REPORT

Tazi Twé
Hydroelectric Project

February 2014

TAZI TWÉ HYDROELECTRIC PROJECT

ENVIRONMENTAL IMPACT STATEMENT

Submitted to:
Canadian Environmental Assessment Agency
#425, 10115 - 100A Street
Edmonton, AB T5J 2W2

Saskatchewan Ministry of Environment
Environmental Assessment Branch
4th Floor – 3211 Albert Street
Regina, SK S4S 5W6

Report Number: 10-1365-0004/DCN-171

ACKNOWLEDGEMENT

Black Lake First Nations, Elizabeth Falls Hydroelectric Limited Partnership and Saskatchewan Power Corporation would like to acknowledge Golder Associates Ltd. and their sub-consultants InterGroup Consultants for the completion of the environmental assessment and the compilation of the Tazi Twé Hydroelectric Project Environmental Impact Statement. Black Lake First Nations, Elizabeth Falls Hydroelectric Limited Partnership and SaskPower would like to acknowledge KGS Group and Peter Kiewit Infrastructure for their contributions to the design of the Tazi Twé Hydroelectric Project.

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1.0 INTRODUCTION

The Tazi Twé Hydroelectric Project (the Project) is a 50 megawatt (MW), water diversion type electrical generating station adjacent to the Fond du Lac River between Black Lake and Middle Lake. The energy produced by the Project will be integrated into the Saskatchewan Power Corporation (SaskPower) electrical system to assist with accommodating the growing energy requirements of northern Saskatchewan communities and to support continued northern economic development. The Project's estimated, gross average annual generation will be approximately 400,000 megawatt hour (MWh) per year.

The Project is located on Chicken Indian Reserve 224 adjacent to the Fond du Lac River between Black Lake and Middle Lake. The Project is located approximately 7 kilometres (km) northeast of the community of Black Lake and 25 km southwest of the Northern Hamlet of Stony Rapids (Figure 1.0-1). The Chicken Indian Reserve No. 224 was created under the Order in Council (OIC) 1978-1647; that is the land is set aside for the exclusive use and benefit of the members of the Black Lake First Nation. The area surrounding the Chicken Indian Reserve No. 224 is provincial crown land and accessible to all aboriginal people for the pursuit of traditional and cultural activities.

The Black Lake First Nation (BLFN) together with SaskPower submitted a Project Description to the Saskatchewan Ministry of Environment (MOE) and the Canadian Environmental Assessment Agency (Agency) for the proposed Project in January 2013. On February 28, 2013, the Agency determined that a federal environmental assessment is required for the Project pursuant to the *Canadian Environmental Assessment Act* (*CEAA* 2012). The MOE has also determined that the Project is a "development" as defined by Section 2(d) of the *Saskatchewan Environmental Assessment Act* (*SEAA*). As such, an environmental assessment has been completed and an Environmental Impact Statement (EIS) is submitted for the Project that will satisfy the federal and provincial environmental assessment processes.

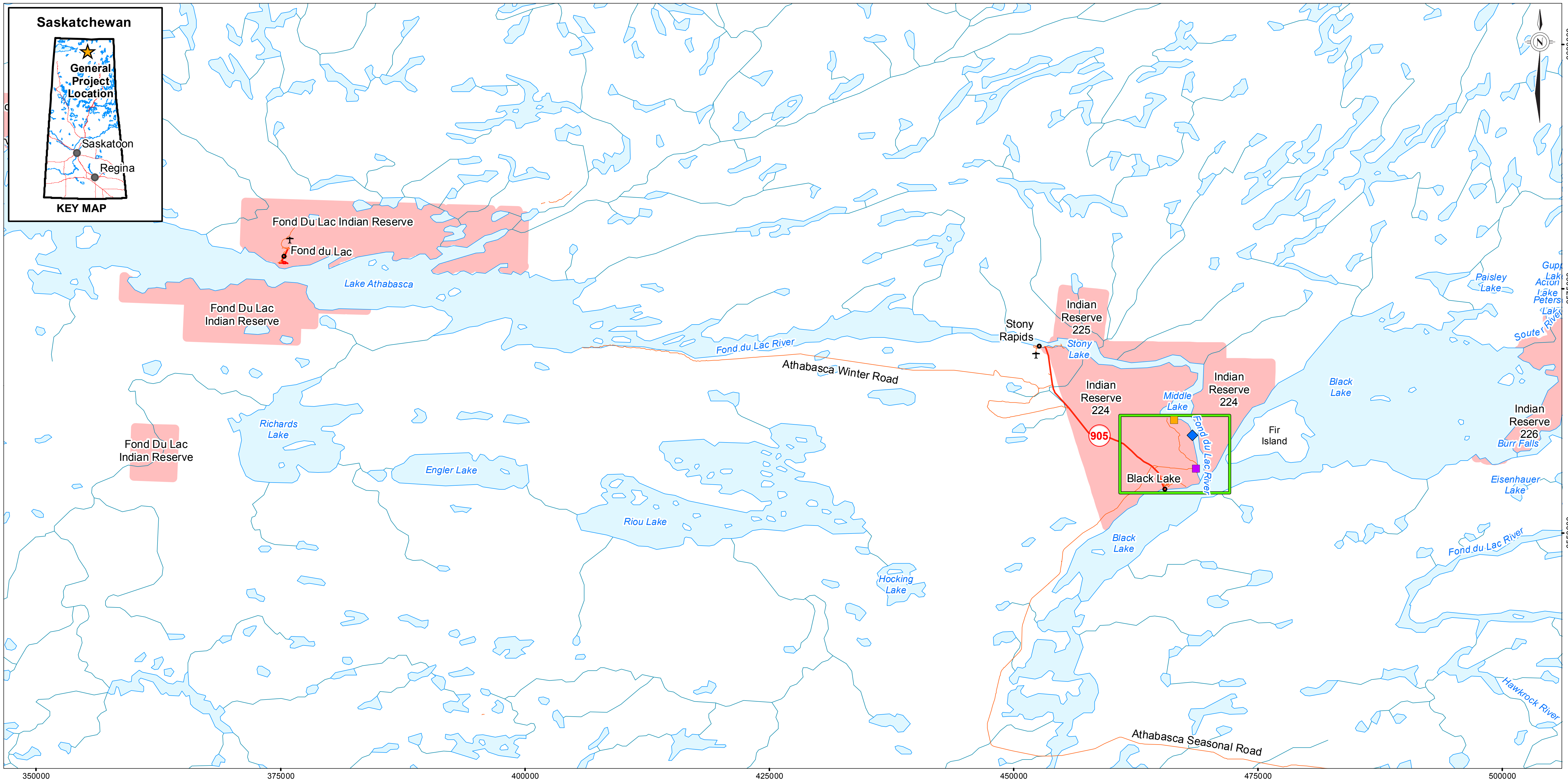
The Agency approved federal EIS Project-specific Guidelines for the Project on April 30, 2013.

This EIS is intended to fulfill the requirements for an environmental assessment under *CEAA* (Government of Canada 2012). Provincial requirements are specified under *SEAA* (Government of Saskatchewan 2010). The federal and provincial environmental assessment processes, as well as the federal and provincial permits, licences, approvals, and authorizations that may be required, are described in Section 2 of this EIS.

The Environmental Impact Assessment (EIA) for the Project will be used as a tool to integrate environmental and social factors into Project planning and encourage decision makers to take actions that promote sustainable development. The goal of this approach is to promote sustainable development, engage First Nations and Métis communities and groups, government agencies, local communities, interest groups and the public, and limit the overall environmental, economic, social, heritage, and health effects of the Project.

1.1 Background

The potential of generating hydroelectric power in this area was first identified by SaskPower in the 1970s. At that time, the demand for power did not warrant further investigation. Interest was reignited by BLFN in the early 2000s. A prefeasibility study and initial design work was completed for the Project between 2001 and 2007 that demonstrated the feasibility of the conceptual design.



LEGEND

HAMLET OR COMMUNITY	ELIZABETH FALLS	GENERAL PROJECT LOCATION
RUNWAY	CAMP GRAYLING	
RIVER	PERMANENT RESIDENT'S CABIN	
HIGHWAY		
ROAD		
INDIAN RESERVE		
WATERBODY		

10 0 10

SCALE 1:400,000 KILOMETRES

REFERENCE

DMTI HIGHWAYS AND ROADS
NTS MAPSHEET 74I, 74J, 74O, 74P
NAD 83 UTM ZONE 13

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

TAZI TWÉ PROJECT LOCATION

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.	
DESIGN			SCALE AS SHOWN	REV. 1
GIS	SM	04/11/13		
CHECK	MT	04/11/13		
REVIEW	MM	04/11/13		

FIGURE: 1.0-1

In light of the positive results of the prefeasibility study, BLFN successfully completed a referendum vote in November 2007 to designate a portion of Chicken Indian Reserve 224 land for the Project. To further advance the Project, BLFN formed the Elizabeth Falls Hydroelectric Limited Partnership (EFHLP) in February 2010 with the mandate to promote and develop the Project. A working relationship was developed between EFHLP and SaskPower in early 2010 that enabled baseline environmental and preliminary engineering work to proceed on the Project. This work provided enough information to initiate the regulatory process. In February 2013, the leadership of BLFN announced an agreement in principle with SaskPower for the advancement and potential development of the Project.

1.2 Proponent

The proponent for the Project is the BLFN together with SaskPower, a Crown corporation incorporated under *The Power Corporation Act of Saskatchewan*. The BLFN's interest is being held through the EFHLP. At this time, it is anticipated that the ownership structure for the Project will be a limited partnership. SaskPower will have a 70 percent (%) interest in the Project and EFHLP will have a 30% interest. SaskPower will be responsible for designing, engineering, permitting and approvals, and construction of the Project. The EFHLP will have representation on an advisory committee that will review Project status, activities, negotiations, schedule, and costs, and will have an opportunity to make recommendations. When completed, SaskPower will have full responsibility and authority to dispatch, operate, and maintain the Project. As an owner, EFHLP will receive monthly cash distributions from the Project based on its ownership interest, and community service and land lease payments.

1.2.1 Corporate Safety, Health, and Environment Policies

The safety and wellbeing of workers is of primary importance to the Project. The Proponent is committed to maintaining a workplace in which safety is part of everything that is done and is equally important as anything else that is done at the facility. The Proponent intends to adopt the SaskPower Safety Management Policy for the Project, which will apply to all employees, contractors, visitors and the operation of the facility once complete.

Limiting the potential effects of the Project is a key design and operational component of the Project. All applicable environmental and health and safety acts (federal and provincial), regulations, permits, and standards will be adhered to throughout the Project. Compliance with current provincial and federal health and safety regulations, as well as SaskPower Safety Policies and Standards is a condition of employment for all personnel and contractors working on the Project. These existing SaskPower procedures and codes of practice cover emergency preparedness, environmental management, workplace safety, public access safety, and spill response for the Project. The Occupational Health and Safety Plan for the Project is described in Section 5.6 of this EIS.

1.2.2 Key Contact Information

On behalf of the Proponent, the principal contact for environmental assessment of the Project is:

Stan Saylor
Environmental Supervisor
Business Development
SaskPower
2025 Victoria Avenue
Regina, Saskatchewan
S4P 0S1
Phone: 306-566-2879
Fax: 306-566-2575
E-mail: ssaylor@saskpower.com

The contacts for the Project who are representatives of EFHLP and SaskPower are:

Ted de Jong
CEO, Elizabeth Falls Hydro Development Corporation
Box 478
Prince Albert, Saskatchewan
S6V 5R8
Phone: 306-922-0099
Fax: 306-922-5075
E-mail: tdejong@padc.ca

Mark Peters
Project Manager
Business Development
SaskPower
2025 Victoria Avenue
Regina, Saskatchewan
S4P 0S1
Phone: 306-566-2993
Fax: 306-566-2575
E-mail: mpeters@saskpower.com

1.2.3 Key Personnel Responsible for Preparing the Environmental Impact Statement

SaskPower received technical assistance and expertise from several consultants to complete the EIA for the Project. The consultants, technical advisors, and the area of their technical contribution to the EIA are listed in Table 1.2-1.

Table 1.2-1: Consultants and Technical Advisors

Consultant	Technical Contribution
Golder Associates Ltd.	Environmental Impact Assessment
KGS Group Consulting Engineers	Engineering, Design and Technical Assessment
Peter Kiewit Infrastructure	Contractor Project Advisory Services

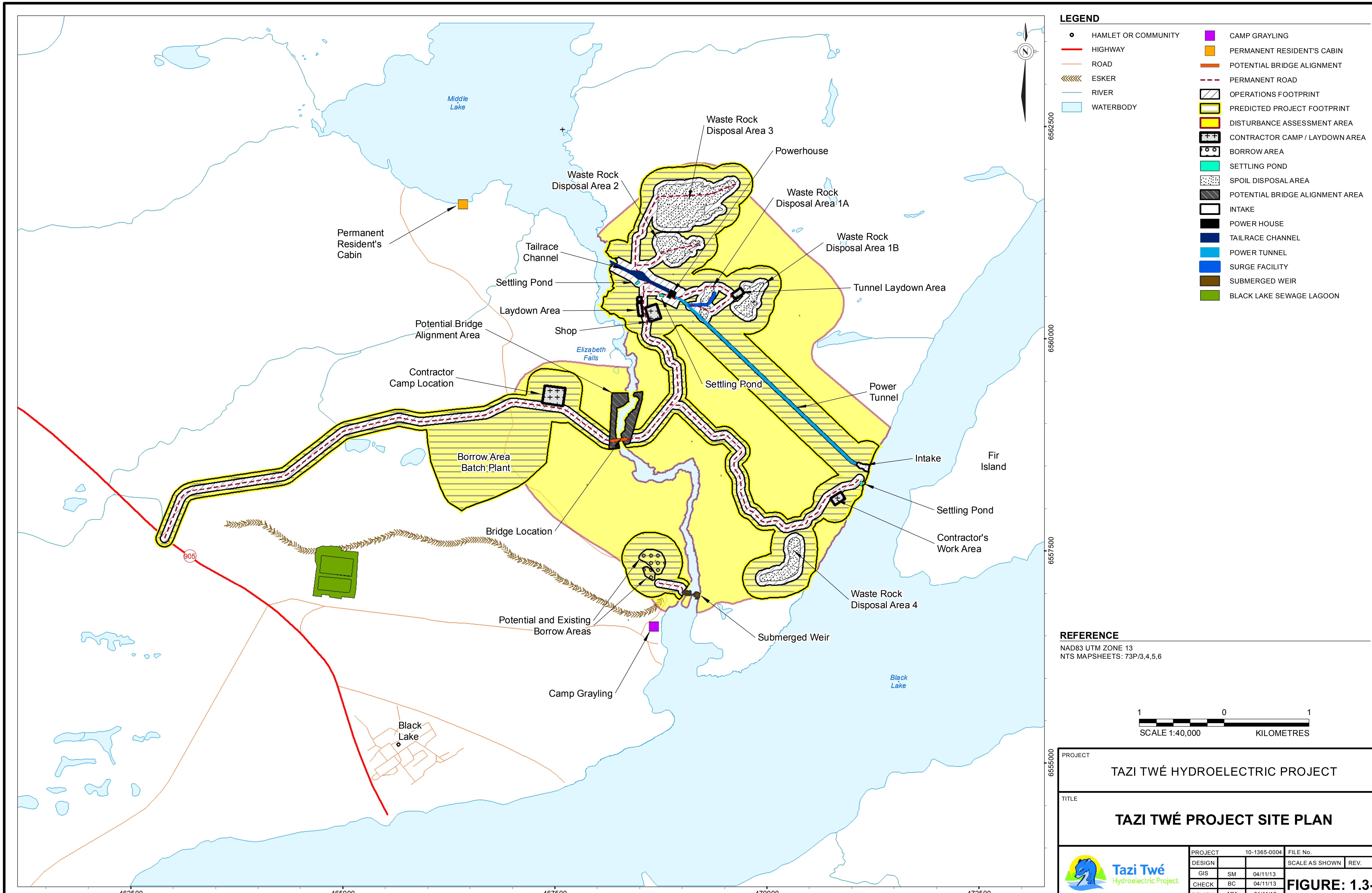
1.3 Project Location and Overview

The proposed Project will be a 50-MW water diversion type electrical generating station. The Project is located on the Chicken Indian Reserve 224, approximately 7 km from the community of Black Lake adjacent to the Fond du Lac River between Black Lake and Middle Lake. Black Lake has an approximate area of 418 square kilometres (km^2) and discharges an average annual flow of 304 cubic metres per second (m^3/s) into the Fond du Lac River, which traverses Elizabeth Falls on its way to Middle Lake. Water from Black Lake will be diverted through an intake and power tunnel to the powerhouse before being released through a tailrace channel into the Fond du Lac River, which ultimately discharges into Middle Lake.

The principal components of the Project consist of the following:

- gravel, all-season access roads to the Project site from the all-season road between the communities of Black Lake and Stony Rapids;
- bridge over the Fond du Lac River;
- powerhouse and associated infrastructure;
- water intake and power tunnel to convey flow from Black Lake to the powerhouse;
- tailrace channel from the powerhouse to the Fond du Lac River just upstream of Middle Lake;
- submerged weir located in the Fond du Lac River at the outlet of Black Lake near Grayling Island;
- settling ponds;
- waste rock disposal areas;
- construction camp;
- transmission lines and switching stations to connect to the northern Saskatchewan electrical grid; and
- all related physical works and physical activities required to carry out these works, including the associated cofferdams, access roads, laydown areas, borrow areas, concrete batch plant, fuel storage facility and fueling areas, explosives storage, and sewage treatment and potable water facilities.

An overview of the Project site plan is shown in Figure 1.3-1.



Middle Lake
Waste Rock Disposal Area 3
Powerhouse
Waste Rock Disposal Area 2
Waste Rock Disposal Area 1A
Waste Rock Disposal Area 1B
Permanent Resident's Cabin
Tailrace Channel
Settling Pond
Tunnel Laydown Area
Laydown Area
Shop
Potential Bridge Alignment Area
Elizabeth Falls
Contractor Camp Location
Settling Pond
Power Tunnel
Borrow Area Batch Plant
Intake
Fir Island
Settling Pond
Contractor's Work Area
Bridge Location
905
Waste Rock Disposal Area 4
Potential and Existing Borrow Areas
Submerged Weir
Camp Grayling
Black Lake
Black Lake
462500
465000
467500
470000
472500
6562500
6560000
6557500
6555000
N
LEGEND
HAMLET OR COMMUNITY
HIGHWAY
ROAD
ESKER
RIVER
WATERBODY
CAMP GRAYLING
PERMANENT RESIDENT'S CABIN
POTENTIAL BRIDGE ALIGNMENT
PERMANENT ROAD
OPERATIONS FOOTPRINT
PREDICTED PROJECT FOOTPRINT
DISTURBANCE ASSESSMENT AREA
CONTRACTOR CAMP / LAYDOWN AREA
BORROW AREA
SETTLING POND
SPOIL DISPOSAL AREA
POTENTIAL BRIDGE ALIGNMENT AREA
INTAKE
POWER HOUSE
TAILRACE CHANNEL
POWER TUNNEL
SURGE FACILITY
SUBMERGED WEIR
BLACK LAKE SEWAGE LAGOON
REFERENCE
NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
1 0 1
SCALE 1:40,000
KILOMETRES
PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT
TITLE
TAZI TWÉ PROJECT SITE PLAN
Tazi Twé
Hydroelectric Project
PROJECT 10-1365-0004
FILE No.
DESIGN
SCALE AS SHOWN
REV. 5
GIS SM 04/11/13
CHECK BC 04/11/13
REVIEW MM 04/11/13
FIGURE: 1.3-1

1.4 Need for and Purpose of the Project

Over the next 10 years the demand for power is expected to double in northern Saskatchewan, which the existing Far North electrical facilities will be unable to serve. The objective of this Project is to develop additional power supply in northern Saskatchewan to assist with accommodating the growing energy requirements of northern Saskatchewan communities, and to support continued northern economic development. As a result, SaskPower is working with BLFN to develop the Project to help enable service of the Far North load into the future.

1.5 Benefits of the Project

The proposed Project is expected to cost approximately $500 million to develop and build. The Project will generate employment, business and investment income benefits for residents of BLFN and the Athabasca region during the construction and operational phases. The main benefits of the Project include short and long term employment opportunities for residents of BLFN and other residents in the Athabasca region, investment in the Project by BLFN that will provide a secure, long-term source of income to improve the quality of life for members of BLFN, improvement of job skills by local residents engaged in the construction and operations of the Project that may be used for future employment opportunities, enhancement of business opportunities by local and regional companies in the provision of goods and services to the Project, and a long-term source of renewable power with low environmental impact that will serve the electrical energy needs of communities and industry located in the Athabasca region.

The construction phase of the Project is expected to take four years. Approximately 250 to 300 jobs will be created during the construction phase of the Project. In 2013, BLFN and SaskPower initiated formal training programs to improve the employment skills of BLFN members in order to maximize job opportunities by local residents in the construction of the Project. Additional on-the-job training programs for local residents will be facilitated by the Proponent and General Contractor selected to construct the Project. The magnitude and extent of the employment benefits derived by local residents will depend on their ability to satisfy the specific skill requirements for jobs related to the Project.

During the operational phase of the Project (90+ years) the Project will provide employment opportunities for six to eight people. Black Lake First Nation (BLFN) and SaskPower intend to prioritize the hiring of local residents for these positions and will implement a training program to achieve that objective.

