bay, with other Inuit residing in southern and western Labrador, St. John's and elsewhere. The Labrador Inuit Land Claims Agreement was signed by the Labrador Inuit and the provincial and federal governments in January 2006 and came into effect on December 1 of that year. The Agreement is a modern comprehensive treaty, and sets out the details of land ownership, resource sharing and self-government in the area covered by the Agreement in Northern Labrador. It also resulted in the establishment of the Nunatsiavut Government, which represents approximately 5,000 beneficiaries of the Agreement.

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The Labrador Métis Association was established in 1985, and renamed the Labrador Métis Nation (LMN) in 1998. The LMN reports a membership of over 6,000 members, who reside primarily in central Labrador and along the southeastern coast of Labrador. The LMN has asserted a land claim in the region, but this has not been accepted for negotiation by the federal and provincial governments (LMN 2008, Internet site).

5.3.4.2 Communities

Labrador has 32 communities, 20 of which are incorporated municipalities. In the Upper Lake Melville area, Happy Valley-Goose Bay and North West River are incorporated communities, each with a mayor, town clerk and town council. Mud Lake is an unincorporated community administered by a volunteer committee. Sheshatshiu is an Innu community with Federal Reserve status and is managed by a Band Council. Labrador community councils are represented by the Combined Councils of Labrador, established in the 1970s.

Located at the mouth of the Churchill River near Lake Melville, Happy Valley-Goose Bay has a population of 7,572 and is the largest community in Labrador (Newfoundland and Labrador Statistics Agency/Community Accounts 2008, Internet site). It is the centre of economic activity for central Labrador, as well as the north, southeast and Labrador Straits regions. In 1996, Happy Valley-Goose Bay became the administrative hub for government services for central and north coast communities when the Newfoundland and Labrador Department of Services and Lands opened the regional Government Service Centre (Government of Newfoundland and Labrador 2008, Internet site). The community contains a number of regional offices of both provincial and federal government departments. As an example of this regional service role, the Labrador Health Centre in Happy Valley-Goose Bay is staffed with family physicians, each of whom is also responsible for the medical care of a coastal community. In addition to primary and secondary schools in the community, Memorial University's Labrador Institute and the College of the North Atlantic provide post-secondary education services for the region.

The economy of Happy Valley-Goose Bay and the Upper Lake Melville area has generally been related to the operation of the military base around which the community developed. The military base has been the primary employer in the Upper Lake Melville area since the 1940s. With current employment levels of 400 civilians and 100 military personnel, the base continues to play a major role in the regional economy. Additionally, the local retail and service sector has developed over the past 60 years. The Happy Valley-Goose Bay economy is primarily wage-based but many area residents, particularly in the smaller communities of the Upper Lake Melville area, continue to pursue subsistence land use activities for cultural reasons and to supplement their income (Town of Happy Valley-Goose Bay 2001, Internet site). Other government offices in Upper Lake Melville include Agrifoods, Forest Resources, and Mines and Energy Boards of NLDNR, the Wildlife Division of NLDEC, and the Department of Labrador and Aboriginal Affairs.

Happy Valley-Goose Bay has benefited from natural resource development in Labrador, particularly the growing mining industry in northern Labrador led by the Voisey's Bay Nickel Company (VBNC, now Vale Inco Newfoundland and Labrador Limited – VINL). Additionally, the completion of the TLH has resulted in new business opportunities in the community, including tourism and business expansion resulting from new trading patterns in the region (Town of Happy Valley-Goose Bay 2001, Internet site).

The TLH connects the Upper Lake Melville Area with western Labrador (Figure 5-7). The connection to southeastern Labrador (Phase III, Happy Valley-Goose Bay to Cartwright), is currently under construction. It will be linked to Phase II of the TLH, which was completed in 2002. In addition to road linkages, the Upper Lake Melville Area is connected to both the Island and the northern coast of Labrador through the provincial ferry service, which operates during the ice-free months (generally, June to September). The area is also served by

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one of Labrador's three airports, which provides service to Newfoundland, mainland Canada and other communities in Labrador, many of which are served by community airstrips.

Mud Lake, North West River and Sheshatshiu are located close to Happy Valley-Goose Bay, near Lake Melville. Government services, including health care, education and social services, are the main employers of the residents of these communities, many of whom work in Happy Valley-Goose Bay. North West River and Sheshatshiu are connected to Happy Valley-Goose Bay by road, whereas Mud Lake is accessible only by helicopter, boat or snowmobile.

Churchill Falls is a community operated by the Nalcor Energy - Churchill Falls, located approximately 300 km west of Happy Valley-Goose Bay. Most the residents of this community are employed by Nalcor Energy - Churchill Falls. Although there is a small service sector, the Churchill Falls Power Station is at the centre of the community's economy.

In northern Labrador, the emergence of a mining industry, including the Voisey's Bay nickel mine and ongoing uranium exploration south of Postville, has made mining and related industries a major employer. This is also the case in western Labrador, where iron ore mining is the dominant industry and primary employer. Labrador City and Wabush have developed a strong industrial base related to the mining sector. They are connected to the rest of Labrador and Quebec by a network of roads, including the TLH.

The QNSLR connects Western Labrador to port facilities in Baie Comeau and Sept-Îles, Quebec (Figure 5-7). In the southeastern and Labrador Straits regions, primary and processing industries are present, with some employment resulting from government services (Labrador West 2008, Internet site).

5.3.4.3 Land Use

Land and resource use activities throughout Labrador include hunting and trapping, angling, wood harvesting, berry picking, snowmobiling and boating. Both Aboriginal and non-Aboriginal persons are active land and resource users and this use occurs for traditional, subsistence and recreational purposes. For residents of the Upper Lake Melville area and Churchill Falls, this activity is generally focused on the areas adjacent to the TLH Phase I between Happy Valley-Goose Bay and Churchill Falls. It also takes place around Grand Lake and many of the former homestead communities near Upper Lake Melville. For both Aboriginal and non-Aboriginal persons in central Labrador, land use takes place throughout the year. Residents of western Labrador also travel to central Labrador for recreational reasons.

Innu land and resource use for subsistence and traditional purposes is widespread; however, current use, including the establishment of camps and the opportunistic harvest of caribou, porcupine, beaver, ptarmigan and other species, is focused on areas adjacent to the TLH Phase I between Happy Valley-Goose Bay and Churchill Falls. Other areas used include the area south of Lake Melville, particularly along the Eagle River and its tributaries.

Ice fishing is a popular activity in Lake Melville, particularly at Partridge Island and in Sandy Point Channel, as well as the area between Mulligan River and North West River. Fish taken include trout, smelt and rock cod. As with inland waters, bag limits do apply. Although no precise statistics are available, more fish are taken during the ice fishing season, which lasts from October to May, than during the remainder of the year.

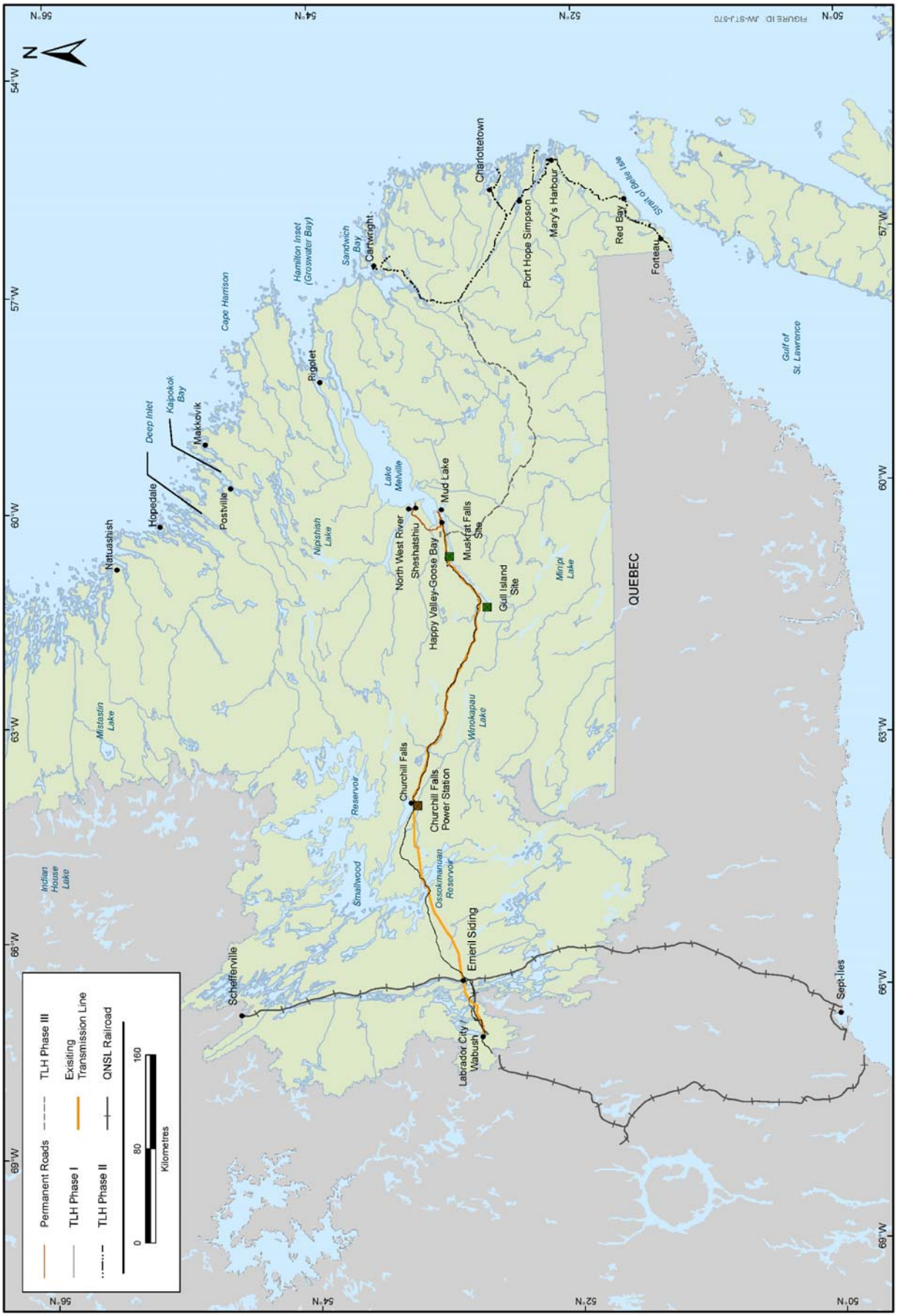


Figure 5-7 Road and Rail System

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Within the Churchill River valley, salmon and trout are the species of choice for both angling and net fishing, and the area between Muskrat Falls and Lake Melville has the highest concentration of activity. The lower Churchill River is, however, not a favoured location for fishing, especially upriver of Muskrat Falls. From Churchill Falls to Winokapau Lake and the surrounding lakes and rivers, trout is the predominant species, while some pike are harvested in shallower waters. Other species such as whitefish and suckers are also fished but are not actively harvested. Between Gull Island and Muskrat Falls, activity is limited, although there is some fishing near Edwards Brook and Lower Brook (J. Powell, pers. comm.).

There is currently a subsistence net fishery in the Lake Melville area and in southern Labrador. Residents are allowed to catch four salmon and 50 trout per license and there is one license issued per household. The DFO and Innu Nation have established a co-management agreement for net fisheries. These agreements set annual harvest limits and manage season and gear restrictions (J. Powell, pers. comm.).

In the 1980s, an unsuccessful effort was made to develop an Innu commercial whitefish fishery in Smallwood Reservoir. The levels of mercury in fish were an impediment at that time. Based on results of ongoing monitoring, levels are now within safe consumption limits for the most species of interest. Preliminary efforts have been initiated by Innu Economic Development (in cooperation with others) to start a training and test fishing program as early as 2009.

An important element of land and resource use is the tourism industry, particularly in central Labrador. The Central Labrador Economic Development Board reports that at least 25 percent of its businesses have self-identified as tourism related (CLEBD 2006). Tourism is expected to increase in the region, with the pending establishment of the proposed Mealy Mountains National Park.

Labrador is divided into eight FMDs. FMD 19 is located within the lower Churchill River watershed. It is the centre of forestry-related activity in Labrador. The total allowable cut (TAC) has been established by Forest Resources Branch of NLDNR at 200,000 m^3. More than 66 percent of the timber lies south of the Churchill River and is not fully accessible (Newfoundland and Labrador Forest Resources and Agrifood 2003, Internet site). The fishery is also a large employer for the coastal communities of Labrador, with 10 processing plants processing a variety of species (NLDLAA 2006).

5.4 Information Availability and Gaps

Dedicated studies for a proposed hydroelectric development at Gull Island and Muskrat Falls and transmission line to Newfoundland were first conducted from 1976 to 1979, in support of an environmental assessment Panel Review under the Federal Environmental Assessment and Review Process and in accordance with requirements of Newfoundland and Labrador. Over 20 component studies, including baseline surveys of both the biophysical and socio-economic environments, were prepared between 1979 and 1980, as supporting documents to the EIS, which was formally submitted to the Panel in April 1980. For a second effort to develop the lower Churchill in 1990, a comprehensive review of information was conducted, but no baseline surveys were conducted. The third Lower Churchill development effort, the CRPP began in 1998. Over 30 studies were prepared between 1998 and 2000 in support of the CRPP in anticipation of an environmental assessment. These developments did not proceed, mainly due to project economics and market access.

The development of the currently configured Project, the fourth effort, began in 2006. Forty-one field programs, modelling studies and environmental baseline reports were completed between 2006 and 2008 detailing various aspects of the aquatic, terrestrial, atmospheric, cultural and socio-economic environments.

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The previous studies and assessments of hydroelectric developments at Gull Island and Muskrat Falls, the studies conducted for the Project, and the other studies conducted in the region (nine baseline studies for TLH Phase III and 16 for the Military Training Area) provide an important and comprehensive baseline of information for conducting this environmental assessment. Any technical limitations of the available information are discussed in the environmental effects assessment chapters.

For the first time, ITK was available for this assessment; however, there are some limitations as noted in the ITKC Report.

> *This discussion of Innu environmental knowledge is by necessity incomplete, as noted at the beginning of the report. Time placed limits on our ability to explore many aspects of Innu knowledge in any depth, and furthermore, the "white room" setting of the focus group and individual interviews removed the ITKC members from contexts probably more conducive to remembering details about the land and its biota, for example, physical presence on the land in the context of travel, hunting, trapping, fishing, and gathering activities. This report is therefore a distillation of Innu environmental knowledge.*
>
> (p. 24)
>
> *To varying degrees, Innu knowledge of animal habitats, anatomy, behaviour, sounds, senses, locomotion, alimentation, and reproduction has been recorded from Innu Elders resident in Mingan (Clément, 1995) and the former Davis Inlet (Clément 1998). Innu botanical knowledge was documented by Clément (1990) for a sample of Mingan Elders. Like his work on Innu zoology, Clément's ethnobotanical study was a major study entailing many months of fieldwork among the Innu and subsequent analysis. Documenting or validating this same knowledge with Sheshatshiu Innu Elders could not be undertaken in any systematic way given time constraints. Therefore, it is assumed that general knowledge related to animal, plant and fish species possessed by Sheshatshiu Innu is more or less similar to the knowledge of their neighbours to the north and south.*
>
> (pp. 10-11)
>
> *Time constraints, as noted in various places throughout this report, posed the major limitation on the amount of environmental knowledge that could be elicited from the ITKC members. In addition, the close transcription and translation of Innu narratives is a time-consuming and expensive proposition, and both time and budgets conspired to limit the volume of Innu discourse that could be examined in detail. Finally, as will be clear from the summary land use biographies below, extensive land use by ITKC members in most of the Mishta-shipu area concluded in the early 1970s, which means that their empirical, observational experience there has not been updated in any significant way for thirty or more years. Under the circumstances, we cannot expect ITKC members to be able to contribute detailed observationally-based information to the current study for the years that they were absent from that part of the territory.*
>
> (p. 11)
>
> *It is important to note that I have not been concerned with determining the veracity of Innu knowledge claims about the environment in relation to some external standard, for example, a western scientific one. The goal is to make sense of Innu knowledge about the "natural environment," with a particular emphasis on the Mishta-shipu (Churchill River) area. The focus, therefore, has been an "emic" versus "etic" one, concentrating on Innu (insider) understandings, constructs, or conscious models of the natural environment. Furthermore, I have no interest in attempting to demonstrate that Innu knowledge about the land, animals and plants is comparable to western science (cf. Clément, 1995), as such a comparison is beyond the mandate of the ITKC, and would require significant input from people with botanical, zoological, and ecological expertise. I shall return to this point in the conclusion of the report.*
>
> (p. 11)

> *A number of academic critics have observed that TEK research is a distillation of knowledge that is embedded within complex social relations and knowledge structures, and that the representation of TEK in reports such as this one decontextualize and therefore distort the knowledge (Ellis, 2005; Nadasdy, 1999; Stevenson, 1996). "A whole array of stories, values, social relations and practices, all of which contribute substance and meaning to aboriginal people's relationship to the environment, must be 'distilled out' of TEK before it can be incorporated into the institutional framework of scientific resource management" (Nadasdy, 1999:7). This criticism has some validity in my view, and it should be kept in mind when reading this report. However, any act of ethnographic representation is an unavoidable exercise in distillation, and we do not stop sifting through the overwhelmingly rich detail of human experience simply because it is impossible to represent this richness in its entirety. Nonetheless, we must recognize that a report of this nature cannot do full justice to lifetimes of experience on the land, and all the nuances of Innu thinking and discourse about the natural world.*
>
> (pp. 11-12)

5.5 Likely Future Environmental Conditions without the Project

The construction and expansion of human activities in the region are expected to continue with or without the Project, although the timelines and levels of effort may vary. In the absence of the Project, the region is expected to experience changes in climate and, to a smaller degree, changes in background air quality and atmospheric deposition from the long-range transport of air contaminant emissions.

The predictions from global circulation models for the region suggest warmer temperatures and slightly higher rainfall amounts over the next century. Relative humidity and cloud cover are anticipated by most models to increase, resulting in a decrease in incident solar radiation. These conditions generally indicate a more stable atmosphere. Most modelling results indicate lower wind speeds and less diurnal temperature change over the next century in the region. These predictions are broadly applicable with or without the Project being developed.

Changes in ice processes within the lower Churchill River are not expected to be substantial, nor detectable from the existing situation, in the absence of the Project. However, some changes such as river flows at Gull Island or Muskrat Falls may be detectable.

Ecological processes within the two ecozones (Eastern Taiga and Boreal Shield) are not expected to change substantially. As the climate changes, a lagged change may occur in the ecozones. These may include changes in the areal extent of the ecozones, the average temperature of the ecozones, the growing season, or the ability to support existing plant and animal species. One change that may be associated with milder winter conditions is the recent outbreak of such insects as the hemlock looper that is currently attacking coniferous forest in the Churchill River valley. Dead and dying trees were first noted in 2006 near Gull Island. If this outbreak continues, much of the coniferous cover in the Churchill River watershed could be at risk.

Increased human activities and associated effects on forest cover, in combination with climate change, may affect the distribution and/or abundance several species of wildlife. Species such as moose, Red-tailed Hawk, Mourning Dove and others associated with areas south of the Churchill River are relatively new to the area and may continue to disperse. Conversely, several species are considered of special conservation status. Their decline may be addressed through deliberate management actions, although the fate of the RWM Caribou Herd remains tentative. The Provincial Wildlife Division and Recovery Team believe recovery of this Herd is possible, although the Herd has declined dramatically in the last 20 years, with an estimate of 97 animals in 2001 (Chubbs et al. 2001).

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In the absence of the Project, GHG and long-range transport of air pollutant (LRTAP) would continue to contribute in a potentially measurable way to climate change, and acid deposition in the region. However, given the increasingly stringent emissions standards on criteria air contaminant emissions in Canada and the United States, the LRTAP contribution to adverse effects on air quality and to acid rain may not be measurable.

Labrador is likely to see zero to modest population growth. Any increases will likely be the result of in-migration, mainly to western Labrador, in response to growth in mining activity. Demographic growth may be further stimulated in central Labrador through new activity and federal government investment at 5 Wing Goose Bay.

In general, the Labrador economy will continue to be highly dependent on the resource sector, especially on iron ore mining in Western Labrador and nickel mining in northern Labrador. This activity is also important to central Labrador, which is a service centre for the latter region. The next decade is also likely to see increased petroleum industry activity in the Labrador Sea, which may provide additional economic opportunities in northern Labrador (including Nunutsiavut) and central Labrador. However, all such activity is vulnerable to resource cycles and related social and economic challenges.

Growth in tourism is also expected, given improved transportation infrastructure within and beyond Labrador, the development of a Mealy Mountains National Park, growth in recreational fishing and ecotourism and increased international awareness of such sites as Battle Harbour and Red Bay. Forestry and fishing will continue to be important to some smaller communities.

The creation of Nunutsiavut will likely be followed by progress on other Aboriginal land claims, leading to greater autonomy. This may help in addressing the social, economic and cultural challenges currently experienced among Aboriginal people.

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6.0 REGULATORY CONTEXT AND SCOPE OF ASSESSMENT

This chapter outlines the regulatory context for this environmental assessment and provides a brief description of the scope of assessment that has been determined by the provincial and federal governments for the Project. The description of the regulatory context (Section 6.1) includes an explanation of the purpose of this EIS and the provincial and federal government environmental assessment process milestones. In Section 6.2, the scope of the Project, factors to be considered and the scope of those factors are described as determined jointly by the provincial and federal government. Section 6.3 describes the regulatory consultation, and Section 6.4 describes the applicable legislation.

6.1 Regulatory Context

The Project is subject to environmental assessment requirements of the *NLEPA* and the *CEAA*. This EIS presents the results of the environmental assessment that was carried out according to these requirements, specifically Section 57 of *NLEPA* and Section 16 of *CEAA*.

6.1.1 Purpose of the Environmental Impact Statement

The EIS sets out the need, purpose and rationale for the Project, provides a Project description (Chapter 4) and a description of the environment in which it will be built and operated. The EIS includes a discussion of alternatives to the Project (Chapter 2), and alternative means of carrying out the Project (Chapter 3).

The EIS provides a consideration of the environmental effects of the Project, including: (a) the environmental effects of malfunctions or accidents and any cumulative effects that are likely to result from the Project in combination with other projects or activities that have been or will be carried out; (b) significance of these effects; (c) measures that are technically and economically feasible that would mitigate any significant adverse environmental effects of the Project; and (d) monitoring and follow-up programs. The effects of the Project on the environment are also assessed. The EIS also addresses the potential effects of the Project on the capacity of renewable resources that are likely to be significantly affected by the Project to meet the needs of present and future generations.

6.1.2 Provincial and Federal Environmental Assessment Processes

This section describes the aspects of the Project that have triggered the requirement for an environmental assessment and then describes the process milestones that have occurred and will follow submission of this EIS.

6.1.2.1 Environmental Assessment Triggers

Under *NLEPA*, the Project is defined as an undertaking subject to Part X, pursuant to Section 34(1)(a) and 34(1)(d) of the *Environmental Assessment Regulations* and therefore required registration:

> *34. (1) An undertaking that will be engaged in electric power generation and the provision of structures related to that power generation, including:*
>
> *(a) the construction of dams and associated reservoirs where the area to be flooded is more than 50 hectares; and*
>
> *(d) the construction of hydroelectric power developments with a capacity of more than one megawatt.*

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Under *CEAA*, DFO and Transport Canada are federal authorities with regulatory responsibilities to conduct an environmental assessment by virtue of *Law List Regulation* triggers that have been determined to apply to the Project. These responsible authorities (RAs) see that an environmental assessment is conducted prior to the issuance of federal permits and authorizations for the Project.

The following *Law List Regulations* triggers apply to the Project:

- *issuance of authorization by DFO for work related to the construction of the hydroelectric generation facilities with the potential for harmful alteration, disruption or destruction of fish habitat pursuant to sub-section 35(2) of the Fisheries Act; and*
- *issuance of a permit by Transport Canada for the construction of the hydroelectric generation facilities pursuant to sub-section 5(1) of the NWPA.*

6.1.2.2 Environmental Assessment Process Milestones

Registration/Project Description

A joint Registration/Project Description document was filed with the NLDEC and the CEA Agency on December 1, 2006. That document initiated the provincial and federal environmental assessment processes.

Provincial Determination

Upon consideration of the registration, the Newfoundland and Labrador Minister of Environment and Conservation advised, on January 26, 2007, that an EIS was required pursuant to *NLEPA*.

Federal Determination

The federal Minister of Environment announced, on June 5, 2007, that an independent review panel pursuant to *CEAA* would conduct the environmental assessment.

Joint Review Process Established

To reduce duplication of effort and maximize the effectiveness of the environmental assessment processes, the governments of Newfoundland and Labrador and Canada developed and issued a Joint Review Panel Agreement on January 8, 2009 pursuant to Section 72 of *NLEPA* and Sections 40 and 41 of *CEAA*. As a part of the process outlined in the agreement, a joint review panel (the Panel) was appointed by the provincial Minister of Environment and Conservation and by the federal Minister of Environment to review and assess the environmental effects of the Project.

Environmental Impact Statement Guidelines

The provincial and federal governments, with input from the public, developed EIS Guidelines jointly. Draft EIS Guidelines were issued in December 2007 for review and comment by the public. Comments were received up to February 27, 2008. Final EIS Guidelines were issued jointly by the federal and provincial government on July 15, 2008.

The purpose of the EIS Guidelines is to identify the nature, scope and extent of the information and analysis required for the EIS. The EIS Guidelines have been appended (Appendix IB-E) for reference, along with a Table of Concordance to guide the reader in finding where the EIS addresses the Guideline requirements.

Environmental Impact Statement Prepared and Submitted

As proponent, Nalcor Energy is responsible to prepare and submit this EIS pursuant to the *NLEPA* and *CEAA*. Nalcor Energy has:

- collected the baseline information;
- conducted consultation with the Aboriginal community and the public;
- completed the analyses required to evaluate the potential environmental effects and cumulative environmental effects of the Project;
- proposed mitigation to reduce adverse environmental effects and optimize positive effects; and
- recommended follow-up to verify environmental effects predictions and evaluate the effectiveness of mitigation.

This EIS addresses the requirements contained in the Guidelines and presents the results of the environmental assessment. Nalcor Energy has determined measures that are required to mitigate any adverse environmental effects and the significance of residual environmental effects.

Public Hearings and Panel Review

Following submission of the EIS, the Panel will consider all public comments received on the document and determine whether adequate information has been presented upon which to base the environmental effects analysis. Panel Hearings will be organized and conducted once the Panel has determined that it has the necessary information. The Panel will consider the results of the hearings and its environmental effects analyses. It will then submit a report with recommendations to the provincial Minister of Environment and Conservation, and to the federal Minister of the Environment.

Government Decisions

In considering the Panel's final report and its conclusions and recommendations, the respective governments will make decisions on whether the Project may proceed and, if so, on what conditions. The federal Minister will refer the Project back to the RAs (DFO and Transport Canada) for appropriate action based on the federal decision.

6.2 Scope of Assessment

The scope of assessment refers to the regulatory determination of what is required for consideration in the environmental assessment. In broad terms, the scope of assessment refers to:

- the elements of the Project that shall be assessed (i.e., the scope of the Project);
- the factors to be considered in the environmental assessment (i.e., what issues shall be addressed in the environmental assessment); and
- the scope of the factors to be considered (i.e., to what extent shall those issues be considered in the environmental assessment).

The scope of assessment for this environmental assessment was established by the governments of Newfoundland and Labrador and Canada in the final EIS Guidelines, and through the Joint Review Panel Agreement and Terms of Reference issued January 8, 2009. The authority for establishing the scope of assessment under *CEAA* arises from Section 15 (scope of Project) and Section 16 (factors to be considered and the scope of those factors to be considered).

The scope of assessment that has been established in the Panel Terms of Reference (Schedule 1 of the Agreement) directs the following factors to be considered in the environmental assessment of the Project:

1. *Purpose of the Project/undertaking*
2. *Need for the Project/undertaking*
3. *Rationale for the Project/undertaking*
4. *Alternative means of carrying out the Project/undertaking that are technically and economically feasible and the environmental effects of any such alternative means*
5. *Alternatives to the Project/undertaking*
6. *Extent to which biological diversity is affected by the Project/undertaking*
7. *Description of the present environment which may reasonably be expected to be affected, directly or indirectly, by the Project/undertaking, including adequate baseline characterization*
8. *Description of the likely future condition of the environment within the expected life span of the Project/undertaking if the Project/undertaking was not approved*
9. *Environmental effects of the Project/undertaking, including the environmental effects of malfunctions, accidents or unplanned events that may occur in connection with the Project/undertaking*
10. *Any cumulative environmental effects that are likely to result from the Project/undertaking in combination with other projects or activities that have been or will be carried out*
11. *The significance of the environmental effects*
12. *Mitigation measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the Project/undertaking, including the interaction of these measures with existing management plans*
13. *Proposals for environmental compliance monitoring*
14. *Measures to enhance any beneficial environmental effects*
15. *Need for and requirements of any follow-up program in respect of the Project/undertaking*
16. *Capacity of renewable resources that are likely to be significantly affected by the Project/undertaking to meet the needs of the present and those of the future*
17. *Extent of application of the Precautionary Principle to the Project/undertaking*
18. *Comments received from Aboriginal persons or groups, the public and interested parties by the Panel during the environmental assessment*
19. *Factors related to climate change including GHG emissions*
20. *Proposed public information program*

The Terms of Reference establish the scope of the assessment that the Panel shall undertake. The EIS Guidelines (Appendix IB-E) provide more detail and further define the scope of assessment.

6.2.1 Scope of the Project

The scope of the Project for the purposes of the environmental assessment is the hydroelectric generation facilities at Gull Island and Muskrat Falls, and interconnecting transmission lines to the existing Labrador grid.

The Gull Island facility consists of a generation station with a capacity of 2,250 MW that includes:

- a dam 99 m high and 1,315 m long; and
- a reservoir 213 km² in area at an assumed full supply level of 125 m asl.

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The dam is to be a concrete-faced, rockfill dam. The reservoir will be 232 km long, and the area of inundated land will be approximately 85 km² at full supply level. The powerhouse will contain five Francis turbines.

The Muskrat Falls facility consists of a generation station with a capacity of 824 MW that includes:

- a concrete dam with two sections on the north and south banks of the river; and
- a reservoir 101 km² in area at an assumed full supply level of 39 m asl.

The south section dam will be 29 m high and 325 m long, while the north section will be 32 m high and 432 m long. The reservoir will be 59 km long and the area of inundated land will be 41 km² at full supply level. The powerhouse will contain four propeller or Kaplan turbines, or a combination of both.

The transmission lines consist of:

- a 735 kV transmission line between Gull Island and Churchill Falls; and
- a double-circuit 230 kV transmission line between Muskrat Falls and Gull Island.

The 735 kV transmission line will be 203 km long and the 230 kV transmission lines will be approximately 60 km long. Both lines will likely be lattice-type steel structures. The location of the transmission lines will be north of the Churchill River; the final route is the subject of a route selection study.

The Project design will be refined as engineering details are developed. In Section 4.3.3 of the EIS Guidelines (Appendix IB-E), Nalcor Energy is required to describe in the EIS the scope of the Project for which the EIS is being conducted, including the construction, commissioning, operation and maintenance, foreseeable modifications of the facilities and, where relevant, the demobilization, closure, decommissioning, and restoration of the construction facilities, related to the undertaking. The requirements of the Project description to be presented in the EIS include:

- a description of spatial boundaries of the Project;
- a description of principal structures and related works;
- temporal boundaries of Project phases;
- construction associated with
  - reservoir preparation
  - dams
  - reservoirs
  - generation stations
  - access infrastructures
  - borrow pits, quarries, spoil areas
  - transmission facilities
  - personnel requirements
  - temporary structures and infrastructures
- mitigation and compensation works;
- demobilization work;
- operation and maintenance including; and
  - operating regime
  - access roads

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  - transmission facilities
  - personnel requirements
  - fuel hazardous/dangerous goods and waste handling
  - operating permits and authorizations
- approach to decommissioning.

These are described in greater detail in Section 4.3.3 of the EIS Guidelines (Appendix IB-E). The Project description is provided in Chapter 4.

6.2.2 Factors to be Considered and Scope of the Factors

As described above, the scope of assessment includes consideration of the factors that are to be considered in the environmental assessment and the scope of those factors. These have been defined in detail in the EIS Guidelines (Appendix IB-E). In outlining these, the governments have included consideration of the mandatory factors as defined under *NLEPA* and *CEAA*. They have also defined the scope of issues to be considered, and to what extent.

6.2.2.1 Factors to be Considered

As outlined in the EIS Guidelines (Appendix IB-E), the mandatory factors to be included in the environmental assessment are prescribed in Section 57 of *NLEPA* and Sections 16 (1)(a) to (d), and (2) (a) to (d) of *CEAA* and include:

- the environmental effects of the Project, including the environmental effects of malfunctions or accidents that might occur in connection with the Project, and any cumulative environmental effects that are likely to result from the Project in combination with other projects or activities that have been or will be carried out;
- the significance of the effects referred to in the preceding paragraph;
- comments from the public, if any, received as part of an assessment process;
- technically and economically feasible measures that would mitigate any significant adverse environmental effects of the Project;
- the need, purpose and rationale of the Project;
- alternatives to the Project;
- alternative means of carrying out the Project that are technically and economically feasible and the environmental effects of any such alternative means;
- the need for, and the requirements of, any follow-up program for the Project; and
- the capacity of renewable resources that are likely to be significantly affected by the Project to meet the needs of the present and those of the future.

6.2.2.2 Scope of the Factors to be Considered in the Environmental Assessment

The EIS Guidelines (Appendix IB-E) provide very specific requirements regarding the scope of the issues to be included in the EIS. These requirements include information and analyses required for consideration, including a description of the Project, description of the existing environment, the evaluation of environmental effects, mitigation measures and public participation.

The sections of the EIS where Guideline requirements are addressed and summarized in the Table of Concordance provided in Appendix IB-E.

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6.3 Regulatory Consultation

The Project Team has had, and continues to have, ongoing consultations with a number of regulatory agencies and with four levels of government: municipal, Aboriginal, provincial and federal. Details of consultation to the time of submittal of the EIS are provided in Chapters 7 and 8.

6.4 Legislation, Regulations, Guidelines, Policies

The EIS Guidelines require that the EIS identify and discuss the relationships between the Project and relevant legislation and policies. These relationships are presented in Chapter 1. Consideration and integration of the requirements of existing legislation, regulation and policies are integral to Project planning and design and a thorough record and cross-check are developed as part of EPPs that will be developed for specific Project phases and locations. The activities, associated permits or approvals, relevant legislation and agencies that are and/or will be relevant to the Project are listed in Appendix IB-G.

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7.0 PUBLIC CONSULTATION

This chapter addresses public consultation as it relates to the Project. It describes how Nalcor Energy has informed and consulted with the residents, communities, community organizations, interested regional and national organizations, resource users, other stakeholders, government agencies and the general public. This chapter and Appendix IB-I explain the results of these consultations. The concerns and interests identified through the public consultation process and where they are addressed in the EIS are in Appendix IB-I. That appendix also describes the consultation program for the remainder of the environmental assessment process.

In accordance with the EIS Guidelines (Appendix IB-E), Nalcor Energy developed consultation methods and tools that comply with *CEAA* legislation and with the NLDEC policy and are described in Sections 7.3 (Methods) and 7.4 (Consultation Activities). Section 7.5 (Issues Identification) contains a summary of the results of the public consultation program.

The consultation process with Aboriginal groups and communities is presented in Chapter 8.

7.1 Purpose

Public participation is a central objective of the environmental assessment process and a means to identify, record and account for public concerns and interests. From the perspective of regulatory agencies, there are two purposes for the consultation required by the EIS Guidelines (Appendix IB-E): to inform the public about all aspects of the Project and the environmental assessment process; and, to identify their interests and concerns.

Public consultation enables meaningful dialogue with the people who have an interest in the Project. It is an opportunity to share Project information and to receive information and comments from the public.

7.2 Guiding Principles

Nalcor Energy believes that sustained communication with residents who will be affected by the Project is a priority. Nalcor Energy also believes that the communities and businesses of Upper Lake Melville area, Churchill Falls and western Labrador, and the Province in general, should have timely and accurate information about the Project. Stakeholders should have the opportunity to discuss with representatives of Nalcor Energy both the positive and adverse aspects of the Project that may affect them.

As a general approach, the scale and effort of public participation increases with proximity to the Project. Thus, the effort to date has focused on communities in Upper Lake Melville (i.e., Happy Valley-Goose Bay, North West River, Sheshatshiu and Mud Lake), Churchill Falls, western Labrador (Labrador City and Wabush), Natuashish and, to a lesser extent, St. John's.

Meaningful consultation can only take place if the public has a clear understanding of the Project as early as possible in the review process. Therefore, Nalcor Energy adheres to the following guiding principles for its public participation program:

- provide up-to-date information describing the Project to the public and the communities most likely to be affected by the Project;
- involve the main interested parties in determining how best to deliver information;
- deliver programs and information in a timely manner;
- be responsive to public input and concerns and take these into account during Project design and planning;
- record accurately and respond appropriately to public concerns raised;

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- identify and use effective means to provide accurate and complete information; and
- conduct public meetings/consultations in accordance with applicable regulatory requirements and guidelines.

The approach to public consultation taken by Nalcor Energy is based on the premise that public participation is a fully integrated and iterative process, which includes the following considerations:

- begin consultation early and conduct it often, because expectations and acceptance within communities can change with time, and information and previous knowledge might be forgotten;
- allow communities time to consider and review Project information, concerns and issues;
- consider the community's workload and seasonal availability;
- provide information on plans, locations, timing and associated environmental issues in a non-technical way;
- follow rigorously a public consultation process that is based on a work plan that includes specific milestones, locations, dates, times responsibilities, audiences, intended outcomes and communications tools, but is sufficiently flexible to respond to changing circumstances or external requests;
- show how input from the community and local knowledge has affected Project decisions or plans;
- provide consistent key messages and information to all stakeholders;
- respond to queries, questions and issues in an appropriate manner;
- work with stakeholders so that viewpoints are heard;
- provide regular information, especially with respect to changes in Project plans; and
- extend the consultation program to include all Project phases.

7.3 Methods

The methods used to record and incorporate input and to disseminate Project information (including the EIS) are key to effective consultation. The methods employed for the Project are described below.

7.3.1 Project Website

The Project website is at www.lowerchurchillproject.ca and contains Project information, contact information, updates on public consultations and current news about the Project.

The website, launched in February 2007, contains all of the documents and information available at an open house, as well as other background information on the Project. The Project website also has a section containing current and archived news about the Project.

Finally, the website allows interested individuals to identify whether they are interested in receiving Project news and updates via e-mail.

Specific information contained on the Project website includes:

- background information about Nalcor Energy and hydroelectric generation;
- information about the Project and its environmental assessment including a copy of the Project Registration;
- archived news headlines regarding the Project and dates of public consultation events;
- information about important Project-related environmental issues;

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- summaries of baseline reports from 1998 to 2007; and
- information sheets, presentations and newsletters.

7.3.2 Electronic News Notifications

The Project website includes a function whereby viewers can subscribe to a Project email distribution list. Subscribers receive news advisories as they are posted to the website. This enables subscribers to stay current with the Project without having to check the website frequently. As of August 2008, there are 155 subscribers to this service.

As of July 2008, there have been 22 news advisories sent to this distribution list (Appendix IB-I).

7.3.3 Project Newsletter

A Project newsletter published in fall 2008 was emailed to all subscribers to the news advisory system. It was also mailed to residents of Labrador, government agencies, and to those who had indicated in the open house exit surveys an interest in receiving Project updates. Project newsletters will be published twice yearly (and posted on the website) throughout the environmental assessment process and during Project construction.

7.3.4 Community Information Centre

A drop-in storefront Community Information Centre is scheduled to open in Happy Valley-Goose Bay in 2009. The centre will provide an accessible and inclusive resource that will demonstrate Nalcor Energy's commitment to provision of timely and accurate Project information. The centre will also seek to receive feedback on the Project through dialogue with the interested public.

7.3.5 Information Sheets

To date, eight information sheets based upon the preliminary issues scoping for the Project were developed and distributed publicly. The topics are:

- mercury in reservoirs;
- greenhouse gases;
- socio-economic assessment;
- environmental assessment process;
- aquatic studies;
- terrestrial studies;
- reservoir formation; and
- historic resources studies.

Each sheet provides information in clear language that responds to the most frequent questions posed on that issue. Other information sheets will be developed as the need arises. People can obtain information sheets at meetings, open houses and on the Project website.

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7.3.6 Posters

To facilitate discussion at the open houses and other meetings, a series of full colour and illustrated posters (1.3 m by 1.6 m) were created for the Project. These posters focused on the following themes:

- Lower Churchill Project - identifies the resource development site locations, states a potential completion date and shows conceptual illustrations of the future reservoirs.
- Transmission Interconnection: Corridor Selection - outlines transmission line requirements and the corridor selection process.
- Environmental Baseline Studies - references the baseline work associated with the environmental assessment and specifically features aquatic, terrestrial, historic resources and socio-economic studies.
- Environmental Benefits - describes the Project potential to displace GHG emissions, outlines what GHG are and provides Canadian statistics for GHG emissions in the energy sector.
- Environmental Commitment - outlines the environmental assessment process by stages.
- Newfoundland and Labrador Hydro - this poster outlines the commitments of the Corporation to the public.

Other descriptive posters will be developed as the need arises.

7.3.7 Public Advertisements

All public meetings are advertised widely using regional newspapers, radio ads, posted notices, website posting, email and mail-outs. As well, a distribution list is maintained and updated regularly. A copy of an open house advertisement can be found in Appendix IB-I.

7.3.8 Exit Surveys

Exit surveys were provided to participants as a means of obtaining feedback on the effectiveness of the open houses and technical workshops. The survey form includes contact information and various means of forwarding comments.

7.3.9 Open Houses

The open house type of meeting has been used extensively to provide maximum opportunity for one-on-one interchanges and allow participants to decide on the level of engagement that is appropriate to their needs and interests.

All meetings are advertised well in advance of each event and in accordance with EIS Guidelines requirements. Suitable locations and hours are selected to allow for daytime and evening attendance. Staff records the number of people attending each event. Display material is provided on the Project, the baseline studies, and major issues and concerns. Handout material is available to attendees, who are requested to indicate their interest in receipt of Project information. Exit survey forms are offered to attendees as one means of providing feedback on and improving the effectiveness of subsequent open houses. Members of the Project Team including, as appropriate, specialist consultants, staff the open houses. Host personnel carry out a debriefing at the conclusion of each session to record key points of conversations with attendees in addition to receiving written comments. A written report is prepared to document the issues raised and to identify any recommended follow-up.

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7.3.10 Issues Database

An issues database has been maintained for the Project based on all communications with stakeholders, including telephone conversations, emails and letters. The information gathered is used to determine common and recurring issues, compile new information and understand frequently asked questions.

7.3.11 Technical Workshops

Technical workshops have been and will continue to be offered to share knowledge, achieve an understanding of the key issues for the Project, and to lay a solid foundation for future consultations on these and other issues.

Workshop participants are invited based on their expression of interest. The workshops generally followed a format of a presentation on the specific issue, followed by a question and answer session and discussion.

The desired outcomes of the technical workshops are to:

- share information and provide opportunities to discuss opinions and ideas on the subject;
- begin to build a common understanding of the issues and where gaps in knowledge and understanding exist;
- demonstrate an interest in the views and concerns of stakeholders;
- establish a respectful relationships with stakeholders; and
- finish each workshop with a plan for next steps.

7.3.12 Meeting Minutes

A written record, based on a template, is kept for all open houses and technical workshops. Documented criteria include a list of/number of attendees, issues raised via questions, Project Team responses and whether follow-up is required. The record was later circulated to attendees for their information.

7.4 Consultation Activities

The following section outlines the public consultation program activities completed to date (generally to September 2008).

On November 14, 2005, a meeting was held in Happy Valley-Goose Bay among 24 groups and individuals from throughout Labrador. Attending were Premier of Newfoundland and Labrador Danny Williams, other members of the Government of Newfoundland and Labrador and representatives of Hydro. The meeting was the first public consultation for this Project and it established the intent that public consultations be a central component of the Project approval process. Hydro committed to ongoing, continuous, meaningful consultation with the people of Labrador regarding this Project.

7.4.1 Open Houses

Nine open houses were held throughout the Project area and on the Island of Newfoundland up to September 2008 (Table 7-1). The purpose of the open houses was to introduce the Project, provide initial Project information and obtain feedback on how the various groups and individuals want to receive ongoing information.

Table 7-1 Project Open Houses to Date

Community	Date	Attendance
Churchill Falls	April 15, 2007	21
Happy Valley-Goose Bay	April 16, 2007	38
North West River	April 17, 2007	12
Labrador City	May 29, 2007	26
Labrador City	March 10, 2008	7
Happy Valley-Goose Bay	March 12, 2008	12
North West River	March 13, 2008	10
St. John's	May 27, 2008	67
Rigolet	September 16, 2008	8

The content of the open houses included:

- update of information;
- Project description;
- transmission interconnection;
- environmental commitment;
- overview of baseline studies; and
- description of commitments.

Open houses were advertised in the local media several weeks in advance, and centrally located for ease of access. These sessions were offered over several hours to encourage attendance and the sessions were well staffed so that attendees were able to interact readily with Project personnel who could answer questions and share information. Posters were on display and copies of information sheets provided for people to review and take away, along with an exit survey on their impressions. The issues raised by participants are discussed in Section 7.5.

Once the EIS is submitted, a second series of open houses will be held to share updated information with the public.

7.4.2 Technical Workshops

The topic for the initial set of technical workshops arose from issue scoping associated with the public comments on the draft EIS Guidelines. The Project Team reviewed all of the comments and concluded that the most common issues were methylmercury, impact on Mud Lake, need for knowledge about the Project, and energy alternatives to the Project.

All but one of the technical workshops offered to date were held in Upper Lake Melville. A technical workshop was held in St. John's on energy alternatives where many provincial groups who had commented on this topic are based.

Based on feedback from residents in Happy Valley-Goose Bay, it was decided the energy alternatives technical workshop in the Project area would be first. This workshop took place on June 3, 2008, and the St. John's meeting was on July 9, 2008. A second energy alternatives workshop is planned for Happy Valley-Goose Bay, as a number of interested parties were unable to participate in the first workshop.

The four technical workshops held to date are listed in Table 7-2.

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Table 7-2 Workshops Held Before the Submission of the Environmental Impact Statement

Workshop	Location	Date	Attendance
Methylmercury	Happy Valley-Goose Bay, NL	May 20, 2008	11
Mud Lake issues	Mud Lake, NL	May 20, 2008	18
Energy alternatives	Happy Valley-Goose Bay, NL	June 3, 2008	5
Energy alternatives	St. John's, NL	July 9, 2008	16

7.4.3 Other Meetings

Several individual meetings have been held with stakeholders and more are planned. The Project Team will meet individually with the major stakeholder groups, many of whom have been participants in open houses, technical workshops and/or have been in direct contact with Project staff.

Meetings with regulators, resource managers and focused interest groups have been ongoing since November 2005. The agencies and the number of meetings are listed in Appendix IB-I. As of September 2008, over 100 meetings have been held, including:

- 66 with federal government departments (41 of these with DFO);
- 42 with provincial government departments;
- nine with special interest groups; and
- nine with municipal governments and inter-agency committees.

The topics discussed have varied, reflecting the mandate/interests of participants. Most common subjects included:

- Project update;
- environmental assessment process and schedule;
- baseline study design; and
- permits and authorizations.

7.4.4 Speeches

An estimated 43 speeches about the Project have been given by senior management provincially, nationally and internationally. The audiences have ranged from the Combined Councils of Labrador and various organizations in Labrador to major energy forums in both Canada and the United States.

A complete list of the speeches including dates, speakers, audiences and subject matter can be found in Appendix IB-I.

7.4.5 Educational Involvement

Nalcor Energy recognizes the importance of consulting with the educational sector to advise students, educators and educational agencies of Project progress and to inform them of workforce projections and training requirements. As of August 2008, there have been eight meetings with representatives of this sector (Table 7-3).

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Table 7-3 Meetings with Educators and Educational Agencies

Meeting Participants	Purpose	Date
Newfoundland and Labrador Department of Education	Skills task force	October 25, 2007
Women in Resource Development Committee (WRDC) Jan Burry	Techsploration	December 7, 2007
Newfoundland and Labrador Department of Education - Industrial Training, Denise Hanrahan	Apprenticeship training program	December 18, 2007
Newfoundland and Labrador Department of Human Resources, Labour and Employment	Labour force modelling	December 23, 2007
College of the North Atlantic, Blake Cryderman, Chair Community and Corporate Services, Joanne O'Leary Business Development Coordinator, Labrador	College capacity	March 6, 2008
College of the North Atlantic Goose Bay, Winnie Montague, Campus Administrator, Bob Simms, Director of Community Training	College capacity	March 6, 2008
College of the North Atlantic, Blake Cryderman, Chair, Community and Corporate Services	College capacity	March 19, 2008
College of the North Atlantic	Orientation to trades and technology	March 20, 2008

As the Project moves forward, there will be increased focus on educational presentations. Planning meetings have been held with relevant training institutions to discuss how best to consult and work with students, both locally and provincially. School visits are planned to commence in 2009. Project information has been presented at high school career fairs. This involvement with education institutions will continue throughout Project planning and implementation.

7.5 Issues Identification

The issues identified in the public consultation process to date have provided input to Project planning and served to focus the EIS. The issues are summarized in Table 7-4 and listed in detail in Appendix IB-I. Each of these issues have been considered and addressed within this EIS where appropriate.

Table 7-4 Issues Overview

Issue	Details	Date and Location
Environmental assessment process	• Coordination of the provincial and federal assessment processes • The separation of transmission and generation of power from the lower Churchill • The need for a Project description, importance of consultation with the public • Intervener funding	Churchill Falls (April 15, 2007) Happy Valley-Goose Bay (April 16, 2007)
Fish and fish habitat	• Changes in fish populations • The need for fish passage facilities will exist • Fish mortality in the turbines • Loss of fish habitat	Churchill Falls (April 15, 2007) Happy Valley-Goose Bay (April 16, 2007)
Participation of Innu Nation and other Aboriginal groups	• Project involvement	Happy Valley-Goose Bay (April 16, 2007) North West River (April 17, 2007)

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Table 7-4 Issues Overview (cont.)

Issue	Details	Date and Location
Climate change	• Churchill Falls Power Station and its effect on local weather • An environmental audit should be done on the river • Loss of boreal forest and the associated loss of carbon credits • Scepticism whether the Project will replace other sources of energy (that are not as clean)	Happy Valley-Goose Bay (April 16, 2007)
Ecosystem	• Effects of the Project on fish species in the reservoir including how populations could change • Effects on the Red Wine Mountains Caribou Herd • Availability of wildlife data • Effects on raptor feeding • Changes in methylmercury levels • Sewage build-up/disposal in the Churchill River • Effects on Lake Melville	Churchill Falls (April 15, 2007) Happy Valley-Goose Bay (April 16, 2007) North West River (April 17, 2007) Rigolet (September 16, 2008)
Resource use	• Effects on land and resource use (e.g., fishing, management of forest resources and hunting and trapping by Aboriginal groups) • Effects on use of the river for transportation	Happy Valley-Goose Bay (April 16, 2007) North West River (April 17, 2007) Churchill Falls (April 15, 2007) Mud Lake (May 20, 2008)
Public consultation	• Opportunity for input into environmental assessment process	Churchill Falls (April 15, 2007) Happy Valley-Goose Bay (April 16, 2007) North West River (April 17, 2007) Labrador City (May 29, 2007)
Socio-economics	• Employment and training, business opportunities	Happy Valley-Goose Bay (April 16, 2007) North West River (April 17, 2007) Labrador City (May 29, 2007)

As one example of issues identification and follow-up, a meeting in Mud Lake provided a useful interchange that focused on travel across the lower Churchill River between that community and Happy Valley-Goose Bay. The Project Team then directed its consultants to incorporate into their modelling studies a close examination of ice freeze-up and break-up timing during Project operations (when operation of the generation sites will influence downstream hydrology). As well, a resident of the community provided a long term record of freeze-up and break-up dates, which served to improve the quality of baseline data. Nalcor Energy plans to continue this dialogue through further meetings and discussions, and using the identified range of consultation mechanisms.

7.6 Future Plans

Consultations with the public and government have provided Nalcor Energy with valuable insight into issues, Project design and useful advice when it comes to developing guidelines, policies and programs.

The public consultation concordance tables (Appendix IB-I) demonstrate where issues raised by Aboriginal groups and the public have been addressed within the EIS document. Much of the input from the consultations was integrated into the mitigations and effects management strategies within this EIS.

All public consultation activities will continue through the environmental assessment process, including open houses, technical workshops, meetings and speeches. Indeed, as noted, consultation will be an important component of the Project throughout all phases. Appropriate consultation tools will be used, including a

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regularly updated Project website, electronic newsletters, updated information sheets and posters. Following the submission of this EIS to the regulatory agencies, Nalcor Energy will again hold open houses in the communities of interest to introduce the EIS, provide a Project update and answer any questions. In addition, there will be further technical workshops on issues that arise from the EIS. Activities planned for the coming months are presented in Table 7-5.

Table 7-5 Post-Environmental Impact Statement Submission Meetings

Intent	Meeting Type	Meeting with	Location	Tentative Time
Introduce public to the EIS	Open house (with a presentation and an open question and answer session)	General public	Sheshatshiu Natuashish Rigolet Labrador City Mud Lake North West River Happy Valley-Goose Bay St. John's	Spring 2009
Discuss specific issues in detail	Technical workshop	Interested individuals	Upper Lake Melville	Spring 2009

8.0 ABORIGINAL CONSULTATION

The Aboriginal history in Labrador and contemporary culture provide an important context for the environmental assessment of the Project. A more detailed outline of the history of Labrador is provided in Volume III, Section 2.9. Aboriginal and public participation is a central objective of the environmental assessment process. Aboriginal consultation has a similar primary objective as described for public consultation (Chapter 7): to identify and address concerns and interests related to the Project.

8.1 Introduction

The Project is located in central Labrador, an area presently under land claims negotiation between Innu Nation and the provincial and federal governments. Nalcor Energy has been working directly with Innu Nation regarding the environmental assessment of hydro development on the lower Churchill River since 1998. More recently, other Aboriginal groups have been engaged in discussions about the Project.

8.2 Contemporary Aboriginal Groups and Governments

8.2.1 Labrador Innu

Labrador Innu (formerly known as Montagnais or Naskapi Indians) reside primarily in two communities: Sheshatshiu, in central Labrador and Natuashish, on the Labrador north coast. Innu also reside in other parts of Labrador, the Island of Newfoundland and elsewhere.

The Sheshatshiu Innu and the Mushuau Innu of Natuashish comprise separate Bands. Each community has a Reserve with an elected Chief and Council. These communities are collectively represented by Innu Nation, an elected political organization that represents Innu in aspects of governance including land claim negotiation and other processes related to resource development and management including consultation and negotiation with Nalcor Energy regarding the Project.

The Labrador Innu claim Aboriginal rights (Figure 8-1) and title to much of Labrador, and refer to the area as Nitassinan. The Innu land claim was accepted for negotiation by the Government of Newfoundland and Labrador, and the Government of Canada, with formal negotiation commencing July 1991. An Agreement-in-Principle (the interim step before a Final Land Claims Agreement) is now being negotiated. A recent agreement between Innu Nation, Nalcor Energy and Newfoundland and Labrador called Tshash Petapen (New Dawn) Agreement (Government of Newfoundland and Labrador 2008, Internet site), addressed the issue of land claims and included designation of lands as one important ingredient of the land claims settlement process.

The Labrador Innu Land Claim Area includes the lower Churchill River watershed. It is the only land claim in this watershed that has been accepted for negotiation by both the federal and provincial governments.

8.2.2 Labrador Inuit

Labrador Inuit are primarily resident in the area they call Nunatsiavut (the communities of Nain, Hopedale, Makkovik, Postville and Rigolet on the Labrador North Coast) and in the central Labrador communities of North West River and Happy Valley-Goose Bay (Figure 8-1), with other Inuit residing in Cartwright, Labrador City, St. John's and elsewhere. There are approximately 5,000 Labrador Nunatsiavut beneficiaries.

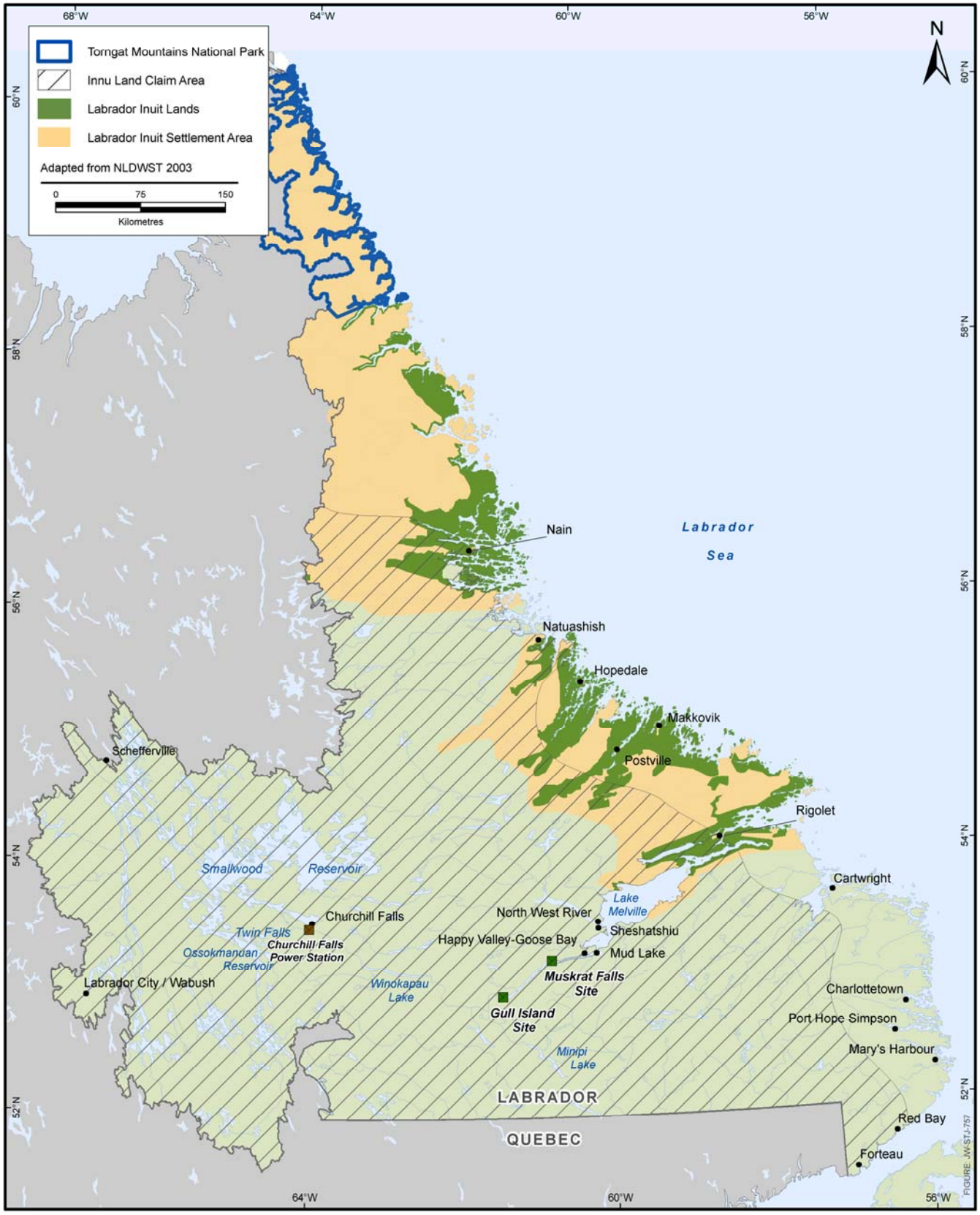


Figure 8-1 Labrador Innu Land Claims Area and Labrador Inuit Lands/Labrador Inuit Settlement Area

The Labrador Inuit Land Claims Agreement (Agreement) came into effect on December 1, 2005. This Agreement sets out the details of land ownership, resource sharing and self-government within the area covered by the Agreement in northern Labrador. The Agreement establishes the LISA, consisting of approximately 72,500 km^2 in northern Labrador and 48,690 km^2 of the Labrador Sea. Within the LISA, Labrador Inuit own 15,800 km^2 referred to as Labrador Inuit Lands (LIL) (Figure 8-1). While the LISA does not overlap the lower Churchill River watershed, there are a considerable number of Labrador Inuit residing adjacent to the Project in the communities of North West River, Happy Valley-Goose Bay and Labrador City.

Self-government is a key component of the Agreement. The Agreement provided for the establishment of a regional Inuit government, referred to as the Nunatsiavut Government, which has law-making authority over Inuit on LIL and Inuit rights throughout the LISA. In addition, the Agreement provided for the establishment of Inuit Community Governments to replace the previous municipal governments in Nain, Hopedale, Makkovik, Postville and Rigolet. These new governments exercise powers similar to those exercised by municipalities elsewhere in the Province.

8.2.3 Labrador Métis

The LMN comprises 6,000 members, who live throughout Labrador and elsewhere, with concentrations in the Lake Melville area and along the southern coast of Labrador from Cartwright to Mary's Harbour. The Labrador Métis Association was established in 1985 and renamed the LMN in 1998.

The LMN has several agreements with the federal and provincial governments. In July 2008, the LMN announced a multi-year funding agreement with the federal government to provide core funding and operational support. The agreements with the federal government pertain to Fisheries Management, Land Claims Research, Aboriginal Diabetes Awareness, Human Resource Development and Habitat Stewardship. The LMN has also worked with the provincial government to address sustainable forestry management.

The LMN has asserted a land claim in the region that overlaps the Project Area; however, this claim has not been accepted for negotiation by either the federal or the provincial governments.

8.2.4 Quebec Innu

There are also Innu (not considered part of Innu Nation) who reside in communities in Quebec throughout the Lac-Saint-Jean and Upper and Lower North Shore regions. Quebec Innu participate in land use and harvesting activities (particularly hunting) in Labrador (Mailhot 1997).

The land claim areas of seven Quebec Innu communities extend into Labrador, including Natashquan (Nutashkuan), Mingan (Ekuanitshit), La Romaine (Unamen Shipi), St-Augustin (Pakua Shipi) and Sept-Îles along the Lower North Shore, and the Innu of Schefferville (Matimekush-Lac John) and Kawawachikamach, 15 km northeast of Schefferville. These communities are in various stages of comprehensive land claims negotiations with the governments of Canada and Quebec. However, the land claims of Quebec Innu groups in Labrador have not been accepted for negotiation by the Government of Newfoundland and Labrador.