BLFN and SaskPower intend to maximize the use of local and regional based companies in the construction and operation of the Project which will result in new business and employment opportunities benefiting residents in the Athabasca region. Local and regional businesses are well positioned to provide goods and services to the Project as they have developed considerable capacity serving the construction and operational needs of the mining industry located in the Athabasca region.

The Project is a major investment opportunity for BLFN that is expected to generate a long-term source of income which will be used to address community needs and improve the quality of life of BLFN members. Other benefits to the local residents include new infrastructure, such as roads and bridge over the Fond du Lac River.

The Project will create a new source of electrical power to serve the growing demand by communities and industry located in the Athabasca region. The energy produced by the Project is sustainable, renewable and will help SaskPower to maintain a diverse supply of electricity without producing any greenhouse emissions. The Project will also enhance the reliability of the supply of electrical energy in northern Saskatchewan.

1.6 Report Organization

The EIS is organized into a main document (including associated appendices) and annexes. The assessment of potential effects on the biophysical and socio-economic environments is organized by valued component (VC); that is, all information pertaining to a VC (i.e., study areas, existing environment, residual effects assessment, uncertainty, and monitoring and follow-up) is provided within the VC section.

Sections of the main document may be supported by appendices and annexes. Appendices are not stand-alone documents. For example, the Existing Environment section within the Surface Water Quality VC section of the EIS will provide an understanding of water chemistry levels in the aquatic receiving environment. The text within the main document interprets and summarizes the data, whereas, the data to support the discussion is provided in the appendix. The annexes are stand-alone technical documents and include reports of previous studies that were completed during baseline studies and Project development. These documents provide important pieces of supporting information for review by technical subject-matter experts. For example, stand-alone Baseline Reports, which are summarized within each VC section (i.e., Existing Environment section) of the main document, have been prepared for various disciplines.

The main document is organized into the following 24 main sections.

- **Executive Summary -** describes the key Project elements and key findings of the EIS, with particular reference to the overall conclusions of the assessment. This section will focus on items of known or expected public concern and the potential for significant adverse environmental effects, as well as likely benefits of the Project and the methods used to arrive at such conclusions.
- Section 1 **Introduction -** introduces the Project, provides an overview of the Project, including location and schedule, and describes the need for the Project.
- Section 2 **Regulatory Framework -** provides a description of the regulatory process required for the development of the Project.
- Section 3 **Environmental Setting -** provides a summary of the baseline studies completed in support of the Project. The purpose of the environmental setting is to provide context so that the reader can understand where the Project is situated with respect to the main existing environmental features. This information is then used in the assessment of potential environmental effects from the Project.
- Section 4 **Project Alternatives -** provides a description of alternatives to the Project as well as any alternative means of carrying out the Project that were considered during the Project planning phase. A description of the alternatives considered and rationale for the preferred alternative is included.
- Section 5 **Project Description -** describes the Project as it is planned to proceed through construction, operations, and closure. The description will include a timeline for all phases of the Project and a discussion of Project components and activities, including supporting infrastructure that will be required for the Project. The scope of the description will be conceptual and will incorporate reasonable assumptions, as appropriate.
- Section 6 **Information Distribution, Engagement, and Consultation -** describes the approach to engage First Nations and Métis communities and groups, regulatory agencies, and the public. This section includes a summary of the meetings and discussions that have occurred, the issues raised, and describes

additional engagement activities to be completed. A summary of the activities completed by the EFHLP as part of Duty to Consult also will be provided.

- **Section 7 Environmental Assessment Approach -** outlines the overall assessment approach, including selection of valued components (VCs), establishment of spatial and temporal boundaries, identification of Project interactions and associated mitigation, assessment of residual environmental effects, and determination of significance.
- **Sections 8 to 20 -** environmental effects assessment presents the results of the EIA for each of the selected VCs. Topics covered within each of these discipline-specific sections include a description of the study areas established for the assessment, summary of the existing environment, identification of Project interactions and mitigation, residual effects analysis, and determination of significance. These discipline sections included in this EIS are as follows:
  - Section 8 Atmospheric Environment;
  - Section 9 Hydrogeology;
  - Section 10 Hydrology;
  - Section 11 Surface Water Quality;
  - Section 12 Fish and Fish Habitat;
  - Section 13 Soils and Terrain;
  - Section 14 Vegetation;
  - Section 15 Wildlife;
  - Section 16 Heritage Resources;
  - Section 17 Land Use;
  - Section 18 Economy;
  - Section 19 Community Services and Infrastructure; and
  - Section 20 Human Population and Health.
- **Section 21 Environmental Management, Monitoring, And Follow-Up -** includes a summary of the environmental management, monitoring and follow-up programs proposed for the Project.
- **Section 22 Corporate Commitments -** includes a summary of corporate commitments made by the Proponent,
- **Section 23 Summary of *Canadian Environmental Assessment Act* Section 5 Requirements – i**ncludes a summary of the changes to components of the environment with federal jurisdiction, changes to components of the environment that would occur on federal or transitional boundary lands and an overall conclusion for the EIA.
- **Section 24 Conclusions –** This section provides the conclusions of the environmental assessment relating to how the Project interacts with the biophysical, cultural, and social environment at and near the Project.

1.7 References

Government of Canada. 2012. *Canadian Environmental Assessment Act*.

Government of Saskatchewan. 2010. *The Environmental Assessment Act*.

1.8 List of Acronyms

Term	Definition
Agency	Canadian Environmental Assessment Agency
BLFN	Black Lake First Nation
CEAA	*Canadian Environmental Assessment Act*
EFHLP	Elizabeth Falls Hydroelectric Limited Partnership
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
MOE	Ministry of Environment
OIC	Order in Council
Project	Tazi Twé Hydroelectric Project
SaskPower	Saskatchewan Power Corporation
SEAA	*Saskatchewan Environmental Assessment Act*
VC	valued component

1.9 List of Units

Term	Definition
%	percent
km	kilometre
km^2	square kilometres
m^3/s	cubic metres per second
MW	megaWatt
MWh	megaWatt hours

2.0 REGULATORY FRAMEWORK

This section is intended to describe the regulatory framework within which the Environmental Impact Assessment (EIA) for the Tazi Twé Hydroelectric Project (Project) will be completed. Specifically, this section of the Environmental Impact Statement (EIS) will:

- indicate that the Project is subject to review under the *Canadian Environmental Assessment Act 2012* (*CEAA*) and provide a brief explanation of the federal process;
- indicate that the Project is subject to review under the *Saskatchewan Environmental Assessment Act* (*SEAA*) and provide a brief explanation of the provincial process;
- provide a list of the agencies, departments, organizations, or other participants likely to be involved in the environmental assessment process;
- identify the environmental and other specific regulatory approvals and legislation that are applicable to the Project at the federal, provincial, First Nation, and municipal levels;
- identify government policies, resource management, planning or study initiatives pertinent to the Project or EIA and discuss their implications;
- identify any treaty or self-government agreements with Aboriginal groups that are pertinent to the Project or the EIA; and
- provide a list of the provincial, or national objectives, standards, or guidelines that have been used in the evaluation of predicted environmental effects.

2.1.1 Federal Environmental Assessment Process

Under Section 8 of the *CEAA 2012*, a Project Description is required to initiate the screening process through which the Canadian Environmental Assessment Agency (Agency) will determine if a federal environmental assessment is required for all designated projects. Designated projects are defined under the *Regulations Designating Physical Activities* (2012).

Under Section 5 of the *CEAA* 2012 effects or changes that may be caused to the following as a result of the Project must be considered:

- fish and fish habitat, as defined in the *Fisheries Act*;
- aquatic species, as defined in the *Species at Risk Act* (*SARA)*;
- migratory birds, as defined in the *Migratory Birds Convention Act* 1994; and
- effects to Aboriginal peoples that may result in effects to health and socio-economic conditions, physical and cultural heritage, the current use of lands and resources for traditional purposes, or any structure, site or thing that is of historical, archaeological, paleontological, or architectural significance.

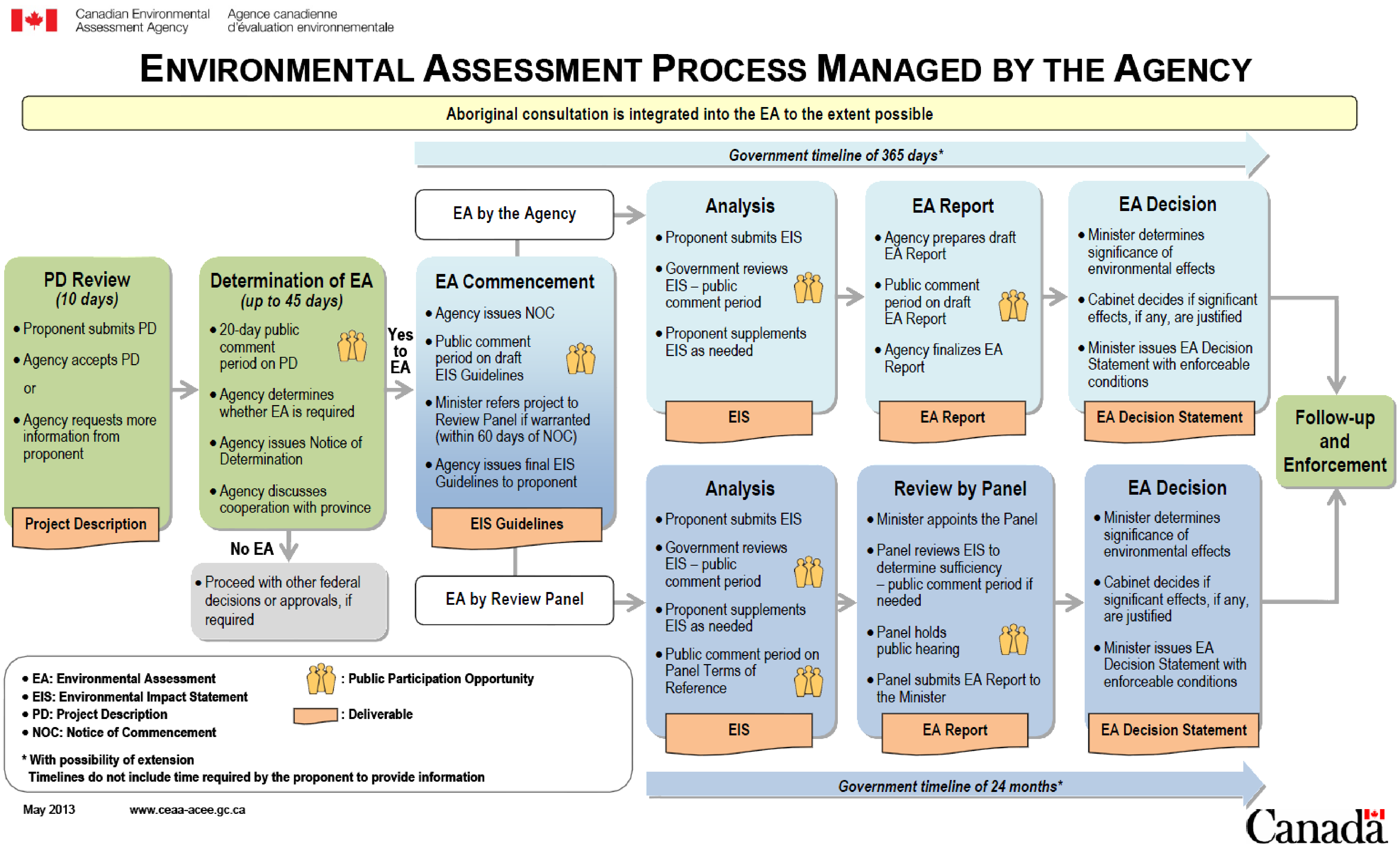
A Project Description was submitted to the Agency for review on January 2, 2013. On February 28, 2013, the Agency determined that a federal environmental assessment would be required for the Project pursuant to the *CEAA 2012 designated project list,* as the proposed Project would involve the diversion of 10,000,000 cubic metres per year (m^3/year) or more of water from a natural waterbody (i.e., Black Lake) into another natural water body (i.e., Fond du Lac River). This involves the completion of an EIA and submission of an EIS is required for the Project. This decision marked the start of the Agency's 365-day review period (i.e., the environmental assessment commencement phase). The Agency's environmental assessment process and timeline is outlined in Figure 2.1-1.

As part of the environmental assessment commencement phase, the Agency drafted EIS Guidelines to identify the information requirements for the preparation of an EIS for the Project, to be assessed pursuant to the *CEAA 2012*. These draft EIS Guidelines were available for public review and comment on the Agency's Registry internet site. Public comments, including comments from Aboriginal groups, as well as input from federal departments were incorporated into the final EIS Guidelines. The Agency issued the final EIS Guidelines on April 30, 2013.

The Agency will review the EIS for adequacy and accuracy and compliance with the EIS Guidelines. A Table of Concordance, which cross references the information presented in the EIS with the information requirements identified in the EIS Guidelines, is provided in Appendix 2.1. The Agency may require the proponent to complete additional studies or provide additional information to address deficiencies. Once the Agency deems the EIS to be complete and accurate, a summary of the EIS and the EIS are posted on the Registry Internet Site for public review and comment. The Agency drafts an Environmental Assessment Report that includes the following:

- rationale, conclusions, and recommendations regarding the potential environmental effects of the Project;
- mitigation that was taken into account;
- significance of the residual adverse environmental effects; and
- follow-up program requirements.

The draft environmental assessment is made available for public comment. Once the Environmental Assessment Report is final, it is submitted to the Saskatchewan Ministry of Environment (MOE) for review and Ministerial Decision on the Project. The Minister may identify mitigation and follow-up programs as conditions to the Decision Statement.



REFERENCE
CANADIAN ENVIRONMENTAL ASSESSMENT AGENCY, 2013

PROJECT	TAZI TWÉ HYDROELECTRIC PROJECT			
TITLE	CANADIAN ENVIRONMENTAL ASSESSMENT ACT REVIEW PROCESS			
PROJECT	10-1365-0004		FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	31/07/13	FIGURE: 2.1-1	
CHECK	BC	31/07/13		
REVIEW	MM	31/07/13		

Tazi Twé Hydroelectric Project

2.1.2 Provincial Environmental Assessment Process

A simplified flow chart of the provincial environmental assessment process is presented in Figure 2.1-2. The provincial environmental assessment process begins with the submission of a Technical Proposal to the Environmental Assessment Branch (EAB) of the MOE to determine if the Project is considered a ”development”. A “development” as defined in *SEAA (*2010), is any project, operation or activity or any alteration or expansion of any project, operation, or activity, which is likely to:

- have an effect on any unique, rare, or endangered feature of the environment;
- substantially use any provincial resource and in so doing pre-empt the use, or potential use, of that resource for any other purpose;
- cause the emission of any pollutants or create by-products, residual or waste products which require handling and disposal in a manner that is not regulated by another Act or Regulation;
- cause widespread public concern because of potential environmental changes;
- involve a new technology that is concerned with resource use and that may induce significant environmental change; or
- have a significant effect on the environment or necessitate a further development, which is likely to have a significant effect on the environment.

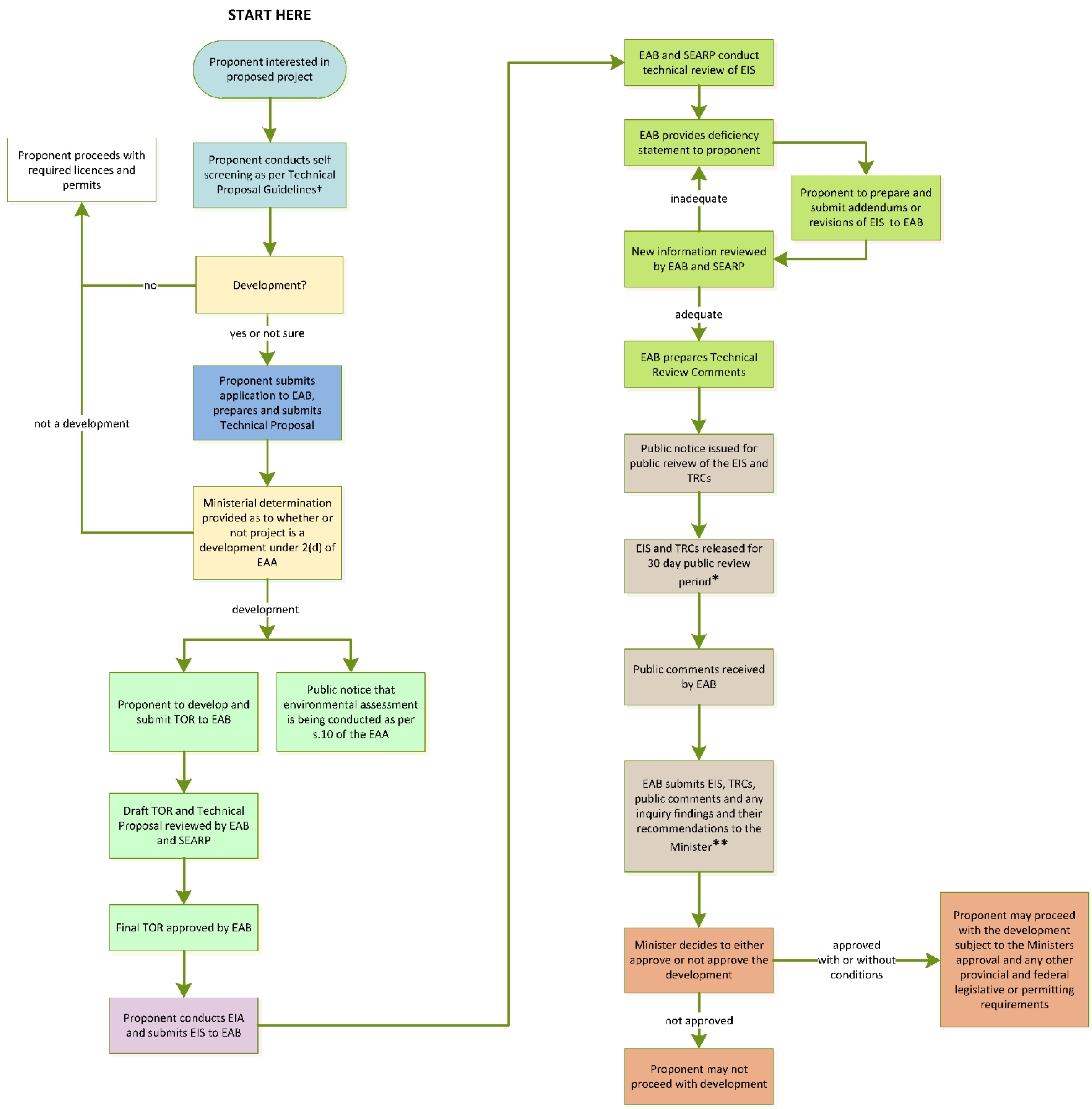
A Technical Proposal was submitted to the MOE on January 2, 2013. The MOE determined that the Project is a “development” as defined by Section 2(d) of the *SEAA* on February 27, 2013. As such, an EIA is required and an EIS submitted for the Project that satisfies the provincial environmental assessment process.

If a project is considered a “development”, then the proponent is required to draft the Terms of Reference (TOR) for the EIS. Similar to the EIS Guidelines, the TOR outline the required scope of the EIA, identify the key effects to be studied, and provide a set of criteria to judge the completeness of the EIA by regulatory agencies.

Draft TOR for the proposed Project were submitted to MOE on May 31, 2013. These TOR take into account and compliment the EIS Guidelines provided by the Agency on April 30, 2013. Consequently, it is the intent of the Proponent that these consolidated TOR will serve as the comprehensive foundation upon which the EIA for the Project will be conducted. Comments on the draft TOR were received from MOE on July 2, 2013. The proponent reviewed the comments and revised the TOR as necessary following additional discussion with MOE. The MOE accepted the TOR as final on August 7, 2013.

The MOE will coordinate an inter-ministry review of the EIS using a standing panel of representatives from provincial departments and agencies, which is known as the Saskatchewan Environmental Assessment Review Panel (SEARP). If the EIS does not contain all relevant information, the MOE will issue Technical Review Comments and direct the proponent to complete additional studies or provide additional information to address deficiencies. Once a revised EIS is submitted and deemed satisfactory by MOE, the EIS will be made available for public review and comment.

The Saskatchewan Environmental Assessment Process



- Proposal Development
- Impact Assessment
- Application
- Review
- Screening
- Public Comment
- Scoping
- Decision by Minister

†Changes to a development with prior Ministerial Approval require review by EA Branch

Key

TPG – Technical Proposal Guidelines
EAB – Environmental Assessment Branch
EAA – The Environmental Assessment Act
TOR – Terms of Reference
SEARP – Saskatchewan Environmental Assessment Review Panel
EIA – Environmental Impact Assessment
EIS – Environmental Impact Statement
TRCs- Technical Review Comments

* Any person may: make a written submission to the minister within 30 days from the date when the minister first gives notice or if the minister considers it appropriate, within an additional period of 30 days.
**Minister may require public meetings or public inquiry into all or any aspect of the development at any time prior to making a decision about the development

REFERENCE
MINISTRY OF ENVIRONMENT, GOVERNMENT OF SASKATCHEWAN, 2013

TAZI TWÉ HYDROELECTRIC PROJECT

SASKATCHEWAN ENVIRONMENTAL ASSESSMENT PROCESS

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004	FILE No.
DESIGN		SCALE AS SHOWN REV. 0
GIS	SM	31/07/13
CHECK	BC	31/07/13
REVIEW	MM	31/07/13

FIGURE: 2.1-2

Following the completion of the public review period, the MOE will make a recommendation to the Minister of Environment for a decision on whether the proposed Project can proceed. The MOE may or may not include approval conditions on a decision to allow the Project to proceed. Once approval is granted, the necessary regulatory permits and authorizations can be obtained.