In land claims negotiations, the Innu from Natashquan are represented by the Conseil Tribal Mamuitun mak Nutakuan, which also represents other Quebec Innu communities whose claims do not extend into Labrador. The communities of Mingan, St-Augustin and La Romaine are represented by the Assemblée Mamu Pakatatau Mamit. Innu from Schefferville and Innu from Sept-Îles are represented by the Corporation Ashuanipi. The Naskapi Band of Quebec was created in 1984 by the *Cree Naskapi (of Quebec) Act* (CNQA). In April 1996, the name of the Band was changed to Naskapi Nation of Kawawachikamach (the Nation), effective May 1999. The Nation is a First Nation with a population of approximately 850 registered Indians, beneficiaries of the

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Northeastern Quebec Agreement (NEQA). The Nation asserts a claim to parts of Labrador, including portions of the Project area.

8.3 Consultation

Consultation has been ongoing with Innu Nation since 1998 and, more recently, with other Aboriginal groups.

8.3.1 Innu Nation

Innu Nation has provided input and guidance to field studies for the environmental assessment of the Project beginning in 1998. At that time, the Project concept included power generation facilities at Gull Island and Muskrat Falls as well as diversion of additional water into the Smallwood Reservoir.

8.3.1.1 Environmental Assessment Consultation and Participation: 1998 to 2001

In spring 1998, a three party environmental planning group (Innu Nation, Hydro-Québec and Hydro) was established to consult on the overall environmental assessment approach and the field studies needed to support it. All three parties provided input into the design of the field programs and review of the associated reports.

While the group was active, more than 30 field studies were completed during the field seasons of 1998 through 2000. Innu were trained (particularly as archaeological field assistants) and employed in each field program. Elders were consulted regarding field programs near Muskrat Falls, and a consultation with elders was held in their winter camp south of Natuashish.

Prior to the start of engineering and environmental fieldwork in 1998, Innu Nation provided cultural sensitivity sessions to Project staff and consultants. The planning group also initiated an issues scoping workshop in 2001 that was well attended and provided important information for the current assessment through the report, *Churchill River/Mishta-shipu Power Project: Potential Residual Environmental Effects on Innu and Innu Communities* (Griffiths 2001).

During 1998 to 2001, the three parties negotiated a Process Agreement that formalized the working relationship on environment, community consultation and other matters, such as benefits. The environmental planning group was active until this concept of the Project was shelved in 2001. This planning group laid the foundation for the current assessment.

8.3.1.2 Environmental Assessment Consultation and Participation: 2005 and Ongoing

With renewed interest in developing the hydroelectric potential of the lower Churchill River in 2005, Innu Nation was asked to work with the Project Team on the environmental assessment.

Consultation and negotiations with the Labrador Innu resumed in late 2005 under a Process Agreement (May 2006 to August 2008), and focused on the following three activities:

- consultation on the environmental and engineering aspects of the Project;
- Innu community consultation; and
- IBA negotiations.

Further information on each of these processes, including the manner in which they have been considered and incorporated into the environmental assessment, is provided in the following sections.

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8.3.1.3 Environmental and Engineering Task Force

A Task Force composed of representatives from the Project and Innu Nation was established in 2006 to facilitate Innu involvement in planning, conducting and reviewing the environmental and engineering work for the Project during the research and preparation for the environmental assessment.

The Task Force included Project environmental and engineering personnel, as well as a technical advisor and an environmental assessment advisor hired by Innu Nation through the Process Agreement. In addition to these two full time Task Force positions, resources were provided for Innu Nation to engage additional technical and expert advice, as required.

The Task Force reviewed and discussed the environmental assessment approach, methodology for the assessment, and the format and content of the EIS. This process included discussion of existing natural and human environments, potential environmental issues, potential environmental effects and mitigation to reduce potential environmental effects.

Through the Task Force, regular updates and briefings were provided on the nature and status of the Project. The Project Team also consulted with Innu Nation regarding the design, implementation and review of the Project's environmental baseline studies and the engineering program (including the technical designs for environmental and engineering studies). This process is detailed in the Process Agreement. Through the Task Force, Innu Nation provided technical review and comments, which were considered in the final design of the studies.

This same process was followed to review draft environmental baseline reports and engineering reports. Again, comments provided by Innu Nation were considered and incorporated, where appropriate, into the final reports. Tables of concordance that indicated responses to the comments provided were prepared and provided to Innu Nation.

The Task Force met regularly to:

- review and discuss technical specifications for planned and ongoing environmental and engineering studies;
- have regular updates on the status of this work while in progress; and
- review draft and final reports associated with these studies.

An Innu Nation Environmental Monitor, funded under the Process Agreement, observed activities during the environmental and engineering field programs. The monitor also assessed compliance with the associated environmental standards and permit conditions. Reporting to Innu Nation, the monitor identified issues that were discussed subsequently by the Task Force.

8.3.1.4 Innu Traditional Knowledge

The Task Force provided a forum to discuss ITK. The eventual result of these discussions was the development and implementation of an Innu-led process to document and share ITK for the EIS, based on an approach and methodology proposed by Innu Nation. This process is described in the ITKC Report:

> *Despite the importance of direct experience, the evidence is clear that Innu Elder knowledge is derived from a variety of additional sources. Oral tradition, which refers to the intergenerational transmission of knowledge, is one such source. For example, one ITKC member said "I went as far as Minai-nipiu-paushtik[u] but I heard stories from my grandparents about their hunting north and south of Uinukapau (Winokapau Lake)" (P1.28.11.06). Another member said she learned a great deal about Mishta-shipu from her husband's father who was a recognized expert in the region given his lengthy history of land use there. "They had different names for brooks and portages that came from Shimiu Pastitshi. Shimiu learned these from people who came before him" (P2.29.11.06). Knowledge of medicinal plants and their uses was transmitted among women from older to younger generations. "Assiuashik[u] is the name of the medicine. It has real medicine in it which is good to treat child fevers and stomach flu. I learned this from the old women, and I have kept this knowledge all along. They are like doctors; all the Innu women were like that" (P2.7.12.06). Knowledge acquired from older Innu may have been reinforced by direct experience, as indicated by another ITKC member who said, "I believe what they told us, because I have seen this. Our teachers were our parents, grandparents. That's how we learned, from the stories they told us. That's what I teach my children" (P3.8.2.07).*
>
> (pp. 12-13)

The ITKC was established as an adjunct to the Task Force. The role and purpose of the ITKC was to discuss, document and share ITK for consideration in the Project's environmental assessment. The ITKC, composed of Innu Elders and a Researcher/Facilitator, was in place from July 2006 until mid-2007. The Committee met regularly over that period to discuss and share Innu information and perspectives on:

- key ecological, historical and cultural features of the region;
- how Innu use the environment;
- the environmental studies undertaken for the environmental assessment;
- the potential environmental effects of the Project; and
- potential mitigation measures, their effectiveness, and any residual environmental effects.

Innu Nation provided ITK documented through this process to the Task Force for discussion and, as relevant and appropriate, incorporation into the environmental assessment, according to a protocol developed by the Project Team and Innu Nation (Section 9.1.1). The ITKC Report was provided to the Task Force (Appendix IB-H).

The Project also sponsored a visit by Elders to the site of the last known Shaking Tent ceremony in the fall of 2006. A video of the visit was made and a written report prepared. The report is presented in Appendix IB-J.

8.3.1.5 Innu Community Consultation

The Project Team and Innu Nation developed and implemented a process for consultation on the Project in the communities of Sheshatshiu and Natuashish. Through funding and resources provided by the Project, an Innu Community Consultation Team was established in 2000, before the current Project was defined.

The Innu Community Consultation Team provided information and conducted ongoing consultation with Innu with respect to the Project. A range of approaches and techniques have been used to date, including community meetings, newsletters, radio programs, drop-in centres and site visits. The Project Team participated in community meetings in Sheshatshiu and Natuashish (as requested by Innu Nation) to provide information and updates on the Project. Information and support is provided to the Innu communities to answer questions and discuss particular issues or concerns on an ongoing basis.

Ongoing Innu community consultation is an important means of informing Innu about the nature and status of the Project, and reveals what Innu think about the Project and its potential environmental and socio-economic effects. This information has provided input to Project planning and decision-making as well as to the environmental assessment. Innu community consultation has served as a forum for Innu Nation to consult with its membership during IBA negotiations. Innu questions and concerns were incorporated in the environmental assessment through the issues-scoping exercise for this EIS.

8.3.1.6 Impacts and Benefits Agreement Negotiations

Nalcor Energy and Innu Nation are currently involved in negotiations toward an IBA, which will define how Labrador Innu participate in and benefit from the Project. In September 2008, the Tshash Petapen (New Dawn) Agreement was announced between Innu Nation, Nalcor Energy and the Province (Government of Newfoundland and Labrador 2008, Internet site).This agreement addresses some of the aspects of an IBA including provisions for royalty payments to Innu Nation and mechanisms for participation by Labrador Innu in the Project as well as a schedule for conclusion of the IBA. The Tshash Petapen (New Dawn) Agreement represents an important milestone for both the Project and Labrador Innu.

The IBA will include processes for continued discussion and cooperation on the Project during its planning, construction, and operation and maintenance phases. The IBA will also include mechanisms for reducing potential adverse environmental effects on Innu and Innu communities and for creating and enhancing potential benefits. These will include processes and provisions related to Innu employment, training, business opportunities, workplace policies and conditions, environmental protection and Innu commercial participation in the Project. The IBA is referenced throughout this EIS as it pertains to potential Project effects and benefits for Innu.

8.3.1.7 Other Innu Nation Participation in the Project

While the Process Agreement that was negotiated with Innu Nation outlined more formal processes for consultation and negotiations respecting the Project, Innu Nation and its members have also participated in other aspects of Project planning and the environmental assessment.

The primary consultant team for the environmental assessment research and analysis for the Project was led by Minaskaut Limited Partnership (Minaskaut), a joint venture between Innu Economic Development Corporation and Jacques Whitford Limited. In addition to collaborating with Innu for a previous project design in 1998, the Project initiated training for Innu in techniques for archaeological investigations in Project field programs. Innu field assistants involved in various field studies for the Project also received standard safety orientation before going into the field on Project work. During the engineering and environmental fieldwork, from January 2006 through July 2008, more than 40 Innu worked on Project field studies as assistants, technicians, cutters, labourers and camp support.

In 2008, the Project Team worked with Innu Nation to develop a training and employment database that will facilitate efforts by Innu Nation and companies associated with the Project to attract Innu employees to the Project. Individuals at workshops in Natuashshish and Sheshatshiu, which were hosted and facilitated jointly by Innu Nation and Project personnel, provided information for the database.

Innu Nation officials and members participated in public open houses held in North West River, Sheshatshiu, Natuashish, and Happy Valley-Goose Bay in 2007 and 2008. These open houses sought public input regarding the Project for consideration in planning and the environmental assessment.

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Innu Nation representatives, including members of the Task Force, were invited to Project technical workshops held in Happy Valley-Goose Bay and in St. John's. These workshops have proven to be effective forums for detailed discussion of key issues, and will be continued. Innu Nation representatives will be invited to future workshops.

8.3.2 Nunatsiavut Government

Although the Project's physical footprint does not include lands under Nunatsiavut Government jurisdiction, the Project Team met with the Nunatsiavut Executive Council in May 2008 to provide a Project briefing and open lines of communication between the two parties. A working session between the Director, Environment Division, Department of Lands and Natural Resources for Nunatsiavut and Project personnel followed this meeting.

Nunatsiavut Government representatives were invited to Project open houses and technical workshops. A Project open house was held in Rigolet, a community within Nunatsiavut, in September 2008. Project personnel also met with representatives of the community government and the elected member of the Nunatsiavut Assembly.

8.3.3 Labrador Métis Nation

Discussions were initiated with the executive of the LMN during spring 2007. LMN has provided comments on the draft EIS Guidelines as part of the public review process.

During spring and summer 2008, senior Project personnel held meetings with representatives of the LMN in Happy Valley-Goose Bay to exchange information about the Project, the environmental assessment and possible LMN interests. LMN was provided with:

- the Lower Churchill Hydroelectric Generation Project Environmental Assessment Registration document;
- a book of maps that illustrates the anticipated reservoir areas and predicted extent of flooding in detail;
- maps that show the proposed site layouts at Gull Island and Muskrat Falls; and
- Project information packages.

At that time, it was agreed to provide support for initial LMN community consultation on the Project, based on a jointly developed workplan. These meetings provided a basis for continued and ongoing Project-related discussions and for establishing a working relationship with LMN.

8.3.4 Quebec Innu

Quebec Innu communities provided comments on the draft EIS Guidelines during public review under the environmental assessment process. Shortly after receiving these comments, discussions were initiated in May 2008 with six Quebec Innu First Nations that assert land claims within Labrador. The Project Team offered to meet with these Chiefs and other representatives of the Bands to provide a general overview of the Project and to discuss and respond to any questions or issues. The Bands were also invited to provide any information that they felt would be relevant to consider for Project planning and the environmental assessment. The Bands were asked how they would like to be consulted on the Project, its environmental assessment and overall planning and development. Each Band was provided with the following information (translated into French):

- the Lower Churchill Hydroelectric Generation Project Environmental Assessment Registration document;
- a book of maps that illustrates the anticipated reservoir areas and predicted extent of flooding in detail;

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- maps that show the proposed site layouts at Gull Island and Muskrat Falls; and
- Project information packages.

Ongoing communication mechanisms were established with each of the Quebec Bands and, as of the submission of the EIS, initial meetings have been held with most communities with schedules established for the remainder. In October 2008, the Naskapi Nation of Kawawachikamach contacted the CEA Agency requesting that the Nation be included in Project consultations with Aboriginal communities. In November 2008, the Naskapi Nation was provided with the same information sent earlier to Quebec Innu communities.

8.3.5 Incorporation of Issues and Concerns

8.3.5.1 Innu Nation

Consultation with Innu Nation regarding development of the hydroelectric potential of the lower Churchill River took place during 1998 through 2001, and resumed in 2005 for the current Project design. The above discussions and comments about the Project were used to develop a summary of the key Innu issues and associated responses (Table 8-1). A detailed list of all the issues identified through Innu Nation consultation is provided in Appendix IB-I.

Table 8-1 Innu Concerns

Innu Concerns	Project Team Comment
Consultation	
• There was no consultation with Innu regarding the construction of the Churchill Falls Project • Consultation should be meaningful • Project information must be available to all Innu	• A variety of means were used to consult with Innu in Sheshatshiu and Natuashish • ITK has been respected and used in the EIS • Special efforts were made to consult with Elders • Consultation with Innu has been ongoing since 2005
Culture	
• Concerns that the Project will affect the Innu spiritual connection to the land • Wage employment will conflict with traditional values • Concern that country foods will not be available (e.g., loss of access, contamination)	• Project Team has attended community meetings in Sheshatshiu and Natuashish • There have been extensive discussions with Innu and advisors to Innu Nation • Cultural sensitivity training has been provided • Provisions for cultural leave and country food at the work site are being discussed with Innu Nation
Community Health	
• Concern regarding more employment will worsen existing social problems such as alcohol and drug addiction • Need to understand the benefits of the Project to Innu	• Nalcor Energy supports efforts to increase the number of trained social services staff who speak Innu-aimun • A proposed new approach for job sharing, on-the-job training, and outreach family treatment will be discussed with Innu Nation
Benefits	
• There should be long term benefits for all Innu, including elders • Must include training and employment	• The Project environmental and engineering work to date has employed Innu and used Innu companies • There are ongoing efforts to assist Innu to build a training and employment database • Hiring policies will include specific efforts to train and hire Innu • Efforts will be made to create a comfortable and supportive work place for Innu • Nalcor Energy and Innu Nation are negotiating a Lower Churchill Project IBA. Key elements of the commercial terms of the IBA include a structured royalty regime under which Innu will be entitled to receive an annual royalty payment based upon a percentage of net proceeds from the generation component of the Project

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Some issues of great importance to Innu are outside the scope of the EIS (e.g., land claims and the environmental effects of the Churchill Falls Project). However, the recent Tshash Petapen (New Dawn) Agreement is intended to address these matters. In addition to direct discussions with Innu Nation about the Project, the overall database and understanding of historical and contemporary presence and use of the Churchill River and surrounding landscape has been enhanced through traditional knowledge provided by Labrador Innu. This information is complemented by extensive research and field surveys conducted on cultural heritage resources for the EIS.

One example of cooperation with Innu Nation is the Elders' field trip to the location of the last known Shaking Tent ceremony held in Labrador (Appendix IB-J). This site will be lost to inundation when the Muskrat Falls Reservoir is impounded. Assisting and funding the visit and its documentation, has enhanced the memory and awareness of this culturally important site and activity.

Consultation with Innu Nation has included several approaches, described in Section 8.3.1. Many issues, comments and questions raised by members of Innu Nation have been documented during:

- Task Force discussions;
- open houses in Sheshatshiu and Natuashish in 2006 and 2007;
- a multi-party workshop in 2001 (prior to the current Project design);
- discussions with Elders;
- community consultation from 2005 to 2008;
- technical workshops;
- discussions with Innu Nation leaders; and
- comments on the draft EIS guidelines in February 2008.

8.3.5.2 Other Aboriginal Groups

In addition to consultation with Innu Nation, Nalcor Energy has also contacted Nunatsiavut Government, LMN and Quebec Innu to offer information and solicit discussion about the Project. These organizations have all provided comment on the draft EIS Guidelines and Nalcor Energy will continue its efforts to fulfill consultation requirements for these organizations in a manner that is both compliant with the Guidelines and consistent with Project objectives for consultation.

9.0 ENVIRONMENTAL ASSESSMENT APPROACH AND METHODS

The approach and methods that are used in the environmental assessment for the Project are compliant with the requirements of the *CEAA*, the *NLEPA* and its Regulations and the EIS Guidelines. The methods used in conducting this assessment are intended to provide reviewers with a clear understanding of how the Project will interact with the environment and of the environmental effects that will result from this interaction.

Issues of concern or potential environmental effects were identified in the EIS Guidelines and are also based on the results of stakeholder and public consultation, local and existing knowledge regarding potential environmental effects of industrial projects (specifically hydroelectric projects), as well as the Study Team's knowledge of the existing environment in the area and professional judgement. The assessment is organized around these identified issues of concern or potential environmental effects.

Aboriginal traditional and community knowledge was considered in the preparation of the EIS in accordance with the EIS Guidelines. As defined in the EIS Guidelines:

> *traditional and community knowledge may be regarded as the knowledge, understanding and values that Aboriginal and local communities have in relation to the environment and the potential environmental effects of the Project and proposed mitigation measures. This knowledge is based on personal observation, collective experience and/or oral transmission.*

This environmental assessment was developed in consideration of sustainable development and a precautionary approach. The EIS demonstrates that Project activities were assessed and mitigation measures were discussed and incorporated into Project design in a precautionary manner considering any potential for serious or irreversible damage to the environment, especially with respect to ecological functions and integrity, and ability to maintain biological diversity. All assumptions about the environmental effects of the proposed actions are explained, as well as approaches to reduce or eliminate adverse environmental effects. Proposed mitigation, follow-up and monitoring activities, particularly in areas where scientific uncertainty exists in the prediction of environmental effects, are identified.

The methods used for this environmental assessment consist of steps that have been generally applied to each Valued Environmental Component (VEC) or Key Indicator (KI). Some variations in presentation of information have been made where appropriate to accommodate the differences in VECs. In this way, Project-related environmental effects are assessed at either the VEC or KI level. Using the methods described below, the environmental effects analyses are presented in Volume IIA and Volume IIB (Biophysical Assessment) and Volume III (Socio-Economic Assessment).

9.1 The Knowledge Base

In preparing the EIS, two important sources of information have been relied upon: local community and Aboriginal Traditional Knowledge (the latter as communicated through Innu Nation) and an extensive body of field data collected from the biophysical environment. These provide a basis for conducting the analysis, which leads to the predictions of environmental effects. This section presents the knowledge base available and describes how it has been employed to support the EIS. As well, descriptions are provided of a range of models used to define interaction processes between the Project and the biophysical environment, as well as to make quantifiable predictions of effects.

A description of the approach to the collection of Aboriginal traditional and community knowledge is provided in Sections 9.1.1 and 9.1.2. Aboriginal, traditional and community knowledge has been incorporated into the assessment of relevant VECs or KIs. Sources of Aboriginal traditional and community knowledge include an ITKC

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Report provided by Innu Nation entitled: *Innu Kaishitshissenitak Mishta-shipu, Innu Environmental Knowledge of the Mishta-shipu (Churchill River) Area of Labrador in Relation to the Proposed Lower Churchill Project* (Innu Nation 2007) (Appendix IB-H) and information gathered through informant interviews for land and resource use. The ITKC Report presents data organized by both location and species, allowing this information to be effectively incorporated into the EIS.

9.1.1 Innu Traditional Knowledge

Aboriginal Traditional Knowledge (ATK) is described as:

> *a body of knowledge built up by a group of people through generations of living in close contact with nature. ATK is cumulative and dynamic. It builds upon the historic experiences of a people and adapts to social, economic, environmental, spiritual and political change* (*CEAA* Interim Principles).

In addition to the ITKC Report, Innu Nation has also provided a *Report on the Fieldtrip to Ushkan-shipiss, October 14, 2006* (Innu Nation 2008). As agreed with Innu Nation, both reports are included in their entirety in the EIS in Appendices IB-H and IB-J.

Innu Nation has cautioned not to over interpret ITK and advised that the EIS should remain flexible to the provision of multiple interpretations of environmental phenomena and of scientific and traditional knowledge. Nalcor Energy has been cautious and respectful in the application of ITK to the environmental assessment of the Project. ITK is incorporated in verbatim quotes throughout the EIS at appropriate locations. The quotes are identified by boxed and italicized text, so that the information is not misrepresented.

The ITKC Report has provided:

- factual knowledge about the environment;
- factual knowledge about past and current use of the environment;
- values about how things should be and what is proper to do in relation to the environment; and
- Innu cosmology by which information about the environment is organized.

Nalcor Energy has incorporated knowledge about the environment and its use, principally in the descriptions of the existing environment (Chapter 5 and in Volume IIA, Chapter 2 and Volume III, Chapter 2). The information on values held is placed according to topic in the environmental effects prediction and effects management sections of the EIS. Descriptions of the environment and its change over time and space reflect available ITK and provide an improved understanding of local environmental processes.

ITK has been considered with respect to alternatives within the Project. For example, the spiritual importance of the knoll at Muskrat Falls led to a careful examination of alternatives that could minimize or reduce disturbance to the site. The ITK assisted in planning for the prevention or reduction of potential adverse environmental effects, as shown in the various mitigation and effects management measures identified throughout the EIS. ITK has been taken into account in the process of analysis and prediction of environmental effects, including cumulative effects.

The geographic extent of the ITKC Report was defined as follows:

> *The geographic extent for the study focused on the Mishta-shipu valley from Patshishetshuanau (Churchill Falls) to the mouth of the river, covering the area that would be affected by the Muskrat Falls and Gull Island dam structures as well as transmission lines within or near the valley (Map 1). Various incidental references to animals and plants in other parts of the territory were noted as was general information concerning animal behaviour, reproduction, predator-prey relationships, alimentation, etc. Topics for discussion in the focus group meetings were chosen by me, however, there was some deviation from this plan on occasion in order to deal with specific questions raised by ITKC members. A semi-directive interview technique was used in the individual interviews (see Huntington, 1998).*
>
> (pp. 4-6)

The ITKC Report also followed procedures for eliciting information.

> *Formal eliciting procedures, inspired by the methods of semantic ethnography, were adopted for certain aspects of this inquiry, but only to a small extent given the time limitations of this study (see Black, 1967; Tyler, 1969). Such procedures entail a systematic, controlled question-response method in which questions are formulated in the informant's language in order to elicit his/her semantic categories, and to avoid ethnocentric imposition of outsider (etic) ones. The researcher needs to understand exactly what question an informant is responding to, which is why the question has to be formulated properly in the first place. Learning how to ask the right question in the informant's language is the starting point in this method, and it is here that bilingual co-researchers can be of immense help (Black and Metzger, 1969).*
>
> (p. 6)
>
> *Having established the toponymic infrastructure for subsequent discussion, the ITKC was asked to describe in general terms the state of the environment today compared to years gone by. One purpose of this discussion was to obtain some understanding of what might constitute ecosystem health indicators for the members.*
>
> (p. 7)
>
> *During the second and third group sessions, documenting Innu knowledge about the environment (animals, plants, habitat, etc.) in the study area was the priority. The Innu Nation's GIS specialist assisted with data recording during one meeting, where participants were asked to identify animal and plant locations on digitally projected basemaps, with the GIS specialist entering data directly into a GIS data base. However, this approach was abandoned during subsequent meetings because all but one of the participants could not read maps.*
>
> (p. 8)
>
> *…"factual knowledge about past and current use of the environment" was also obtained from ITKC participants during these sessions in order to provide a good understanding of the empirical, observational basis upon which their knowledge is grounded. Information concerning Sheshatshiu Innu animal and plant taxonomies was documented to a very limited extent, and only with the goal of organizing species lists according to emic categories.*
>
> (p. 8)

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> *Working with the ITKC members in focus group sessions and as individuals facilitated the recording of general knowledge of the species found in the valley and their habits and habitats based on longer-term experience, and shared knowledge from other community members who have land use in the Mishta-shipu area. Their values about the land, animals, and plants were recorded, as well as information about their "religious ideology" and "epistemology" that informs inferences about environmental change (Usher's Category 3 and 4 TEK).*
>
> (p. 8)

Information regarding the biophysical field program and Project description were provided to the ITKC.

> *Data derived from biological survey of the Mishta-shipu area were tabled for the consideration of ITKC members during the third sessions in order to supplement their knowledge of the environment in the project area, especially given the fact that they have not traveled there in recent years. These data consisted of (1) the locations of furbearer species obtained during an April 2006 furbearer winter use survey conducted by Sikumiut Environmental Management Ltd. (2) an inventory of terrestrial species for the hydro project study area obtained from Minaskuat Limited Partnership, and (3) fish species distribution mapping from AMEC Americas, Earth and Environmental. The list of avian species in the inventory of terrestrial species was reviewed at length with two ITKC members to determine if Innu know of these species in the study area, and if lexical items for the species exist in Innu-aimun.*
>
> (p. 9)
>
> *The hydro project description (see Map 1) was presented to the ITKC at the beginning of the fourth and fifth sessions focusing on the following components:*
>
> - *two dam complexes, one at Manitu-utshu (Muskrat Falls), the other at Tshiashku-nipi (Gull Lake);*
> - *the reservoirs behind these dams, with special attention to the new shoreline to be created by the reservoir, the geographic extent of the flooding, the habitats to be inundated, and winter draw-down;*
> - *the two transmission lines, one from Manitu-utshu to Tshiashku-nipi, the other from Tshiashku-nipi to Patshishetshuanau (Churchill Falls).*
>
> *Photographs and maps of the dams, transmission lines, other infrastructure, and reservoirs (obtained from NLH) were used to help inform the ITKC members about project features.*
>
> (p. 9)
>
> *Once the project description had been presented, members of the two ITKC groups were asked to consider the possible impacts of the Project upon the land, biota and other ecosystem components within the study area. Nachel Nuna, who is a fully literate Innu-aimun-English translator, assisted with this process during one session by recording the propositions concerning potential project impacts on flip-chart paper in Innu-aimun. Detailed notes concerning the project impact discourses were kept by me throughout the meetings, and extracts of some of these discourses were subject to close transcription and translation as noted previously. Marguerite MacKenzie, a Memorial University linguist who specializes in Algonquian languages, was consulted thereafter with respect to a linguistic analysis of the transcribed material.*
>
> (p. 10)

> *Throughout this process, close attention was paid to the ways in which the ITKC members talk about the impacts (discourse) of the Project. Definitive cause-effect versus speculative statements, inferences, predictions and the like were noted. More will be said about this in the section dealing with Project impact discourses below.*
>
> (p. 10)
>
> *In February 2007, the NLH and Innu Nation Task Force met with the ITKC to review the project description, answer questions about the Project, and hear directly from the members about their concerns. The discussion provided additional information concerning Innu thinking about the Project impacts which has been incorporated in this report.*
>
> (p. 10)
>
> *A final meeting with the committee was held in April 2007 to report the results of the study, clarify certain questions concerning Innu vocabulary, and to discuss ethical considerations related to anonymous data sourcing in this report. ITKC members gave their permission to list their names as participants in the study, but asked that specific information concerning observations and impact propositions not be attributed to them directly. As a result, all attribution throughout this report has been coded so as to maintain the anonymity of individual sources of information.*
>
> (p. 10)

To organize the ITK in a manner consistent with western science, the ITKC used the following procedures:

> *6. Knowledge content: what Innu know about Mishta-shipu*
>
> *For the purpose of this discussion, I have parsed Innu environmental knowledge according to a number of western scientific categories such as geography, taxonomy, animal behaviour and reproduction, predator-prey relationships, species distribution, habitat, and anatomy. These are etic not emic categories, as no traditionally-minded Innu person would organize the presentation of knowledge in this manner and, in fact, there appear to be no Innu terms for these categories. For example, Innu certainly possess a taxonomy for the classification of animal and plant species, and I present elements of this taxonomy in this report, but there is no word in Innu-aimun for "taxonomy" per se.*
>
> (p. 24)

The ITKC Report uses an approach called discourse analysis to draw out ITKC comments regarding potential environmental effects of the Project, as described below:

> *10. Mishta-Shipu Hydro Project: Discourses Concerning Potential Impacts*
>
> *In previous sections, we looked at how members of the ITKC know what they know, and then moved on to sample Innu knowledge concerning Mishta-shipu. The task now is to make sense of various propositions advanced by the ITKC about future impacts of the proposed Project. What are these propositions, upon what basis are they made, and in what context? An analytical tool known as "discourse analysis" will be used to assist with this task. I take note of Usher's point that "The boundary between observation and inference is not always evident, however, because people may state as fact or consequence what scientists would characterize as inference or deduction" (2000:186).*
>
> (p. 68)

> *At the outset we should remember that the discursive environment of the Innu is constituted through a number of communications media. These include interpersonal interaction and dialogue, as well as modern media of mass communication including local and regional radio stations (e.g. open line shows), news papers, internet chat groups, and television. Moreover, discourses by ITKC members are embedded in a discursive environment that includes a variety of often interrelated subject categories, as has been observed among other indigenous peoples. Ellis (2005:71) notes that "Traditional knowledge experts draw from a board range of knowledge and experience when communicating. Environmental knowledge, cultural values history, politics, and the broad concerns and aspirations of their people may often inform the speech of an elder or other land user participating in an environmental hearing or technical session."*
>
> (p. 69)
>
> *There is an historic component to this in that the current discursive environment is the result of 60 or more years of accumulating experience, individual contemplation, social interaction and discussion on the part of the ITKC members. Besides the Lower Churchill Hydro Generation Project, other discourses that they participate in relate to the Churchill Falls project and the flooding of Meshikamau (Michikamau Lake), the Voisey's Bay Mine-Mill project, commercial forestry operations such as Labrador Linerboard and even the Dickie Lumber Company operation, military flight training, highway construction, prosecutions of Innu under provincial game laws, settlement in government built villages, breakdown in the intergenerational transmission of knowledge, growth of various social pathologies and dependence on government institutions, and with this loss of personal and collective autonomy. Innu integration into the so-called global village of mass communication and consumer culture also helps give content and shape to this discourse environment.*
>
> (p. 69)

The consultant working with the ITKC emphasized the importance of the mode of expression used by Innu as they provide information or comment and took precautions to be accurate.

> *…In examining ITKC member propositions and themes concerning predicted hydro dam impacts, I have wanted to pay careful attention to the ways in which these are expressed in the Innu language, in part because I have not always trusted the translation to convey all of the nuances in the original Innu-aimun. I first encountered this issue in the context of the environmental assessment of military flight training, where speculative comments about the impacts of low-flying jets were interpreted as definitive cause and effect statements. Maintaining a cautious stance vis-à-vis translations is important because some interpreters infer the intentions of the people they translate for, what they think speakers intend to say versus what they actually say, thereby over translating the narratives and reading more into them than had actually been stated. In addition, unbeknownst to the third party, some interpreters insert their own observations or opinions in to the translation.*
>
> *Given the fact that I am not a fluent speaker of Innu-aimun, I have had to court heavily on the interpretation skills of my co-researcher to communicate all the necessary subtleties of both the Innu and English languages. Furthermore, virtually all of the data for this report and the subsequent analysis relies on his interpretation and the English texts that they have generated. From the outset, I was anxious to ensure that the co-researcher paid particular attention to the different ways that sources of information or knowledge are marked linguistically in Innu-aimun so that they could be translated properly into their English equivalents. To this end, we discussed some of the nuances in interpretation required for the work in advance of the ITKC meetings and individual interviews, and the co-researcher appeared to have no problem appreciating these issues. Thus, his occasional footnotes throughout the meetings to the effect that a speaker was providing "an inference" gave me as some reassurance that important linguistic nuances were being conveyed.*
>
> (pp. 70-71)

> *Nevertheless, it was deemed prudent to subject a number of the narratives from the ITKC participants to a more detailed analysis by means of word for word written transcription and a close translation (see Appendix 2). This was done both as a way of spot-checking the quality of interpretation provided by the co-researcher as well as a vehicle for the exploration of the grammatical markers for different types of knowledge and reasoning underlying the discourse. This is as close as we can get to the primary Innu discourses concerning the future impacts of the hydro project, keeping in mind that interpretations provided by the co-researcher are always one step removed from these discourses because they are provided in English, and are frequently glosses or summaries of the statements made by the ITKC participants. With the exception of the transcriptions and close translations, the discourses analyzed here are removed one step further because the majority of them are not verbatim transcription of what the co-researcher said, but are my notes of the translations of the Innu-aimun discourses taken during the meetings.*
>
> (pp. 70-71)

The ITKC were asked to provide specific environmental effects predictions and spoke to effects on caribou, black bear, beaver, furbearers, partridge, ducks, geese and fish, as well as country medicine and water quality. They also provided the following general comment:

> *10.3 An inventory of impact propositions*
>
> *Having devoted three days in group sessions with the ITKC participants discussing the potential impacts of the Project on the land, water, animals, fish, trees, bushes, berry plants, and other biota, it became apparent that the participants believe that these impacts are obvious. The land and the various animal and plants species that live there will be flooded, and animals that do not evacuate the flood zones will die. . It was not surprising, therefore, to encounter a certain impatience on the part of ITKC members when I tried to parse the range of impacts into smaller units, for example, the particular impacts of flooding on every species known to them in the project area.*
>
> (p. 84)

There is no inference that Innu or others have endorsed or support the conclusions of the EIS. Through the process of EIS review and Panel Hearings, Innu, other Aboriginal peoples and the public will have an opportunity to apply their knowledge, values and perceptions in commenting on the predictions made in this EIS and to present their views on these matters.

The EIS describes a proposed program of follow-up and monitoring. ITK has been employed in the process of selection of monitoring targets (e.g., species or populations of special importance or concern to Innu will be selected for monitoring programs). The use of ITK in environmental monitoring programs will be facilitated through the Task Force or successor organization.

9.1.2 Local Community and Other Sources of Knowledge

Local community knowledge augments other information used for the assessment. Local community knowledge was obtained from residents of Upper Lake Melville and Churchill Falls through:

- focus groups held in conjunction with the Communities VEC;
- interviews and discussions with representatives of public and private training groups;
- technical workshops;
- community meetings such as the meeting in Mud Lake, which provided access to important information regarding ice formation and break-up; and

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- open houses and focused face-to-face or telephone surveys such as were done to support consideration of the Land and Resource Use VEC and the Cultural Heritage Resources VEC.

In addition to the ITK gathered for this assessment (Section 9.1.1), there has been a continuing involvement of Innu in the working groups (1998 to 2002 Working Group) and a Task Force (2006 to 2008). This involvement encompassed the design of the field programs conducted to enhance understanding of the existing environment.

As well, the knowledge gained through baseline surveys conducted during 1998 to 2000 were brought together and considered in a joint consultation forum to identify potential residual environmental effects from the Project as conceived at that time (Griffiths 2001). The output from this workshop served to inform the process of VEC identification and planning for the 2006 Registration of the Project, and was included in the consideration of effects predictions, as was information from the ITKC Report.

In addition, Innu, other Aboriginal people and the public have all had an opportunity to participate in the process of Guidelines development for the Project environmental assessment. Innu Nation, LMN and the Quebec Innu all provided input to the EIS Guidelines, which identify the VECs and the associated scope of assessment.

Collection and maintenance of local community knowledge has been and will be ongoing during the Project. Local community knowledge will provide input to the Project's EPP and will be used to develop monitoring and follow-up programs.

9.1.3 Baseline Data Analyses and Modelling

Baseline data collected for the Project is described in Appendix IB-F and summarized in Volume IIA, Volume IIB and Volume III of the EIS. Much of this information was used to support the environmental assessment process with respect to defining zones of influence and to provide a basis for quantifying effects.

In several cases, mathematical models were used to provide quantifiable environmental effects predictions, either to supplement or to replace the use of qualitative means (e.g., professional judgement). The various models employed, described below, are:

- aquatic zone of influence;
- regression model to predict levels of methylmercury;
- ice dynamics modelling;
- water and sediment quality modelling;
- sediment plume dispersion;
- salt water intrusion model;
- bank stability modelling;
- fish habitat modelling;
- noise zone of influence;
- GHG emissions modelling;
- ELC;
- caribou habitat modelling; and
- economic modelling.

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Model results are presented in appropriate sections of Volume IIA and Volume IIB, Biophysical Assessment and Volume III, Socio-Economic Assessment.

9.1.3.1 Aquatic Zone of Influence

In order to establish the zone of influence (ZOI) downstream of the proposed dams, an estuary modelling study used hydraulic modelling to examine the effects in the estuary caused by variation in flows in the Churchill River (AMEC 2001). The modelling enabled conclusions to be reached on the nature and extent of temperatures, salinity and current velocity effects over the area from the river mouth east to Goose Bay and beyond Goose Bay Narrows. The model allowed for examination of a range of flow variation (e.g., doubling or halving the natural regime).

9.1.3.2 Methylmercury

The predicted methylmercury concentrations in fish in the lower Churchill River system were established using screening-level regression models based on the extent of proposed flooding and flow rates. These results were combined with an assessment of trends from existing reservoirs to estimate the likely timing and magnitude of increased fish mercury concentrations.

9.1.3.3 Ice Dynamics Modelling

Modelling of water temperatures and ice formation throughout the lower Churchill River was conducted to determine the physical and temporal effects of the two dam structures. This modelling process involved two phases:

- the collection and review of information pertaining to the physical characteristics, climate and ice processes of the lower Churchill River. This was done to better understand the existing ice regime and included a field survey to document the 2006 end-of-winter ice cover extent and break-up processes; and
- thermal and dynamic ice modelling to enable prediction of changes that might occur as a result of the Project.

Thermal modelling to analyze water temperatures throughout the reach was done using HEATSIM, a computer modelling program. The water temperature results of the HEATSIM model were then used as input to an ice dynamics model, ICESIM (a computer program developed by Acres International Limited, now Hatch Limited, in the late 1960s to facilitate the design of hydroelectric plants on the Nelson River in Manitoba, Canada). The model has been refined and used for many river ice studies in Canada. The model is able to simulate the ice formation process at freeze-up, and parts of the breakup process, for many kinds of conditions and types of rivers. It is well documented and not difficult to apply, although a thorough understanding of river ice is required to maximize the accuracy of the model results.

ICESIM simulates various ice processes including:

- rate of ice generation;
- ice cover advance;
- ice deposition and transport;
- ice erosion;
- border ice growth; and
- ice retreat by shoving (movement due to external forces such as wind and river flow).

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ICESIM simulates the water levels and velocities along a river due to the effects of these ice processes; for example, ice pans may be transported and accumulate under an existing ice cover, with the result of increasing the upstream water level, so that the ice cover progresses upstream.

ICESIM also determines ice thickness, based on calculations of internal ice stresses to find the strength and thickness needed to achieve a stable cover. ICESIM can also account for a reduction in the internal stresses due to grounding, or cohesion to instream features such as islands. The model was used to examine phenomena throughout each reservoir, as well as at specific locations of interest, such as the ice road between Mud Lake and Happy Valley-Goose Bay, and the Black Rock Bridge.

9.1.3.4 Water and Sediment Quality Modelling

A modelling study of sediment and water quality in the lower Churchill River system was conducted to forecast levels of nutrients (phosphorus) and total suspended solids in the river post-impoundment. Average concentrations of total suspended solids and total phosphorus (the limiting nutrient in most water bodies) were modelled in surface water, deep water and bottom sediment cells. The sensitivity of the model to selected key parameters was tested by setting those parameters to high and low values. Best- and worst-case scenarios were also determined by setting all key sensitivity analysis parameters to values that produced the highest total suspended solids and lowest total phosphorus concentrations. Results were compared against total suspended solids and total phosphorus levels from other reservoirs, water bodies and watercourses. The model produced long term projections (e.g., 20 to 50 year scenarios). The results were also used to project the influence of changes in nutrient levels in primary production (phytoplankton).

9.1.3.5 Sediment Plume Dispersion

The fate of sediments carried from the Gull Island and Muskrat Falls construction sites was predicted by hydraulic modelling studies based on mean flows for the months of May through November (when the river is not expected to be covered by ice). Sediment plume distribution maps were constructed to illustrate the results of the studies and sediment loading rates in depositional areas were calculated for different construction activities.

A sediment transport analysis was carried out for each dam site to determine the extent, duration and fate of potential sediment plumes generated by construction activities. For each dam, a 3D numerical model was set up representing a portion of the Churchill River extending several kilometres downstream of the construction site. The 3D sediment dispersion models were set up using the computational fluid dynamics model FLOW-3D. The FLOW-3D model computes the variation in flow velocity and direction in three dimensions, throughout the full width and depth of the river, and can also track the motion of particles (such as suspended sediment) in the flow.

Depending on the site, sediment-loading activities were calculated for:

- installation of temporary construction bridge;
- Phase I of main cofferdam construction;
- Phase II of main cofferdam construction (closure);
- initiation of flow diversion; and
- initial spillway channel and powerhouse tailrace flow.

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9.1.3.6 Salt Water Intrusion Model

The 1980 EIS identified the Churchill River below Muskrat Falls as potentially susceptible to salt water intrusion from Goose Bay during the temporary reduction in river flows, which would occur during reservoir impoundment. Dominant species of fish (sucker, pike, and whitefish) were identified as at risk if subjected to salt water. To determine the extent of any salt water intrusion that could occur, a three-dimensional numerical model of the Churchill River and Goose Bay estuary was set up using DHI MIKE 3, a 3D hydraulic modelling package applicable to simulations of flows in rivers, lakes, estuaries, bays and seas. The model was set up using data from bathymetric surveys of the Churchill River and Canadian Hydrographic Service nautical chart data, and temperature and salinity measurements from the 1998-1999 field program (AMEC-BAE 2001).

The DHI MIKE 3 model was used to simulate the effect of impounding the Gull Island Reservoir under average flow conditions and assuming that all flow from upstream of Gull Island was cut off. The effects of a flow release over the spillway at Gull Island (30 percent MAF at Gull Island, taken to be approximately 500 m^3/s) were also examined.

9.1.3.7 Bank Stability Modelling

Bank stability along the lower Churchill River as a result of reservoir formation and operation was assessed by using existing data to produce a wave energy model for the area. Stations along the shoreline were selected (typically every 3 km on both sides of the river) to calculate the annual wave energy at those locations. A rating and classification system was then developed for the reservoir banks, which rated the proposed shoreline on three items: terrain stability, soil erosion potential and wave energy. Criteria for these classifications were determined from a terrain stability mapping and classification system developed by the Government of British Columbia for use in their forest industry. These ratings were then incorporated into a GIS program where it produced a map identifying potential areas of shoreline erosion (bank retreat/recession rate) based on a product of the three classifications.

9.1.3.8 Fish Habitat Modelling

Over the past decade, a model has been developed for measuring and predicting productive fish habitat within the lower Churchill River (McCarthy et al. 2006). The model is based on extensive field surveys that characterized the physical features of the habitat (substrate, water velocity) and habitual use patterns by fish species (and life cycle stage). A large inventory has been accumulated to describe habitat use for every aquatic habitat type in the affected watershed. The database was cross-checked and validated through additional field sampling. The data were then run through models which produced a measurable parameter (Habitat Utilization Index - HUI expressed in hectares) that could be used in effects prediction. The method has been subject to peer review and endorsement (Smokorowski and Derbowka 2007).

9.1.3.9 Noise Zone of Influence

Construction activities will create noise within the immediate construction site and the sounds of these activities can transmit some distance before they are attenuated. In order to simulate the noise from the traffic on access roads, the US Department of Transportation Traffic Noise Model (TNM) was used to calculate the sound pressure levels at varying distances from the road.

The internationally recognized sound calculation program, CADNAA, was used to estimate the noise resulting from the operation of typical groupings of construction equipment at different distances. The effects of wind on outdoor sound propagation during different weather conditions could cause large variations in Project-related

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sound levels measured at a receptor. Consequently, the ISO 9613 noise model was used to simulate downwind propagation under a mildly developed temperature inversion and to provide a worst-case representation of potential effects.

9.1.3.10 Greenhouse Gas Emissions Modelling

In accordance with IPCC guidelines, the long term trends in GHG emissions from the Churchill River watershed, following the construction of the generation facilities at Gull Island and Muskrat Falls, were modelled and evaluated using three separate methods (Tier 1, 2 and 3). Tier 1 and Tier 2 used generic calculations to estimate emission rates from land flooding only (Tier 1) or land flooding and degassing at turbines and spillways (Tier 2). Tier 3 involves detailed accounting of all carbon stocks, processes and fluxes relevant to the Project. Carbon sources and sinks were estimated for the watershed and modelled from conditions pre-impoundment, as well as in Year 2 post-impoundment and Year 20 post-impoundment. This approach was used to represent the high emissions due to rapid initial vegetation decomposition of a young reservoir and the lower emissions of a reservoir at maturity after most vegetation has decomposed. As climate change is a process influenced by GHG emissions globally, a global carbon budget was also constructed for comparison with the relative contribution of the Project's net GHG emissions.

9.1.3.11 Ecological Land Classification

An ELC was prepared in support of the EIS (Minaskuat Inc. 2008a, 2008b), to describe the ecological mosaic of the lower Churchill River valley. The ELC allows the effects of the Project on the surrounding environment, including the anticipated zone of flooding, to be better understood and quantified. A full description of the ELC for the lower Churchill River watershed is in the *Project Area Ecological Land Classification, Lower Churchill Hydroelectric Generation Project* report (Minaskuat Inc. 2008a, 2000b).

To examine the area of the proposed reservoirs, an area 2 km on either side of the Churchill River, from Churchill Falls to Lake Melville, was mapped at a scale of 1:20,000. A 1 km wide corridor of the proposed transmission line was also included in the scope of this classification for the Project footprint. The ELC for this area comprises 1,635.4 km^2 (Volume IIA, Figure 2-16). The ELC identified ecotypes based on predominant vegetation, geomorphology and soil.

A regional ELC of the entire lower Churchill River watershed was completed by combining earlier work by Lopoukhine et al. (1977) that was updated using more recently-acquired data known as Earth Observation for Sustainable Development (EOSD) from the Canadian Forest Service (2007, Internet site). This Landsat (30 m spatial resolution imagery) was reduced to 17 broad land-cover classes and generalized in a GIS at a scale of 1:250,000.

9.1.3.12 Caribou Habitat Modelling

Several analyses were conducted to quantify three potential Project effects (direct habitat loss, indirect habitat loss and alteration of movements) on the RWM Herd. These analyses focused on the RWM Herd because of its small size, sedentary nature and limited range, which make it particularly vulnerable to Project effects. The analyses included:

- a resource selection function (RSF) analysis to identify habitat availability within the RWM Herd home range and subsequent habitat loss caused by the Project;
- an analysis of ZOI around existing disturbances in the Herd's home range to identify potential displacement distances from development;

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- a Least-cost Path (LCP) analysis to identify potential movement corridors of the RWM Herd across the lower Churchill River; and
- a home range analyses to identify occurrence of the RWM Herd north and south of the lower Churchill River and the existing TLH transmission line corridor.

9.1.3.13 Economic Modelling

The economic effects assessment was conducted using a model developed specifically for Newfoundland and Labrador-based resource projects, which has previously been applied to several large mining and oil and gas projects proposed or occurring within the Province. Economic effects associated with the Project were analyzed as a whole and by Project component from the following perspectives:

- financial, using cash flow projections for capital expenditures;
- economic, which considers direct, indirect and induced effects on employment and incomes of workers and businesses. Economic effects were analyzed for the Province, Labrador, and the Upper Lake Melville area (Economic Zone 3); and
- treasury, which measured direct, indirect and induced taxation effects received by the provincial government.

The primary information source used in the economic effect analysis was the construction phase cash flow profiles. The cash flow model for the Project defined the major classifications of expenditures by type, amount and duration. Included in the data was an expenditure breakdown including labour, materials and equipment. The parameters used in the economic effect analysis were gathered from a number of sources including Statistics Canada and other similar economic effect assessments on projects in the Province.

9.2 Valued Environmental Component Selection

The environmental assessment focuses on VECs, which are biophysical and socio-economic components that are valued by society and can be indicators of environmental change. This approach is consistent with those described in Beanlands and Duinker (1983) and in Barnes et al. (2000) and reflects generally accepted practice for environmental assessments (Figure 9-1).

In order to comprehensively consider the potential environmental effects of the Project on some VECs, KIs were selected and assessed. The KIs were selected through a comprehensive issues-scoping process, which included stakeholder and public consultation (Chapter 7) and Aboriginal consultation (Chapter 8). The final KIs reflect input from regulators, stakeholders, Aboriginal groups, the public and the Study Team. A KI is selected for many reasons, such as:

- it is sensitive to Project environmental effects, based in part on existing knowledge;
- it is important to local communities and resource users;
- it is important regionally, provincially, nationally or internationally (e.g., it has been designated for specific management or protection measures by regional, provincial, national or international authorities);
- it is associated with environmental effects on related resources and broader systems (e.g., ecological, economic, social or cultural);
- it is a key linkage in a pathway between the Project and environmental effects on VECs;
- data are available on the status of the KI; and
- it is identified as an aspect of concern during regulatory, public and stakeholder consultation.

A description of each VEC and rationale for its selection is presented within the introductory sections of each of the biophysical and socio-economic assessments (Volume IIA, Volume IIB and Volume III). The selection of VECs and KIs was in accordance with the EIS Guidelines.

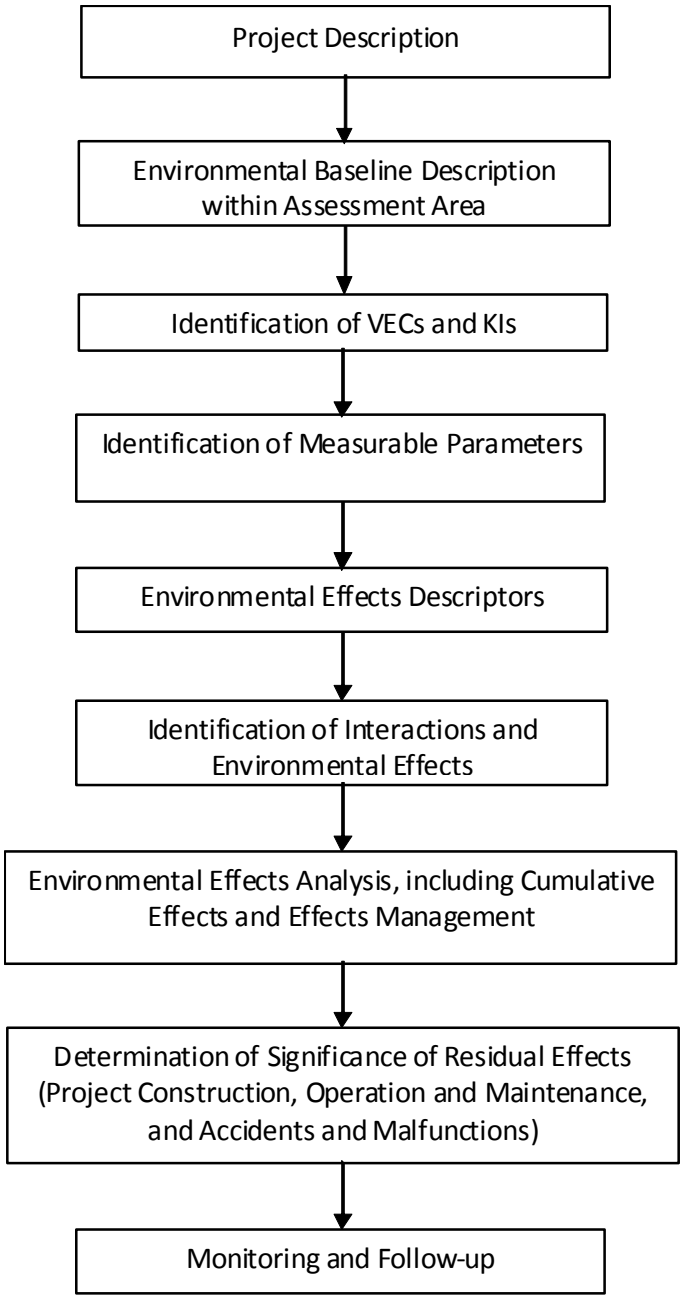


Figure 9-1 Environmental Assessment Methods

The number and nature of the KIs selected is dependent on the nature of the VEC being consideration and the nature of the Project-environment interactions. KIs are selected for the following VECs:

- Atmospheric Environment;
- Aquatic Environment;
- Terrestrial Environment;
- Economy, Employment and Business;

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- Communities; and
- Cultural Heritage Resources.

Land and Resource Use was assessed without KIs because it provided an appropriate level of focus and scope for environmental effects assessment. The various activities associated with this VEC overlap and are not necessarily discrete (e.g., snowmobiling and trapping may occur together). Therefore, different activities are assessed within the single VEC, with Project activity interactions being assessed through measurable parameters.

Where KIs have been selected, their assessment follows the same general steps described for the VEC-level assessment. For each KI, the definition and rationale for selection is presented, and any relevant linkages to other KIs are described. For each VEC or KI, the measurable parameters that are used to quantify environmental effects are described (e.g., amount of an emission, areal extent of habitat changed, number of jobs created, number and type of archaeological sites that might be disturbed). A measurable parameter is a measurable aspect of a VEC or KI that can be quantified and compared against a baseline value or condition. The VECs, KIs and measurable parameters used in the environmental assessment are listed in Table 9-1.

Table 9-1 Valued Environmental Components, Key Indicators and Measurable Parameters

Valued Environmental Component	Key Indicator	Measurable Parameter
Biophysical Environment		
Atmospheric Environment	Climate	• GHG emissions
	Air Quality	• Air pollutants (PM, PM_{10}, $PM_{2.5}$, SO_2, NO_X and VOCs)
Aquatic Environment	Fish and Fish Habitat	• Habitat quantity in units/hectares for river and standing water • Change in fish habitat quality, including – temperature – TSS – total phosphorous • Change in fish distribution and abundance, including – habitat usage – mortality • Change in fish health
Terrestrial Environment	Caribou, Moose, Black Bear, Marten, Porcupine, Ruffed Grouse, Wetland Sparrows, Other Species of Concern	• Change in habitat: quantity (proportion) of primary habitat that will be altered or lost • Change in health: a relative measurement of the potential for change in health • Mortality: number of fatalities as a proportion of the population
	Beaver	• Change in habitat: the number (proportion) of breeding sites (i.e., active colonies for Beaver) that will be altered or lost. • Change in health: a relative measurement of the potential for change in health • Mortality: number of fatalities as a proportion of the population
	Canada Goose, Surf Scoter, Harlequin Duck	• Change in habitat: the quantity (proportion) of staging and breeding habitat (i.e., the amount of open water available in the Spring at traditionally used staging areas) that will be altered or lost • Change in health: a relative measurement of the potential for change in health • Mortality: number of fatalities as a proportion of the population
	Osprey	• Change in habitat: the number (proportion) of breeding sites (i.e., active nests for Osprey) that will be altered or lost • Change in health: the Hazard Quotient (HQ) as determined through an Ecological Risk Assessment (ERA) • Mortality: number of fatalities as a proportion of the population

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Table 9-1 Valued Environmental Components, Key Indicators and Measurable Parameters (cont.)

Valued Environmental Component	Key Indicator	Measurable Parameter
Socio-economic Environment		
Economy, Employment and Business	Economy	• Direct, indirect and induced income generated in Newfoundland and Labrador from Project construction and operation and maintenance • Direct, indirect and induced corporate taxes, personal taxes and other revenues, including payroll taxes and Worker's Compensation premiums, to Newfoundland and Labrador
	Employment	• Direct, indirect and induced employment levels in Newfoundland and Labrador, Labrador and its regions from Project construction and operation and maintenance • Employment by gender and Aboriginal status • Labour force participation rate • Employment rate
	Business	• Number of businesses in the construction and related trades sectors in Labrador • Value of contracts obtained by Labrador and Newfoundland businesses
Communities	Physical Infrastructure and Services	• Roads - design capacity (i.e., number vehicles/hr) • Port - maximum load that can be transferred from vessel to dock • Airport/passenger terminal - design capacity • Water/sewer - design capacity • Power - design capacity • Communications - design capacity • Waste - design capacity of landfill site • Industrial and commercial real estate - available industrial and commercial real estate
	Social Infrastructure and Services	• Security – Police - officer/population ratio – Fire - number of calls requiring a response • Education – Teacher/student ratio – Design capacity • Housing and accommodations – Building lot availability
	Community Health	• Health services – Capacity (e.g., doctor/population ratio; nurse/population ratio; beds available per 1,000 population) • Physical environment – Level of methylmercury in humans
Land and Resource Use	Not applicable – environmental assessment is conducted for VEC (Land and Resource Use)	• Hunting/trapping/fishing - changes in access, fish and wildlife habitat, hunting/trapping areas and health of fish and wildlife for human consumption • Navigation and winter travel - changes in access • Recreational use - change in number of cabins • Forestry - change in land base available for timber cultivation • Mineral lands - changes in area of leased or licensed mineral lands • Special areas - changes in number of special areas • Berry picking and medicinal plants - changes in berry picking areas and areas with medicinal plants • Agriculture - change in quantity of lands zoned for agriculture • Landscape/river aesthetics - pre- and post-development aesthetic value

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Table 9-1 Valued Environmental Components, Key Indicators and Measurable Parameters (cont.)

Valued Environmental Component	Key Indicator	Measurable Parameter
Socio-economic Environment (cont.)		
Cultural Heritage Resources	Historic and Archaeological Resources	• Number of sites that will be lost or disturbed

9.3 Environmental Assessment Boundaries

For each VEC, appropriate spatial and temporal boundaries for the environmental assessment are established. Boundaries are used to focus an assessment and to help determine the most effective use of available resources. Specific boundaries are defined for the VECs by considering applicable Project components, activities, likely interactions and the nature of the VEC in question, among other considerations.

9.3.1 Assessment Area

An Assessment Area is defined for each KI or VEC, as appropriate. An Assessment Area is the spatial extent within which the significance of Project environmental effects is determined. The spatial boundary captures the extent of Project environmental effects and provides a sufficiently large area for context. The temporal boundary is defined by the construction (2010 to 2020), and operation and maintenance phases (2017 onwards). The Assessment Area is also determined in consideration of ecological or socio-economic boundaries, and administrative and technical boundaries described below.

9.3.2 Ecological and Socio-economic Boundaries

Ecological and socio-economic boundaries are determined by the spatial and temporal characteristics and distributions of the VECs and their potential interactions with the Project. Spatial ecological boundaries are determined by the distribution and movement patterns of biophysical components (e.g., seasonal migrations of various fish and wildlife species) or physical elements (e.g., watersheds). Temporal ecological boundaries consider the relevant characteristics of the VECs, including the natural or seasonal variation of a population or species, or any sensitive or critical periods such as spawning or migration.

Similarly, spatial socio-economic boundaries are determined by the characteristics of the VECs and their potential interactions with the Project. For example, boundaries may reflect the location of Project activities, and the location of communities, land uses, labour force distributions and other socio-economic phenomena likely to be affected by those activities. Temporal socio-economic boundaries focus on the construction and operation and maintenance phases.

9.3.3 Administrative and Technical Boundaries

Administrative boundaries refer to spatial and temporal considerations relevant to an environmental assessment due to administrative, political or jurisdictional reasons. This includes resource management areas, regional economic zones or political districts, as well as periods associated with management plans and activities. It may also include legislative prohibitions that are applicable to Project activities such as protection of special areas.

Technical boundaries are determined by any practical or technical limitations that may be associated with the analysis and evaluation of potential environmental effects, such as data limitations or analytical constraints. These are also identified and described as appropriate.

9.4 Existing Environment

The existing (baseline) environment is described for each VEC or KI. The description of the existing environment at the VEC level is kept to a higher or regional level, with detailed descriptions provided for the individual KIs. The existing environment for all of the biophysical VECs is presented in Volume IIA, Chapter 2. The existing environment for all of the socio-economic VECs is presented in Volume III, Chapter 2.

The baseline descriptions include an overview of the sources of information and methods used to understand and describe the existing environment for that VEC, including existing data and literature, baseline studies conducted for this EIS, and Aboriginal traditional and community knowledge. This generally leads to a description and discussion of the general characteristics and status of the VEC.

Where KIs have been selected, the existing environment is described for each. As compared to the VEC description, the KI descriptions of existing conditions tend to be more focused and provide detailed information specific to the conditions of each KI, including:

- an overview of any relevant data collection methods including a description of relevant field programs or other studies conducted specifically in support of this assessment;
- an overview of the baseline conditions of the KI based on available information regarding the existing conditions of the KI; and
- a presentation of ITK relevant to the KI being considered.

An important and data-rich baseline of information is available for conducting this environmental assessment. Dedicated studies were first conducted for a proposed hydroelectric development at Gull Island and Muskrat Falls in 1978 and 1979, in support of an environmental assessment Panel Review under the Federal Environmental Assessment and Review Process and in accordance with requirements of Newfoundland and Labrador. Over 30 component studies, including baseline surveys of both the biophysical and socio-economic environments, were prepared between 1979 and 1980, as supporting documents to the EIS, which was formally submitted to the Panel in April 1980. For the second effort to develop the lower Churchill in 1990, a comprehensive review of information was conducted, but no new baseline surveys were conducted. The third initiative, the CRPP began in 1998. More than 25 baseline studies were prepared between 1998 and 2000 in anticipation of an environmental assessment. These developments did not proceed, mainly due to project economics and market conditions.

The development of the currently configured Project, the fourth effort, began in 2006. Over 40 field programs and environmental baseline reports were completed between 2006 and 2008 covering the aquatic, terrestrial, atmospheric, and socio-economic environments. This work was also planned to complement and supplement past baseline studies. The Study Team took a methodical approach to the identification of existing sources of data and the need for additional field studies or primary data collection efforts. This allowed resources and effort to be focused in areas with the greatest need.