2.1.3 Participants in the Environmental Assessment

The agencies, departments, organizations, and other participants likely to be involved in the environmental assessment process are listed below. The Agency is the federal responsible authority for the Project; however, other federal regulators identified as having a key role or interest in the Project include:

- Fisheries and Oceans Canada (DFO);
- Aboriginal Affairs and Northern Development Canada (AANDC);
- Transport Canada (TC);
- Health Canada (HC);
- Environment Canada;
- Natural Resources Canada (NRCan); and
- Canadian Wildlife Service (CWS).

Provincial regulators identified as having a key role or interest in the Project include the following:

- MOE – EAB;
- MOE – Fish and Wildlife Branch;
- Ministry of Government Relations - First Nations, Métis and Northern Affairs (FNMNA);
- Ministry of Highways and Infrastructure;
- Ministry of Economy (previously known as Ministry of Industry and Resources); and
- Water Security Agency (WSA) (previously known as Saskatchewan Watershed Authority).

Communities for which the Proponent has sought engagement regarding potential or established Aboriginal rights and Treaty rights and related interests that could be affected by the Project include:

- Black Lake Denésuline First Nation;
- Hatchet Lake Denésuline First Nation;
- Fond du Lac Denésuline First Nation;
- Métis Nation – Saskatchewan Northern Region 1, Stony Rapids Local 80;
- Métis Nation – Saskatchewan Northern Region 1, Uranium City Local 50; and
- Métis Nation – Saskatchewan Northern Region 1, Camsell Portage Local 79.

Other agencies, organizations, and groups identified as stakeholders potentially having a potential interest in the Project, and for which engagement has been offered, include:

- Camp Grayling;
- Mayor and Council Northern Hamlet of Stony Rapids;
- Prince Albert Grand Council – Athabasca Region;
- Athabasca Health Authority;
- New North;
- Northern Labour Market Committee (NLMC);
- Athabasca Basin Development - Board of Directors;
- Athabasca Keepers of the Water;
- Canadian Parks and Wilderness Society, Saskatchewan (CPAWS);
- Saskatchewan Environmental Society (SES);
- Regional suppliers;
- local outfitters and resource users;
- uranium industry; and
- regional educations and training institutes.

2.1.4 Regulatory Permitting

Regulatory permitting (i.e., licensing) occurs after environmental assessment approval and includes the submission of specific applications, and supporting design and project management documentation seeking specific construction and operating approvals. Federal and provincial permits, licences, approvals and authorizations that may be required for the Project are listed in Table 2.1-1.

The proponent is aware of recent changes to the *Navigable Waters Protection Act* (*NWPA*). Based on information available, it appears unlikely that a permit under the *NWPA* will be required for construction activity associated with the Fond du Lac River; however, the changes have not yet been proclaimed. As such, the permit has been identified as a potential requirement; further discussions with TC – Navigable Waters Protection may be required.

A Band Council Resolutions (BCR) is required from the Black Lake First Nation (BLFN) Chief and Council to manage activities such as resource management within the BLFN. The proponent is not aware of any other permits, approvals, or authorizations required at the municipal level at this time.

Table 2.1-1: Federal and Provincial Acts and Regulations that May be Required for the Project

Jurisdiction	Related Regulations	Permits Required
Federal Acts		
Canadian Emission Reduction Incentives Agency Act, S.C., 2005, c. 30	■ n/a	■ n/a
Canadian Environmental Assessment Act, 2012, S.C., 2012, c.19, s.52	■ Regulations Designating Physical Activities, SOR/2012-147 ■ Prescribed Information for the Description of a Designated Project Regulations, SOR/2012-148 ■ Cost Recovery Regulations, SOR/2012-146	■ Environmental Assessment Approval
Canadian Environmental Protection Act, 1999, C-15.1	■ Environmental Emergency Regulations, SOR/2003-307 ■ Federal Above Ground Storage Tank Technical Guidelines, P.C. 1996-1233 ■ Federal Halocarbon Regulations, 2003 SOR/2003-289 ■ Federal Underground Storage Tank Guidelines ■ Inter-provincial Movement and Hazardous Waste Regulations, SOR/2002-301 ■ National Pollutant Release Inventory and Municipal Wastewater Services May 2003 ■ Ozone-depleting Substances Regulations, 1998 SOR/99-7	■ n/a
Canadian Water Act, R.S.C., 1985, c. C-11	■ Guidelines for Canadian Drinking Water Quality	■ n/a
Canadian Wildlife Act, R.S.C., 1985, c. W-9	■ Wildlife Area Regulation, C.R.C., c. 1609	■ n/a
The Fisheries Act, R.S.C., 1985, c. F-14 (amended 2012)	■ n/a	■ Authorization For Harmful Alteration or Disruption, or the Destruction of fish habitat (Section 35) ■ As well as requirements under other sections of the act (may include Sections 20, 30, 32, and 36 as the final 2012 changes come into force)
Indian Act R.S.C. 1985, c.I-5	■ Indian Reserve Waste Disposal Regulations, C.R.C., c.960 ■ Indian Timber Regulations C.R.C., c.961 ■ Sand and Gravel Regulations	■ Permit to use land in a reserve for the disposal or storage of waste, or to burn waste on any land in a reserve ■ Licence to cut timber on surrendered lands or on reserve land ■ Lease of Land (Section 53) ■ Access Permit (Section 20)

Table 2.1-1: Federal and Provincial Acts and Regulations that May be Required for the Project (continued)

Jurisdiction	Related Regulations	Permits Required
Federal Acts		
Migratory Birds Convention Act, S.C., 1994, c. 22	■ *Migratory Bird Regulations, 2010 C.R.C., c. 1035*	■ n/a
*Navigable Waters Protection Act, R.S., 1985, C. N-22**	■ n/a	■ Work Approval
Species at Risk Act, S.C. 2002, c. 29	■ n/a	■ n/a
Transportation of Dangerous Goods Act, 1992, C.34	■ Transportation of Dangerous Goods Regulations, SOR/2001-286	■ n/a
Provincial Acts		
The Clean Air Act, S.S. 1986-87-88, C-12.1	■ The Clean Air Regulations, R.R.S c. C-12.1 Reg 1	■ Permit to Construct ■ Permit to Operate
The Environmental Assessment Act, S.S. 1979-80, E-10.1	■ n/a	■ Environmental Assessment Approval
Environmental Management and Protection Act, R.R.S. 2010, c. E-10.22	■ The Environmental Spill Control Regulations, R.R.S c.D-14 Reg 1 ■ The Hazardous Substances and Waste Dangerous Goods Regulations, R.R.S., c. E-10.2, Reg 3 ■ The Water Regulations, 2002, R.R.S. c. E-10.21 Reg 1 ■ Halocarbon Control Regulations, c. E-10.21 Reg 2 ■ Used Oil Collection Regulations, R.R.S., c. E-10.2 Reg 8	■ Hazardous Substances and Waste Dangerous Goods Permit to Construct (Section 10) ■ Hazardous Substances and Wastes Dangerous Goods Permit to Operate (Approval to Store - Section 9) ■ Approval to Construct - Water Works ■ Approval to Operate – Water Works ■ Permit to Construct - Aquatics Habitat Protection Permit
Forest Resources Management Act, 1996, F-19.1	■ The Forest Resources Management Regulations, 1999, F-19.1 Reg 1	■ Forest Product Permit
Fire Prevention Act, S.S. 1992, F-15.001	■ The Saskatchewan Fire Code Regulations, F-15.001 Reg 1 ■ The Fire Insurance Fees and Reporting Regulations, F-15.001 Reg 2	■ n/a
Fisheries Act (Saskatchewan), S.S. 1994, F-16.1	■ The Fisheries Regulations, 1994, F-16.1	■ n/a
The Heritage Property Act, S.S. 1979-80, H-2.2	■ The Heritage Property Regulations, Sask. Reg 279-80	■ n/a

Table 2.1-1: Federal and Provincial Acts and Regulations that May be Required for the Project (continued)

Jurisdiction	Related Regulations	Permits Required
Provincial Acts		
Highways and Transportation Act, S.S. 1987, H-3.01	■ The Controlled Access Highways Regulations, H-3 Reg 7 ■ The Highways and Transportation Regulations, H-3.01 Reg 1 ■ The Erection of Signs Adjacent to Provincial Highways Regulations, 1986	■ Approach Permit ■ Oversize / Overweight permits ■ Roadside Permit ■ Off-premise Sign Application ■ On-premise Sign Application
The Northern Municipalities Act, 2012, N-5.2	■ The Northern Municipalities Regulations, 2011, N-5.2 Reg 1	■ Road Maintenance Agreement
Occupational Health and Safety Act, S.S. 1993, O-1.1	■ Occupational Health and Safety Regulations, 1996, R.R.S., c. O-1 Reg 1	■ n/a
Provincial Lands Act, S.S. 1978, P-31	■ Saskatchewan Wetland Conservation Corporation Land Regulations, 1993, P-31, Reg 14 ■ Crown Resource Land Regulations, P-31, Reg 17 ■ Provincial Lands Regulations, SR145/68	■ n/a
The Water Power Act, R.S.S. 1978, c. W-6 (and/or The Dominion Water Act R.C.S, 1985 c. W-4)	■ SR906/68 - The Regulations governing the administration of *Provincial Water Powers and the Water Power Act*	■ Water Power Licence
The Water Security Agency Act, S.S. 2006, W-8.1th	■ Saskatchewan Watershed Authority Regulations, R.R.S., c. S-35.03 Reg1	■ Water Rights Licence
Weed Control Act, 2010, S.S. W-11.1	■ Weed Control Regulations, W-11.1, Reg 1	■ n/a
Wildlife Act, S.S. 1998, c. W-13.12	■ Wildlife Regulations, W-13.1, Reg 1 ■ Wildlife Management Zones and Special Areas Boundaries Regulations, 1990, W-13.1 Reg 45 ■ Wildlife-Landowner Assistance Regulations, 1981, W-13.1, Reg 48 ■ Wild Species at Risk Regulations, W-13.1 Reg 1	■ n/a
Municipal		
Black Lake First Nation	■ n/a	■ Band Council Resolution

*Act is currently being revised. Changes to the Act had not come into force at the time this table was generated. Changes to the Act will have to be reviewed in context of the Project once additional information is available.
n/a = not applicable

2.1.5 Treaty or Self-government Agreements

In 2009, an Order in Council (OIC; P.C.2009-305) was approved by the Governor General in Council, pursuant to paragraph 39(1)(c), and Section 40 of the *Indian Act* (Government of Canada 1985), designating portions of the Chicken Indian Reserve No. 224, 225, and 226 for exploration and development of minerals, development of a hydroelectric facility, and commercial leasing purposes.

The Project is located within the Chicken Indian Reserve No. 224, which was created under the OIC 1978-1647; that is the land is set aside for the exclusive use and benefit of the members of the BLFN. The area surrounding the Chicken Indian Reserve No. 224 is provincial crown land and accessible to all aboriginal people for the pursuit of traditional and cultural activities. Traditional resource use by the people of this area is a defining feature of their cultures and identities. In addition to hunting/trapping of various wildlife species, traditional land use also includes fishing, and gathering of plants and berries for domestic use.

The Project may have the potential to adversely affect Treaty and Aboriginal rights and the pursuit of traditional land uses. Fish have been a vital part of traditional life in the region and continues to be prepared for consumption based on local cultural practices. Pursuant to Section 5 of the *CEAA 2012*, the potential to affect the ability of aboriginal people to maintain traditional land and resource use must be evaluated. Based on interviews with Aboriginal people residing near the Project, the following animals and plants have been identified as valued species in relation to hunting, trapping, fishing, and gathering for domestic or commercial use:

- birds: Canada goose (*Branta canadensis*), grouse (“chicken”), ptarmigan, and ducks;
- mammals: barren-ground caribou (*Rangifer tarandus groenlandicus*), moose (*Alces alces*), pine marten (*Martes martes)*, muskrat (*Ondatra zibethicus)*, beaver (*Castor canadensis)*, snowshoe hare (*Lepus americanus)*, otter (*Lontra canadensis)*, red fox (*Vulpes vulpes),* black bear (*Ursus americanus*), wolf (*Canis lupus*), and lynx (*Lynx canadensis)*;
- fish: lake whitefish (*Coregonus clupeaformis)*, lake trout (*Salvelinus namaycush*), northern pike (*Esox lucius)*, walleye (*Sander vitreus)*, Arctic grayling (*Thymallus arcticus)*, and suckers; and
- vegetation: blueberries (*Vaccinium spp.)*, bog cranberries (*Vaccinium vitis-ideae)*, wild strawberries (*Fragaria virginiana)*, moss berries (*Vaccinium spp.),* and reindeer lichen (*Cladonia rangiferina)*.

Construction and operation of the Project has the potential to benefit the local, regional, and provincial economy. Direct effects involve the initial expenditures made for the Project. Indirect effects include the secondary business transactions that result from the initial expenditures. Induced effects are third round effects from the spending of incremental labour income in the economy after removing a portion for taxes and savings.

The BLFN played a key role in determining what they would like to see applied with respect to resource management policies. The proponent and BLFN are working together on developing agreements and policies intended to benefit BLFN. Implementation of the Project’s environmental design features and mitigation to decrease potential Project-environment interactions with aquatic and terrestrial components would reduce potential effects to traditional and non-traditional land and resource use activities. For example, to reduce potential effects to local fish and wildlife populations, policies will be in place during construction to prohibit hunting, trapping, harvesting and fishing by non-Band members during construction.

2.1.6 Standards, Guidelines, and Objectives Used in the Environmental Assessment

The objectives, standards, or guidelines used to assist in the evaluation of potential environmental effects are listed in Table 2.1-2.

Table 2.1-2: Standards, Guidelines, and Objectives Used in the Environmental Assessment

Agency or Association	Name of Standard, Guideline or Objectives
National	
Canadian Environmental Assessment Agency	Reference Guide: Determine whether a Project is Likely to Cause Significant Adverse Environmental Effects
Canadian Council of Ministers of the Environment (CCME)	Water Quality Guidelines for the Protection of Aquatic Life
	Canada-Wide Standards for Particulate Matter (PM) and Ozone by Year 2010
Canadian Wildlife Service - Environment Canada	Environmental Assessment Best Practice Guide for Wildlife at Risk in Canada*
Department of Fisheries and Oceans (DFO) Canada	Operational Statements, and Adaptive Management Monitoring and Mitigation Strategies
	Freshwater Intake End-of-Pipe Fish Screen Guidelines
	Fisheries and Oceans Canada Saskatchewan Operational Statement - Timing Windows
	Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters
Transportation Association of Canada	National Guide to Erosion and Sediment Control on Roadway Projects (2005)
Provincial	
Ministry of Environment – Environmental Assessment Branch (MOE-EAB)	Environmental Assessment in Saskatchewan. A High-level overview of the Environmental Assessment Process for Developments within Saskatchewan under the E*nvironmental Assessment Act*. November 2012
Ministry of Environment (MOE)	Activity Restriction Guidelines and Set-back Distances for Wildlife Species
Ministry of Environment (MOE)	Surface Water Quality Objectives
Ministry of Environment (MOE)	Saskatchewan Air Quality Modelling Guideline (2012)
Alberta Utility Commission (AUC)	Rule 012: Noise Control Directive
Ontario Ministry of Environment (Ontario MOE)	Noise Pollution Control (NPC) publication 119 of the Municipal Noise Control By-law
Ontario Waterpower Association (OWA)	Best Management Practices (BMP) Guide for the Mitigation of Impacts of Waterpower Facility Construction

*Listed includes all species that are designated as "at risk", "rare", "endangered", "threatened", "special concern", or otherwise tracked by federal and provincial regulatory agencies.

2.2 References

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2.3 List of Acronyms

Acronym	Definition
AANDC	Aboriginal Affairs and Northern Development Canada
Agency	Canadian Environmental Assessment Agency
BCR	Band Council Resolutions
BLFN	Black Lake First Nation
CCME	Canadian Council of Ministers of the Environment
CEAA	*Canadian Environmental Assessment Act*
CPAWS	Canadian Parks and Wilderness Society, Saskatchewan
CWS	Canadian Wildlife Service
DFO	Fisheries and Oceans Canada
EAB	Environmental Assessment Branch
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
FNMNA	First Nations, Métis and Northern Affairs
HC	Health Canada
MOE	Ministry of Environment
NLMC	Northern Labour Market Committee
NRCan	Natural Resources Canada
NWPA	*Navigable Waters Protection Act*
Project	Tazi Twé Hydroelectric Project
SARA	*Species at Risk Act*
SEAA	*Saskatchewan Environmental Assessment Act*
SEARP	Saskatchewan Environmental Assessment Review Panel
SES	Saskatchewan Environmental Society
TC	Transport Canada
TOR	Terms of Reference
WSA	Water Security Agency

3.0 ENVIRONMENTAL SETTING

3.1 Introduction

This section presents and overall summary of the existing environment of the Tazi Twé Project (Project). The Project location is shown in Figure 3.1-1. The Universal Transverse Mercator (UTM) coordinates of the power house, which is a permanent feature through to the end of operations, are Zone 13 468,874 metres (m) Easting 6,560,529 m Northing. Each discipline section in this Environmental Impact Statement (EIS) provides a high-level summary of the Project's existing environment information and the detailed methods and results are provided in the baseline annexes.

3.2 Climate and Meteorology

The Black Lake area has a subarctic continental climate with short, cool summers and long, very cold winters. Seasonal and daily air temperatures can range by tens of degrees Celsius (°C); while the underlying processes of energy exchange and transformation occur within and between air, soil, snow pack, and surface waters. Precipitation (including snowfall) and evaporation (including evapotranspiration and sublimation) govern the availability of moisture in the environment. Wind influences microclimate over the landscape and enhances evaporation and blowing snow.

The communities of Stony Rapids and Black Lake experience extreme seasonal temperature variations. In the summer, mean maximum daily air temperatures reach a July high of 22.7°C, while in January mean minimum temperatures are as low as -30°C (Environment Canada 2013). The mean annual temperature is -3.4°C. Mean annual precipitation at Stony Rapids is 424 millimetres (mm) with 66 percent (%) of the precipitation occurring as rainfall during the spring, summer, and fall (Environment Canada 2013). Annually and seasonally, most winds come from the southwest or northwest with some variability in their strength among the seasons. Seasonally, winds have the highest average speeds in spring (18.6 +/- 10.0 kilometres per hour [km/h]), and lowest speeds in summer (14.5 +/- 8.5 km/h).

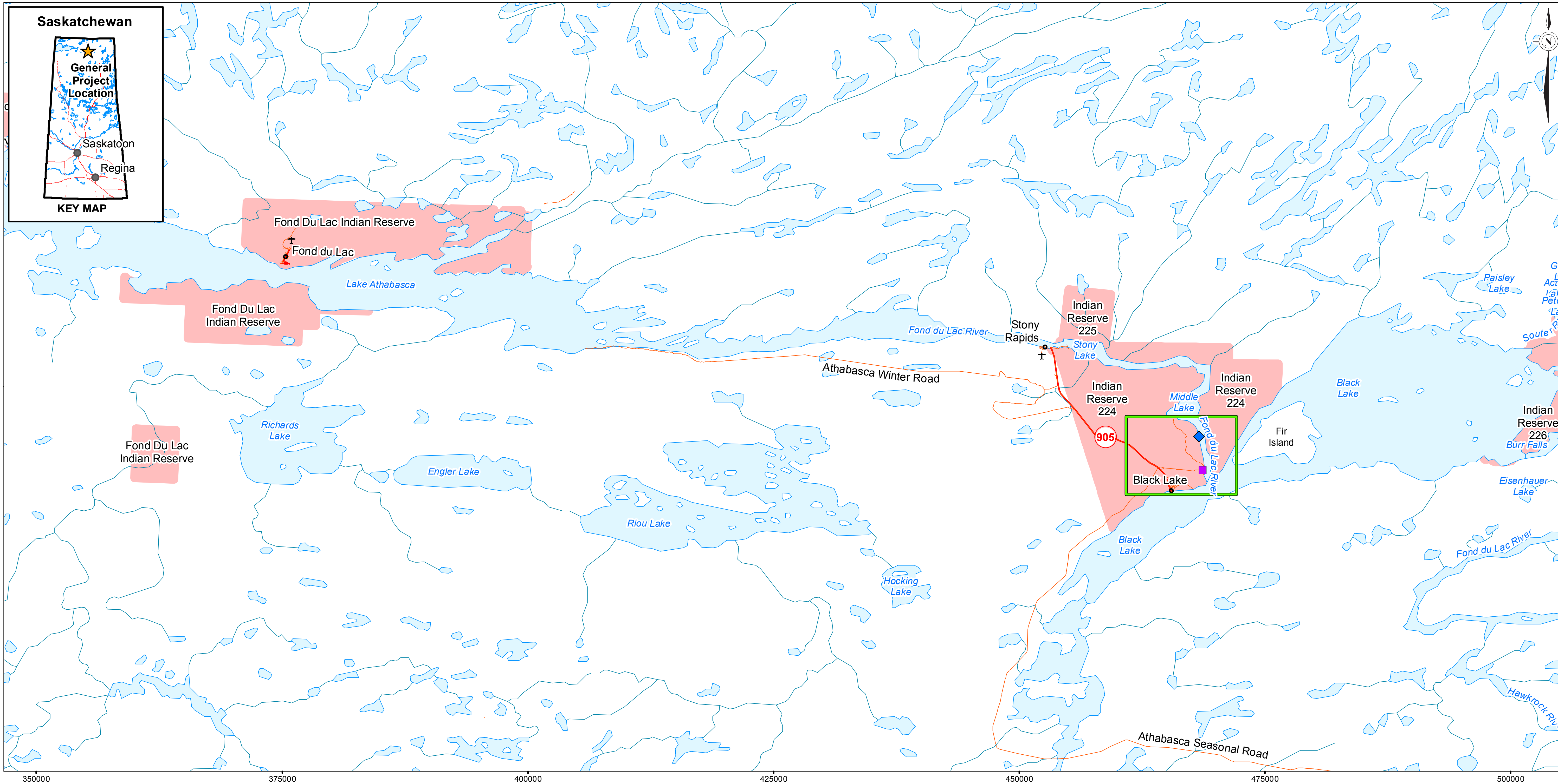
3.3 Geology

The bedrock in the area consists of Precambrian age crystalline gneiss complex and the Athabasca Formation (e.g., conglomerates and sandstones) to the east and west of the Fond du Lac River, respectively. The topography surrounding the Project primarily is bedrock-controlled with low to moderate relief. The area forms part of the Lake Athabasca drainage basin.