Throughout the planning and implementation of the field programs from 1998 onward, input and guidance have been sought from Innu Nation. An informal environment and engineering advisory group was active from 1998 to 2002 with participation by Hydro, Innu Nation and Hydro-Québec. The Environment Task Force was established between the Project Team and Innu Nation in 2005.

Based on knowledge of the potential Project interactions and associated issues, the Study Team identified key questions that the EIS would need to address for applicable KIs or VECs. For instance, a key question was how the creation of the reservoir would affect the habitat available for particular species. For these species, it was important to identify the types of habitat currently used by the species and the quantity of this habitat available

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in the Assessment Area. Based on the key questions and upon a review of existing sources of information, VECs and KIs were grouped into categories, those where:

- there was sufficient existing information to address the requirements of the EIS;
- available data collected by others (e.g., provincial government) could be analyzed to address the specific information requirements of the EIS; and
- data gaps required the collection of additional data.

For the VECs or KIs that were classified in the latter category, programs were developed using methods most suitable to the nature of the VEC or KI and the type of information required. For example, a winter track program using ground transects was developed to characterize existing conditions for furbearers, as this is the best time of year to document their presence. In some cases, programs were specific to a single KI. In other cases, a program was able to address a variety of KIs at a given time or location. For those KIs where trends are a critical component of the nature of the KI, such as small mammal cycles, the program was designed to determine where they are in their population cycle. In this case, consideration of the small mammal cycle is important as it has a great influence on one of their main predators, marten, which has a subsequent environmental effect on trapping.

As described above, for many other biological KIs, habitat association was the main focus given the quantity of habitat to be altered by the Project and the ability to quantify habitat and measure habitat alteration. Therefore, the field studies focused on identifying the relative value of habitat types for various species (i.e., primary, secondary and tertiary habitat). Identifying areas of concentrations for species at various times of year can provide insight into subsequent environmental effects on Aboriginal and other land use and preferred hunting areas.

For socio-economic VECs and KIs, data were collected through field surveys (e.g., historic resources overview assessment), informant interviews (land and resource use), telephone surveys (fish consumption and angling) and secondary sources, such as Statistics Canada and Newfoundland and Labrador Community Accounts.

A list of all field programs and associated environmental baseline reports or technical data reports that were prepared in support of this assessment is provided in Appendix IB-F. All study methods followed accepted techniques and, where appropriate, were presented to and approved by the appropriate provincial and/or federal agencies in advance of the study (i.e., most required a permit for implementation, which required government approval of the study methods). Quality assurance and quality control procedures were implemented and recognized experts served in senior review capacity for many programs including review of program design and report preparation.

Field study results have been analyzed to provide quantitative insight into the current conditions of VECs and KIs within the respective Assessment Areas. In situations where data are not available, the nature and reason for the data gap have been addressed in the EIS. An alternate approach is developed to address the issue and is often based on the use of available qualitative data and conservative assumptions, rendering any predictive statements conservative.

9.5 Environmental Effects Descriptors

For each VEC or KI, the criteria used to provide a common basis or characterization for potential environmental effects is described.

9.5.1 Criteria for Describing Environmental Effects

The criteria used to characterize potential environmental effects for VECs and KIs are described below. These criteria establish the framework or context for the assessment of environmental effects. The criteria that are listed below are consistent with those outlined in *CEAA* guidance documents and the EIS Guidelines, although each is modified as necessary to apply specifically to the VECs being considered. This is particularly important for the Economy, Employment and Business and Communities VECs where some categories are sometimes inappropriate (e.g., reversibility) or redundant (e.g., social context). These criteria establish the framework or context for the assessment of environmental effects. They are presented at the VEC level, where they are consistent among the KIs. Where differences occur, they are presented at the KI level. The criteria are as follows:

- **nature:** the ultimate long term trend of the environmental effect (e.g., positive, neutral or adverse);
- **magnitude:** the amount or degree of change in a measurable parameter or variable relative to existing conditions;
- **geographical extent:** the area over which the environmental effect will occur;
- **timing:** the Project phase within which the environmental effect will occur;
- **frequency:** the number of times during the Project or a specific Project phase that an environmental effect might occur (e.g., one time or multiple times);
- **duration:** the period of time over which the environmental effect will occur;
- **reversibility:** the likelihood that a VEC or KI will recover from an environmental effect, including consideration of active management techniques (e.g., habitat restoration works). This may be due to the removal of a Project component/activity or due to the ability of a VEC or KI to recover or habituate. As well, reversibility is considered on a population level for biophysical VECs. Therefore, although an environmental effect like mortality is irreversible to an individual animal, the environmental effect on the population may be reversible;
- **ecological or social context:** the general characteristics of the area in which the Project is located, as indicated by existing levels of human activity and associated disturbance; and
- **level and degree of certainty of knowledge**: level of confidence in the knowledge that supports the prediction.

Where applicable, the extent to which the Project affects biological diversity (i.e., species richness) is also indicated. Environmental protection goals and objectives, as set out in applicable legislation and policies are addressed for species of special concern.

9.5.2 Determination of Significance

In consideration of the above criteria, the definition of a significant adverse environmental effect is provided for each VEC or KI, as appropriate. The definition represents a threshold beyond which any changes or environmental effects resulting from the Project are considered likely to be significant and adverse when taking into consideration proposed mitigation measures. Significance definitions are provided for residual environmental effects (i.e., the environmental effect remaining after the application of mitigation or effects management measures). The thresholds developed for this assessment are based on guidance from the CEA Agency, applicable regulatory standards and requirements, previous environmental assessments, and the professional experience of the Study Team. In some cases, significance definitions vary for each or some of the KIs identified within a VEC. In these cases, KI-specific definitions are provided. Where applicable, significance

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criteria have also been defined for positive environmental effects, which allow potential benefits, resulting from the Project, to be articulated.

9.6 Potential Interactions and Identification of Environmental Effects

An early step in the environmental effects analysis involves the identification of potential interactions between Project components and activities and each of the VECs or KIs. For clarity and ease of reference, environmental effects on Economy, Employment and Business and Communities VECs are referred to as socio-economic effects. For the purpose of this EIS, socio-economic effect is defined as an environmental effect, pursuant to *CEAA*.

9.6.1 Identification of Interactions

To maintain the thorough and consistent assessment of all aspects of the Project for all VECs and KIs, a list of Project activities and components that included both Project phases (i.e., construction and operation and maintenance) were developed. Potential accidents and malfunctions are also included in the list. The Study Team considered each activity or component and determined if the Project was likely to interact with the KI. Table 9-2 is an example of the list used for the following KIs:

- Climate;
- Air Quality;
- Fish and Fish Habitat;
- GR Caribou Herd;
- RWM Caribou Herd (Species of Concern);
- Moose;
- Black Bear;
- Beaver;
- Marten;
- Porcupine;
- Canada Goose;
- Surf Scoter;
- Ruffed Grouse;
- Osprey;
- Wetland Sparrows;
- Harlequin Duck (Species of Concern);
- Other Species of Concern;
- Physical Infrastructure and Services;
- Social Infrastructure and Services;
- Community Health;
- Land and Resource Use; and
- Historic and Archaeological Resources.

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Table 9-2 Categorization of Potential Key Indicator/Valued Environmental Component Project Interactions - Example

Project Activities or Physical Works	Key Indicator 1	Key Indicator 2	Key Indicator 3	Key Indictor 4
Construction				
Upgrading and constructing site access roads				
Site preparation and construction of site buildings				
Excavation for and installation of generation components				
Concrete production				
Transmission line construction				
Site water management				
Camp operations				
Vehicular traffic on site				
Quarrying and borrowing				
Reservoir preparation				
Impounding				
Employment				
Transportation and road maintenance				
Expenditures				
Operation and Maintenance				
Water management and operating regime				
Operation of generation facilities				
Site waste management				
Inspection, maintenance, repairs along transmission line				
Employment				
Transportation/presence and maintenance of access roads				
Expenditures				
Decommissioning				
Not applicable				
Accidents and Malfunctions				
Dam failure				
Forest fire				

Notes:

0 No measurable interaction will occur. Assessment of environmental effects is not required

1 Identified interactions that are well understood, are subject to prescribed environmental protection measures or normal regulatory processes, and/or which can be mitigated/optimized through the application of standard environmental protection or socio-economic management measures and practices. Based on past experience and professional judgement, the potential environmental effects resulting from these interactions are rated not significant

2 Identified interactions that may result in more substantive environmental or socio-economic effects and/or public or regulatory concern. These interactions require more detailed analysis and consideration in the environmental assessment, in order to predict, mitigate and evaluate potential environmental effects

The Project activities that may interact with the Economy, Employment and Business VEC and with the Communities VEC are limited to employment, expenditures and transportation (including transportation of people and materials to site) and in one case, water management and operating regime. Therefore, these are the only Project activities that were considered in the environmental effects analysis for these two VECs.

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9.6.2 Interaction Ranking

For each potential interaction between a Project component/activity and a KI or VEC, a rating of 0, 1 or 2 has been provided:

- if there is no potential for interaction between a Project activity and a KI or VEC, an assessment of environmental effects is not required, and the interaction is categorized as 0. It is not considered further in the EIS;
- if a potential interaction between a Project component or activity and a KI or VEC is identified, but is not likely to be measurable, the interaction is categorized as 1. Such interactions are well understood and are subject to prescribed mitigation or codified practices. Based on past experience and professional judgement, the potential residual adverse environmental effect can be confidently rated as **not significant**. These interactions are subject to a less detailed environmental assessment. Justification is given for such categorizations; and
- if a potential interaction between a Project component or activity and a KI or VEC is identified that may result in measurable or substantial environmental effects, or greater public and regulatory concern, the interaction is categorized as a 2. These potential interactions require more detailed analysis and consideration in the environmental assessment in order to predict, mitigate and evaluate potential residual environmental effects.

All interactions ranked as a 1 are discussed for each VEC, including a discussion of potential environmental effects and significance of the adverse residual environmental effects. By addressing these interactions at the screening level, it allows the analysis to efficiently meet the requirements of the environmental assessment while providing focus on the interactions of greatest importance and concern (i.e., those ranked a 2) and eliminates repetition in assessing interactions that are subject to standard prescribed environmental protection measures.

In identifying and categorizing potential Project-VEC or Project-KI interactions, the Study Team has taken a precautionary approach; in any case where there is a degree of uncertainty involved, such interactions are subject to the more detailed level of assessment (i.e., ranked a 2). In all cases, the rating of an interaction as a 1 indicates that the residual adverse environmental effect is rated as not significant.

In some cases, where there is potential for positive environmental or socio-economic effects to occur, the interaction is indicated as such.

For each KI, all Project activities and components predicted to result in an interaction ranked as 2 are carried forward for consideration in the environmental assessment of the KI. Depending on the number of environmental effects for each KI, the potential environmental effects that may result from interactions with these Project components and activities are either presented in a table format (Table 9-3 as an example) or in the text.

Table 9-3 Environmental Effect 1 - Project Activities Ranked as 2 for Key Indicators - Example

Project Activities or Physical Works	Key Indicator 1	Key Indicator 2	Key Indicator 3	Key Indicator 4
Construction Phase				
Upgrading and constructing site access roads				
Site preparation and construction of site buildings				
Excavation for and installation of generation components				

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Table 9-3 Environmental Effect 1 - Project Activities Ranked as 2 for Key Indicators - Example (cont.)

Project Activities or Physical Works	Key Indicator 1	Key Indicator 2	Key Indicator 3	Key Indicator 4
Construction Phase (cont.)				
Concrete production				
Transmission line construction				
Site water management				
Camp operations				
Vehicular traffic on site				
Quarrying and borrowing				
Reservoir preparation				
Impounding				
Employment				
Transportation and road maintenance				
Expenditures				
Operation and Maintenance Phase				
Water management and operating regime				
Operation of generation facilities				
Site waste management				
Inspection, maintenance, repairs along transmission line				
Employment				
Transportation/presence and maintenance of access roads				
Expenditures				
Decommissioning Phase				
Not applicable				
Accidents and Malfunctions				
Dam failure				
Forest fire				
Note: Only those interactions that are categorized as a 2 are carried forward from Table 9-2 and indicted on this table by a check mark (✓)				

9.6.3 Identification of Environmental Effects

Environmental effects are defined to represent a change, alteration or modification of a specific aspect of the KI. For biophysical KIs, examples of potential environmental effects include change in habitat, change in health or mortality. For socio-economic VECs, potential environmental effects include changes in the quantity and quality of specific parameter values such as employment, income levels and health and well-being, or demands on infrastructure (e.g., port or airport traffic) and for services (e.g., education, policing). The identification of environmental effects is based on documented experience with previous projects and activities, consideration of Aboriginal traditional and community knowledge and the professional experience and judgement of the Study Team, as well as concerns raised through the issues scoping process. All interactions identified in these tables are fully considered in the assessment.

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9.6.4 Existing Knowledge

Existing knowledge regarding the Project's likely interactions with the environment are presented and discussed at either the VEC level or in the individual KI assessments, depending on the nature of the VEC. This summary includes information from the literature on other hydroelectric projects (some on the Churchill River), as well as from relevant Aboriginal traditional and community knowledge collected as part of this EIS. Existing knowledge is considered in and contributes to the identification of potential Project-environment interactions, the prediction and evaluation of environmental effects (both Project-specific and cumulative), the selection of KIs and in the identification of environmental effects management measures and appropriate follow-up in this EIS. Knowledge of these effects from other activities in the Project region, where it exists, has been supplemented with existing knowledge from other regions that share similar ecosystems or community structures. The existing knowledge section presents the results of literature reviews and discusses the relevance of findings in terms of the Project features.

9.6.5 Accidents and Malfunctions

The environmental assessment of accidents and malfunctions includes the definition of scenarios and the subsequent environmental effects analysis for each KI or VEC, using the same environmental assessment methods described here. The results of the environmental assessment of accidents and malfunctions are presented in Volumes IIB, Chapter 6 and Volume III, Chapter 7.

9.7 Environmental Effects Analysis and Effects Management

9.7.1 Environmental Effects Analysis

An environmental effects analysis is conducted for each of the identified environmental effects for each VEC or KI. As relevant and appropriate, each environmental effect is assessed for each of the Project phases (i.e., construction, and operation and maintenance), for accidents and malfunctions and specifically for each Project activity. The environmental effects analysis is based, in part, on the existing knowledge referred to above, as well as input from experts, stakeholders and regulators, and the professional judgement of the Study Team. Wherever possible, model projections or other analytical tools have been employed to produce scientifically defensible analyses.

The environmental effects are analyzed using the existing conditions, as described above, as the baseline scenario. In this way, any past effects resulting from human or natural influences are incorporated into the environmental assessment. The analysis includes both direct and indirect ways that the Project may interact with the VEC or KI.

Where possible, environmental effects are quantified based on the measurable parameters identified for each VEC or KI (e.g., area of habitat to be altered or percentage of population affected). Quantification of environmental effects is based on the defined Assessment Area. Where it is not possible to measure environmental effects quantitatively, a qualitative assessment is conducted.

9.7.2 Environmental Effects Management

Included within the assessment of each environmental effect is the identification of proposed environmental effects management, which includes planned mitigation and optimization measures. *CEAA* defines mitigation as

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the elimination, reduction or control of the adverse environmental effects of the project, and includes restitution for any damage to the environment caused by such effects through replacement, restoration, compensation or any other means.

Optimization refers to measures designed to enhance or maximize any positive environmental effects that may result from the Project (e.g., continuous improvement plans as per the Environmental Policy). Effects management is considered an integral aspect of the environmental assessment. In many cases, effects management has been incorporated into the:

- design of the Project (i.e., in the siting and design of Project components, and in compliance with design standards, legislation and regulations and best practices);
- corporate commitment and philosophy of the proponent (e.g., commitments to stakeholder consultation and corporate environmental, health and quality management systems); and
- EPP.

The Project would not proceed without environmental effects management; it is integral to the design of the Project. Therefore, the accurate assessment of environmental effects requires acknowledgement of the positive or mitigating influence of these management measures (i.e., it would be misrepresentative to predict environmental effects in the absence of these measures).

Environmental effects management is identified for each potential environmental effect and Project phase assessed, where feasible. The rationale for and effectiveness of the proposed environmental effects management measures is discussed and evaluated, particularly where mitigation has been proven through use in similar projects. The potential for mitigation failure has also been discussed with respect to risk and severity of consequence for a dam failure. At the end of the EIS, proposed environmental effects management measures are summarized; identification of responsibilities and accountability with specific respect to contractors and subcontractors will be part of the detailed program proposals submitted before the start of the Project.

In a socio-economic context, the objective of environmental effects management is to minimize adverse environmental effects where possible and to mitigate them where they cannot be minimized, ideally to levels where the environmental effect is not significant. Where environmental effects are potentially beneficial, the objective is to try to generate or enhance those benefits. Environmental effects management has become an increasingly important component of the environmental assessment process. In some cases, potential environmental effects can be anticipated and managed through Project design or through EPPs. However, a variety of other effects management planning tools have emerged specifically to address socio-economic issues. Most common among these are benefits plans, which are designed to examine and optimize possible environmental effects. A benefits plan is a comprehensive document that details the proponent's approach, policies and procedures with respect to local industrial benefits. It commonly addresses matters such as supplier development, procurement, education, training, hiring and succession planning, technology transfer and research and development.

Another related but often more comprehensive tool is the IBA. IBAs are contractual arrangements between the proponent and particular Aboriginal groups. They are typically confidential documents and may contain:

- provisions for hiring and training commitments;
- procurement processes;
- support of local businesses;
- direct payments to the affected group or groups;

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- measures designed to protect the environment; and
- valued social and cultural components (for a discussion of the range of items that may be included in IBAs, refer to Kennett 1999).

Nalcor Energy is currently involved in IBA negotiations with Innu Nation.

The environmental effects for each VEC or KI are characterized and presented in an environmental effects summary table (Table 9-4), which includes a summary of proposed environmental effects management, as well as a ranking for each of the defined and applicable significance criteria described in Section 9.5. Summary tables are completed for each VEC or KI and are appendices to Volume IIA, Volume IIB and Volume III. The environmental effects resulting from accidents and malfunctions are summarized in Volume IIB, Chapter 6 and Volume III, Chapter 7.

Table 9-4 Summary of Environmental Effects of the Project on Valued Environmental Component or Key Indicator - Example

Project Phase - Construction		
Environmental Effect	**Contributing Project Activity or Physical Works**	**Proposed Effects Management**
Effect #1		
Nature		
Magnitude		
Geographic Extent		
Duration/Frequency		
Reversibility		
Ecological Context		
Level and Degree of Certainty of Knowledge		
Project Phase – Operation and Maintenance		
Environmental Effect	**Contributing Project Activity or Physical Works**	**Proposed Effects Management**
Effect #1		
Nature		
Magnitude		
Geographic Extent		
Duration/Frequency		
Reversibility		
Ecological Context		
Level and Degree of Certainty of Knowledge		

9.8 Summary of Residual Environmental Effects and Evaluation of Significance

The EIS Guidelines define residual environmental effects as:

> *those adverse effects or significant environmental effects which cannot or shall not be avoided or mitigated through the application of environmental control technologies, best management practices or other acceptable means*.

Only residual environmental effects are assessed for significance. Residual environmental effects of the Project are described for each Project phase based on definitions developed specifically for each VEC or KI. The residual adverse environmental effects are rated as **significant** or **not significant** according to these definitions.

The residual environmental effects and their significance determination are presented in a summary table for each VEC or KI (Table 9-5). To meet the requirements of *CEAA* and the EIS Guidelines, those residual environmental effects that are predicted to be significant and adverse have been further considered based on the likelihood of the significant environmental effect occurring. In addition, the capacity of significantly affected renewable resources to meet the needs of present and future generations is considered.

Table 9-5 Summary of Residual Environmental Effects Significance Matrix for Valued Environmental Component or Key Indicator - Example

Criteria	Construction Phase	Operation and Maintenance Phase
Nature		
Magnitude		
Geographic Extent		
Duration/Frequency		
Reversibility		
Ecological or Social Context		
Certainty		
Significance		
Likelihood		

9.9 Cumulative Environmental Effects

Environmental effects from an individual project can accumulate and interact with the effects of other past, ongoing and reasonably foreseeable future projects and activities to result in cumulative environmental effects. As stated in subsection 16(1) of *CEAA,* every environmental assessment must consider *"…any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out*", as well as the significance of these environmental effects.

A cumulative environmental effects assessment is conducted for all VECs and KIs for which residual environmental effects resulting from the Project have been identified. The cumulative environmental effects assessment determines whether and how any of the Project's identified residual environmental effects will act in combination with the environmental effects of other relevant projects or activities. The process for assessing cumulative environmental effects includes, as appropriate:

- scoping the cumulative environmental effects assessment, including VECs and KIs to be considered, boundaries of the assessment and other projects and activities to be considered;
- analysis of the cumulative environmental effects on the VEC or KI;
- identification of potential effects management measures for cumulative environmental effects;
- determination of the significance of residual cumulative environmental effects; and
- development of follow-up (monitoring) measures, as required, to verify environmental effects predictions and effectiveness of effects management measures.

One of the first steps in undertaking a cumulative environmental effects assessment is the initial identification of other actions whose effects will likely act in combination with those of the Project under review. The screening

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of other projects and activities relevant to the cumulative environmental effects assessment was conducted based on the criteria described in Figure 9-2 and Table 9-6. This screening process resulted in eight projects and activities identified for inclusion in the cumulative environmental effects assessment (Table 9-7). The assessment and evaluation of the cumulative environmental effects of the Project, in combination with other projects and activities, consider the nature and degree of change from these existing environmental conditions.

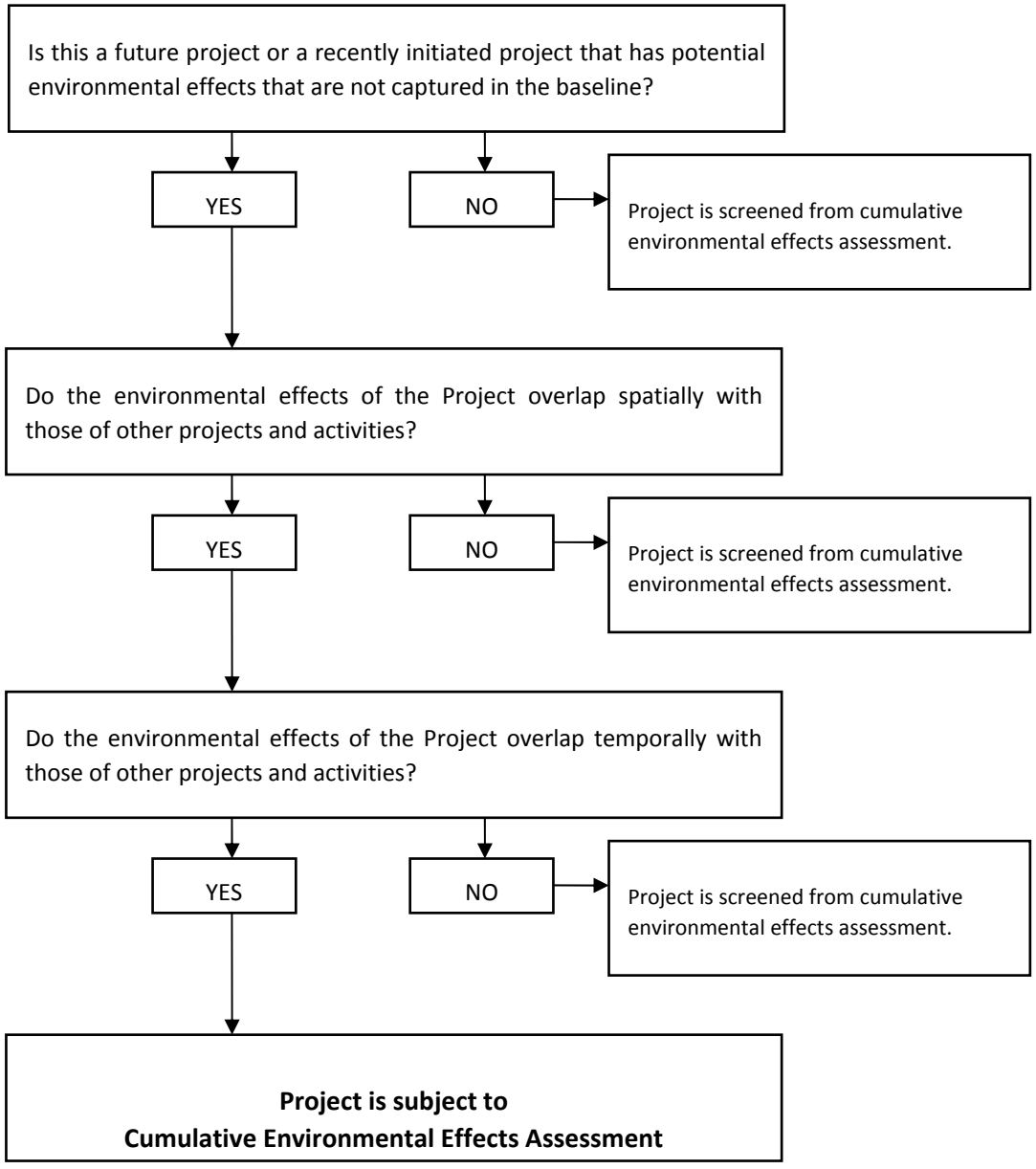


Figure 9-2 Cumulative Environmental Effects Assessment Screening Process

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Table 9-6 Criteria for Identification of Other Projects and Activities

Criteria	Rationale and Application of Criterion
Status of other project or activity: Reasonably foreseeable, past and present projects	• With some exceptions, the cumulative environmental effects assessment does not specifically consider past and present projects and activities because the environmental effects resulting from these projects and activities are captured in the description of the baseline conditions • Potential exceptions are recently initiated projects and activities where the environmental effects are also recent and may not be fully reflected in the existing baseline conditions (e.g., Black Rock Bridge and the TLH, or projects/activities that will probably change in nature and degree in the foreseeable future (e.g., Voisey's Bay Mine/Mill), or could be affected by the Project (e.g., Cultural and Recreational Land Use))
Status of other project or activity: Reasonably foreseeable, past and present projects (cont.)	• Reasonably foreseeable projects and activities are highly likely to be implemented and typically include those identified in approved development plans or those that are in other advanced stages of planning (e.g., forest management plans) • Hypothetical and speculative projects and activities are not considered as part of the cumulative environmental effects assessment
Potential for a temporal overlap of environmental effect: The environmental effects from other projects or activities should overlap temporally with the time frame that is relevant to the Project	• The Project timeframe includes the construction, and operation and maintenance phases • To be included within the cumulative environmental effects assessment, the effects from other projects and activities should have a measurable or meaningful overlap with some portion of the Project timeframe
Potential for a spatial overlap of environmental effect: The effects from other projects or activities should overlap with the Project Assessment Area as defined in the environmental effects analysis for the various VECs or KIs	• For the cumulative environmental effects assessment, projects should have an identified or expected zone of influence that may overlap with the geographic area likely affected by the Project area of interest. The potential for and nature of such spatial overlap will vary according to VEC or KI

Table 9-7 Projects and Activities Considered in Cumulative Environmental Effects Analysis

Project or Activity	Status	Potential for Cumulative Environmental Effects
Voisey's Bay Mine/Mill • Located in northern Labrador, south of Nain • Producing nickel mine and mill	Past and Present Project	Due to physical distance between Mine/Mill and the proposed Project, biophysical cumulative environmental effects are not anticipated. Potential for cumulative environmental effects with socio-economic VECs are considered in the assessment
Labrador West Mining Developments • Several proposed iron ore mines in western Labrador have been registered pursuant to *NLEPA*	Past and Present Activity	Due to physical distance between mining developments in western Labrador and the proposed Project, biophysical cumulative environmental effects are not anticipated. Potential for cumulative environmental effects with socio-economic VECs are considered in the assessment
NATO Special Forces Training (Military Training) • Base for low-level flying exercises • The base is not presently conducting regular low-level flying exercises	Past and Present Activity; Reasonably Foreseeable Activity	Could interact cumulatively with biophysical and socio-economic VECs

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Table 9-7 Projects and Activities Considered in Cumulative Environmental Effects Analysis (cont.)

Project or Activity	Status	Potential for Cumulative Environmental Effects
General Economic and Infrastructural Development in the Upper Lake Melville Area • Civil works • Sewage disposal • Sewage discharged into the Churchill River (Sewage is discharged into the Churchill River from the town of Happy Valley-Goose Bay. Average daily flow rate, as monitored for purpose of designing a sewage treatment facility, is 85 L/s) • Construction of new metal camera targets within the low-level flying area • Miscellaneous civil works on Base • General road improvements	Past and Present Project; Reasonably Foreseeable Activities	Due to limited physical nature of this activity, biophysical cumulative environmental effects are not anticipated. Potential for cumulative environmental effects with socio-economic VECs are considered in the assessment
Cultural and Recreational Land Use • Hunting and trapping • Boating and angling • Snowmobiling - 1,500 km of snowmobile trails running from Postville-Makkovik to North West River, and from North West River to Happy Valley-Goose Bay and through the Churchill River valley to Labrador West • Other uses such as camping, berry-picking	Past and Present Activity; Reasonably Foreseeable Activities	Could interact cumulatively with biophysical and socio-economic VECs, in area of spatial and temporal overlap
Commercial Forestry • Management District 19A 5 year Operating Plan was registered pursuant to *NLEPA* • Includes timber harvesting, road construction and maintenance and silviculture activities	Past and Present Activity; Reasonably Foreseeable Activity	Could interact cumulatively with biophysical and socio-economic VECs, in area of spatial and temporal overlap during the operation and maintenance phase
TLH • Includes the road link between Cartwright and Happy Valley-Goose Bay (Phase III), ongoing upgrades to TLH Phase I, and Black Rock Bridge TLH Phase III • Scheduled for completion in 2009 • Approximate clearing of 750 ha (30 m along entire stretch of highway) Phase III of the TLH is a two-lane, gravel surface highway between Happy Valley-Goose Bay and Cartwright Junction (87 km south of Cartwright), where it connects with the Phase II route of the TLH. The approximately 250 km long highway is the final link in a highway system extending from the Labrador Straits region in southeastern Labrador to western Labrador and onwards through Quebec. The highway crosses the Churchill River at Black Rock Bridge (see below) (NLDWST 2003). Construction is being carried out in phases over an eight-year period, beginning in 2003 and scheduled for completion in 2009 (D. Tee, pers. comm.)	Past and Present Reasonably Foreseeable Activity	Could interact cumulatively with biophysical and socio-economic VECs, in area of spatial and temporal overlap

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Table 9-7 Projects and Activities Considered in Cumulative Environmental Effects Analysis (cont.)

Project or Activity	Status	Potential for Cumulative Environmental Effects
TLH (cont.) TLH Phase I • TLH Phase I from Wabush to Happy Valley-Goose Bay is and will continue to be upgraded Black Rock Bridge • Bridge spanning the Churchill River near Muskrat Falls. The bridge is part of the TLH (Phase III) • Construction completed 2007 Located approximately 8 km upstream from Happy Valley-Goose Bay. The bridge consists of two sections: a 500 m causeway and a 360 m bridge. As the bridge is a very recent addition to the road network and Churchill River, its environmental effects on the local environment, both terrestrial and aquatic, may not yet have been fully realized		
Additional Transmission	Reasonably Foreseeable Project	Could interact cumulatively with biophysical and socio-economic VECs, in area of spatial and temporal overlap

The environmental effects of other past projects are reflected in the existing baseline environment, as described in the existing conditions sections for each VEC and KI. These have therefore been considered integral in the Project environmental effects assessment as the following examples demonstrate:

- the existing environmental conditions include the environmental effects associated with the Churchill Falls Power Station, which has been in operation for over 35 years;
- in many cases, the current threatened status of a species is a reflection of anthropogenic activities such as over-harvesting or alteration of habitat. Therefore, in describing the baseline conditions for these species, the environmental effects of these past activities are already captured; and
- the existing economic conditions of a community like Happy Valley-Goose Bay have been shaped by existing projects and activities including those of the Department of National Defence, Vale-Inco Newfoundland and Labrador Ltd., and government infrastructure projects, such as the TLH (Phases I, II and III).