3.3.1 Bedrock Geology

The bedrock east of the Fond du Lac River includes Precambrian age metamorphic rocks. This includes blocks of ancient continental crust, each bounded by faults, and younger metamorphosed volcanic and sedimentary rock. Mid-Proterozoic sedimentary rocks of the Athabasca Group of the Athabasca Basin underlie most of the area west of the Fond du Lac River. These consist of sandstone, conglomerate, and siltstone deposited about 1.7 billion years ago in an inland sea over older Precambrian basement rocks (Acton et al. 1998).

Two geologically distinct formations are recognized in the area: a hybrid Gneiss complex of the Tantato Domain and Athabasca Group sedimentary rocks. A prominent unconformity along the eastern shore of Black Lake (Black Lake Shear Zone) separates these two formations at the east end of the Project site. The Black Lake shear zone strikes northeast with the Black Lake Fault forming the north shore of Black Lake.



LEGEND

- VILLAGE
- RUNWAY
- RIVER
- HIGHWAY
- ROAD
- WATERBODY
- INDIAN RESERVE
- ELIZABETH FALLS
- CAMP GRAYLING
- PERMANENT RESIDENCE'S CABIN
- GENERAL PROJECT LOCATION

10 0 10

SCALE 1:400,000 KILOMETRES

REFERENCE

DMTI HIGHWAYS AND ROADS
NTS MAPSHEET 74I, 74J, 74O, 74P
DATUM: NAD 83 PROJECTION: UTM ZONE 13

PROJECT	TAZI TWÉ HYDROELECTRIC PROJECT			
TITLE	PROJECT LOCATION			
PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 1
GIS	SM/LR	12/12/12		
CHECK	MT	12/12/12	FIGURE: 3.1-1	
REVIEW	BC	12/12/12		

Tazi Twé Hydroelectric Project

3.3.2 Surficial Geology

The topography surrounding Elizabeth Falls is primarily bedrock controlled with low to moderate relief. The area forms part of the Lake Athabasca drainage basin. Most of the prominent landforms in the area result from glacial action. To the east of the Fond du Lac River (Tazin Lake Upland Ecoregion), ancient Precambrian rocks, rising more than 100 metres (m) above the surrounding terrain, create a rugged, almost mountainous landscape. Upland elevations are dominated by bedrock exposures with discontinuous veneers of sandy till and the lowlands are covered by a thin layer of level to gently undulating till deposits. To the west of the Fond du Lac River (Athabasca Plain Ecoregion), landscapes formed on flat-lying sandstone bedrock and sandy glaciofluvial deposits; there are fewer lakes and wetlands than to the east. Prominent features include eskers, flutings, and drumlins, which mark the northeast-southwest direction of ice movement during the last glaciation. A terrace deposit on the west side of Black Lake (approximately 100 m wide and 2.5 km in length) is characterized by talus and glacial sand deposits.

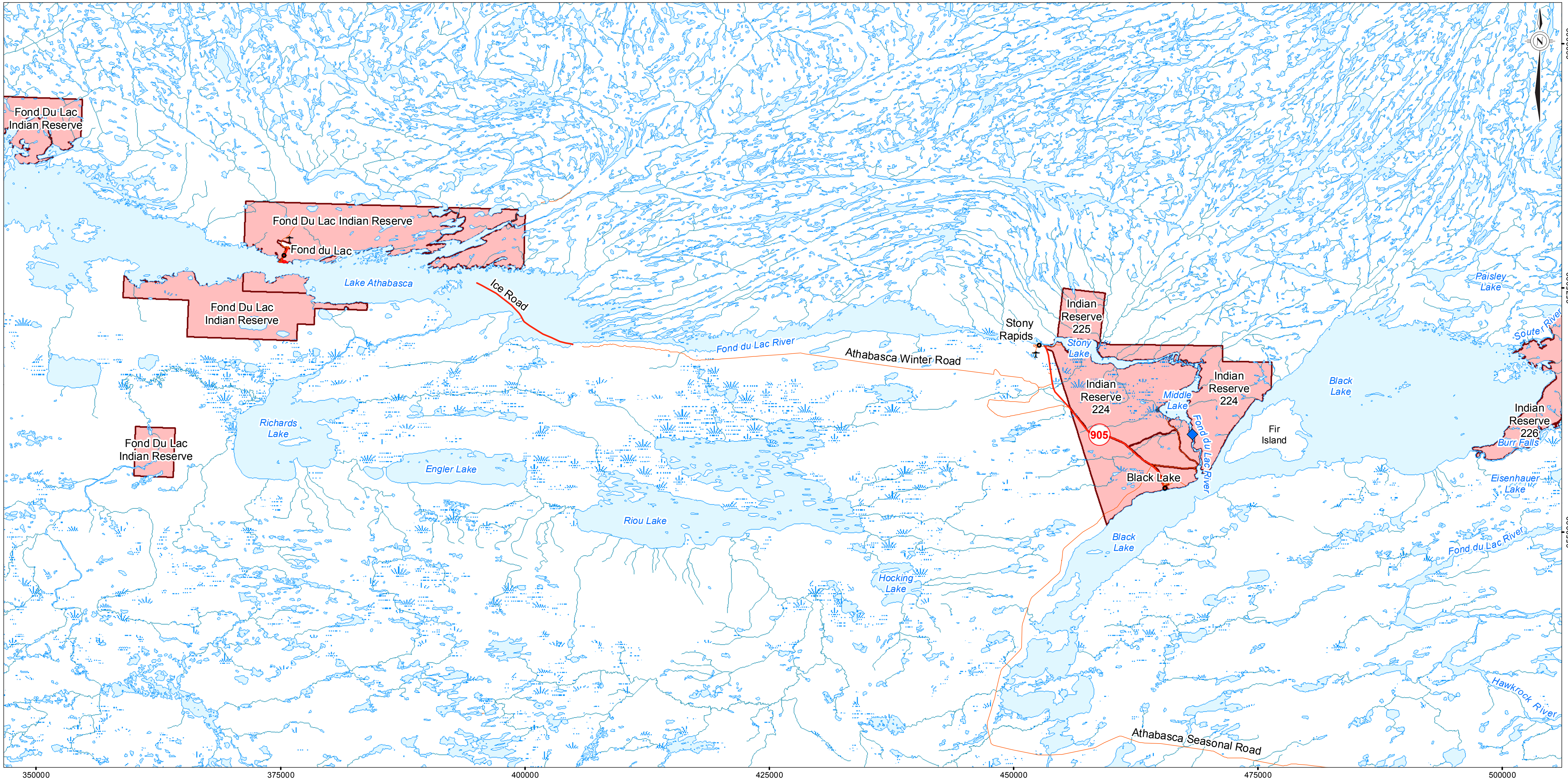
3.4 Hydrogeology

Precambrian bedrock formations in Saskatchewan do not readily permit groundwater flow, except as fracture flow (i.e., from high elevation areas towards Black Lake, Fond du Lac River, and Middle Lake). The Tazin Lake Upland Ecoregion has discontinuous sandy and boulder glacial deposits, so active groundwater flow generally is confined to localized shallow fracture systems and flow directions are likely similar to the topographic grade. The supply of groundwater is limited by the widespread distribution of permafrost. The sandstone bedrock and the overlying glacial deposits in the Athabasca Plain Ecoregion are highly permeable so groundwater flows easily.

3.5 Hydrology

The river systems in the forested zone of Saskatchewan tend to consist of networks of lakes connected by fast-flowing, short stretches of stream (Pomeroy et al. 2005). The Project is located on the Fond du Lac River in the Athabasca River basin of Northern Saskatchewan, between Black Lake and Middle Lake. The Project is located on the Fond du Lac River between Black Lake and Middle Lake (Figure 3.5-1).

Black Lake is at the upstream end of the Project with outflows discharging from the lake down the Fond du Lac River and eventually into Lake Athabasca, approximately 50 km downstream of the Project. Black Lake has three notable inflows: the Fond du Lac River, the Cree River, the Chipman River; and one outflow: the Fond du Lac River. The Chipman River flows from the north and enters Black Lake at its most northern point. The Cree River enters Black Lake from the south; the Fond du Lac River, carrying the largest inflow, enters Black Lake from the east with headwaters upstream of Wollaston Lake.



LEGEND

VILLAGE	ELIZABETH FALLS
HIGHWAY	
ROAD	
RIVER	
WETLAND	
WATERBODY	
INDIAN RESERVE	

REFERENCE

DMTI HIGHWAYS AND ROADS
NTS MAPSHEET 74I, 74J, 74O, 74P
DATUM: NAD 83 PROJECTION: UTM ZONE 13

10 0 10
SCALE 1:400,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROLELECTRIC PROJECT

TITLE

SURFACE WATER

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 2
GIS	SM/LR	10/07/13	**FIGURE: 3.5-1**	
CHECK	LJ	25/07/13		
REVIEW	BC	25/07/13		

Black Lake has two main sections, one to the southwest of the outflow and a larger section to the northeast. The southwest section is approximately 25 km long and has a maximum width of less than 5 km, while the northeast section is approximately 40 km long and has a maximum width of less than 20 km. Black Lake has a total surface area of 418 km^2 and has a maximum depth of about 58 m. Middle Lake is a widening of the Fond du Lac River before the river continues toward Lake Athabasca. Middle Lake has a total surface area of 7.5 km^2 and a maximum depth of about 14 m. At the outlet of Black Lake, the Fond du Lac River has an upstream drainage area of 50,800 square kilometres (km^2) and receives minimal additional runoff from an area of 10.6 km^2 to the inflow of Middle Lake. The Fond du Lac River between Black Lake and Middle Lake has a total length of 6.1 km and a total change in elevation of approximately 36 m. From 1963 to 2011, the Fond du Lac River had an average flow rate of 304 cubic metres per second (m^3/s), a maximum flow rate of 860 m^3/s, and a minimum flow rate of 114 m^3/s.

The upland area is largely devoid of surface water, with the exception of 0.2 km^2 of small ponds, 9.5 km^2 of wetland areas, and 15 km of streams. There are three streams in the upland area, the largest of which drains an area of 80.5 km^2 and flows into the south end of Middle Lake.

3.6 Fish and Fish Habitat

Lake trout (*Salvelinus namaycush*), Arctic grayling (*Thymallus arcticus*), lake whitefish (*Coregonus clupeaformis*), walleye (*Sander vitreus*), and northern pike (*Esox lucius*) are found in the cold waters of the Tazin Lake Upland ecoregion. In the Athabasca Plain ecoregion cold-water species such as lake trout, Arctic grayling, lake whitefish, northern pike, and walleye are common. Overall, there is a low level of fish species richness in the Tazin Lake Upland Ecoregion and a moderately low level in the Athabasca Plain Ecoregion.

Fish and fish habitat surveys were completed in Black Lake, Fond du Lac River (between Black Lake and Middle Lake), and Middle Lake between June 2010 and July 2012. During the fish habitat mapping and assessments 16 fish species were captured in Black Lake (Table 3.6-1), 12 fish species were captured in the Fond du Lac River between Black Lake and Middle Lake (Table 3.6-2), and 9 fish species were captured in Middle Lake (Table 3.6-3). A full discussion of the results of these surveys is presented in Annex III and in Section 12.0 of this EIS.

Deep, fast-flowing runs, rapids, deep pools, and waterfalls are the most common type of habitat in the Fond du Lac River between the Black Lake outflow and the Middle Lake inflow. Flat-water habitat is most abundant in the Middle Lake outflow area. Barriers or potential barriers to upstream fish migration include Elizabeth Falls and two additional waterfall-type habitats.

Table 3.6-1: Fish Species Captured in Black Lake from May 2010 to February 2011

Common Name	Scientific Name	Total Number Captured
Arctic grayling	*Thymallus arcticus*	46
burbot	*Lota lota*	112
cisco	*Coregonus artedi*	9
lake chub	*Couesius plumbeus*	130
lake trout	*Salvelinus namaycush*	505
lake whitefish	*Coregonus clupeaformis*	272
longnose sucker	*Catostomus catostomus*	267
ninespine stickleback	*Pungitius pungitius*	13
northern pike	*Esox lucius*	45
round whitefish	*Prosopium cylindraceum*	16
slimy sculpin	*Cottus cognatus*	86
spottail shiner	*Notropsis hudsonius*	6
trout-perch	*Percopsis omiscomaycus*	7
walleye	*Sander vitreus*	24
white sucker	*Catostomus commersonii*	372
yellow perch	*Perca flavescens*	6

Table 3.6-2: Fish Species Captured in the Fond du Lac River from May to October 2010 and in July 2012

Common Name	Scientific Name	Total Captured		
		Upstream (Black Lake Outflow)	Downstream (Middle Lake Inflow)	Middle Section (Fond du Lac River)
Arctic grayling	*Thymallus arcticus*	1,161	695	5
burbot	*Lota lota*	1	15	0
longnose sucker	*Catostomus catostomus*	1	282	1
white sucker	*Catostomus commersonii*	45	168	1
lake whitefish	*Coregonus clupeaformis*	0	18	1
round whitefish	*Prosopium cylindraceum*	0	0	5
cisco	*Coregonus artedi*	0	24	0
northern pike	*Esox lucius*	0	9	0
walleye	*Sander vitreus*	1	3	2
slimy sculpin	*Cottus cognatus*	1	573	0
spottail shiner	*Notropsis hudsonius*	0	12	0
trout-perch	*Percopsis omiscomaycus*	0	1	0

Table 3.6-3: Fish Species Captured in Middle Lake from May 2010 to February 2011

Common Name	Scientific Name	Total Number Captured
Arctic grayling	*Thymallus arcticus*	7
burbot	*Lota lota*	25
lake chub	*Couesius plumbeus*	4
lake whitefish	*Coregonus clupeaformis*	34
longnose sucker	*Catostomus catostomus*	23
ninespine stickleback	*Pungitius pungitius*	28
northern pike	*Esox lucius*	49
slimy sculpin	*Cottus cognatus*	31
white sucker	*Catostomus commersonii*	50

The shoreline of Black Lake near the proposed water intake is relatively homogeneous, dominated by a cobble and boulder shelf that extends out from shore a short distance (about 50 m), before dropping off abruptly into 25 to 30 m of water. Along the shelf, the substrate size increases as the depth increases and becomes boulder dominant at the drop-off. At depths of 25 to 30 m, the bottom levels out with a finer sand/silt substrate. Fish sampling efforts completed in this area suggest that the large cobble and boulder substrate along the shelf provides suitable cover for small-bodied fish including lake chub and juvenile large-bodied fish including yellow perch (*Perca flavescens*). The habitat along the steep drop-off was found to support a variety of adult large-bodied fish including cisco (*Coregonus artedi*), lake trout, round whitefish (*Prosopium cylindraceum*), lake whitefish, longnose sucker (*Catostomus catostomus*), white sucker (*Catostomus commersonii*), and walleye. Areas of emergent vegetation were present along the shoreline and the terrestrial shoreline vegetation near the water intake consisted predominantly of low shrubs.

The tailrace outlet bay is located just upstream of Middle Lake. This area is composed of a large slack water area along the east shore and an area with faster flows along the downstream outlet of the bay. The bay is characterized by slack water resulting in a predominantly sand and silt substrate. The bay contains large woody debris and emergent vegetation around its perimeter. The mouth of the bay is exposed to river currents, and, as a result, is dominated by gravel, cobble, and boulder substrates. Fish sampling in the bay found northern pike and whitefish in the slack water and Arctic grayling in the faster flows near the mouth of the bay.

3.7 Terrain and Soils

The Project is situated on a transitional area between the boundaries of two Ecoregions that are separated by the Fond du Lac River. The Athabasca Plain Ecoregion is on the west side of the Fond du Lac River and the Tazin Lake Upland Ecoregion is on the east side of the river (Acton et al. 1998). The Athabasca Plain Ecoregion is characterized by glaciofluvial deposits, varying from homogeneous deposits of fine sand to heterogeneous deposits of sand and cobble. Brunisolic soils (i.e., forest soils with brownish coloured B horizons) typically form on these glaciofluvial deposits. Gleyed Brunisolic soils, Gleysolic soils (i.e., water saturated mineral soils), and Organic soils occur in low-lying and poorly drained areas.

Steep bedrock outcrops characterize the Tazin Lake Upland Ecoregion. Mineral and organic soils occur on nearly level bedrock surfaces and in mid to lower slopes of gently inclined bedrock faces. Organic soils exist on boulder glacial till and bedrock. Brunisolic soils are found on thin deposits of sand and boulder glacial till that is underlain by bedrock. Gleysolic and Organic soils occur in low lying and poorly drained areas.

Mineral soils identified during the baseline field program included Brunisolic (15 total), Gleysolic (11 total, 3 of which were peaty phase), Regosolic (3 total), and Podzolic (1 total) soils. Soils at 11 locations were classified as Organic. Eleven of the sites surveyed were identified as Bedrock (classified as a non-soil). Soils classified within the Brunisolic Order include Eluviated Eutric Brunisol, Eluviated Dystric Brunisol, Gleyed Eluviated Brunisol, and Orthic Dystric Brunisol. The Podzolic soil was classified as an Orthic Humo-Ferric Podzol. Regosolic soils include Orthic Regosol and Cumulic Regosol. Gleysolic soils included Rego Gleysol, Orthic Gleysol, peaty phase Rego Gleysol, and peaty phase Orthic Gleysol. Organic soils identified included Terric Mesisol, Typic Fibrisol, Terric Fibrisol, Hydric Fibrisol, and Hemic Folisol.

3.8 Vegetation

The east side of the Fond du Lac River is characterized by forests of black spruce (*Picea mariana*), but because fire is a frequent occurrence in the area, forests of jack pine (*Pinus banksiana*) are common (Acton et al. 1998). White spruce (*Picea glauca*) tends to occur along the margins of fens and marshes, and stands of trembling aspen (*Populus tremuloides*) typically occupy low, sheltered areas. The characteristic vegetation on the west side of the Fond du Lac River is open jack pine forest that develops on the sandy glaciofluvial sediments present in the area (Acton et al. 1998). Stands of mixedwood containing species such as black spruce, jack pine, and white birch (*Betula papyrifera*) are also common. Riparian areas typically contain black spruce, jack pine, and white birch, as well as alders (*Alnus* species) and willow (*Salix* species). Wetlands are typically dominated with black spruce, with tamarack (*Larix laricina*) and dwarf birch (*Betula pumila*) frequently intermixed with the black spruce in these areas.

Field surveys were completed at different times during the growing seasons in 2010 and 2012 to capture an inventory of both early and late flowering species. Field survey information was used to characterize and to map vegetation types (i.e., ecological landscape classification [ELC] map units), compile a vegetation inventory of observed species in each vegetation map unit, and document the presence of listed and traditional use species identified during the surveys.

3.8.1 Listed Plant Species

Sixteen provincially listed vascular plant species have been historically or recently documented within the area surrounding the Project site (Saskatchewan Conservation Data Centre [SKCDC] 2012). Two historical and seven current listed plant observation locations occur in the immediate vicinity of the Project. Lake Huron tansy (*Tanacetum bipinnatum* ssp. *huronense* [syn. *Tanacetum huronense* var. *floccosum*]), a historical observation near the Project, is listed as Special Concern under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (2012) and as Special Concern under Schedule 1 of the *Species at Risk Act* (*SARA)* (2012). This species is not identified as a provincial wild species at risk under the *Wildlife Act* (1998) and was not observed during the 2010 and 2012 field programs. Forty-four provincially listed lichen species were documented in the Project area; however, these were widely distributed throughout the area (SKCDC 2102).

Six provincially listed forbs and one listed graminoid were documented during the 2010 and 2012 field programs. These species included ground-fir (*Diphasiastrum sitchense* [syn. *Lycopodium sitchense*]), limestone oak fern (*Gymnocarpium jessoense* ssp. *parvulum*), alternate-flowered water milfoil (*Myriophyllum alterniflorum*), Labrador lousewort (*Pedicularis labradorica*), hairy butterwort (*Pinguicula villosa*), mountain woodsia (*Woodsia scopulina*), and Russet sedge (*Carex saxatilis* [syn. *Carex saxatilis* var. *rhomalea*]). No COSEWIC, *SARA, or Wildlife Act* listed species were observed during the 2010 and 2012 field surveys.

Because a plant survey cannot confirm the absence of listed plants, the plant communities present in the area were rated for their potential to contain habitat suitable for listed plant species (i.e., based on growing condition indicators or plant associations). The listed plant habitat potential of the area to the east of the Fond du Lac River has a predominantly moderate to low potential to contain listed plant species. This is because of the regenerating forest habitats that were affected by fire in 1989; however, early serial listed species could occur if growing conditions are optimal. Localized areas that have high potential to contain listed species are present. The area to the west of the Fond du Lac River has a predominantly moderate to high potential to contain listed plant species, with the exception of those areas associated with the regenerating forest (1996 fire), and the existing disturbance areas (e.g., Black Lake, trails, and roads).