For each VEC or KI, the Project's predicted residual environmental effects have been reviewed for potential spatial and temporal overlap with the Projects and activities listed in Table 9-7. Only projects with both overlapping spatial and temporal environmental effects are included in the assessment of potential cumulative environmental effects (Figure 9-2).

The approach used for the Project-specific environmental effects analysis is also used for the cumulative environmental effects assessment. However, the cumulative environmental effects assessment is largely qualitative in nature, based on experience and expert opinion. The use of this qualitative assessment is particularly applicable to reasonably foreseeable projects and activities. Where available and applicable, regulatory standards and guidelines are used as the basis for considering the potential for adverse cumulative environmental effects. Emphasis has been placed on attempting to describe the proposed Project's contribution to the predicted cumulative environmental effects.

Opportunities to address or discuss effects management of other projects and activities will be limited. Therefore, the focus of discussion is on identifying any additional management measures that can be implemented to further reduce the Projects' contribution to the predicted cumulative environmental effect or

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to enhance Nalcor Energy's contribution to regionally based management strategies or research and monitoring efforts.

As described for Project environmental effects on VECs and KIs, predicted cumulative environmental effects are characterized in terms of magnitude, geographic extent, frequency, duration, reversibility, ecological or socio-economic context, and level of degree of uncertainty of knowledge as relevant for each KI or VEC (Section 9.5). The significance of the residual adverse cumulative environmental effects is determined on the basis of the same criteria applied for determining the significance of Project environmental effects on KIs. Residual positive cumulative environmental effects have also been identified.

9.10 Monitoring and Follow-up for Valued Environmental Components

The purpose of monitoring has been defined in the EIS Guidelines as:

> *Monitoring programs will see that the Project is implemented as proposed, that the mitigation or compensation measures proposed to minimize the Project's environmental effects are effectively implemented, and that the conditions set at the time of the Project's authorization and the requirements pertaining to the relevant laws and regulations are met*.

The purpose of the follow-up program is to *verify the accuracy of the predictions made in the assessment of the environmental effects as well as the effectiveness of the mitigation measures*. This information will be used to refine and optimize mitigation measures and implement adaptive management measures associated with the Project.

Where possible, the measurable parameters identified and used to quantify Project environmental effects are also used to guide the development of the follow-up programs. One important criterion for monitoring relates to the level of certainty of knowledge pertaining to environmental effects predictions (i.e., where there is a low level of certainty, a precautionary approach will be taken and monitoring implemented).

Where appropriate, the description of the proposed monitoring and follow-up programs includes a general discussion of program elements to the level of detail allowed at the time of writing the EIS. At this stage of Project planning, the information is described at an overview level. It is anticipated that prior to Project construction and as a condition of Project approval, Nalcor Energy will be required to submit fully detailed monitoring plans for review to appropriate agencies. This information will include:

- objectives and schedule;
- design and methodology (overview);
- frequency, duration and geographic extent;
- reporting and response mechanisms;
- approaches to monitoring cumulative environmental effects;
- approaches to incorporating knowledge of independent experts, government agencies, communities, holders of Aboriginal knowledge and renewal resource users and experience gained from previous and existing monitoring programs;
- procedures for auditing effectiveness of planned programs; and
- communications plan for disseminating monitoring results to appropriate parties.

At this stage, the information provided is intended to convey Nalcor Energy's approach and corporate commitment to monitoring.

9.11 Sustainability

In the planning and design of the Project, Nalcor Energy has considered the following objectives:

- preservation of ecosystem integrity, including the capability of natural systems to maintain their structures and functions and to support biological diversity;
- respect for the right of future generations to the sustainable use of renewable and non-renewable resources; and
- attainment of desirable and equitable social and economic benefits.

The incorporation of sustainability into the EIS has been one of the basic premises of Project design. An evaluation of sustainability is presented in Volume IIB, Chapter 7 and Volume III, Chapter 8. The environmental effects analysis of biophysical VECs considers ecosystem integrity and the sustainability of resources, while the socio-economic effects analysis addresses the attainment of social and economic benefits.

9.12 Precautionary Approach

As called for in the EIS Guidelines, and consistent with Nalcor Energy's planning process, the Project has been examined in a careful and precautionary manner. This precautionary approach has included the following considerations:

- conservative assumptions have been made to predict the environmental effects of the Project and the approaches to prevent and reduce adverse effects;
- where the degree of interaction between the Project and the VEC or KI was not fully known, a complete effects analysis was conducted. Environmental effects management measures have been proposed for adverse environmental effects, including those that are not significant;
- the lack of scientific certainty regarding the probability of environmental effects occurring was not used as a reason for postponing environmental effects management measures;
- appropriate and cost-effective actions to prevent serious or irreversible damage as a consequence of the Project have been proposed; and
- follow-up and monitoring have been proposed, where appropriate.

9.12.1 Precautionary Principle and Certainty

The Precautionary Principle definition is given as: *Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation* (United Nations Environment Programme 1992, Internet site).

In considering the predicted residual environmental effects of the Project, the Precautionary Principle has been applied. Where there is any lack of scientific certainty regarding the probability of a biophysical or socio-economic effect, this has not been used as a reason to postpone or minimize effects management (mitigation) measures.

Within the environmental effects assessment chapters of Volume IIA, Volume IIB and Volume III, Nalcor Energy has described the approaches to reduce or minimize adverse environmental effects. The level and degree of certainty of knowledge associated with environmental effects predictions is stated for each prediction. As well, the criteria to be applied in design of monitoring and follow-up programs have included level and degree of certainty. To err on the side of caution, environmental effects predictions are based on conservative values (i.e., at the high end of the scale wherever predictions result in a range of possibilities).

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10.0 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

10.1 Introduction

Having successfully operated hydroelectric generation projects in the Province for more than 40 years, Nalcor Energy and its predecessors has experience dealing with the challenges posed by the sometimes-harsh Newfoundland and Labrador environment. As part of the planning and design process, the Project Team carefully considered the physical environment of the Project site and surrounding area.

This chapter describes the current and anticipated environmental conditions for the Assessment Area, and identifies and discusses the potential effects of the environmental events on the Project.

Climate change scenarios are also considered within this chapter.

10.2 Environmental Assessment Boundaries

10.2.1 Temporal and Spatial Boundaries

The spatial boundaries for the assessment of the effects of the environment on the Project include the lower Churchill River watershed (Figure 5-1). The temporal boundary includes the construction (10 years) and operation and maintenance phases of the Project.

10.2.2 Administrative and Technical Boundaries

The Project requires a large number of permits and approvals under numerous acts, regulations, standards and guidelines as outlined in Appendix IB-G. Thus, the engineering design of the Project considered extreme environmental conditions and fulfills design criteria that the respective authorities and agencies require to withstand potential physical environmental effects. In addition, or as part of these standards, the design life is taken into consideration so that materials selected for construction will provide safe, durable, and corrosion resistance function and operation.

10.2.3 Assessment Area

The Assessment Area for the assessment of effects on the Project is the footprint of the Project (i.e., physical area of and around the Project facilities including the reservoirs and the facilities themselves).

10.2.4 Determination of Significance

A significant effect of the environment on the Project is one that:

- harms Project personnel or the public;
- results in a substantial delay in construction (e.g., more than one season);
- results in a long term interruption in service;
- damages infrastructure and compromises public safety; or
- damages infrastructure to the extent that repair is not economically or technically feasible.

The environmental consequences of an event related to failure of a Project component (e.g., damage to infrastructure) are discussed in Section 4.11, and assessed in Volume IIB and Volume III.

10.3 Selection of Environmental Factors

The environmental factors considered during the Project design process include wind, current, storm surges, severe precipitation events, flooding, extended dry periods, ice, earthquakes and climate change. These factors can produce loading or other forces that will be incorporated into Project design criteria.

Wind is an important consideration in transmission line design, especially in combination with ice loading; however, it is less important for the design of the generation facilities.

Water current is not considered a governing factor in the design and operation of the generation facilities, because the approach channels are designed to maintain acceptable water velocities to intakes or spillways. Current is not discussed further in this chapter.

Storm surges are changes in water level caused by atmospheric forcing associated with storms. Set-up from high winds will cause water to pile up higher than sea level; adjustment of sea level to changes in barometric pressure (e.g., low pressure at the centre of a weather system) may have a secondary effect. In addition, as a storm depression travels over the water surface, a long surface wave will accompany its propagation. Depending on the storm track, this wave may propagate directly up on shore and, if accompanied by shoaling and funnelling, will further compound the water level rise. As a result, particularly in low-lying regions or at times coincident with high tide, coastal flooding may occur. Given this is largely a coastal phenomenon, and the inland location of Muskrat Falls, storm surge will not physically propagate this far or be an effect on the Project. Therefore, storm surges are not discussed further.

Severe precipitation events are a governing factor in the design and construction of the generation facilities as an input to determining the probable maximum flood. Precipitation is discussed in the context of flooding and its influence on the design and construction of the generation facility. Flooding is also governed by other factors, including the flow regime of the river, which reflects both precipitation and run-off from the watershed. The existing flow regime of the river is discussed in this chapter, as well as potential changes to flow regime due to climate change.

Extended dry periods were not evidenced in the baseline conditions for precipitation and flow regime. As such, reduction in inflow is discussed in the context of a potential outcome of climate change.

Ice is an important factor in the design, construction and operation of the generation facilities. The formation of river ice is the primary concern. Baseline and future ice conditions are presented in this chapter, as well as how they are considered for design and construction. Baseline conditions for rime/glaze ice are detailed in this chapter, accompanied by a discussion of the influence of icing on design loads for transmission lines.

Earthquakes are included under seismic events and can influence the design of the generation facilities. Baseline conditions are included in this chapter.

In addition to the factors suggested in the EIS guidelines, three other components of the environment have been identified that may influence the design, construction and operation of the Project: lightning, forest fires and vegetation growth. These three environmental factors are also discussed in this chapter in relation to the generation facilities and the transmission lines.

Climate change is discussed in the context of the Project and its potential to affect many of the environmental factors that influence the design, construction and operation of the Project.

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10.4 Current and Anticipated Environmental Conditions

As part of the environmental and engineering studies, there has been an ongoing analysis of baseline conditions at the Project sites. As well, modelling has been carried out to determine the future conditions with the presence of the generation sites. Both current and anticipated environmental conditions are considered in the design of the Project, as described in the following sections. The Project has been robustly designed to withstand a wide range of climatic conditions. Some aspects of the environment apply solely to either the generation component or the transmission line component of the Project and some apply to both.

10.4.1 Wind

Wind statistics for Happy Valley-Goose Bay and Churchill Falls were collected from 1971 to 2000 (Table 10-1 and Figure 10-1). For Happy Valley-Goose Bay, monthly mean wind speeds range from 13.5 m/h in July to 17 km/h in December and January, with a most frequent direction from the southwest. The lowest maximum hourly wind speed is 58 km/h, recorded in June, and the highest is 84 km/h, recorded in January. The highest wind gust (143 km/h) is in January, and comes from the north. The average number of days per year with wind speeds greater than 52 km/h is 12.5; the average number of days per year for wind speeds greater than 63 km/h is 3.5 days.

Table 10-1 Wind Statistics (1971 to 2000) for Happy Valley-Goose Bay and Churchill Falls

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Happy Valley-Goose Bay												
Mean speed (km/h)	16.9	15.9	16.3	15.3	14.3	14.6	13.5	13.6	14.7	15.5	16.6	17.0
Most Frequent Direction (from)	SW	W	W	NE	NE	NE	NE	W	SW	SW	W	SW
Maximum Hourly Speed (km/h)	84	77	77	65	77	58	64	69	72	74	81	81
Maximum Gust Speed (km/h)	143	129	106	98	103	122	101	101	122	111	133	111
Direction of Maximum Gust (from)	N	S	NE	W	W	W	W	SE	W	W	W	NW
Days with Winds ≥52 km/hr	2.1	1	1.3	0.5	0.3	0.5	0.4	0.6	0.8	1.1	1.6	2.2
Days with Winds ≥63 km/hr	0.6	0.3	0.3	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.5	0.7
Churchill Falls												
Mean speed (km/h)	14.2	15.1	16.7	16.4	14.4	13.9	12.4	12.5	13.9	14.9	14.6	14
Most Frequent Direction (from)	W	W	NW	NW	NW	NW	W	W	W	W	W	W
Maximum Hourly Speed (km/h)	67	65	63	65	52	48	52	63	63	56	74	64
Maximum Gust Speed (km/h)	113	97	96	98	98	80	101	113	97	98	103	101
Direction of Maximum Gust (from)	W	S	W	W	S	SW	SW	NW	NW	SW	NW	W
Days with Winds ≥52 km/hr	1.1	0.9	0.8	0.7	0.1	0.0	0.2	0.3	0.5	0.3	0.5	0.7
Days with Winds ≥63 km/hr	0.2	0.1	0.2	0.1	0.1	0.0	0.1	0.1	0.2	0.1	0.1	0.2
Source: Environment Canada 2007, Internet site												

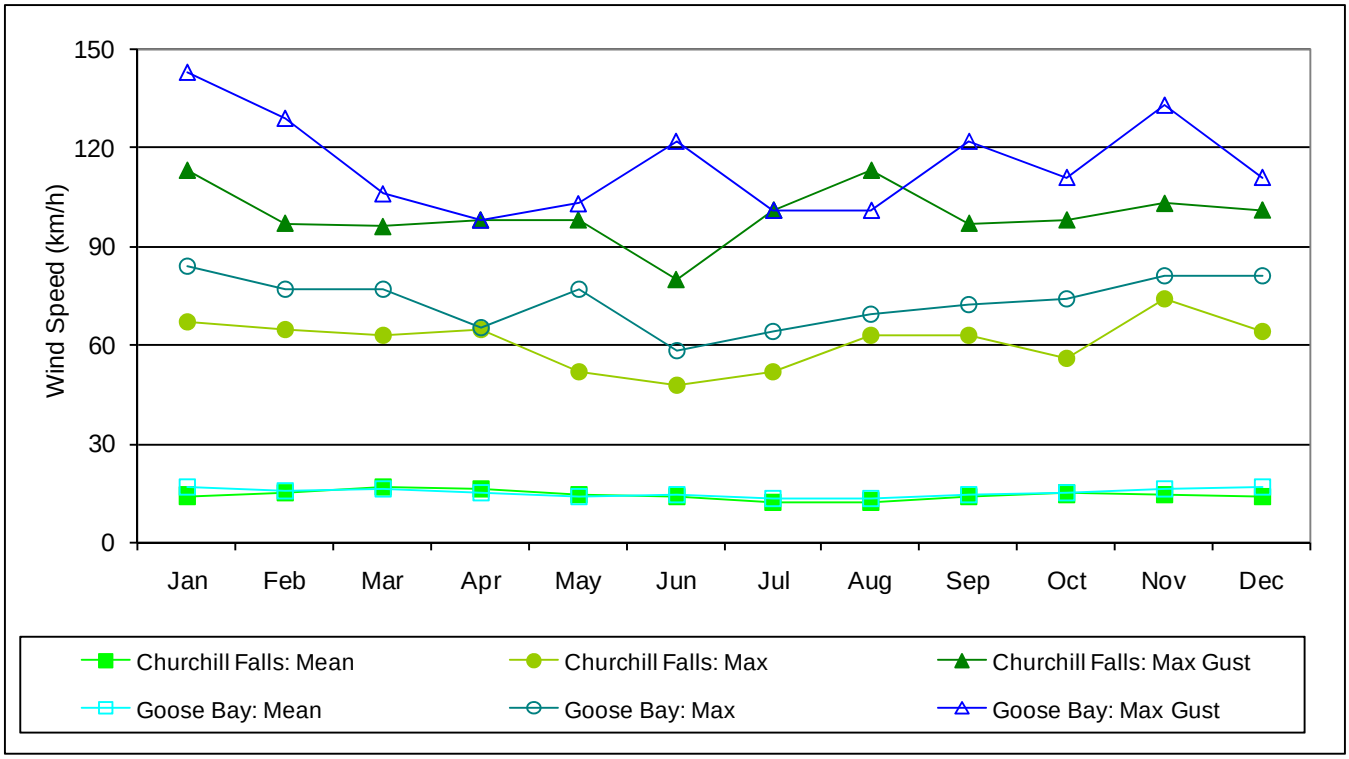


Figure 10-1 Wind Speed Statistics (1971 to 2000) for Happy Valley-Goose Bay and Churchill Falls

For Churchill Falls, monthly mean wind speeds range from 12.4 km/h in July to 16.7 km/h in March, with the most frequent direction from the northwest (Table 10-1). The lowest monthly, maximum hourly wind speed is 48 km/h in June; the highest monthly, maximum hourly wind speed is 74 km/h in November. The highest wind gust occurs in January and August at 113 km/h from a westerly direction. The average annual number of days per year with wind speeds greater than 52 km/h is 5.9 and for wind speeds greater than 63 km/h is 1.4 days (Table 10-1).

The most frequent wind direction for Happy Valley-Goose Bay is west or southwest from August to March and northeast from April to July. For Churchill Falls, the most frequent wind direction is west from July to February and northwest from March to June (Table 10-1).

10.4.2 Slope Stability

Slope failures can be triggered by atmospheric processes, geologic processes, natural and anthropogenic modification of the landscape. Slope failures can occur in any season, and are most likely to be triggered by weather events such as rain, snow, or freezing and thawing of pore water. Permanent and variable factors influence slope failures. Permanent factors are characteristics of the landscape that remain unchanged or vary little from a human perspective (i.e., the steepness of a slope or rock type that slowly changes over time). Variable factors are characteristics that change quickly as a result of some triggering event such as ground vibration (i.e., earthquakes or blasting), a rapid rise in groundwater levels and increased soil moisture due to intense precipitation and human activity.

A bank stability study of the potential environmental effects of the reservoirs on the new shoreline and riverbanks was conducted by AMEC in 2007 (AMEC 2008). This study also considered the influence of bank stability on sediment loading in the river. The study included an analysis of baseline conditions as well as future conditions.

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An estimate of wave conditions along the river is provided in the bank stability study because wave action will influence bank stability (AMEC 2008). The estimate was based on the future conditions of the reservoir with the facilities and associated reservoirs in place. Annual data from the nearby weather station in Happy Valley-Goose Bay were obtained and used to produce a wave energy model for wind, climate and fetch data. Stations along the shoreline were selected (typically every 3 km on both sides of the river) to calculate the annual wave energy at those locations. Wave heights will be fetch limited and will be low. For example, for winds of 20 km/h (11 knots) and a fetch of 1 km, waves will be approximately 10 cm, while for winds of 80 km/h (43 knots) and a fetch of 8 km (an extreme situation where the wind blows tangentially along the river for some distance) waves will be approximately 1 m only.

For the purposes of the study of environmental effects on the Project, the Project was divided into three sections:

1. downstream from Muskrat Falls to Lake Melville;
2. Muskrat Falls Reservoir; and
3. Gull Island Reservoir.

A rating and classification system was developed to rate the reservoir banks for three sections of the Project:

1. terrain stability;
2. soil erosion potential; and
3. wave energy.

Conclusions from the study (AMEC 2008) include the following:

- Raising water levels will generally result in a more stable shoreline (with the exception of beach redevelopment) in areas with a homogeneous lithology (uniform physical characteristics within the rock and soil located in the area).
- In areas with layered lithologies (non-uniform physical characteristics), increased hydrostatic pressures may occur, resulting in increased pore pressures within the clay layers, thus increasing its instability and resulting in the reactivation of progressive slides until an equilibrium is re-established.
- Minimal shoreline erosion is expected within the Gull Island Reservoir. Slope stability concerns are anticipated to be localized and generally limited to undermining of the shoreline during the reestablishment of a shoreline and small slides and falls.
- Raising the shoreline for the Muskrat Falls Reservoir will result in the establishment of a new shoreline and beach/bluff development. Erosion and the ongoing undermining of the post-construction shoreline will continue, potentially for decades, until the redevelopment of a stable shoreline.
- Very little bank movement is anticipated during winter, because the ground and reservoir will be frozen for the majority of this period. Increased activity is anticipated during the spring thaw and during periods of high winds and heavy rain.

Overall, once new shorelines have been established in the two reservoirs, the banks will be more stable than the existing baseline condition; however, Muskrat Falls Reservoir will continue to experience various forms of slumping, especially on the southern banks, albeit at a reduced rate.

10.4.3 Precipitation

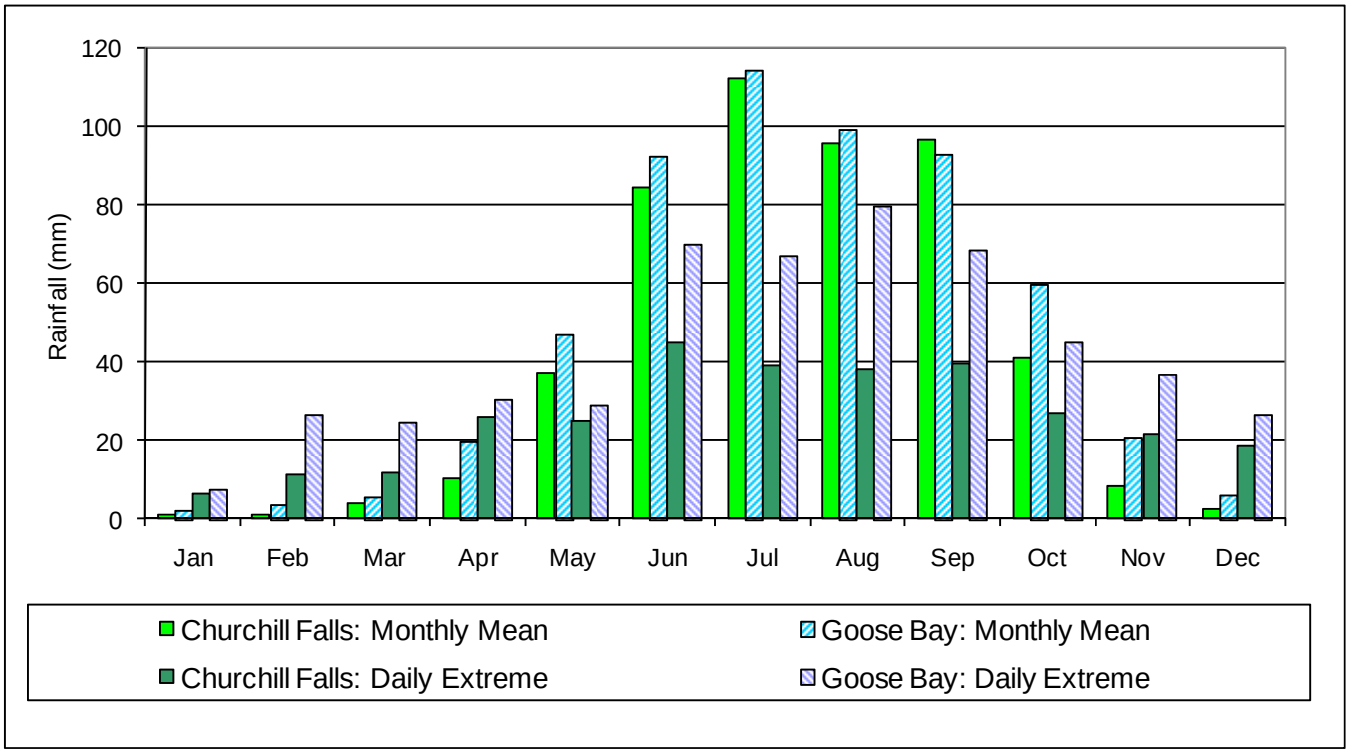
The highest monthly precipitation (including both rainfall and snowfall) for both Happy Valley-Goose Bay and Churchill Falls occurs in July, with the daily extreme precipitation in June. The average annual precipitation is

similar at both locations, with 949 mm at Happy Valley-Goose Bay and 926 mm at Churchill Falls. A summary of the average number of days per year above selected precipitation amounts is provided in Table 10-2.

Table 10-2 Annual Average Number of Days per Year above Given Precipitation Amounts (1971 to 2000) for Happy Valley-Goose Bay and Churchill Falls

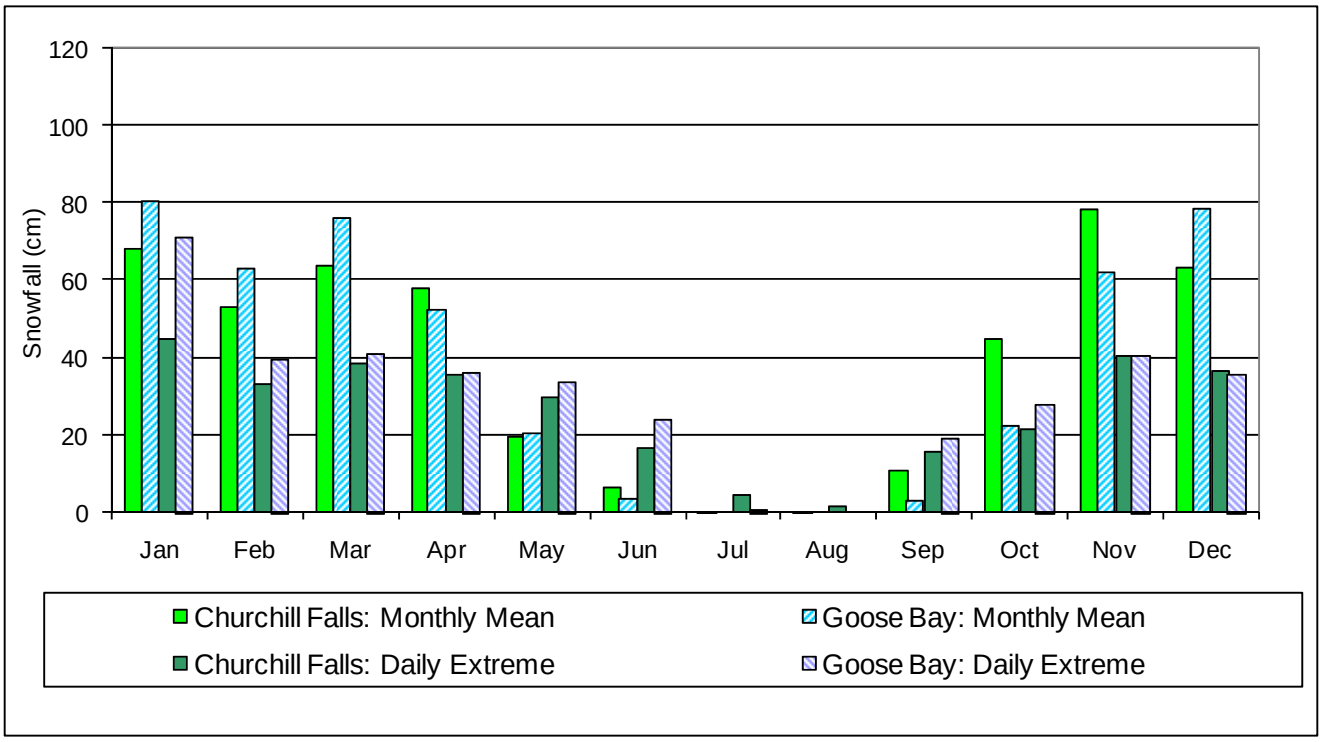
Precipitation	Happy Valley-Goose Bay	Churchill Falls	Average
≥5 mm	61.3	62.5	61.9
≥10 mm	29.8	25.9	27.9
≥25 mm	3.9	2.9	3.4
Source: Environment Canada 2007, Internet site			

Monthly mean and daily extreme rainfall is shown in Figure 10-2 and snowfall is shown in Figure 10-3. Monthly mean and daily extreme snow depth for both sites is presented in Figure 10-4. Compared to Churchill Falls, Happy Valley-Goose Bay has greater rainfall and snowfall from December to March. Both locations have similar seasonal precipitation patterns, with the maximum monthly rainfall occurring in July and the lowest occurring from November to April, when snowfall is greatest. On average, monthly maximum snowfalls are 78 cm in November for Churchill Falls and 80 cm in January for Happy Valley-Goose Bay. Extreme daily snowfall amounts are 71 cm for Happy Valley-Goose Bay and 44 cm for Churchill Falls in January. The extreme snow depths are 262 cm for Churchill Falls in February, and 206 cm for Happy Valley-Goose Bay in March.



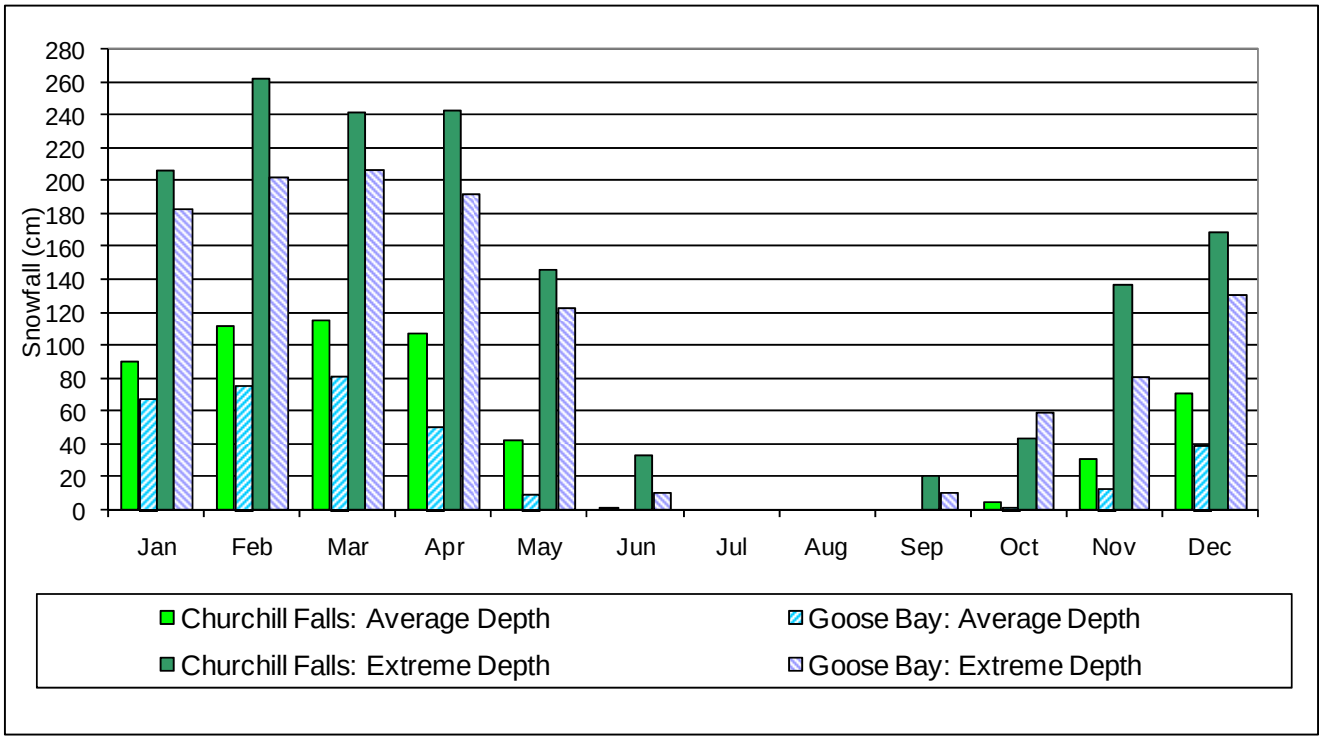
Source: Environment Canada 2007, Internet site.