3.8.2 Traditional Use Plants

There are many traditional uses of forest plant species. Most traditional use plants are harvested for food, medicine, and tools. Gathered goods such as berries, herbs, mushrooms, and medicinal plants are used for local trade, sale, or gifts (Athabasca Land Use Planning Interim Advisory Panel 2003). Currently, gathering for domestic use is mainly for berries, particularly blueberries (*Vaccinium* spp.), bog cranberries (*Vaccinium vitis-ideae*), moss berries (*Vaccinium* spp.), and strawberries (*Fragaria virginiana*), as well as other edible vegetation, such as mushrooms, when available (Black Lake and Stony Rapids KPI Program 2012).

Many traditional use plants such as black spruce, willow, crowberry (*Empetrium nigrum*), bog cranberry, Labrador tea (*Rhododendron groenlandicum* [syn. *Ledum groenlandicum*]), and prickly rose (*Rosa acicularis*) are commonly found in many different plant communities. However, there are a few traditional use species, such as acerbic bulrush (*Schoenoplectus acutus*) and tamarack, which are more restricted in their distribution and tend to be associated only with a few plant community types; however, these species typically are abundant within those plant communities. Vegetation types were assessed for potential to support traditional use plants. Field survey results and habitat preference of traditional use plants were used to determine the potential of each ELC map unit to support traditional use plants.

3.9 Wildlife

Wildlife species represent an integral part of the terrestrial environment and many species have important cultural, social, or economic value. Wildlife populations and diversity are low in the Athabasca Plain Ecoregion compared to elsewhere in the Shield. Localized populations of moose (*Alces alces*), black bear (*Ursus americanus*), and grey wolf (*Canis lupus*) are most prominent. Barren-ground caribou (*Rangifer tarandus groenlandicus*) and arctic fox (*Vulpes lagopus*) occasionally overwinter in the area. Other wildlife in the area also include woodland caribou (*Rangifer tarandus caribou*), lynx (*Lynx lynx*), beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), snowshoe hare (*Lepus americanus*), waterfowl (including ducks, geese, pelicans [*Pelecanus* spp.], and sandhill cranes [*Grus canadensis*]), grouse, and other birds (Acton et al. 1998).

Black bear, wolverine (*Gulo gulo*), moose, and grey wolf inhabit the Tazin Lake Upland Ecoregion and migratory barren-ground caribou and arctic fox sometimes enter the region during winter. Birds of this region include red-throated loon (*Gavia stellata*), greater yellowlegs (*Tringa melanoleuca*), white-crowned sparrow (*Zonotrichia leucophrys*), and golden eagle (*Aquila chrysaetos*), with willow ptarmigan (*Lagopus lagopus*) appearing during winter (Acton et al. 1998).

Baseline wildlife surveys were completed in 2012 to determine available habitat types and the abundance and diversity of wildlife species present in the area (Table 3.9-1). A full discussion of the survey results is presented in Annex IV and Section 15.0 of this EIS.

Table 3.9-1: Wildlife Species Observed During 2012 Surveys

Common Name	Scientific Name	Common Name	Scientific Name
Mammals			
American marten	*Martes americana*	Muskrat	*Ondatra zibethicus*
Beaver	*Castor canadensis*	Red fox	*Vulpes vulpes*
Black bear	*Ursus americanus*	Red squirrel	*Tamiasciurus hudsonicus*
Canada lynx	*Lynx canadensis)*	River otter	*Lontra canadensis*
Fisher	*Martes pennanti*	Snowshoe hare	*Lepus americanus*
Grey wolf	*Canis lupus*	Vole species	*Microtus* spp.
Mink	*Neovison vison*	Weasel species	*Mustela* spp.
Moose	*Alces alces*	Wolverine	*Gulo gulo*
Mouse species	*Peromyscus* spp.		
Upland Breeding Birds			
Alder flycatcher	*Empidonax alnorum*	Northern flicker	*Colaptes auritus*
American crow	*Corvus brachyrhynchos*	Northern waterthrush	*Seiurus noveboracensis*
American redstart	*Setophaga ruticilla*	Olive-sided flycatcher	*Contopus cooperi*
American robin	*Turdus migratorius*	Orange-crowned warbler	*Vermivora celata*
Bay-breasted warbler	*Dendroica castanea*	Palm warbler	*Dendroica palmarum*
Black-backed woodpecker	*Picoides arcticus*	Pine siskin	*Carduelis pinus*
Black-capped chickadee	*Poecile atricapilla*	Ptarmigan species	*Lagopus muta or L. lagopus*
Blackpoll warbler	*Dendroica striata*	Red crossbill	*Loxia curvirostra*
Blue-headed vireo	*Vireo solitarius*	Red-eyed vireo	*Vireo olivaceus*
Boreal chickadee	*Poecile hudsonica*	Ruby-crowned kinglet	*Regulus calendula*
Cape May warbler	*Dendroica tigrina*	Savannah sparrow	*Passerculus sandwichensis*
Cedar waxwing	*Bombycilla cedorum*	Song sparrow	*Melospiza melodia*
Chipping sparrow	*Spizella passerina*	Swainson's thrush	*Catharus ustulatus*
Common redpoll	*Carduelis flammea*	Swamp sparrow	*Melospiza georgiana*

Table 3.9-1: Wildlife Species Observed During 2012 Surveys (continued)

Common Name	Scientific Name	Common Name	Scientific Name
Upland Breeding Birds (continued)			
Dark-eyed junco	*Junco hyemalis*	Tennessee warbler	*Vermivora peregrina*
Fox sparrow	*Passerella iliaca*	Tree swallow	*Tachycineta bicolor*
Gray jay	*Perisoreus canadensis*	Vesper sparrow	*Pooecetes gramineus*
Grouse species	*Bonasa umbellus, Tympanuchus phaisianellus, or Falcipennis canadensis*	White-throated sparrow	*Zonotrichia albicollis*
Hairy woodpecker	*Picoides villosus*	Wilson's warbler	*Wilsonia pusilla*
Hermit thrush	*Catharus guttatus*	Winter wren	*Troglodytes troglodytes*
Least flycatcher	*Empidonax minimus*	Yellow warbler	*Dendroica petechia*
Lincoln's sparrow	*Melospiza lincolnii*	Yellow-bellied sapsucker	*Sphyrapicus varius*
Magnolia warbler	*Dendroica magnolia*	Yellow-rumped warbler	*Dendroica coronata*
Nashville warbler	*Vermivora ruficapilla*	-	-
Waterbird Species			
American widgeon	*Anas americana*	Mallard	*Anas platyrhynchos*
Belted kingfisher	*Megaceryle alcyon*	Merganser species	*Mergus merganser* or *M. serrator*
Blue-winged teal	*Anas discors*	Northern pintail	*Anas acuta*
Bonaparte’s gull	*Larus philadelphia*	Northern shoveler	*Anas clypeata*
Bufflehead	*Bucephala albeola*	Sandhill crane	*Grus canadensis*
Canada goose	*Branta canadensis*	Surf scoter	*Melanitta perspicillata*
Common goldeneye	*Bucephala clangula*	Swan species	*Cygnus buccinator or C columbianus*
Common tern	*Sterna hirundo*	White-winged scoter	*Melanitta fusca*
Gull species	*Larus canus*, *L. delawarensis*, *L. californicus*, or *L. argentatus*	-	-
Raptors			
Bald eagle	*Haliaeetus leucocephalus*	Osprey	*Pandion haliaetus*
Merlin	*Falco columbarius*	Red-tailed hawk	*Buteo jamaicensis*
Northern harrier	*Circus cyaneus*	Sharp-shinned hawk	*Accipiter striatus*
Amphibians			
Boreal chorus frog	*Pseudacris maculata*	Wood frog	*Rana sylvatica*

3.9.1 Listed Wildlife Species

Twenty-eight provincial and federal listed species have the potential to occur in the area. Three provincially tracked species, two COSEWIC-recommended species, and one *SARA*-listed species were observed during wildlife baseline surveys in 2012. The *SARA*-listed species observed was olive-sided flycatcher (*Contopus cooperi*). Horned grebe (*Podiceps auritus*) and wolverine are COSEWIC listed species that were observed. Bald eagle (*Haliaeetus leucocephalus*), sandhill crane, and an unknown swan species are provincially tracked species. Tundra swan (*Cygnus columbianus*) and trumpeter swan (*Cygnus buccinator*) are both provincially tracked species.

3.9.2 Traditional and Non-traditional Use of Wildlife Species

Traditional use of species in the area includes hunting of wolf, black bear, and moose and trapping of smaller mammals such as American marten, snowshoe hare, and red squirrel (*Tamiasciurus hudsonicus*). The Project is located within the wildlife management zone (WMZ) 76, in which non-traditional use of wildlife species are managed. There are two black bear hunting seasons in WMZ 76: April 15 to June 30, and August 25 to October 14. One bear, of either sex, can be taken by resident and non-resident hunters; only female bears with young-of-year cubs cannot be hunted. Moose can be hunted, by residents and non-residents, between September 1 and November 30; one bull moose can be taken per person.

Snow geese (*Chen caerulescens*) can be hunted between April 1 and May 31. Snow geese, Canada geese (*Branta canadensis*), and sandhill cranes can be hunted from September 1 to December 16. Ducks, American coots, and Wilson's snipes (*Gallinago delicata*) can be hunted between September 1 and December 16, and ptarmigan species can be hunted from November 1 to March 31. Sharp-tailed grouse, ruffed grouse, and spruce grouse can be hunted from September 15 to December 7.

3.10 Heritage Resources

Historical archaeological remains can be found in northern Saskatchewan. Early travelers, such as Samuel Hearne, Peter Pond, Alexander Mackenzie, David Thompson, Richard King, George Back, Charles Camsell, and Joseph Tyrell, contributed to the survey and mapping of the extreme north of Saskatchewan (Fung 1999). David Thompson is considered the first explorer to pass through the Black Lake area (Minni 1975). Sent by the Hudson Bay Company (HBC) to find a shorter route to the Athabasca country, Thompson ascended the Churchill and Reindeer Rivers to Reindeer Lake in 1796, then crossed to Wollaston Lake and up Black River to the east end of Lake Athabasca (i.e., a more direct route to the Athabasca country than previously used by HBC). Many northern communities came into existence following the establishment of the fur trade in this area (Fung 1999).

A number of archaeological surveys have been carried out in the region. The most relevant archaeological work in relation to the current Project was completed in the 1970s and 68 heritage resources were identified around Black Lake, Middle Lake, Stony Lake, and the Fond du Lac River. In 2012, archaeological baseline work related to the currently proposed Project was completed. Assessments were carried out along the Fond du Lac River, the west shore of Black Lake and the south shore of Middle Lake under Archaeological Resource Investigation Permit No. 12-1445. A full discussion of these survey results is presented in Annex V and Section 16.0 of this EIS. No new Heritage Resources were identified during the assessment; however, four of the eight previously recorded heritage resources were successfully identified. These heritage resources were originally recorded by Sheila Minni as part of her 1972 and 1974 studies.

Six of the known heritage resources consisted of small Precontact lithic find and scatters, two of which contained diagnostic tools. These included a distinct microblade typical of the Arctic Small Tool Tradition that dates from approximately 3,500 to 2,600 Before Present (BP), and a diagnostic Early Taltheilei point suggested dates from 2,600 to 1,800 BP. The remaining two heritage resources were historical Dené sites that included a cemetery immediately northwest of Camp Grayling dating from the late nineteenth to mid-twentieth centuries, and a campsite and single grave located on Middle Lake also suggested to date from the late nineteenth century, through to contemporary times.

As part of the 2012 baseline studies, attempts were made to revisit the known heritage resources recorded along the Fond du Lac River and Middle Lake. Four of these heritage resources were successfully identified but the remaining four sites could not be positively identified. None of the known heritage resources is in conflict with the Project footprint. The cemetery is the heritage resource nearest to a Project component. It is located within 60 m of an existing road extending north from Camp Grayling.

3.11 Land Use

The Dené ("People of the Barrens") and their ancestors have lived in northern Saskatchewan, particularly in the Athabasca region, for an estimated 8,000 years (Meyer 1981). Prior to settlement in contemporary First Nation communities, the Dené had a subsistence economy based on the barren-ground caribou. Following contact with European peoples, HBC encouraged the Dené people to move into the boreal forest so they could assist with the fur trade (Gillespie 1976). Today, residents of the Black Lake First Nation (BLFN) use an expansive region, including areas of the Northwest Territories, for traditional land and resource use.

The Project is located within the Chicken Indian Reserve No. 224. The Chicken Indian Reserve No. 224 was created under the Order in Council (OIC) 1978-1647; that is the land is set aside for the exclusive use and benefit of the members of the BLFN. The area surrounding the Chicken Indian Reserve No. 224 is provincial crown land and accessible to all aboriginal people for the pursuit of traditional and cultural activities. The BLFN have identified specific lands as their traditional territory, including Fur Blocks N-24 and N-80, as well as north beyond present-day settlements and the border of Saskatchewan and the NWT traditional territory (Black Lake and Stony Rapids KPI Program 2011-2013).

Traditional resource use by the people of this area is a defining feature of their culture and identity. Trapping continues to be an important activity for some Black Lake community members, particularly for elders who have spent considerably more of their lives living on the land. Residents of the region consider caribou a very important species and most hunting for caribou by residents of BLFN takes place outside of the Project area, in the northern reaches of Saskatchewan and into the Northwest Territories. While barren-ground caribou is considered a very important species hunted by residents of the region, moose, black bear, and waterfowl, such as ducks and geese, also are hunted.

Forest fires have limited hunting and other resource use in the Project area. However, since the forest started to regenerate, small mammals, moose and birds have returned and some hunting, trapping, and snaring occurs in the region. In addition, burned and regenerating areas around Middle Lake and on Fir Island in Black Lake support several plant species, particularly berries. Blueberries, bog cranberries, moss berries, and strawberries are gathered by community members for domestic use, such as jam production and freezing, from mid-summer to late fall.

Fish have been a vital part of traditional life in the region and continue to be an important food source for members of the local community. The majority of fishing for domestic use takes place on Stony Lake, with some fishing on Middle Lake and Black Lake. Black Lake also has a small commercial fishery during the summer. Lake whitefish, lake trout, northern pike, walleye, suckers, and grayling are among the preferred species.

Ice fishing takes place on Black Lake and Stony Lake, but is less prevalent on Middle Lake due to open water and thin ice during the winter months. Domestic fishing rarely is targeted to specific species due to the use of gillnets in summer; however, lake whitefish is preferred because it is easily smoked. Lake trout fishing occurs near the junctions of the Fond du Lac River and local lakes, particularly in fall, and grayling are prevalent in the Fond du Lac River near Elizabeth Falls.

There are many traditional uses of forest plant species. Residents collect wood for heating fuel. Some trees and plants with cultural significance are used in medicinal, ceremonial, and spiritual activities. Recent burn areas around Middle Lake and on Fir Island on Black Lake support several plant species, particularly berries (e.g., blueberries, bog cranberries, moss berries, and strawberries), which are gathered by community members for domestic use. Other edible vegetation, such as mushrooms, is available in the area around Middle Lake and south of Black Lake.

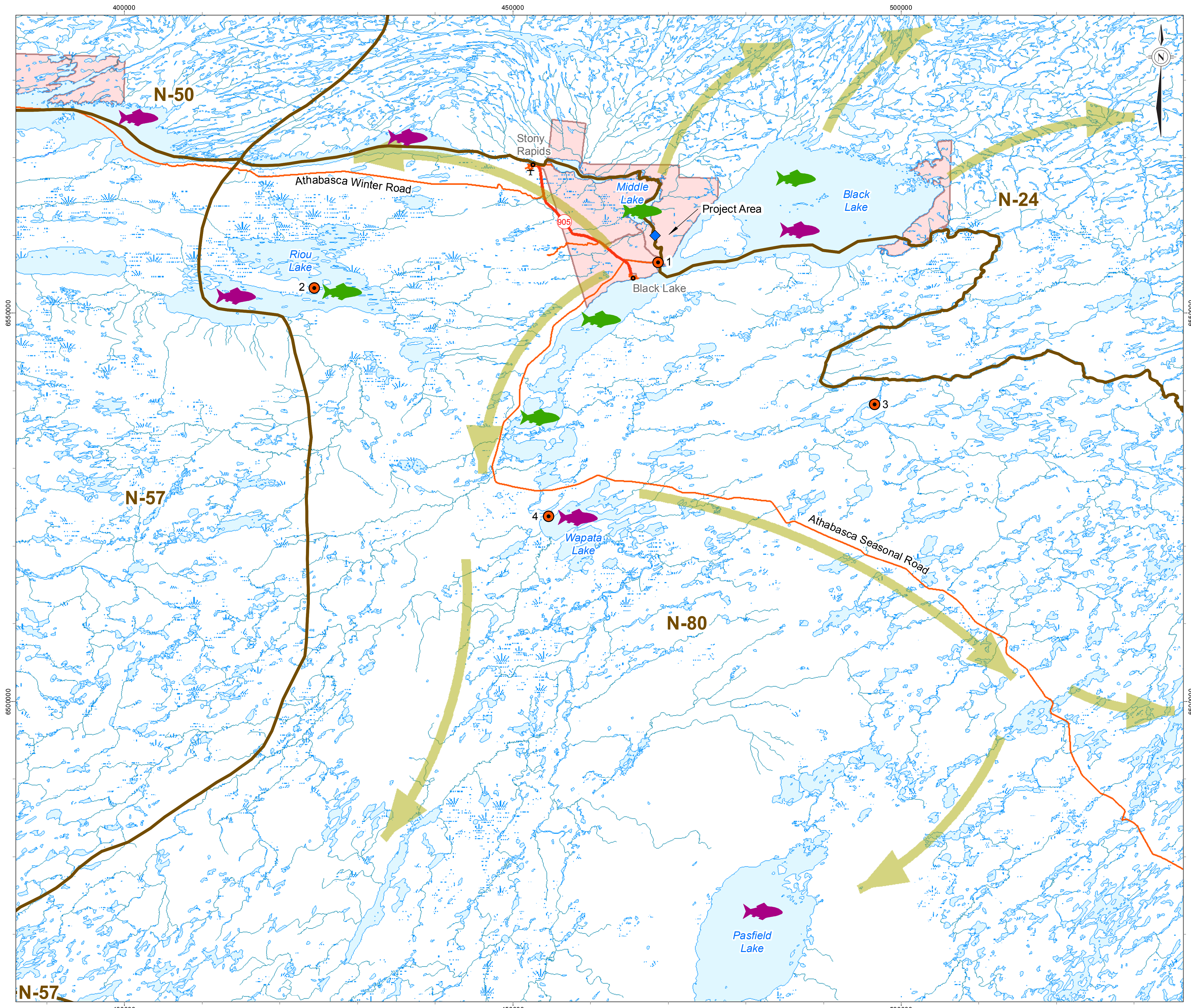
Small trails occur throughout the region, most of which are trunk trails connecting larger roads. These trails are used to access cabins and campsites, and to portage through the area. In the past, the area around the proposed Project site was used as a travel corridor when following the caribou herds and as a temporary campsite for spring fishing prior to ice break-up on Black Lake.

The only mining activity currently taking place in the Athabasca region is uranium mining. No mining activities are taking place in the area around the Project. However, numerous mineral deposits have been identified in the area, including uranium, gold, base metals, and other minerals. Twenty-six outfitting lodges operate in the Athabasca region, with three lodges and outfitters offering sport fishing and hunting services within a 50 km radius of the proposed Project site around the communities of Black Lake and Stony Rapids. Land and resource use in the area is shown in Figure 3.11-1 and a full discussion of traditional and non-traditional land use is presented in Annex VI and Section 17.0 of this EIS.

3.12 Economy

The communities of Black Lake and Stony Rapids have a variety of community-based businesses that range from taxi services to local contractors (Keewatin Career Development Corporation 2012). Additionally, both communities actively seek to build capacity and expand their business holdings. In the community of Black Lake, a dedicated Band employee focuses on bringing training to the community and nurturing local businesses. In the Northern Hamlet of Stony Rapids, the approach to developing local business is less organized, but it is a goal of community members that more residents become employed and more local business initiatives succeed (Black Lake and Stony Rapids KPI Program 2011-2013).

In addition to community-based contractors that work in the resource sector, other companies in the Athabasca region are not based in either the communities of Black Lake or Stony Rapids, but employ residents of both communities. To employ residents, position-specific training has been offered, which helps build capacity in the communities by creating a workforce that possesses not only position-specific skills, but also transferable ones that could help them acquire and retain other positions in different companies (Black Lake and Stony Rapids KPI Program 2011-2013).



LEGEND

- ELIZABETH FALLS
- VILLAGE
- PROVINCIAL ROAD
- ATHABASCA WINTER/ SEASONAL ROAD
- INDIAN RESERVE
- FUR BLOCK BOUNDARY

LODGES AND OUTFITTER CAMPS

1. CAMP GRAYLING
2. CAMP GRAYLING ON RIOU LAKE
3. HAWKROCK WILDERNESS ADVENTURES
4. CREE RIVER LODGE

- DOMESTIC FISHING LAKE
- COMMERCIAL FISHING LAKE
- BLACK LAKE FIRST NATION RESOURCE USE MOVEMENT

REFERENCE

CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

10 0 10
SCALE 1:500,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

BLACK LAKE FIRST NATION
LAND AND RESOURCE USE

Tazi Twé
Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM/LR	28/06/13		
CHECK	KD	24/07/13		
REVIEW	HS	25/06/13		

FIGURE: 3.11-1

The top five industries in which residents of the community of Black Lake were employed in 2006 were education services industries (23.6%), mining and oil and gas extraction (23.5%), health care and social assistance industries (17.6%), public administration (14.7%), and construction industries (8.8%). Residents of the Black Lake community also are employed in the administrative and support, waste management, and remediation services (5.9%), which includes janitorial and security services.

The average income in the community of Black Lake is $21,860 per year (Stats Canada 2007). The average income in the Athabasca Basin communities, including the communities of Black Lake and Stony Rapids, is lower than the provincial average income. Many of the everyday costs of living in northern Saskatchewan (e.g., food and fuel) are higher than in other areas of Saskatchewan (Northern Economic Summit 2012). The high cost of goods in the community is compounded by the high cost of utilities; electricity bills alone often take up a large percentage of a household's monthly income.

3.13 Infrastructure and Community Services

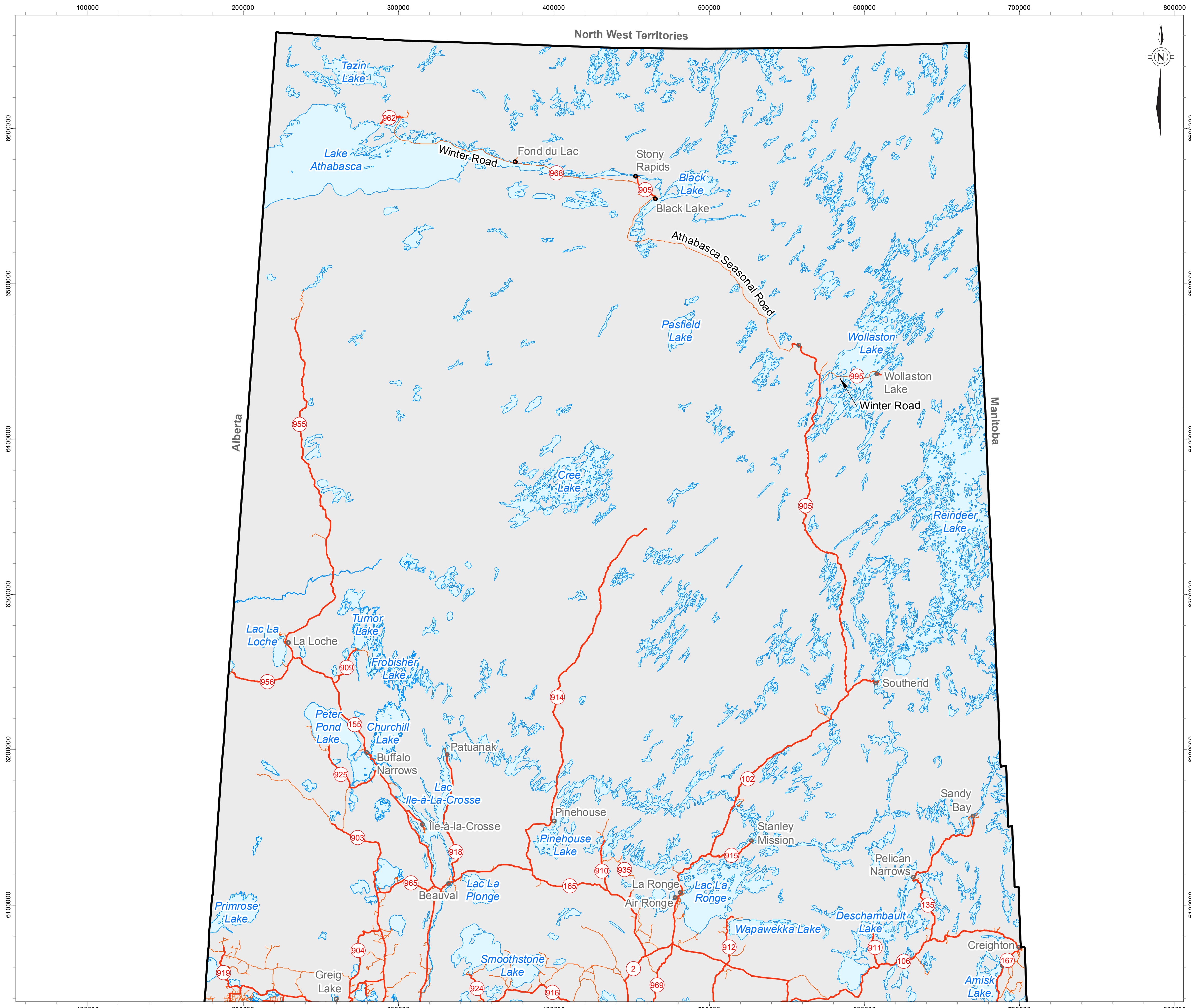
The region is located in the northern-most part of Saskatchewan and is sparsely populated compared to other areas of the province. The Athabasca region consists of seven communities, including First Nations, northern settlements, and a northern hamlet. The communities of Black Lake and Stony Rapids are located closest to the proposed Project site. The BLFN is a proponent of the Project and the Project will be constructed on its reserve territory.

The BLFN and the Northern Hamlet of Stony Rapids have been the focus of the socio-economic characterization near the Project. The Project site is located approximately 7 km from the community of Black Lake and about 25 km southeast of Stony Rapids. Highway 905, west of the Fond du Lac River, joins these two communities (Northern Economic Summit 2012).

The communities of Black Lake and Stony Rapids each have schools. Father Porte Memorial Dené School in the community of Black Lake is a First Nation operated facility offering Pre-Kindergarten to Grade 12. There were approximately 410 children enrolled for the 2011/2012 school year (Black Lake and Stony Rapids KPI Program 2011-2013). The school in Stony Rapids had a total enrolment of 55 students as of September 30, 2011 (NLSD 2011). The school program is from Kindergarten to Grade 9. Since the Stony Rapids School does not offer grades 10 to 12, students wishing to complete the high school curriculum either attend Father Porte Memorial Dené School in the community of Black Lake or a school in a more southerly community. There are no post-secondary institutions in the Athabasca region, although Northlands College offers training and adult education programs throughout northern Saskatchewan (Cameco 2011).

Road access to the Athabasca region of northern Saskatchewan originates at Highway 102, which extends north from La Ronge to its terminus in Southend. Highway 905 branches north off Highway 102 near Southend to Points North Landing. Beyond Points North Landing, Hwy 905 continues as a gravel seasonal road, known as the Athabasca Seasonal Road. Highway 905 between the communities of Black Lake and Stony Rapids is an all-season gravel road (Figure 3.13-1).

Stony Rapids and Black Lake communities are served by an airport in Stony Rapids (Northern Economic Summit 2012). Scheduled passenger flights into Stony Rapids are available from Pronto Airways and Transwest Air. During the summer months, there is limited barge service to ship goods from east to west from Stony Rapids to Fond du Lac, Uranium City, and Camsell Portage (Cousins and Coneghan 2006). The barge is privately run (Canada 2012).



LEGEND

- VILLAGE
- HIGHWAY
- ROAD
- WATERBODY

REFERENCE

CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

50 0 50

SCALE 1:2,500,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

PROVINCIAL HIGHWAYS IN NORTHERN SASKATCHEWAN

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM/LMR	28/06/13	**FIGURE: 3.13-1**
CHECK	KD	24/07/13	
REVIEW	HS	25/06/13	

3.14 Population and Health

The community of Black Lake had a population of 1,070 in 2011 and the median age is 22.5 (Statistics Canada 2012a). Dené is the language spoken in about 95% of the homes in Black Lake. In comparison, Stony Rapids had a population of 243 in 2011 and the median age is 31.0 (Statistics Canada 2012b). Dené is spoken in about 40% of the homes in Stony Rapids (Northern Economic Summit 2012).

Residents of the communities of Black Lake and Stony Rapids have access to the Athabasca Health Authority (AHA) health facility located outside of Stony Rapids on BLFN reserve land. Patients requiring emergency services that are unavailable at the AHA health facility usually are transported to La Ronge, Prince Albert, or Saskatoon, depending on their needs (Athabasca Health Authority 2013). A full discussion of the population and health of the region is presented in Annex VI and Section 20.0 of this EIS.

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3.16 List of Acronyms

Term	Definition
AHA	Athabasca Health Authority
BLFN	Black Lake First Nation
BP	Before Present
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
ELC	Ecological Landscape Classification
EIS	Environmental Impact Statement
HBC	Hudson's Bay Company
OIC	Order in Council
Project	Tazi Twé Hydroelectric Power Project
SARA	*Species at Risk Act*
SKCDC	Saskatchewan Conservation Data Centre
WMZ	wildlife management zone

3.17 List of Units

Term	Definition
%	percent
°C	degrees Celsius
ha	hectares
km	kilometre
km^2	square kilometres
km/h	kilometres per hour
mm	millimetre
m	metre
m^2	square metre
m/s	metres per second
m^3/s	cubic metres per second
ppbv	parts per billion volumetric
$\mu g/m^3$	micrograms per cubic metre
µm	micrometres

4.0 PROJECT ALTERNATIVES

This section of the Environmental Impact Statement (EIS) identifies alternatives to and alternative means of carrying out the Tazi Twé Hydroelectric Project (the Project) that are socially and environmentally acceptable, and technically and economically feasible. The alternatives evaluated represented options considered based on existing technology and practices common within the power-generation industry. Professional knowledge and experience relating to existing practices and technology were used to evaluate each option. Environmental, engineering, and socio-economic criteria were used to evaluate the alternatives associated with the Project. The preferred options selected for the Project are described in Section 5.0.

4.1 Alternatives to the Project

SaskPower provides electrical energy to meet industrial and residential demand on SaskPower's Far North electrical supply system. Transmission and generation facilities have been constructed over the years to meet existing demands for power; however, over the next 10 years the demand for power is expected to double in northern Saskatchewan. The existing Far North electrical facilities will be unable to serve these new demands.

In anticipation of these new demands, SaskPower has used a multifaceted approach to improve the level of service. For example, SaskPower is upgrading the existing transmission line in northern Saskatchewan to increase the transfer capability to the north from the generation facilities located in southern Saskatchewan. These reinforcements will improve the capacity and efficiency of the line; however, they will not provide enough capacity to serve fully the forecast demand in the north. SaskPower is assessing the possibility for large industrial customers to curtail their demand for power during peak periods and receive payment to reduce their load when needed; however, this demand response solution is somewhat limited in northern Saskatchewan. For example, industrial users often maintain a 24-hour operation, which creates a low variation in daily power consumption. Demand response programs do not facilitate economic growth as mines are built or expanded. Additional supply of electricity, through purchased power, alternative means of transfer from the south, or new power generation, will still be required to meet the demand for power in northern Saskatchewan.

Alternatives to the Project that were evaluated are discussed below.

Dam and Spillway: A 45 metre (m) high dam and spillway structure could be constructed across the Fond du Lac River at the downstream end of the falls, just upstream of Middle Lake. This option would have the advantage of easier and more precise management of downstream river flows and that a water intake and power tunnel would not be required. However, this option would flood a large amount of terrestrial land and eliminate the presence of the falls; including the Arctic grayling (*Thymallus arcticus*) habitat that currently exists. In addition, this option would require a large amount of fill material from the local area, which also results in disturbance to the terrestrial environment. During engagement activities completed for the Project, the community expressed aversion to the dam and spillway alternative.

Purchased Power: Load growth in northern Saskatchewan could be provided through the purchase of capacity and energy from Manitoba Hydro, through the transmission line connection to their system at the Border Station near Flin Flon, Manitoba. This option would result in reduced disturbance to the aquatic and terrestrial environment as most of the required infrastructure is already developed. However, discussions with Manitoba Hydro about existing and future arrangements indicate that the purchase of energy cannot be guaranteed over the long-term. Given the uncertainty with this supply option, it was not selected as the preferred alternative.

Transmission Pathway to the North: It is technically possible to transfer up to 75 megawatts (MW) of electricity generated in southern Saskatchewan through the Manitoba Hydro system, to serve the load in northern Saskatchewan through the Border Station near Flin Flon, Manitoba. This option would result in reduced disturbance to the aquatic and terrestrial environment as most of the required infrastructure is already developed. However, there is a risk that transmission constraints could limit the amount of power that can be transferred in the future or at certain times of the year, which will affect the reliability of electricity supply to the north. As a result, this alternative was not selected as the preferred option.

Diesel Generation: Diesel generation is a proven technology that involves the combustion of diesel fuel in a reciprocating engine coupled to a generator, which produces electricity. Unit size ranges from 1 to 20 MW and can easily be located where electrical energy is needed. This technology can be rapidly deployed, typically requiring between 18 and 24 months for installation. The challenge with diesel generation is that it is costly, requires the transportation of fuel to remote locations, and produces emissions. The use of diesel generation to supply the energy needs of Saskatchewan's north is not preferred as it is a more expensive and less environmentally sustainable alternative.

Wind: Wind power generation is best developed in areas where there is strong and consistent wind. The wind regime in northern Saskatchewan is insufficient to develop economically this type of power generation. As well, the intermittent nature of wind power would require backup generation by an alternative power source to provide a reliable supply of power. This option was not selected as the preferred option.

Hydro: A number of locations in northern Saskatchewan could be developed as hydroelectric power sites. SaskPower could consider some or all of these locations in the coming years, to meet the growing demand for power in the north. Preliminary evaluation of these potential sites identified the Project. More specifically, the Project is the most advanced of the available options and is able to meet the current and near future demands in northern Saskatchewan, although it will not be able to provide fully the expected future demand for power in the north.

The Black Lake First Nation (BLFN) has been pursuing a long-term economic development project to address the disparity experienced by its members. One of the preferred projects considered is hydroelectric power production at Elizabeth Falls, which is located on their reserve land. SaskPower and the BLFN have worked together to investigate the potential of the site and conduct environmental studies to advance the Project. In 2013, an agreement in principle between the BLFN and SaskPower was signed to pursue the Project as a partnership. The agreement meets the need of SaskPower to secure additional power generation capacity in northern Saskatchewan, while providing a revenue source with employment and business opportunities for the BLFN.

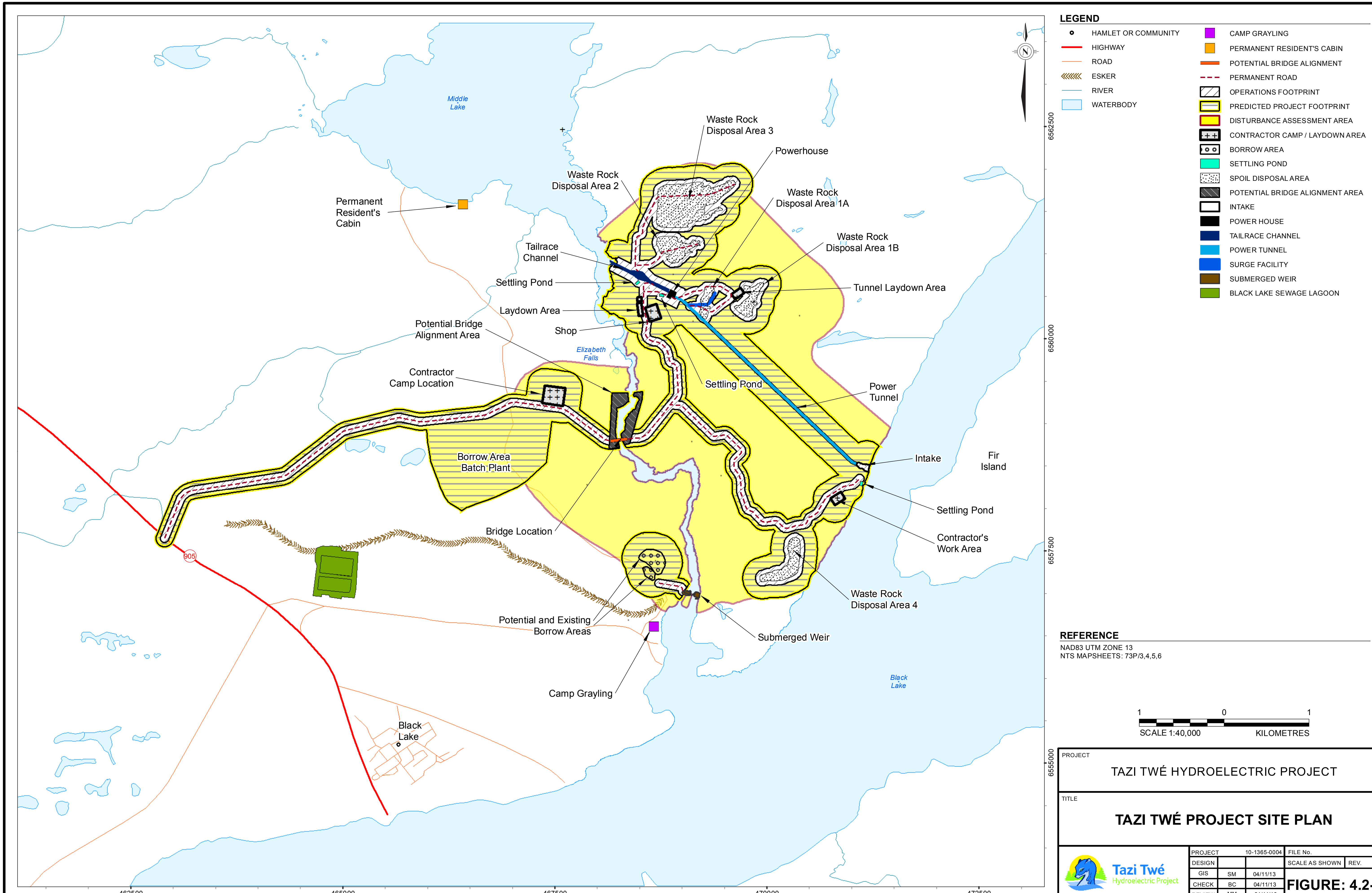
4.2 Alternative Means of Carrying Out the Project

This section describes the technically and economically feasible ways the Project could be carried out. Alternative components, activities, management systems, or mitigation considered during the Project planning are described. The design options are described to illustrate clearly the differences, advantages, and disadvantages of the alternatives. This section also discusses the environmental, engineering and technical, and socio-economic considerations used to evaluate the design alternatives.

Because the design of the Project is still being finalized, preferred options have not yet been selected in some cases. In these cases, applicable alternatives have been included in the Project Description (Section 5.0) and the most conservative option has been assessed within this EIS. For example, the maximum area of potential disturbance, highlighted in Figure 4.2-1, was assessed to take into account uncertainty in the locations of site infrastructure (e.g., power tunnel alignment, powerhouse, and waste rock disposal areas).

The following subsections provide details on alternative means of carrying out the Project including options relating to the:

- water intake;
- power tunnel and surge facility;
- power generation capacity;
- turbine selection;
- tailrace channel;
- submerged weir;
- access roads;
- bridge location;
- borrow areas;
- waste rock disposal areas;
- construction power options;
- construction camp facilities and contractor's work areas; and
- sewage treatment and potable water facilities.


Middle Lake
Permanent Resident's Cabin
Waste Rock Disposal Area 3
Waste Rock Disposal Area 2
Powerhouse
Waste Rock Disposal Area 1A
Waste Rock Disposal Area 1B
Tailrace Channel
Settling Pond
Tunnel Laydown Area
Laydown Area
Shop
Potential Bridge Alignment Area
Elizabeth Falls
Contractor Camp Location
Settling Pond
Power Tunnel
Borrow Area Batch Plant
Intake
Fir Island
Settling Pond
Contractor's Work Area
Bridge Location
905
Waste Rock Disposal Area 4
Potential and Existing Borrow Areas
Submerged Weir
Camp Grayling
Black Lake
Black Lake
462500
465000
467500
470000
472500
6562500
6560000
6557500
6555000
LEGEND
HAMLET OR COMMUNITY
HIGHWAY
ROAD
ESKER
RIVER
WATERBODY
CAMP GRAYLING
PERMANENT RESIDENT'S CABIN
POTENTIAL BRIDGE ALIGNMENT
PERMANENT ROAD
OPERATIONS FOOTPRINT
PREDICTED PROJECT FOOTPRINT
DISTURBANCE ASSESSMENT AREA
CONTRACTOR CAMP / LAYDOWN AREA
BORROW AREA
SETTLING POND
SPOIL DISPOSAL AREA
POTENTIAL BRIDGE ALIGNMENT AREA
INTAKE
POWER HOUSE
TAILRACE CHANNEL
POWER TUNNEL
SURGE FACILITY
SUBMERGED WEIR
BLACK LAKE SEWAGE LAGOON
REFERENCE
NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
1 0 1
SCALE 1:40,000
KILOMETRES
PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT
TITLE
TAZI TWÉ PROJECT SITE PLAN
Tazi Twé Hydroelectric Project
PROJECT 10-1365-0004
FILE No.
DESIGN
SCALE AS SHOWN
REV. 5
GIS SM 04/11/13
CHECK BC 04/11/13
REVIEW MM 04/11/13
FIGURE: 4.2-1

4.2.1 Water Intake

The water intake directs water into the power tunnel from Black Lake under controlled conditions. It establishes the transition between the free water surface of the lake and the closed conduit flow within the power tunnel. The primary environmental criterion considered for design of the water intake was limiting adverse effects on the aquatic ecosystem, particularly fish populations. For example, two alternatives were considered for the depth of the water intake: near the surface of Black Lake (i.e., surface to 5 m depth) or at greater depths within Black Lake (i.e., greater than 2 to 5 m depth). Constructing a shallow intake near the surface of the lake was preferred because it is expected to keep water temperatures through the tunnel and tailrace similar to those found in the Fond du Lac River. Additionally, the shallow intake is expected to reduce the entrainment of deep-water species such as lake trout (*Salvelinus namaycush*) and cisco (*Coregonus* sp.). Other design considerations for reducing potential effects of the water intake on fish populations included:

- selecting an water intake location away from sensitive fish habitat (i.e., areas where fish may congregate to spawn);
- sizing the water intake opening so that water velocities in the approach channel are below burst speeds of resident fish, thereby promoting avoidance behavior;
- fitting the water intake opening with an “exclusion bar rack” to reduce the potential for fish entrainment by presenting a visual barrier; and
- configuring the water intake structure so that the soffit (ceiling) of the intake passage will be set low enough to prevent entrainment of air into the power tunnel and subsequently reduce the potential for gas bubble trauma in entrained fish.