Figure 10-2 Monthly Mean and Daily Extreme Rainfall (1971 to 2000): Churchill Falls and Happy Valley-Goose Bay



Source: Environment Canada 2007, Internet site.

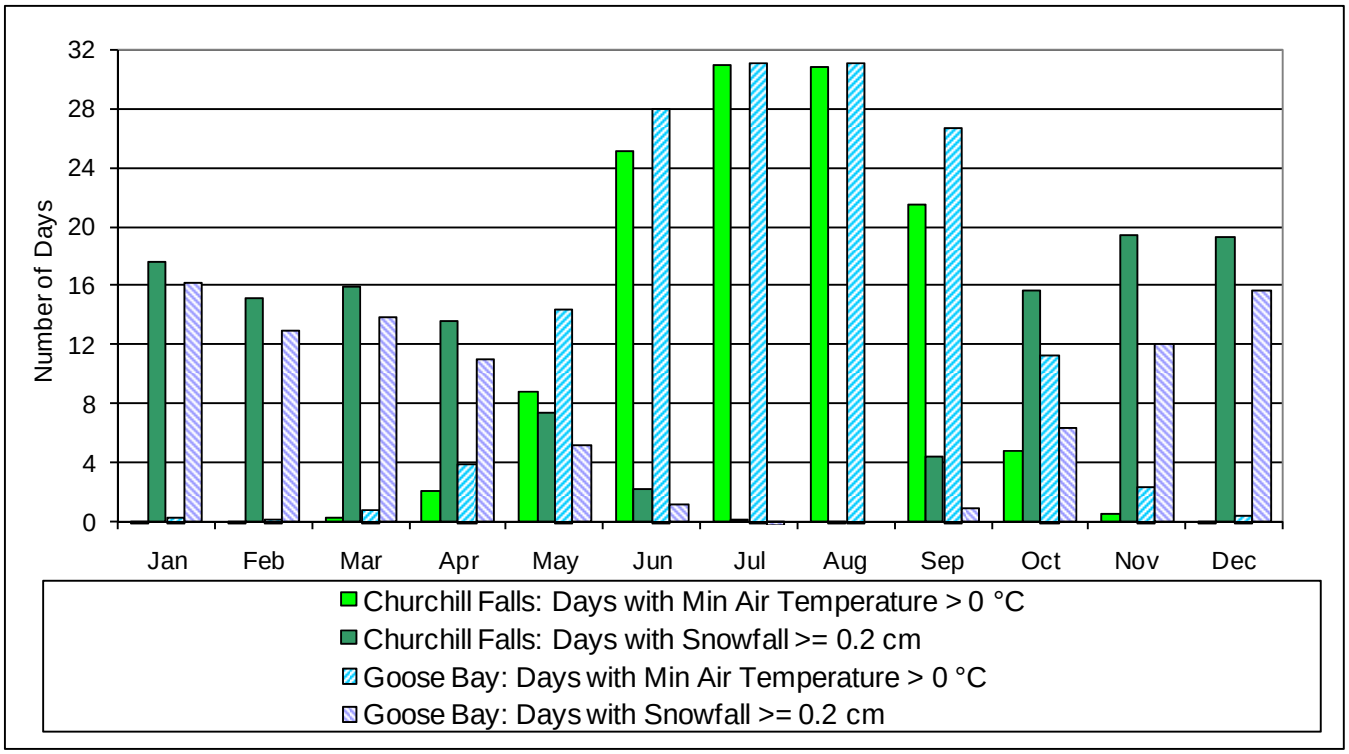
Figure 10-3 Monthly Mean and Daily Extreme Snowfall Amounts (1971 to 2000): Churchill Falls and Happy Valley-Goose Bay



Source: Environment Canada 2007, Internet site.

Figure 10-4 Monthly Mean and Daily Extreme Snow Depth (1971 to 2000): Churchill Falls and Happy Valley-Goose Bay

Wet snow occurs between -1°C and 2°C. For both sites, the number of days with a minimum temperature greater than 0°C and snowfall above or equal to 0.2 cm is shown in Figure 10-5. Days with snowfall greater than or equal to 0.2 cm has occurred each month except for August in Happy Valley-Goose Bay (though is less than six hours in July and August at both locations). The spring and fall months have temperatures less than 0°C as well as snowfall occurrence, so there is a possibility of wet snow occurring during these periods.



Source: Environment Canada 2007, Internet site.

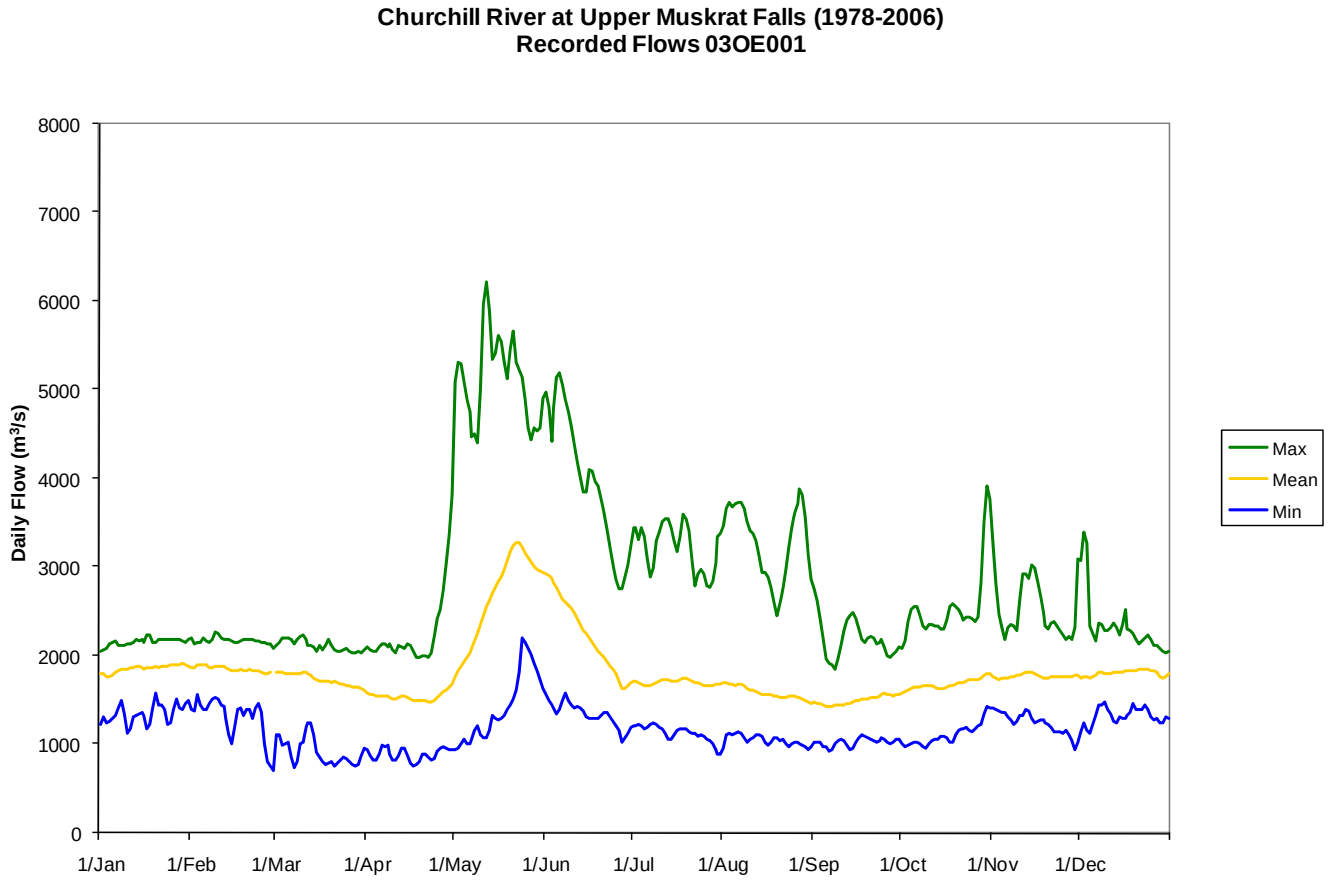
Figure 10-5 Number of Days with a Minimum Temperature above 0°C and Snowfall Greater than 0.2 cm (1971 to 2000): Churchill Falls and Happy Valley-Goose Bay

10.4.4 Flow Regime

The Project has funded several hydrometric stations in and adjacent to the Churchill River that are maintained by Environment Canada. The daily average flow from 1978 to 2006 at Station 03OE001 above Upper Muskrat Falls is illustrated in Figure 10-6. The Churchill Falls Power Station changed the natural flow regime whereby:

- mean winter flows are now higher;
- mean summer flows are now lower;
- the spring runoff peak is earlier and does not last as long; and
- the high flow peaks in the summer no longer occur as they did before the development of Churchill Falls.

The flow of lower Churchill River is mostly regulated by the Churchill Falls Power Station, which contributes approximately 75 percent of the total flow at Muskrat Falls. For the two tributaries to the lower Churchill River (Pena's River and Metchin River), for which Environment Canada maintains hydrometric stations, the mean peak flow coincides with that of the Muskrat Falls station occurring from May to June for the period 1998 to 2006. The maximum flow during this period is 185 m^3/s for Pena's River and 300 m^3/s for Metchin River.



Source: Environment Canada 2007, Internet site.

Figure 10-6 Daily Flow of Churchill River above Upper Muskrat Falls (53°14'52"N, 60°47'21"W) (1978-2006)

As is the case with precipitation, there is a sound understanding of the hydrology of the watershed and this knowledge has been incorporated into Project design for construction and operation. Climate change effects are discussed in Section 10.4.10.

10.4.5 River Ice

The section of the lower Churchill River, from Muskrat Falls to Gull Island, under existing conditions, remains open all winter, with the exception of a few slow moving stretches below Gull Lake and Gull Lake itself. Consequently, very large quantities of frazil and pan ice (consolidated floating pieces) are carried downstream. Frazil ice is a collection of loose, randomly oriented, needle-shaped ice crystals that form in rivers, lakes and oceans. Frazil ice forms in areas with extremely low temperatures that are susceptible to high winds, and has the potential to damage or disrupt operation. Several ice studies have been completed for the lower Churchill River (LaSalle Consulting Group Inc. 1998; Hatch 2008).

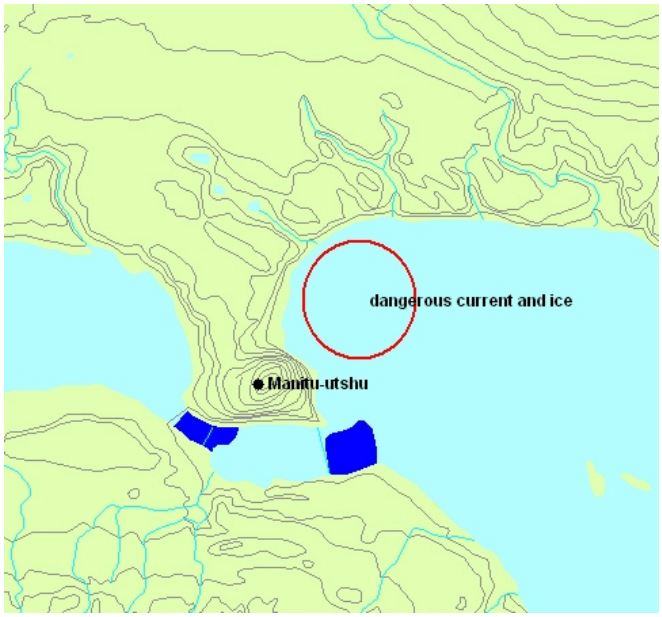
Thermal ice typically forms on Goose Bay, Sandy Island Lake below Gull Lake, Gull Lake and Winokapau Lake. These thermal ice covers are stable and continuous and can initiate the progression of an ice cover upriver as inflowing frazil and slush pans accumulate against the leading edge of the ice cover. The Innu have observed ice jamming causing the river to rise:

> *…., in the fall of 2006, P2 saw a television news report about jammed ice on Mishta-shipu and flooding at Mud Lake. One of her children or grandchildren translated the report for her. Her comment? "Sometimes there's jammed ice by a shoal near the outlet of Mud Lake. This blocks the river and causes the water to rise. But this only ever happened in the spring, never in the fall. I don't understand why the water was so high. The water reached a house on a high bank. The people of Mud Lake were scared and concerned about the flooding" (P2.7.12.06).*
>
> (p. 14)

Goose Bay and Lake Melville are the first areas in southern Labrador to freeze in winter and remain ice covered (Canadian Ice Services 2001). Typically, by the first week of December, Goose Bay is entirely ice covered and by mid-June it is open water. The reach between Goose Bay and Muskrat Falls becomes ice covered early in the winter.

As additional frazil ice produced upstream of Muskrat Falls passes over the falls, it forms a hanging dam at the base of Muskrat Falls. In two winters during the ice observation program (1974 and 1992), the ice cover was observed to progress upstream of Muskrat Falls. The river remains open between Muskrat Falls and Sandy Island Lake, with ice forming there along the banks.

> *It was noted that the cove on the north side of Mishta-shipu below the rapids, and from where the portage commenced when traveling upstream, can be a very dangerous place in the spring (Map 5). The ice is packed on the south side of the rapids at Muskrat Falls, and as a result the current can be very strong in the cove near the portage. Innu avoided this area in the spring because one could easily be capsized by the current or crushed in ice. The late Etuat Rich once saw some military men capsize in this area, with all hands lost except one.*
>
> (p. 43)



Map 5. Location of an area of dangerous current and ice conditions in the spring near Manitu-utshu/Muskrat Falls

Following completion of the main dams and reservoir, frazil ice will no longer form in the reaches upstream of the Gull Island and Muskrat Falls sites. The reservoirs will have a thermal ice cover. Ice phenomena are well understood and have been incorporated into Project design for construction and operations.

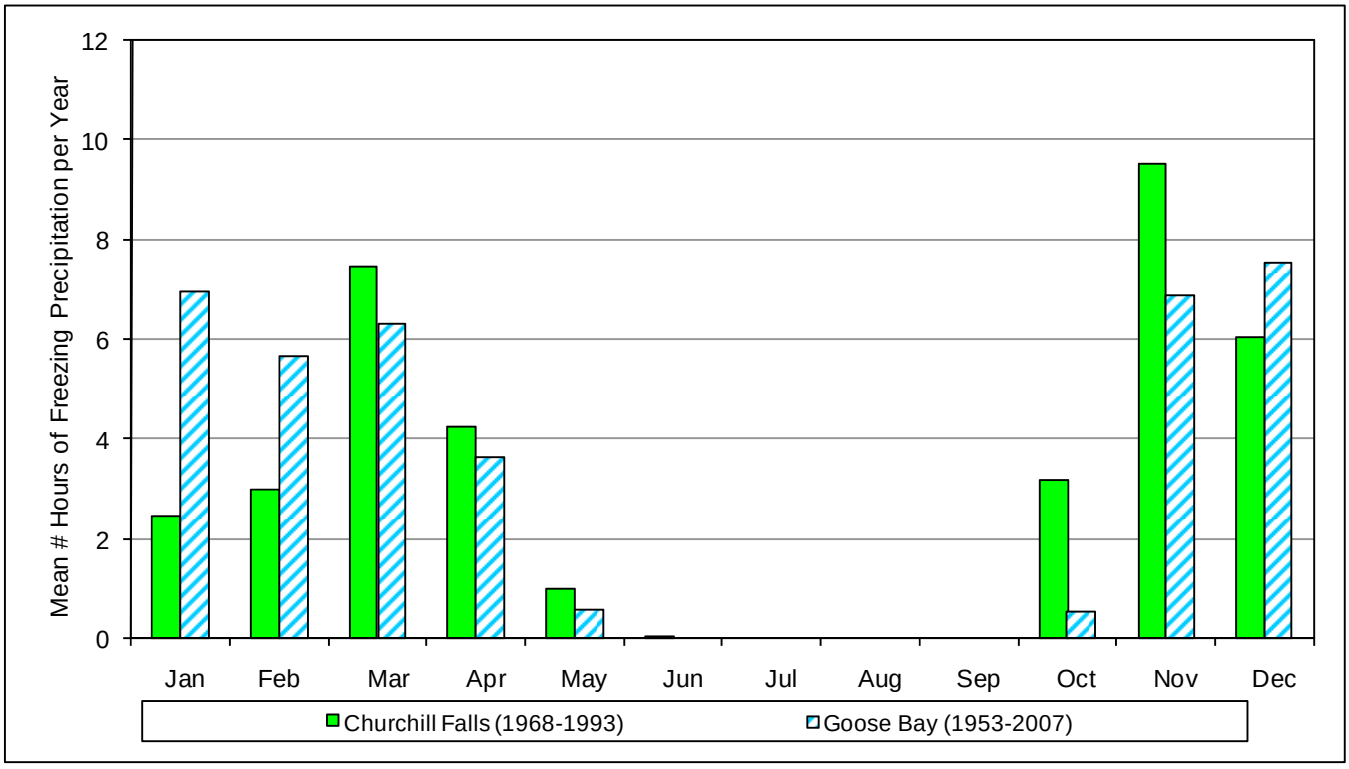
10.4.6 Freezing Precipitation and Ice Accretion

Estimating the maximum amount of ice expected is a fundamental aspect of transmission line design. Two types of ice that can affect transmission lines are commonly known as glaze and rime.

Glaze ice is primarily caused by the freezing of rain or drizzle. It typically creates a smooth, transparent and homogenous ice coating. This was the type of ice that caused so much damage during the 1998 Quebec ice storm.

Rime ice typically forms at higher altitudes, on ridges and mountains. It forms when water droplets in fog freeze to the outer surface of objects. Rime ice looks similar to frozen snow, is often not as dense as glaze ice and clings to surfaces less tenaciously. Rime icing occurs at low temperatures and as such could accumulate in large quantities and might not melt or fall off as quickly as glaze ice.

Monitoring of freezing rain events is part of the hourly weather records collected from the Environment Canada stations at Happy Valley-Goose Bay and Churchill Falls. The results of the analysis of the mean number of hours per month with freezing precipitation observed in the last 50 years are depicted in Figure 10-7. The mean number of hours for Churchill Falls ranges from less than 1.0 in May to 9.5 in November. The freezing precipitation seasons are similar for both stations running from October to the end of May.



Source: Environment Canada 2007, Internet site.

Figure 10-7 Mean Number of Hours of Freezing Precipitation per Year

The probability of freezing rain increases as one moves east in Labrador, since most winter storms track across or south of Newfoundland and keep Labrador on the cold side of the low. High-pressure systems originating from the Arctic become established across Labrador for extended periods during the winter, giving clear skies, but frigid temperatures. Onshore, southeast to northeast winds off the Labrador Sea would tend to increase this risk near the coast and in eastern areas of Labrador, air circulation patterns bring relatively mild, above-freezing

air and rain across surfaces whose temperatures are still below freezing: conditions conducive to freezing precipitation.

Hydro has extensive experience dealing with ice accretion on structures, mainly with respect to transmission lines. This experience has been incorporated into design for construction and operation of Project features, especially transmission line towers and conductors.

10.4.7 Seismic Activity

The continual shifting of large segments of the Earth's crust, called tectonic plates, causes more than 97 percent of the world's earthquakes. The Province is situated in a stable continental region within the North American plate and is a relatively inactive seismic area (Batterson et al. 1999). In Labrador, evidence of two earthquakes has been recorded: in Hopedale on November 30, 1836 and along the Labrador coast just north of Groswater Bay on January 2, 1809.

The relative seismic hazard (likelihood of experiencing strong earthquake shaking) across Canada for single family dwellings (one to two storey structures) is illustrated in Figure 10-8.

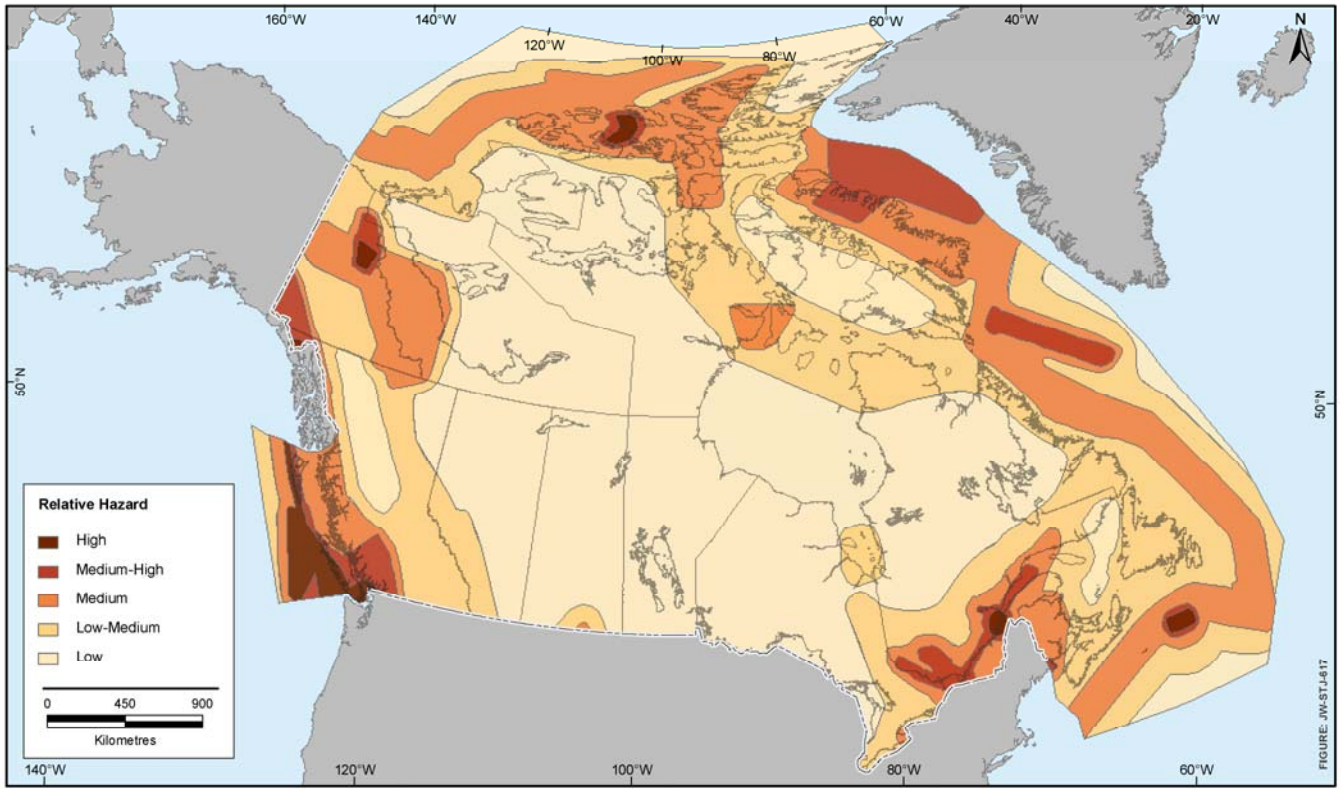


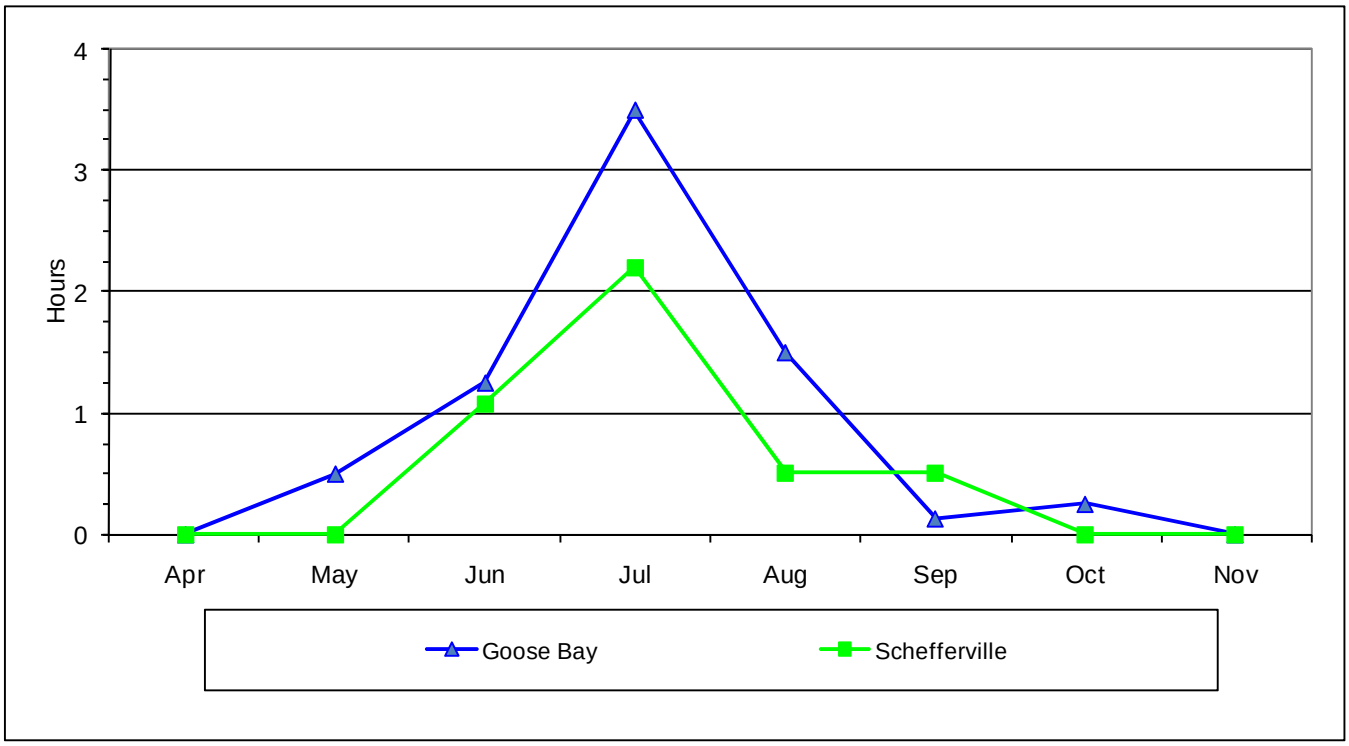
Figure 10-8 Geological Survey of Canada, 2005 Seismic Hazard Map

Five relative hazard increments from low to high are shown. This probability is used in the National Building Code to help design and construct buildings to mitigate effects of earthquakes. For the lower Churchill River, the hazard is low, with the two lowest hazard levels shown: the western part of the Project area in the lowest risk level and the eastern part just into the second lowest. This rating was incorporated into relevant aspects of Project design for construction and operations.

10.4.8 Lightning

Lightning can potentially damage transmission lines and is a major cause of forest fires. Fires caused by lightning generally have a greater potential of burning large areas, since they mostly occur in remote areas where there is longer response times, resulting in fires that are larger and harder to control. Observations of local foresters and studies of lightning activity indicate a single storm can provide an ignition source for numerous fires across a variably-sized area (Komarek 1966; Kourtz 1967; Kasischke and Stocks 2000), for example the average lightning fires per year for Labrador is 23 (E. Earle, pers. comm.).

On average, Happy Valley-Goose Bay receives seven thunderstorm days during the summer each year (Environment Canada 2007, Internet site). The mean number of hours of thunderstorm activity recorded at Happy Valley-Goose Bay and Schefferville, Quebec (Peach 1975) are summarized in Figure 10-9. Within Labrador, there is a decreasing occurrence of storms with increasing latitude (Johnson and Rowe 1975).



Source: Adapted from Peach 1975.

Figure 10-9 Mean Number of Hours of Thunderstorm Activity Recorded at Happy Valley-Goose Bay and Schefferville, Quebec

10.4.9 Forest Fire

The factors that influence forest fire occurrence include the types of vegetation, weather and various ignition sources. The chemical and physical structure and moisture content of vegetation and weather conditions determine whether ignition occurs and for how long a fire persists. In Canada during the 1980s, lightning caused on average 38 percent of the 11,000 forest fires annually (Higgins and Ramsey 1992). The remaining fires were mostly caused by human sources, with a small percentage of unknown sources.

In Labrador, the effects of a forest fire are long lasting as evidenced by the use of place names by Innu:

> *Some ….[place] names encode descriptive geographical information as in Kamashkushiut ('grassy place') and Kamitinishkau ('muddy place, small'), while others reference biota in the area as in Utshashku-minishtik[u] ('muskrat island'), or refer to historical figures and non-human beings. For example, the name Uapushkakamau-shipu ('burnt area lake river') encodes information about the land surrounding the lake at its headwaters called Uapushkakamau, in this case a past forest fire, the traces of which may no longer be obvious to the eye.*
>
> (p. 38)

Fire danger rating systems have been developed to estimate the moisture content forest vegetation. In Canada, forest fire danger is modelled using the Canadian Forest Fire Weather Index System, which incorporates temperature, relative humidity, wind speed and 24 hour precipitation.

The Fire Danger Index (on a scale of zero to 10 with 10 being high risk) indicates that Labrador is considered low. This means fires are likely to be self-extinguishing and new ignitions are unlikely, with any existing fires limited to smouldering in deep, drier layers. There is a slightly greater chance (two to seven) of fire danger around Happy Valley-Goose Bay and the adjacent portion of the lower Churchill River and less of a danger (zero to two) in the upper portion of the lower Churchill River.

According to the *Provincial Sustainable Forest Management Strategy* (Government of Newfoundland and Labrador 2003), while their frequency is low, fires have been the most important natural ecological disturbance of the forests in Labrador. Forest fire statistics for Labrador from 1998 to 2007 indicate the average number of fires for Labrador is 42, the average total area burnt is 32,366 ha and the average lightning fires per year is 23 (E. Earle, pers. comm.). Statistics in Labrador for 2006 indicate 33 fires with 3,279 ha of total area burned and for 2007, 32 fires with 10,799 ha of total area burned. Of the 10,799 ha of total area burned in 2007, 6,000 ha was burned in the region between Churchill Falls and Happy Valley-Goose Bay. The number of fires caused by lightning in Labrador was 11 in 2007 and six in 2006 (Natural Resources Canada 2007, Internet site).

According to a study done by Foster (1983) of the history of fire in the boreal forest of south-eastern Labrador, fires occur from early June to late October, with peaks in ignition in late June and early July. Foster (1983) also found a good correlation between extensive fires and below average summer precipitation in southeastern Labrador. Fires in fall were generally short in duration and did not result in large areas of burn, as fires were extinguished by rain or early snowfall (Foster 1983).

Project design will incorporate features to deal with lightning strikes and provide for safe grounding. The issue of forest fire potential is also addressed in Volume IIA, Volume IIB and Volume III of the EIS as an accidental event.

10.4.10 Climate Change Considerations

Climate change is directly linked to the increase in GHG emissions caused by human activities. These increased levels of GHG have led to an increase in the average temperature of the Earth's atmosphere and oceans, which is commonly referred to as global warming. Potential effects of climate change on regional resources are of increasing importance for energy producers. This subject is addressed in detail in Volume IIA, Chapter 3.

Climate is defined as the statistical average weather conditions over a substantial period. Environment Canada typically provides analysis of climate normals over 30 year periods. Climate change is an acknowledged change in climate documented over two or more periods, each with a minimum of 30 years (Catto 2006).