Technical and engineering criteria considered for the water intake included selecting a size and shape of water intake that:

- streamlines approach flow direction and reduces the hydraulic losses from Black Lake to the power tunnel;
- maintains water intake flow water temperatures similar to those of natural outflows at the Black Lake outlet;
- reduces the potential for vortex development and air entrainment into the water intake by providing adequate submergence of the intake;
- limits the flow velocities in the water intake channel and at the trashracks to reduce vibration and limit potential for fish impinging on the trashracks;
- provides adequate freeboard so overtopping of the structure due to wave action does not occur;
- provision of adequate access to inspect and operate the bulkhead gates for the water intake structure if required;
- reduces the footprint of any required temporary construction works (i.e., cofferdams) to construct the water intake structure;
- considers aesthetics; and
- achieves compliance with industry and regulatory standards.

4.2.2 Power Tunnel and Surge Facility

Decision criteria relating to power tunnel construction alternatives focused on technical and economic feasibility. For example, a number of cross-sectional areas were considered for the tunnel and cost estimates were prepared for each case. Increasing the cross-sectional area of the tunnel increases energy production, but also results in increased cost of tunnel construction. An economic evaluation was undertaken based on estimating the incremental benefit-cost ratio to determine the optimum tunnel cross-sectional areas for various levels of installed generating capacity in the powerhouse.

A number of tunnel alignments connecting to the powerhouse and water intake continue to be reviewed, with power tunnel lengths ranging from 2.65 to 3.3 km. Based on a technical and economic evaluation, the current preferred arrangement consists of a 2.95 km long power tunnel. The longer alignment of 3.3 km was eliminated due to the presence of a valley with 20 m or more of overburden near the downstream end of the alignment. This alignment caused a concern that there would be insufficient bedrock cover over the tunnel to maintain tunnel stability and that up to 200 m of steel lining would be required to reinforce the tunnel (Hatch 2007).

Three options were considered for the method of power tunnel construction. These included an 11 m wide by 10 m high horseshoe shaped (∩) cross-section excavated by drilling and blasting, a circular tunnel excavated by a tunnel-boring machine, and an excavated tunnel with a concrete lining. Of these three options, the drill and blast horseshoe shaped tunnel is anticipated to be the most cost effective.

In summary, the preferred preliminary power tunnel arrangement consists of a 2.95 km long tunnel with a horseshoe shaped cross-section and a minimum rock cover of 30 m in thickness over the majority of the tunnel. It is anticipated that the tunnel will be constructed using the drill-and-blast method.

A surge facility/adit will be incorporated into the Project water conveyance system (Figure 4.2-1). The surge facility is required to control hydraulic transient pressures. The base case design for the surge facility is an inclined tunnel that branches off the power tunnel and daylights at an elevation above the level of Black Lake to accommodate pressure variations in the tunnel. This inclined adit would provide access to drive in the tunnel during construction. An alternate design option that is being considered uses a raised bore vertical shaft excavated in the rock to the surface, above the level of Black Lake. The surge facility will connect to the power conveyance a short distance upstream of the powerhouse.

4.2.3 Power Generating Capacity

Generating capacities ranging from 42 to 50 MW were considered for the Project. The Fond du Lac River at the Black Lake outlet has a long-term average annual outflow of 304 cubic metres per second (m^3/s). To produce 42 MW of power, a flow of 160 m^3/s typically would pass through the power plant, and the remaining 144 m^3/s (on average) would pass through the natural Black Lake outlet into the Fond du Lac River. For the 50 MW power generation alternative, a flow of up to 190 m^3/s would normally pass through the power plant, with the remaining 114 m^3/s (on average) passing into the Fond du Lac River through the existing Black Lake outlet. The preferred generating capacity of the Project is anticipated to be in the order of 50 MW (up to 190 m^3/s discharge rate). This generating capacity was selected based on an optimized balance of installed cost and energy production. It was selected based on consideration of maintaining minimum riparian flows in the Fond du Lac River.

The Project is anticipated to involve two to four turbine generating units. A multiple unit generating plant was selected because it provides more flexibility in operation and scheduling of maintenance outages are easier compared to a single unit power plant. While a single unit plant could cost less to construct, a multiple unit plant results in less energy loss due to forced and planned outages, along with providing better efficiency and control at lower flow rates. In addition, equipment components are smaller and easier to handle.

4.2.4 Turbine Selection

Hydroelectric facilities in Canada generally use either Kaplan or Francis turbines for power generation (Canadian Electricity Association [CEA] 2001). A large proportion of the hydroelectric power generated in the United States is from low- to medium-head facilities containing one of these turbine types (Becker et al. 2003; Odeh 1999). Both Kaplan and Francis style turbines were considered for the Project. Final turbine selection was based on an evaluation of equipment performance (i.e., efficiency and output), equipment costs, and civil costs associated with the equipment, as well as potential implications to fish species.

For the turbine designs that were considered, the specifications emphasized the reduction or elimination, where practical or possible, of oil contained in guide bearings and in the turbine hubs (in the case of the Kaplan turbines). Turbine suppliers were asked to highlight the features of their equipment that are environmentally friendly and fish friendly.

A number of design features associated with the Kaplan turbine have been identified as being more fish-friendly relative to the Francis turbine. One advantage of the Kaplan-type turbine is that the blades of the turbine runner can be adjusted to accommodate variations in water flow and thereby maintain efficiency over a wider range of operating conditions (Paish 2002). Although the capital and maintenance costs are generally lower, Francis turbines become very inefficient when flows drop below 50 percent (%) of normal (Paish 2002). This may have implications for fish injury and mortality, which are generally lowest when facilities are operating at maximum efficiency (CEA 2001).

Because blade pitch can be adjusted to compensate for reduced flows through a Kaplan turbine, formation of shear zones within the draft tube can be reduced (United States Army Corps of Engineers 1995 as cited in Odeh 1999). This source of shear stress, which may be highly injurious to entrained fish, cannot be mitigated in a Francis turbine where the blades are fixed. Spacing between fixed (e.g., a wicket gate) and rotating (i.e., runner) parts in a Francis turbine has also been implicated in greater incidence of grinding and abrasion injuries in fish (Odeh 1999).

The numbers of blades and blade spacing associated with Kaplan versus Francis turbines is thought to influence injury and mortality rates of passed fish. Fish mortality rates reported for Kaplan turbines are generally lower than those reported for Francis turbines. The Scotland and Northern Ireland Forum for Environmental Research (SNIFFER 2011) reported mortality rates of 5 to 20% for juvenile salmonids entrained in Kaplan turbines; mortality associated with Francis turbines was between 5% and 90%. Higher mortality rates associated with Francis turbines have generally been attributed to the fact that they are typically installed at higher-head facilities (Larinier and Travade 2002). Kaplan style turbines are selected for the Project as they are considered more fish-friendly of the two turbine types.

4.2.5 Tailrace Channel

Downstream of the powerhouse, the water from the turbine discharge enters the tailrace channel (Figure 4.2-1). The size of the tailrace channel has been designed to limit head loss, while considering the overall excavation cost. As the power plant is expected to operate at full discharge capacity approximately 90% of the time, the design of the tailrace channel has been based on the full plant discharge. For an installed capacity of approximately 50 MW and full plant discharge of up to 190 m^3/s, the optimum tailrace channel cross-section was determined to require a width of 25 m and a flow depth of 5.5 m resulting in an average flow velocity of 1.4 metres per second (m/s). The cross section and length of the tailrace channel has yet to be finalized; the length in the currently preferred design is approximately 800 m, with a potential range of 600 to 1,100 m, with the shorter length preferred. The tailrace channel will be excavated in bedrock with varying depths of overburden. The final channel width will be selected to reduce the excavated volume and footprint at the site.

For the intermediate length (2.95 km) tunnel, the tailrace location would shift to the east, while maintaining the discharge exit point at the Fond du Lac River. Tailrace excavation on this alignment would be primarily through the bedrock, within limited overburden excavation, and a reduction in tailrace excavation (by approximately 50% overall), to reduce effects on the terrestrial environment. The selection of the final tailrace alignment and length will occur in conjunction with optimizing the tunnel and powerhouse arrangement.

Several options were considered for the location and shape of the tailrace channel outlet. Options were selected based on environmental and engineering considerations. For example, the tailrace channel outlet has been located upstream of critical fish spawning habitat near the Fond du Lac River outflow into Middle Lake to maintain minimum required flows at this location. The tailrace channel outlet will be flared out so the water blends smoothly with the Fond du Lac River and avoids disruption to the dominant flow direction. The alignment and design will be selected to limit adverse effects of changed flows on the spawning channel located downstream. The selection of the final tailrace channel alignment and length will occur in conjunction with optimizing the power tunnel and powerhouse arrangement.

4.2.6 Submerged Weir at the Black Lake Outlet

To maintain historical water levels in Black Lake following construction of the generating station, the flow through the natural outlet of Black Lake will be restricted by the construction of a submerged weir. The submerged weir will be located to the east and west of Grayling Island will span the Fond du Lac River at the Black Lake outlet. The weir will be constructed of clean coarse rockfill. A gated concrete control structure was considered as an alternative to the submerged weir. This structure would be constructed as a combination of adjustable gates and submerged weirs. One advantage of a gated control structure is the ability to manipulate flows in the Fond du Lac River to meet minimum riparian flow requirements, especially during spawning periods or during droughts when the natural outflows are low.

The submerged weir would have limited visibility compared to the concrete control structure, which would have piers, gates, and hoists projecting above the structure, altering the appearance of the natural environment at the lake outlet. The weir also has the advantage of reducing the in water works during construction as opposed to a concrete structure that would require construction of a cofferdam. The submerged weir can be constructed without the need for installation and removal of cofferdams. In terms of the criterion for social acceptability, the BLFN expressed a desire that there not be a concrete weir control structure constructed at the outlet of Black Lake. For these reasons, the submerged rockfill weir was selected as the preferred option.

4.2.7 Access Roads

Several potential permanent access road alignments were presented to the BLFN and local community during public engagement meetings held on April 9, 2013. The input received at these meetings indicated a preference for an entirely new access route rather than following, and potentially affecting, any existing access routes. Additional input indicated preference for a straight-line alignment while avoiding sensitive habitats, as much as possible.

The five road alignment options considered are shown on Figure 4.2-2, with alignments A and C located primarily along existing trails and B, B1, and B2 indicating new routes. The preferred route is Alignment B1, which is also preferred by the community of Black Lake and was the most technically and economically feasible option. Alignments A, B, B2, and C were not preferred for several reasons. Alignment A is near residential and cultural facilities, would require crossing a known fish-bearing stream, and requires traffic to use a greater portion of Highway 905. Alignment B had similar disadvantages as Alignment A and would involve crossing rough terrain, which would increase construction costs. Alignment B2 comes close to, and possibly intersects, the Black Lake sewage lagoon. This option was not preferred because community members expressed concern that the route crosses an esker with high potential to have listed plant species and heritage resources associated with it. Alignment C is along an existing road, but the route cannot be upgraded because there are buried power cables beneath it that are of concern. This option is also near heritage resources, one of which is a cemetery that could be impacted by construction activities if the existing route is made wider and upgraded. This road is the existing access road for Camp Grayling and shared use during construction of the Project would cause major disruption for Camp Grayling users. The preferred route is Alignment B1, which is also preferred by the local community and was the most technically and economically feasible.

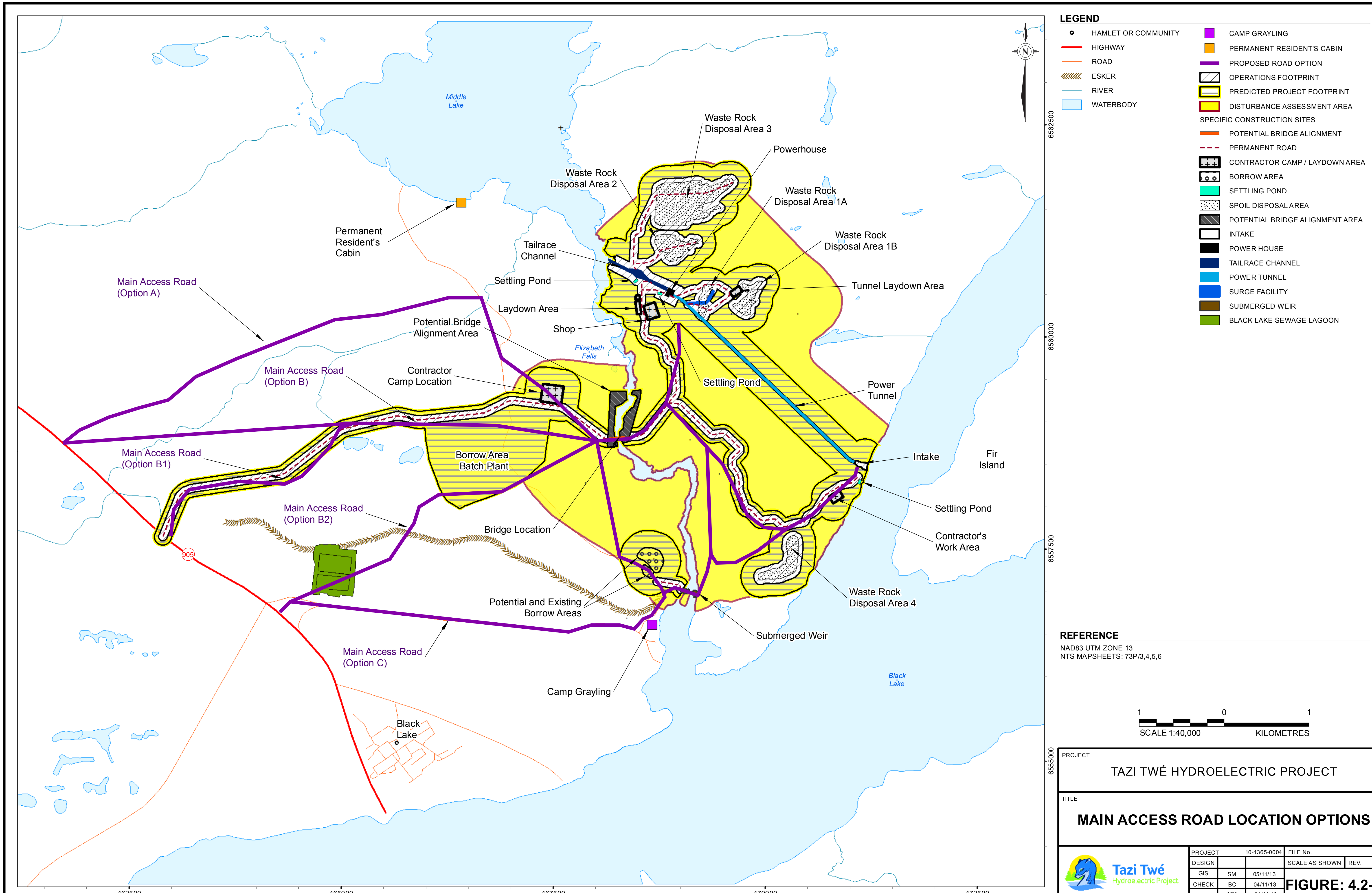
4.2.8 Bridge Location

Two alternate bridge locations across the Fond du Lac River were proposed. Both locations were similar in cost and technically feasible. Based on engagement with the BLFN, the preferred bridge site is located approximately 2 to 3 km downstream of Grayling Island; at a point where the width of the river is relatively narrow (Figure 4.2-2). The location of the bridge over the Fond du Lac River avoids interference with possible heritage trails or historical sites near the bridge abutments on the riverbanks. A second potential location would be parallel to the axis of the proposed weir at the downstream end of Grayling Island. Although technically feasible, the community expressed concern that this location was not preferable.

4.2.9 Borrow Areas

Criteria used for determining the preferred location of borrow areas for the Project includes aggregate suitability, available volume of aggregate, and haul distance. If potential locations have similar quality and quantity of aggregate, then the location closest to the site would likely be used.

Two main sites are under consideration for granular borrow sources, an existing source which is located 0.6 km from Camp Grayling and a source which is located west of the preferred bridge location (Figure 4.2-1). A third potential site northeast of the proposed construction camp could provide suitable materials pending further evaluation of available quantities. Additional surface and subsurface exploration, including access road construction, test excavations, and materials testing would be required to establish the suitability of the optional borrow materials sites.


Middle Lake
Waste Rock Disposal Area 3
Powerhouse
Waste Rock Disposal Area 2
Waste Rock Disposal Area 1A
Waste Rock Disposal Area 1B
Permanent Resident's Cabin
Tailrace Channel
Settling Pond
Tunnel Laydown Area
Main Access Road (Option A)
Laydown Area
Potential Bridge Alignment Area
Shop
Elizabeth Falls
Main Access Road (Option B)
Contractor Camp Location
Settling Pond
Power Tunnel
Main Access Road (Option B1)
Borrow Area Batch Plant
Intake
Fir Island
Settling Pond
Main Access Road (Option B2)
Bridge Location
Contractor's Work Area
905
Waste Rock Disposal Area 4
Potential and Existing Borrow Areas
Submerged Weir
Main Access Road (Option C)
Camp Grayling
Black Lake
Black Lake
462500
465000
467500
470000
472500
6562500
6560000
6557500
6555000
LEGEND
HAMLET OR COMMUNITY
HIGHWAY
ROAD
ESKER
RIVER
WATERBODY
CAMP GRAYLING
PERMANENT RESIDENT'S CABIN
PROPOSED ROAD OPTION
OPERATIONS FOOTPRINT
PREDICTED PROJECT FOOTPRINT
DISTURBANCE ASSESSMENT AREA
SPECIFIC CONSTRUCTION SITES
POTENTIAL BRIDGE ALIGNMENT
PERMANENT ROAD
CONTRACTOR CAMP / LAYDOWN AREA
BORROW AREA
SETTLING POND
SPOIL DISPOSAL AREA
POTENTIAL BRIDGE ALIGNMENT AREA
INTAKE
POWER HOUSE
TAILRACE CHANNEL
POWER TUNNEL
SURGE FACILITY
SUBMERGED WEIR
BLACK LAKE SEWAGE LAGOON
REFERENCE
NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
1 0 1
SCALE 1:40,000
KILOMETRES
PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT
TITLE
MAIN ACCESS ROAD LOCATION OPTIONS
Tazi Twé
Hydroelectric Project
PROJECT 10-1365-0004
DESIGN
GIS SM 05/11/13
CHECK BC 04/11/13
REVIEW MM 04/11/13
FILE No.
SCALE AS SHOWN
REV. 5
FIGURE: 4.2-2

The existing granular borrow pit near Camp Grayling is the most likely source for concrete aggregates for the Project. The existing granular borrow pit source is approximately 600 m north of Camp Grayling on Chicken Reserve 224, with an esker deposit separating the construction camp and the borrow pit. This existing developed borrow pit source has provided the concrete aggregate for most of the concrete poured in the communities of Black Lake and Stony Rapids and as a result the material properties are known. The construction haul route from the borrow pit source to the Project site would be to the north to avoid travel past Camp Grayling. Use of the existing borrow pit source reduces the amount of new surface disturbance and the esker will act as a natural sound and aesthetic barrier.

There could be an opportunity to crush the excavated rock from the powerhouse and tailrace channel to process concrete aggregate. However, this option will be evaluated for cost and suitability after the excavated rock is characterized. If the rock is suitable and cost effective, this option could reduce the amount of material removed and number of haul trips made from the existing borrow pit source.

4.2.10 Waste Rock Disposal Areas

Overburden and waste rock will be produced by excavation during the construction of the water intake, power tunnel, powerhouse, and tailrace channel. Several locations were considered as disposal areas for these materials. Engineering factors considered for determining the disposal locations of the waste rock included:

- proximity to the main access roads;
- potential ability to accommodate disposal of the excavated waste rock;
- suitable topographical features; and
- the ability to perform short- (i.e., during construction) and long-term environmental monitoring.

During community engagement activities, residents of the BLFN stated that they would prefer to see waste rock disposal areas with a lower profile spread over a greater area, rather than smaller and taller waste rock disposal areas that would likely be more visible. Overall, there was a preference for the waste rock disposal areas to be located north of Project facilities on the east side of the Fond du Lac River, as this area is not widely used for resource use. There was agreement in the community that people did not prefer the waste rock disposal areas to be near Black Lake, Middle Lake, the Fond du Lac River, or any associated drainage (e.g., creeks and streams). While preliminary locations have been identified (Figure 4.2-1), waste rock disposal area locations, and volumes will be refined as the Project design is finalized. These various criteria have been, and will continue to be, considered in the final placement and design of the waste rock disposal areas.