Numerous climate-related effects, linked to global warming, have been observed across Atlantic Canada, the entire country and globally. Many of these are anticipated to intensify over the next century; for example, increased temperatures, receding glaciers and permafrost melt, rising sea levels and coastal flooding, changes in precipitation patterns and intensity, as well as drought and low water levels may all occur. Of these, several are predicted to affect Labrador and, consequently, may affect the Project. Over the next century, changes in temperature, precipitation patterns and extreme events are predicted for Labrador (Natural Resources Canada 2008, Internet site). These changes in climate are expected to be more pronounced inland than at the coastal areas due to the moderating effects of the Labrador Sea.

Temperatures are anticipated to be relatively stable along the coast (Cartwright), generally cooler in the spring and summer (-2°C to 0°C), and warmer in the fall and winter (0°C to 4°C) over the next 80 to 100 years. At Happy Valley-Goose Bay for the same period, the changes will be more noticeable, predicted to be much warmer in the summer, fall and winter (5°C to 7°C (winter) by the end of the century), with less change in the spring (-1°C to 2°C) (Lines et al. 2005). This average temperature change will be gradual over the period and will change precipitation types and patterns.

The warmer fall and winter will result in later freeze-up, wetter, heavier snow, more liquid precipitation occurring later into the fall, and possibly more freezing precipitation during those seasons. With little change in spring temperatures, differences in ice formation and break-up patterns will likely be slight over the next century. Changes to precipitation patterns and possibly to the permafrost in the watershed, resulting from warmer weather over the fall and winter months, on the other hand, could lead to earlier ice break-up in portions of the watershed and stronger spring runoff (Natural Resources Canada 2008, Internet site).

Annual precipitation trends over the next 80 to 100 years indicate generally small increases (slight deceases over the next few years, changing to a six to nine percent increase by the end of that period). However, these precipitation trends are of more interest when taken together with the temperature increases and the seasonality of the predicted changes. These trends indicate small decreases in average precipitation amounts over the winter period (three percent), with a small increase during the fall (six percent). There is less agreement among the global circulation and regional downscaling models regarding changes in spring and summer precipitation, ranging from a slight decrease in the spring (two percent) to spring/summer increases of as much as 13 percent (Lines et al. 2005). It is generally considered that the increased precipitation being predicted for western portions of Atlantic Canada may be the result of a greater frequency of dying hurricanes and tropical storms reaching into this area in the summer and fall months (G. Lines, pers. comm.).

The sea level has been rising in Atlantic Canada due to warming trends and the melting of polar ice caps (Government of Newfoundland and Labrador 2003). This is consistent with the observed global increase in sea level of 1.8 mm/yr, from 1961 to 1992, and 3.1 mm/yr between 1993 and 2003 (Bindoff et al. 2007, Internet site). Sea level is expected to rise further over the next century. For example, global sea levels are predicted to rise at a greater rate in the twenty-first century than that observed between 1961 and 2003. According to the Intergovernmental Panel on Climate Change Special Report on Emission Scenarios, by the mid-2090s, global sea levels are projected to rise at a rate of approximately 4 mm per year and reach 0.22 to 0.44 m above 1990 levels (Bindoff et al. 2007, Internet site).

Severe weather is predicted to become more frequent and more severe across the world. Many reports indicate growing insurance claims because of global warming. For instance, in Canada, insured catastrophe losses totalled $1.7 billion between 1985 and 1995, and have increased to $6.7 billion since 1995 (Leadbetter et al. 2006, Internet site). However, many of these predictions are for heavily built-up areas with more structures subject to damage, and for more southerly locations subject to more severe weather conditions, such as

CIMFP Exhibit P-00271 - Appendix K

tornados and hurricanes (W. Richards, pers. comm.). There has been little study to date on the potential for increased severe weather in Labrador.

The environmental effects associated with climate change have been considered in Volume IIA, Chapter 3 of the EIS and in accordance with Environment Canada guidance on methods for effects prediction. The Project design with respect to construction and operation has incorporated the potential changes predicted as a consequence of climate change.

10.5 Consideration of Environmental Factors in Design

Engineering design loads and specifications for the Project are determined according to current and anticipated environmental conditions. The engineering design is based on extreme load events. The baseline data are used to develop these extreme load values but do not directly establish design loads. For example, the hydraulic capacity of the generation facilities is based on an extreme flood event, the probable maximum flood (PMF). The PMF for each of the Gull Island and Muskrat Falls generation facilities exceeds 20,000 m^3/s and the facilities have been designed to this capacity. This design load far exceeds average measured flows and is over three times the maximum flow ever recorded over a 28 year period in the lower Churchill River of 5,100 m^3/s.

Design loads are established using the applicable codes and standards. The Project design adheres to the CDA Dam Safety Guidelines, the National Building Code of Canada (NBC) and Canadian Standards Association (CSA). Additional standards will include those published by organizations such as:

- ANSI – American National Standards Institute;
- ASCE – American Society of Civil Engineers;
- ASME – American Society of Mechanical Engineers;
- ASTM – American Society for Testing and Materials;
- CGS – Canadian Geotechnical Society;
- CSCE – Canadian Society of Civil Engineers;
- CWB – Canadian Welding Bureau;
- EPRI – Electric Power Research Institute;
- IEC – International Electrotechnical Commission;
- IEEE – The Institute of Electrical and Electronics Engineers;
- ISO – International Organization for Standardization;
- NEMA – National Electrical Manufactures Association;
- SSPC – Society for Protective Coatings;
- USACE – United States Army Corps of Engineers; and
- USBR – United States Bureau of Reclamation.

By applying these standards, the Project Team has incorporated and accommodated the potential, predictable effects of the environment on the Project during construction and operation.

10.5.1 Generation Facilities

Slope stability, flooding, ice formation, seismic activity, forest fire, vegetation growth and climate change were considered in the engineering design of the Gull Island and Muskrat Falls generation facilities. The scope of this design activity includes the reservoirs associated with each generation facility.

10.5.1.1 Slope Stability

Slope stability and erosion is an important aspect of the design and operation of the generation facilities. During storms, excess precipitation can cause landslides, and increased channel erosion as well as causing the release of excessive silt into the river.

Minimum shoreline erosion is expected within the Gull Island Reservoir (AMEC 2008). Changes in slope stability are anticipated to be localized and generally limited to undermining of the shoreline during re-establishment. The creation of the Muskrat Falls Reservoir will result in the establishment of a new shoreline and beach/bluff development (AMEC 2008). Potential exists for continuing shoreline erosion within the Muskrat Falls Reservoir, particularly within the first two decades. However, this will not affect the Project or its generation capacity or efficiency as the development of reservoir shoreline, with one exception will not alter the integrity of the reservoir on the dam structures.

The exception is with respect to the neck of land connecting Muskrat knoll to the north shoreline of the river. Development of the Muskrat Falls generation facility will therefore require additional measures to provide adequate stability to the spur for long term operating conditions. The required stabilization measures include:

- installation of additional pumpwells to complement the existing system;
- provision of downstream erosion protection and downstream stabilizing fill to improve downstream stability and eliminate the potential for retrogressive failures;
- local topcutting of the spur and removal of high, steep slopes to improve local stability; and
- provision of erosion protection and a stabilizing upstream berm to protect the upstream slopes from wave action and help prevent local slope failures during the unlikely event of rapid drawdown of the reservoir.

Once implemented, these measures will help to maintain the integrity of Muskrat Falls Reservoir. Ongoing monitoring will confirm the effectiveness of these measures.

10.5.1.2 Flooding

One of the governing factors in the design of the generation facilities is the determination of the PMF. The PMF is defined by the CDA as *an estimate of the hypothetical flood (peak flow, volume and hydrograph shape) that is considered to be the most severe 'reasonably possible' at a particular location and time of year, based on a relatively comprehensive hydro-metrological analysis of critical runoff-producing precipitation (snowmelt if pertinent) and hydrological factors favourable for maximum flood runoff* (CDA 2007). Statistically, this flood represents an extremely remote event, which is the largest flood that can occur in the basin.

The PMF was determined as part of the 2007 engineering studies. The principal objective of this study was to determine the PMF for the Gull Island and Muskrat Falls generation facilities in order to estimate the spillway capacity at each site. The scope included a review of previous studies on the upper and lower Churchill River basins, a meteorology study to estimate the contributors to the PMF, and detailed hydrological modeling of the entire Churchill River basin to estimate the PMF peaks.

A watershed model of the Churchill River basin was calibrated using meteorological data from AEB climate stations at Goose Bay, Churchill Falls, Schefferville and Wabush, snow course, precipitation and lake level data from CF(L)Co. and hydrometric data from eleven Water Survey of Canada (WSC) streamflow stations. The model was then used to test the various combinations of extreme rainfall, temperature and snowpack recommended by the CDA to determine the governing PMF case.

The critical PMF scenario for the upper and lower Churchill River basin is a combination of a 100 year snowpack, a severe temperature sequence, and spring Probable Maximum Precipitation (PMP). The PMF peak is 20,800 m^3/s at Gull Island and 22,420 m^3/s at Muskrat Falls.

The CDA Safety Guidelines classify dams based on the consequence of failure. The classification considers the potential for loss of life, as well as environmental, cultural, infrastructure and economic losses. The most rigorous requirements have been applied to the Gull Island and Muskrat Falls dams. Based on this classification, the dams are being designed to pass the PMF without failing.

In addition to the operational considerations for flooding, the design of the Project also considers the effect of flooding during the construction phase. To facilitate dam construction and prevent overtopping at the Muskrat Falls and Gull Island construction sites, it will be necessary to divert the river around the dam sites, as outlined in Chapter 4. Canadian practice is to accept a five percent risk for such temporary works. The diversion at Gull Island will last approximately two years. At Muskrat Falls, diversion will last about one year. Using accepted practice and based on historical precedent, the flood handling capacity at the Gull Island construction site would be the 1:40 year flood, that is, the flood that has a one in 40 chance of occurrence in any one year. The flood handling capacity at the Muskrat Falls construction site will accommodate the 1:20 year flood.

Without adequate drainage, flooding can also wash out access roads and other construction infrastructure and cause potential construction delays. These design issues are considered under standard design practices and suitable culvert sizes will be installed to provide adequate drainage from each drainage basin.

10.5.1.3 Seismic Activity

An important aspect of the design of any hydroelectric project is the assessment of the seismic hazard of the site. The consequences of seismic events are different for a dam than for related structures such as the powerhouse and spillway. As part of the 2007 engineering studies, four separate studies were undertaken to assess the seismic hazard potential of the development sites and reservoirs.

The earthquake hazard analysis for the Gull Island and Muskrat Falls sites indicates the possibility of occurrence of rare-but-possible moderate seismic events of a low frequency magnitude. The results of probabilistic analyses indicate that, at a probability level of 1:10,000, the ground motions would correspond approximately to local earthquakes of M5.5 to M6 at distances of 30 to 40 km for frequencies greater than 2 Hz. The Project has been designed to withstand such an event.

The earthquake hazard analysis carried out during the seismicity study indicated the peak ground analysis is 0.11 g for Gull Island and 0.09 g for Muskrat Falls.

10.5.1.4 Forest Fire

Only a very intense forest fire blaze would put the generation facilities at risk. This risk will be mitigated by keeping vegetation cleared away from these areas. Additional measures, if necessary, will be determined by the fire and security chief at each plant and may include maintaining a 100 m buffer zone around facilities. These measures will then be incorporated into the Project Emergency Response Plan (details on preventing and containing forest fires are provided in Section 4.11.4).

10.5.1.5 Vegetation

If vegetation is allowed to grow on the slope of the dam, its root system could form seepage paths that could lead to failure of the dam. Vegetation growth can also prevent adequate visual inspection of the dam surface;

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therefore, vegetation will be removed within a buffer zone directly behind the toe of the dam (i.e., downstream slope of the dam). Vegetation growth removal plans will be incorporated into the operating regime of the facilities.

10.5.1.6 Climate Change

As a preliminary step in understanding the potential effect of climate change, a modelling exercise was conducted to estimate the effect of sea level rise. In this study, the affect of a 0.5 m rise in sea level on the water level in the lower Churchill River below Muskrat Falls was determined. Assuming a mean annual river flow, water elevation was predicted for a mean sea level (msl) of 0.5 m at Goose Bay. The change in sea level has less of an effect upstream towards Muskrat Falls. The model indicated that at the base of Muskrat Falls, the simulated river level for mean flow with existing msl, was 2.73 m, while for the same flow and a 0.5 m rise in msl, it was 2.76 m. A final pair of scenarios considering mean river flow and high tide in Goose Bay at 0.4 m yields for the base of Muskrat Falls an elevation of 2.80 m for the 0.5 m rise. The current Project design adequately accounts for climate change and the overall economic feasibility of the Project will not be affected.

Given the state of knowledge regarding the effects of climate change to Labrador, it is not reasonable to introduce an additional, explicit adjustment to account for possible future climate change. The conservative assumptions employed in the PMP calculation and the incorporation of climate change effects into the operation and management plans for the generation facilities, led to the conclusion that changes due to climate change will be within the bounds of the current estimates. As noted, the Project design for both construction and operation is very robust and will accommodate a range of potential climate change scenarios.

Recently, techniques have been under development to downsize Global Climate Model (GCM) output to a local level both spatially and temporally for use in hydrological studies. In dynamic downscaling, a finer-scale Regional Climate Model (RCM) is used (resolution of 10 to 50 km). The RCM incorporates topography and land surface features. The output of the GCM is then used as the atmospheric boundary condition for the RCM. By using this method, the GCM simulates the large-scale atmospheric circulation and the RCM simulates the local climate of interest.

As part of the Project, a program has been initiated in partnership with Memorial University, to study the effects of climate change on the Project through climate modelling using dynamic downscaling. The main objectives of the study are:

- to implement and compare different dynamic downscaling techniques for the lower Churchill River watershed and to recommend a suitable model for further use in the study;
- to develop and implement methods for relating changes in surface climate to changes in runoff regimes for the lower Churchill River system; and
- to develop an initial assessment of how climate change will affect the lower Churchill River system using combinations of emissions scenarios, GCM output and downscaling techniques.

The Project is intended to operate for a minimum of 75 years. A changing climate may alter the dynamics of the watersheds and thus the flow of water and the generation of electricity over the operating life of the Project. If any substantial climate change effects are determined through monitoring or operational observations, or suggested through the ongoing research into potential effects of climate change on the Project, this information will be incorporated into management plans for the Project facilities. As appropriate, the current and forecasted operating procedures will be reconsidered and design changes incorporated into system upgrades. For example, in the event of increased precipitation, the spillway may be used more frequently or the turbines could be upgraded to a higher capacity.

10.5.2 Transmission Line Facilities

The environment can affect transmission lines through wind and ice loading, lightning, forest fires and potentially through climate change.

The total number of lightning and icing outage incidents affecting Hydro transmission lines in Labrador from 1993 to 2007 with duration statistics are summarized in Table 10-3.

Table 10-3 Summary of Lightning and Icing Outage Incidents Affecting Hydro Transmission Lines in Labrador (1993 to 2007)

Year	230 kV [A]		Weather-related Cause	735 kV [B]		Weather-related Cause	138 kV [C]		Weather-related Cause
	No.	Total Annual Duration		No.	Total Annual Duration		No.	Total Annual Duration	
2007	3	15 min	Lightning	3	11 min	Lightning	0		
2006	3	1 hr 46 min	Lightning	1	11 min	Lightning	6	No data	Lightning
2005	7	2 hr 7min	Lightning	1	5 min	Lightning	2	7 min	Lightning
2004	3	4 min	Lightning	0			0		
2003	6	1 hr 5 min	Lightning	0			5	19 min	Lightning
2002	4	35 min	Lightning	0			7	19 min	Lightning
2001	7	5 hr 18 min	Lightning	1	6 min	Lightning	3	11 min	Lightning
2000	0			0			4	31 min	Lightning
1999	3	3 min	Lightning	0			9	2 hr 8 min	Lightning
1998	1	7 min	Lightning	3	7 hr 45 min	Lightning	0		
1997	6	2 hr 9 min	Lightning	17	276 hr 8 min	Icing	6	1 hr 16 min	Lightning
1997	2	1 hr 31 min	Icing	0			0		
1996	0			0			9	42 min	Lightning
1995	0			0			8	1 hr 37 min	Lightning
1994	0			0			4	34 min	Lightning
1993	0			0			1	17 min	High Wind
1993	0			0			1	1 min	Lightning

Source: Hydro
[A] Churchill Falls to Wabush
[B] Churchill Falls to Quebec border
[C] Churchill Falls to Happy Valley-Goose Bay

Since 1993, there has been no outages due to icing on the existing transmission line between Happy Valley-Goose Bay and Churchill Falls.

10.5.2.1 Ice Accretion and Wind

One of the primary causes of major transmission line outages is extreme weather conditions, particularly due to severe wind and conductor icing. The 1998 Quebec ice storm serves as an example of such an extreme weather event.

In general, daily weather does not have any measurable effect on transmission lines; however, understanding extreme events is very important in their design. Extreme Value Analysis provides transmission line loading for maximum ice, maximum wind and a combination of ice and wind. Each load case is estimated and the results are used in the design of the towers, taking into account the possible combinations of the loads. In some cases, extreme loading can be reduced through routing of the transmission line.

Through Extreme Value Analysis, a reasonable magnitude of design load for an acceptable reliability can be determined. The Extreme Value Analysis of transmission line loads takes into account weather properties such as precipitation amount, temperature, humidity and wind speed. This hourly information (which has been collected at Churchill Falls and Goose Bay for many years), as well as mathematical ice accretion models help in the determination of loads that can be expected in the future, so that the line can be designed to reduce the

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chance of failure. Typically, low voltage transmission lines are designed for a one in 50 year load (1:50) without failure. As lines become more important in the system, the return period of this load is typically increased to higher levels such as 1:150 years, and can be as high as 1:500 years to reduce the chance of failure from extreme events. Levels such as 1:500 years are only used for strategic lines where failure could have substantial consequences. The Project transmission lines have been designed to meet the one in 150 year event. Optimization of reliability versus cost is required as selection of higher reliability levels provide for stronger lines, but are subsequently more expensive to construct. For the Project, the design standard has been selected to reflect a high and acceptable level of reliability related to transmission line operation and maintenance.

10.5.2.2 Lightning

Lightning can potentially damage transmission lines and is the number one cause of outages on the existing transmission line. These line outages can range from relatively minor to those that require a substantial amount of time to correct. Protection against lightning outages is achieved through the installation of an overhead shield wire on the transmission structures, which directs the energy from the lightning strike to the ground. The Project transmission lines will include such protection against lightning strikes.

10.5.2.3 Vegetation

All of the transmission lines operated by Hydro are located on a right-of-way that is cleared of any vegetation with a mature height great than 1 m. As standard procedure, all vegetation that can be detrimental to long term maintenance or operation is cleared periodically as required. As well as the standard right-of-way width, any trees outside the right-of-way that could fall across the conductor, called danger trees, are also removed.

10.5.2.4 Climate Change

Similar to the generation facilities, the consideration of climate change will be an ongoing study for the duration of the operating life for the transmission lines. The greatest potential for affecting the transmission lines would be related to temperature shift. If the duration of temperatures in the range of -1°C to 1°C increases then the potential for ice accretion on the conductors could increase. If any substantial climate change effects are determined through monitoring or operational observations, or suggested through the ongoing research into potential effects of climate change on the Project with Memorial University, this information will be incorporated into management upgrading plans for the Project transmission lines. If and as appropriate, the current and forecasted operating procedures will be reconsidered and design changes incorporated into system upgrades. For example, additional mid-span transmission line structures could be installed to account for increased ice load observations.

10.6 Environmental Effects Assessment Summary

The Project Team continues to employ stringent design, construction, operation and maintenance planning methods to address environmental effects of the environment on the Project in a manner that optimizes the safety and efficiency of the Project.

Appropriate monitoring and forecasting will also be in place to address ongoing safety for Project personnel and equipment, and to minimize disruptions to operation and maintenance. The Gull Island and Muskrat Falls generation facilities will typically operate remotely from St. John's using the Energy Management System. The system has been used successfully with Hydro's other hydroelectric facilities for over 15 years and is designed for efficient water use. Remote monitoring systems will measure the following environmental conditions at facility locations:

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- weather, including wind, precipitation, temperature and ice; and
- reservoir, trashrack conditions and tailrace levels.

The design and operational strategies as described will adequately address potential effects that the environment may have on the Project, making it likely that:

- no harm will come to Project personnel or the public;
- there will be no substantial delays in construction (e.g., more than one season);
- there will be no long term interruptions in service;
- there will be no damage to infrastructure that compromises public safety; and
- there will be no damage to infrastructure that would not be economically or technically feasible to repair.

Therefore, the residual adverse effects of the environment on the Project are predicted to be **not significant**.

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12.0 GLOSSARY AND ABBREVIATIONS

0	No interaction will occur. Assessment of environmental/socio-economic effects is not required.
1	Identified interactions that are well understood, are subject to prescribed environmental protection measures or normal regulatory processes, and/or which can be mitigated/ optimized through the application of standard environmental protection or socio-economic management measures and practices. Based on past experience and professional judgement, the potential environmental/socio-economic effects resulting from these interactions are rated not significant.
2	Identified interactions that may result in more substantive environmental or socio-economic effects and/or public or regulatory concern. These interactions require more detailed analysis and consideration in the environmental assessment, in order to predict, mitigate and evaluate potential environmental/socio-economic effects.
backwater	Water held back by a dam.
baseline study/survey	A study/survey designed to establish baseline conditions against which the effects of a project can be compared.
biophysical assessment	Analysis of expected environmental effects on the physical and biological components of the environment; for example, air quality, aquatics, and wildlife on land and in water.
borrow pit	Source of earth material (e.g., sand or gravel taken from one location to be used for fill at another location).
Black Rock Bridge	The bridge associated with the Trans Labrador Highway between Happy Valley-Goose Bay and Cartwright that crosses the lower Churchill River approximately 20 km below Muskrat Falls. The bridge consists of a 500 m causeway from the north side and a 300 m bridge. A temporary dam used during the construction period to permit work below the waterline (e.g., when building the foundations of dams).
buffer area	An area of undisturbed natural vegetation maintained between watercourses (and other sensitive areas) and activities such as right-of-way clearing and grubbing.
cavitation	Noise or vibration causing damage to the turbine blades as a result of bubbles that form in the water as it goes through the turbine. This causes a loss in capacity, head loss, efficiency loss, and the cavity or bubble collapses when they pass into higher regions of pressure.
constraint mapping	A technique using GIS tools to identify areas suitable for an activity (e.g., placement of project infrastructure), base on identifying (and avoiding) areas of ecological sensitivity or certain terrain features.
diversion facilities	Diversion facilities typically redirect water away from a construction site and return it to the natural channel
drawdown	The release of water from a reservoir for power generation, flood control, irrigation or other water management activity.
effects management measure	A measure used to help manage different environmental outcomes of a project, to prevent or limit negative effects or enhance positive ones.
environmental protection plan	A document that details a proposed development or activity, predicts the possible environmental effects on the environment and outlines safeguards to mitigate or control adverse environmental effects.

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environmental assessment	A planning process to predict the environmental effects of a proposed development before it is carried out.
flushing rate	The rate at which all the water in a water body is replaced by new water, determined by the rate of water inflow and outflow.
follow-up/follow-up monitoring	A program designed to verify the accuracy of the environmental assessment of a project, and determine the effectiveness of measures taken to mitigate the adverse environmental effects of a project.
footprint	Area encompassing all physical project activities (e.g., dam, construction camp, reservoir preparation, access roads and associated quarries and borrow areas).
forebays	Reservoirs or canals from which water is taken to run equipment.
greenhouse gases (GHG)	Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that cause the Earth's atmosphere to retain heat. Water vapour, carbon dioxide, nitrous oxide, methane and ozone are the primary greenhouse gases in the Earth's atmosphere.
green tonne	A weight measurement of timber when freshly felled, usually before any natural or artificial drying has begun.
Impacts and Benefits Agreement (IBA)	IBAs are contractual arrangements between a project proponent and a particular Aboriginal group.
impoundment	Body of water formed through collection of water, as by a dam.
Interim Forest Agreement	The Interim Forest Agreement provides for full participation by Innu Nation in management planning, information sharing, development of sustainable forestry practices and preparation of ecosystem-based management plans for the Labrador forest resource.
Innu Traditional Knowledge	The knowledge accumulated by the Innu through generations of living in close contact with nature.
inundation	The filling of a reservoir.
ISO	A certification issued by the International Organization for Standardization (ISO).
issues scoping	The process of focusing an environmental assessment on a concise list of those components of the biophysical and socio-economic environment that are valued (socially, economically, culturally or scientifically) and of interest when considering the potential environmental effects of a project.
Key Indicator (KI)	A Valued Environmental Component might have a KI, which focuses the assessment to a finer level of the environment; in the case of the terrestrial environment, the finer level is often a species; in the socio-economic environment, it is often a component, such as employment.
Labrador Inuit Land Claims Agreement	The Labrador Inuit Land Claims Agreement designates Labrador Inuit Lands that are under the jurisdiction of Nunatsiavut Government. A larger area, knows as Labrador Inuit Settlement Area (LISA) includes land and water areas extending into Lake Melville.
laydown area	An area cleared for the temporary storage of equipment and supplies. Laydown areas are usually covered with rock and/or gravel to ensure accessibility and safe maneuverability for transport and offloading of vehicles.
lower Churchill River	The section of the Churchill River between the existing Churchill Falls Power Station and its mouth at Lake Melville.

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mean annual flow (MAF)	The mean annual flow of a river.
mitigation	An activity that reduces or controls adverse environmental effects of a project.
operation and maintenance	The period of this Project following first power production.
powerhouse	A structure that contains the turbine and generator of a hydropower project.
Precautionary Principle	Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.
Project (the)	Lower Churchill Hydroelectric Generation Project.
residual environmental effect	An environmental effect caused by a project that remains after mitigation measures have been applied
socio-economic assessment	An analysis of expected environmental effects on the social and economic components of the environment (e.g., economy, employment, business and community health).
sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
spillway	It is the channel or passageway around or over a dam through which excess water is released or spilled past the dam without going through the turbines. A spillway is a safety valve for a dam and, as such, must be capable of discharging major floods without damaging the dam, while maintaining the reservoir level below some predetermined maximum level.
stakeholder	A person or group with an interest in the Project.
tailrace	The downstream part of a dam where the impounded water re-enters the river.
tailwater	The water of a tailrace.
transmission line	A device designed for the transmission of electric power. Transmission lines are either overhead, where conductors are suspended from structures, or are composed of buried or submarine cables.
turbine	A rotary engine in which the kinetic energy of a moving fluid is converted into mechanical energy by causing a bladed rotor to rotate.
watershed	The area drained by a single lake or river and its tributaries; a drainage basin.
Valued Environmental Components (VECs)	VECs are biophysical and socio-economic components that are valued by society and can be indicators of environmental change
Year 1	Assumed to be 2010.

ABBREVIATIONS

ANSI ..... American National Standards Institute
ASCE ..... American Society of Civil Engineers
ASL ..... above sea level
ASME ..... American Society of Mechanical Engineers
ASTM ..... American Society for Testing and Materials
ATK ..... Aboriginal Traditional Knowledge
BOD ..... basis of design
CCGT ..... combined cycle gas turbine
CDM ..... conservation demand management
CEAA ..... *Canadian Environmental Assessment Act*
CF(L)Co ..... Churchill Falls (Labrador) Corporation (now referred to as Nalcor Energy - Churchill Falls)
CFRD ..... concrete-faced rockfill dam
CGS ..... Canadian Geotechnical Society
CNQA ..... *Cree Naskapi (of Quebec) Act*
CO_2 ..... carbon dioxide
COSEWIC ..... Committee on the Status of Endangered Wildlife in Canada
CRPP ..... Churchill River Power Project
CSCE ..... Canadian Society of Civil Engineers
CWB ..... Canadian Welding Bureau
DFO ..... Fisheries and Oceans Canada
DND ..... Department of National Defence
ECC ..... energy control centre
EIS ..... environmental impact statement
ELC ..... ecological land classification
EMS ..... environmental management system
EOSD ..... Earth Observation for Sustainable Development
EPP ..... environmental protection plan
EPRI ..... Electric Power Research Institute
ERA ..... ecological risk assessment
ERD ..... earth and rockfill dam
FERC ..... Federal Energy Regulatory Commission
FMD ..... Forest Management District
FSL ..... full supply level
GCM ..... global climate model
GHG ..... greenhouse gases
GIS ..... geographic information system
GMT ..... green metric tonnes
HQ ..... hazard quotient
HSEQ ..... Health, Safety, Environment and Quality
Hydro ..... Newfoundland and Labrador Hydro – a Nalcor Energy company
Hz ..... hertz
IBA ..... Impact and Benefits Agreement
ICUB ..... inclined core with upstream blanket
IEC ..... International Electrotechnical Commission
IEEE ..... The Institute of Electrical and Electronics Engineers
IEMR ..... Institute for Environmental Monitoring and Research

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IMS ..... integrated management system
IPCC ..... Intergovernmental Panel on Climate Change
IPSP ..... integrated power system plan
ISO ..... International Organization for Standardization
ISO-NE ..... Independent System Operator-New England
ITK ..... Innu Traditional Knowledge
ITKC ..... Innu Traditional Knowledge Committee
KI ..... Key Indicator
kV ..... kilovolt
LCC ..... Lower Churchill Consultants
LCDC ..... Lower Churchill Development Corporation
LCP ..... least-cost path
LIL ..... Labrador Inuit Lands
LISA ..... Labrador Inuit Settlement Area
LMN ..... Labrador Métis Nation
LRTAP ..... long-range transport of air pollutant
LSL ..... low supply level
Mt ..... megatonne
MTVC ..... multi-transition vertical core
MW ..... megawatts
NATO ..... North Atlantic Treaty Organization
NCC ..... Nature Conservancy of Canada
NEB ..... The National Energy Board
NEMA ..... National Electrical Manufactures Association
NEQA ..... Northeastern Quebec Agreement
NLDEC ..... Newfoundland and Labrador Department of Environment and Conservation
NLDGS ..... Newfoundland and Labrador Department of Government Services
NLDTW ..... Newfoundland and Labrador Department of Transportation and Works
NLEPA ..... Newfoundland and Labrador Environmental Protection Act
NLESA ..... *Newfoundland and Labrador Endangered Species Act*
NOC ..... National Occupational Classification
NSP ..... Northern Strategic Plan
NWPA ..... *Navigable Waters Protection Act*
OPA ..... Ontario Power Authority
OPS ..... Operational Policy Statement
PMF ..... probable maximum flood
PMP ..... probable maximum precipitation
QNSLR ..... Québec North Shore Labrador Railway
RAs ..... Responsible Authorities
RCC ..... roller compacted concrete
RCM ..... regional climate model
RGGI ..... Regional Greenhouse Gas Initiative
RPS ..... renewable portfolio standards
RSF ..... resource selection function
RTWQM ..... real time water quality monitoring
RWM ..... Red Wine Mountains
SARA ..... *Species at Risk Act*

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SO_2 ..... sulphur dioxide
SSPC ..... Society for Protective Coatings
TAC ..... total allowable cut
TLH ..... Trans Labrador Highway
TNM ..... traffic noise model
TSS ..... total suspended solids
TWh ..... terawatt-hours
USACE ..... United States Army Corps of Engineers
USBR ..... United States Bureau of Reclamation
USDE ..... United States Department of Energy
VBNC ..... Voisey's Bay Nickel Company Limited
VEC ..... Valued Environmental Component
VINL ..... Vale Inco Newfoundland and Labrador Limited
VOC ..... volatile organic compound
WCI ..... Western Climate Change Initiative
WRDC ..... Women in Resource Development Committee
WSC ..... Water Survey of Canada
ZOI ..... zone of influence