4.2.11 Construction Camp Facilities and Contractor's Work Areas

Because of the timing for the construction of bridge access to the east side, the construction camp, and main contractor's work area will be located on the west side of the river, although a decision has not been made on the exact locations (Figure 4.2-1). The proposed locations for the construction camp were selected based on the plans for construction and input from the community of Black Lake. More specifically, the final locations of the construction camp and contractor's work areas will be determined based on technical criteria such as preliminary estimates of required areas, limiting haul distances to the various construction locations, and the anticipated locations of the permanent access road and bridge. Community input will be sought to determine the social acceptability of these locations. The ecological criterion considered in locating these components will be limiting the adverse effects on the terrestrial environment. The alternative locations for the construction camp and contractor's work areas will be within the maximum area of potential disturbance shown in Figure 4.2-1.

4.2.12 Sewage Treatment and Potable Water Facilities

During construction, portable toilet facilities and holding tanks will be provided at various locations on the Project site and indoor plumbing will be provided at the construction camp. Waste will go to sewage holding tanks, which will be emptied regularly and hauled to the Black Lake sewage lagoon. An alternative considered consisted of treating sewage on-site using a self-contained treatment facility. This alternative was rejected because of concerns about reactions from downstream communities (i.e., Stony Rapids and Fond du Lac) that would receive the treated sewage.

One alternative considered for sourcing the potable water required for the construction and operation of the Project was from the communities of Black Lake or Stony Rapids. The water treatment facility in the Northern Hamlet of Stony Rapids is sufficient for the community, but it does not have the capacity to supply drinking water for the construction camp; there are no current plans to upgrade the capacity of the system. It is unknown if the BLFN water treatment system would have enough capacity to supply potable water for the community of Black Lake and the Project. The BLFN is in the process of designing an upgrade to the system and, depending on when the upgrade is completed, might be able to provide potable water to the construction camp in the future.

Potable water for construction and operations is expected to be sourced from one or more new wells located near the camp. If the wells are not feasible, the water potentially could be drawn from Black Lake or the Fond du Lac River. If surface water were used as a source, the pump intakes would be screened to prevent entrainment of fish in accordance with the "Freshwater Intake End-of-Pipe Fish Screen Guideline" (DFO 1995).

4.3 References

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4.4 List of Acronyms

Acronym	Definition
BLFN	Black Lake First Nation
CEA	Canadian Electricity Association
EIS	Environmental Impact Statement
Project	Tazi Twé Hydroelectric Project

4.5 List of Units

Unit	Definition
%	percent
m	metre
m^3/s	cubic metres per second
m/s	metres per second
MW	megawatts

5.0 PROJECT DESCRIPTION

5.1 Introduction

Section 5.0 of the Environmental Impact Statement (EIS) describes the Tazi Twé Hydroelectric Project (Project) as it is planned to proceed through construction, operations, and closure. This section provides a timeline for the Project and discusses Project components, activities, and supporting infrastructure. The scope of this description is conceptual, incorporating reasonable assumptions as appropriate and detailed design information will be provided at the permitting stage. The Project information presented in this section is sufficient to predict potential environmental effects and to address concerns from interested parties.

The proposed Project will be a 50 megawatt (MW) water diversion type electrical generating station. The Project is located approximately 7 kilometres (km) from the community of Black Lake adjacent to the Fond du Lac River between Black Lake and Middle Lake. Black Lake has an approximate area of 418 square kilometres (km^2) and discharges an average annual flow of 304 cubic metres per second (m^3/s) into the Fond du Lac River, which traverses Elizabeth Falls on its way to Middle Lake. Water from Black Lake will be diverted through a water intake structure and power tunnel to the powerhouse before being released through a tailrace channel back to the Fond du Lac River, and ultimately discharging into Middle Lake.

The principal components of the Project consist of the following:

- gravel, all-season access roads to the Project site from the all-season road between the communities of Black Lake and Stony Rapids;
- bridge over the Fond du Lac River;
- powerhouse and associated infrastructure;
- water intake and power tunnel to convey flow from Black Lake to the powerhouse;
- tailrace channel from the powerhouse to the Fond du Lac River just upstream of Middle Lake;
- submerged weir located in the Fond du Lac River at the outlet of Black Lake near Grayling Island;
- settling ponds;
- waste rock disposal areas;
- construction camp;
- transmission lines and switching stations to connect to the northern Saskatchewan electrical grid; and
- all related physical works and physical activities required to carry out these works, including the associated cofferdams, access roads, laydown areas, borrow areas, concrete batch plant, fuel storage facility and fueling areas, explosives storage, and sewage treatment and potable water facilities.

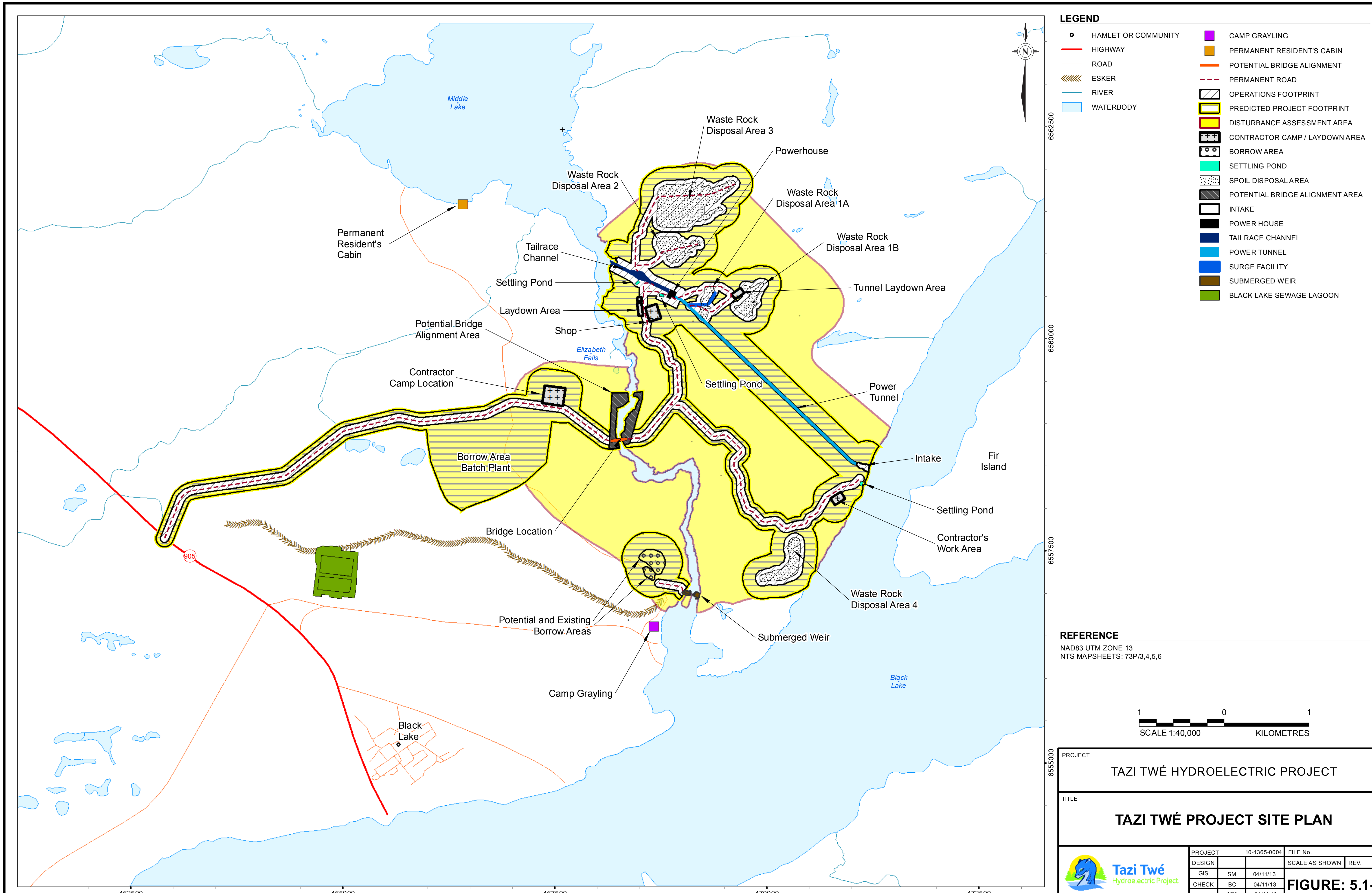
An overview of the Project site plan is shown in Figure 5.1-1. The maximum area of disturbance is highlighted on this plan. The footprint of the Project will be as compact as possible to limit the area affected by Project activities. The maximum extent of disturbance is estimated at 1,620 hectares (ha). It is expected that of this maximum area, 869 ha will actually be required for the Project footprint (i.e., 54 percent [%] of the maximum disturbance area). Of this 869 ha, 589 ha will be reclaimed immediately following construction and about 250 ha will be required for operation. Following closure of the Project, the remaining areas will be reclaimed.

5.2 Project Schedule

This section describes the conceptual Project schedule, including the timing and duration of each of the Project phases (i.e., construction, operation, and decommissioning and reclamation; Table 5.2-1). For the purpose of the Environmental Impact Assessment (EIA) the operating period is assumed to be 90 years.

The main Project phases and estimated timelines are described below and are indicative of the overall Project design and planning throughout 2013. The schedule may change pursuant to finalizing Project design and because of the regulatory approval process. The Proponent will advise of changes, as appropriate..

- Construction - Q3 2014 to Q4 2017 (procurement, off-site fabrication and manufacture, delivery, and installation of the turbines and generators will continue throughout the construction phase):
  - Q3 2014 to Q2 2015 - contractor mobilization and construction camp setup to allow construction to start on main Project components;
  - Q3 2014 to Q3 2015 - access road and bridge construction is scheduled to meet delivery and installation requirements;
  - Q2 2015 to Q4 2017 - construction of the powerhouse and intake structures;
  - Q2 2015 to Q4 2017 - power tunnel, powerhouse, and tailrace channel excavations;
  - Q2 2016 to Q3 2017 – construction of water intake and installation of turbines and generators;
  - Q3 2017 to Q4 2017 – commissioning and plant start-up; construction of submerged weir;
- Operations – Q1 2018 to approximately Q1 2108; and
- Closure - duration of approximately two years following cessation of operations (approximately 2108 to 2110).



LEGEND
HAMLET OR COMMUNITY
HIGHWAY
ROAD
ESKER
RIVER
WATERBODY
CAMP GRAYLING
PERMANENT RESIDENT'S CABIN
POTENTIAL BRIDGE ALIGNMENT
PERMANENT ROAD
OPERATIONS FOOTPRINT
PREDICTED PROJECT FOOTPRINT
DISTURBANCE ASSESSMENT AREA
CONTRACTOR CAMP / LAYDOWN AREA
BORROW AREA
SETTLING POND
SPOIL DISPOSAL AREA
POTENTIAL BRIDGE ALIGNMENT AREA
INTAKE
POWER HOUSE
TAILRACE CHANNEL
POWER TUNNEL
SURGE FACILITY
SUBMERGED WEIR
BLACK LAKE SEWAGE LAGOON
Middle Lake
Waste Rock Disposal Area 3
Powerhouse
Waste Rock Disposal Area 2
Waste Rock Disposal Area 1A
Waste Rock Disposal Area 1B
Permanent Resident's Cabin
Tailrace Channel
Settling Pond
Tunnel Laydown Area
Laydown Area
Shop
Potential Bridge Alignment Area
Elizabeth Falls
Contractor Camp Location
Settling Pond
Power Tunnel
Intake
Fir Island
Borrow Area Batch Plant
Settling Pond
Contractor's Work Area
Bridge Location
905
Waste Rock Disposal Area 4
Potential and Existing Borrow Areas
Submerged Weir
Camp Grayling
Black Lake
Black Lake
6562500
6560000
6557500
6555000
462500
465000
467500
470000
472500
REFERENCE
NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
1 0 1
SCALE 1:40,000
KILOMETRES
PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT
TITLE
TAZI TWÉ PROJECT SITE PLAN
Tazi Twé Hydroelectric Project
PROJECT 10-1365-0004
DESIGN
GIS SM 04/11/13
CHECK BC 04/11/13
REVIEW MM 04/11/13
FILE No.
SCALE AS SHOWN
REV. 5
FIGURE: 5.1-1

Table 5.2-1: Tazi Twé Hydroelectric Project Schedule

Project Phase	Year																	
	2014				2015				2016				2017				2018 to 2108	2109 to 2111
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
Construction																		
Contractor mobilization and setup of construction camp																		
Construction of access roads and bridge																		
Construction of powerhouse and intake structures																		
Excavation of power tunnel, powerhouse, and tailrace channel																		
Excavation of water intake, installation of turbines and generators																		
Commissioning and plant start-up																		
Construction of submerged weir																		
Operations																		
Closure																		

Note: Assuming three months after EIS approval the permit for full construction will be received; and assumes closure will be completed approximately two years following cessation of operations

5.3 Construction

This section describes the construction activities required for the development of the Project components, including site clearing, site access roads, bridge location, development of borrow sources, construction camp, contractor work areas, powerhouse, tailrace channel, submerged weir, and settling ponds. Construction details and design information (as available to date) are provided. This section also describes environmental design features and mitigations that will be implemented to reduce or eliminate potential effects on the environment during construction.

5.3.1 Site Clearing Activities

Clearing of the site is required for construction of water intake, powerhouse, tailrace construction, access road, bridge, construction camp, and contractor laydown area, as well as for development of source sites for borrow material and for waste rock disposal areas. Site clearing, contouring, and excavation during construction have the potential to cause soil erosion, which could cause soil to enter nearby waterbodies.

An Erosion and Sediment Control Plan will be developed based on industry standard Best Management Practices (BMPs), and federal and provincial regulatory requirements. In addition, potential effects of soil erosion will be reduced by implementing the following mitigation practices:

- conducting site clearing, soil salvage, and construction and decommissioning of Project infrastructure (e.g., roads or laydown areas), during dry or frozen conditions, where and when practical;
- applying erosion control practices (e.g., seeding soil salvage stockpiles or silt fences) to salvaged topsoil to reduce potential erosion and sediment transport to surface waterbodies;
- storing salvaged topsoils on-site and away from surface waterbodies;
- applying coarse riprap or other erosion control measures to the banks of watercourses to prevent soil erosion after the removal of culverts;
- conducting site-specific assessments to identify appropriate surficial stripping depths and develop a site-specific soil salvage plan; and
- adhering to the Erosion and Sediment Control Plan.

Site clearing has potential to introduce prohibited, noxious, and nuisance weed species listed under the *Weed Control Act* (2010). To mitigate the transport and introduction of prohibited, noxious, nuisance, and invasive plant species into new areas, construction equipment will be regularly cleaned on site. Equipment used for construction will be locally sourced, if possible. A detailed Weed Plant Management Plan will be designed and implemented to prevent, detect, control (remove), and monitor areas with weed species, particularly those species listed as prohibited, noxious, and nuisance under the *Weed Control Act* (2010). Project environmental design features and mitigation implemented to limit other potential construction-related effects also include:

- avoiding environmentally sensitive areas (e.g., critical wildlife habitat, rare plants and wildlife species, and wetlands) as much as possible;
- limiting clearing of vegetation to the extent possible and only remove vegetation in areas that can pose a hazard or interfere with construction activities;

- completing an appropriate pre-construction survey and applying provincial activity setback guidelines if construction occurs during sensitive nesting, breeding, and rearing periods for wildlife species; and
- ceasing all construction activities and contacting the Heritage Conservation Branch if unanticipated archaeological materials or features are discovered during construction activities.

5.3.2 Site Access Roads and Bridge Location

Road access to the site from southern Saskatchewan will be by Highways 102 and 905 from La Ronge to Points North Landing, and by the Athabasca Seasonal Road from Points North Landing to a continuation of all-season Highway 905 near the community of Black Lake (Figure 5.1-1). These all-season gravel-surface and seasonal sand-gravel/snow-ice roads are maintained by the Saskatchewan Ministry of Highways and Infrastructure. The primary access to the Project site will be from Highway 905 between the community of Black Lake and the Northern Hamlet of Stony Rapids. Summer access over the Athabasca Seasonal Road is often difficult and slow; however the road is passable under most conditions. Sensitive equipment and materials required for construction will likely be transported between late January and late March when the road is in the best condition.

All-season gravel roads and a bridge will be required to access the construction sites of the Project components. During the first year of construction, the main access road will be built extending from Highway 905 and crossing the Fond du Lac River by way of the access bridge. The locations of the bridge and main access road are shown on Figure 5.1-1. Site access roads will also be constructed to the waste rock disposal areas, powerhouse, and water intake. Access roads will link the Project work areas to the selected waste rock disposal areas. The location of these access roads are not fully defined at this stage as the waste rock disposal area locations and volumes will be refined as the design is finalized. Preliminary locations of waste rock disposal areas and associated access roads are shown in Figure 5.1-1. The number of roads will be limited to reduce the effect on the local environment and the possibility of encroachment into previously unknown heritage sites. Culverts will be installed along roadways where drainage crossings have been identified as non-fish-bearing. If fish movement at these drainage crossings becomes apparent during construction, culvert design will be altered to accommodate fish passage.

Permanent roads will be designed to meet current provincial road design standards. Site drainage, erosion, and sedimentation management during construction will be in accordance with the applicable provincial and federal regulations and guidelines. In addition, maintaining roads, setting reduced speed limits, and increasing driver safety awareness to avoid collisions with Project vehicles causing injury or mortality to wildlife and employees. Road maintenance will continue for the life of the Project. Access roads will be gravel-surfaced; therefore, dust abatement techniques will be employed to limit the effect on the environment and to maintain safe visibility for driving. Snow removal will be on-going through the life of the Project to maintain safe winter driving conditions. A discussion will be held with the local community about the ongoing use and maintenance of the access roads at the time of Project closure.

A new bridge will be constructed to provide access to the construction site on the east side of the Fond du Lac River. It will be located approximately 600 m upstream of Elizabeth Falls (Figure 5.1-1). The current bridge design anticipates a single-pier design located mid-point of the bridge span; however, two additional temporary piers could be required during bridge construction Installation of the bridge pier will require construction of a temporary groin or work platform that will extend approximately half way across the river to provide access to the pier installation site. The groin will be constructed of coarse rock and will allow water to percolate. It is anticipated the permanent bridge abutments will be located below the historically normal high-water mark, but above the high-water mark anticipated for the period of Project operation. Bridge construction will occur during winter (i.e., under low flow conditions and outside spawning timing windows for valued components [VCs]) and will require a DFO Authorization..

Due to health and safety concerns during construction, the Project site on the east side of the Fond du Lac River will not be accessible to the public; access will be controlled at the bridge. During Project construction, there will be access restrictions to Project components on the west side of the river in the Project area, although there will be special considerations for local residents. A gate will be placed at the bridge across the river and access to the camp area will be controlled. Project offices will be located at the campsite, and visitors and materials deliveries must report to the Project office before accessing the Project site.

5.3.3 Development of Borrow Sources

Two main sites are being considered for granular borrow sources: an existing source which is located 0.6 km from Camp Grayling and a source which is located west of the Project bridge (Figure 5.1-1). A third potential site northeast of the proposed camp could provide suitable materials pending further evaluation of available quantities. The existing granular borrow source near Camp Grayling likely will be used to provide concrete aggregates for the Project.

The existing granular borrow source is approximately 600 metres (m) north from Camp Grayling on Chicken Reserve 224, with an esker separating the camp and the borrow source. This existing developed gravel pit has been the source for concrete aggregate to supply most of the concrete poured in Black Lake and Stony Rapids. The construction haul route from the borrow area would be north toward the Project site to avoid travelling past Camp Grayling.

There could be an opportunity to crush excavated rock from the powerhouse and tailrace channel to process concrete aggregate. However, this will be evaluated for cost and suitability after the rock is tested. If the rock is suitable and cost effective, this option could reduce the amount of material and number of haul trips from the existing borrow source.

Borrow pits will be located at various locations along the road corridor when they are needed for embankment material, for the roadway subgrade, for granular material for subgrade stabilization, and for future sources of road construction gravel. As construction proceeds, aggregate material that is removed from construction areas could be re-used for other construction purposes.

5.3.4 Construction Camp and Contractor Work Areas

A construction camp will be provided to house workers through construction that will accommodate up to 250 workers (Figure 5.1-1). The construction camp will include dormitories with washroom and laundry facilities, kitchen and dining facility, office space, recreational and commissary complex, water and sewage storage units, and parking spaces. The construction camp will be serviced by the SaskPower electrical distribution system and electrical generator units will initially energize the camp and provide a back-up service. First aid stations will be located on-site at the construction camp. A site ambulance and first aid attendant will also be provided for the Project.

The contractor's work areas will be used to store materials, maintain and assemble equipment, and administer work on the Project. One area will be located near the powerhouse and another will be located near the water intake. Additional contractor's work areas will be located near the bridge location and at the borrow pit, although the specific locations have not been finalized (Figure 5.1-1). The total footprint of the contractor's work areas will be approximately 80,000 square metres (m^2). Granular material, to a depth of 200 millimetres (mm), will be used for surface topping and grading. The areas will be graded for proper drainage and fenced for security.

The contractor's work area at the powerhouse will include office trailers, a concrete batch plant, warehousing, outdoor storage areas, carpentry and reinforcement bending shops, toilet facilities, maintenance buildings, and a fuel storage and vehicle fueling facility. Explosives will be stored on the Project site in licensed magazines provided by the explosive manufacturer. They will be located on the project site in accordance with Transport Canada guidelines. No explosives will be manufactured at site. Provincial and federal regulations, guidelines, and special considerations related to the storage and transportation of fuels and explosives, and the handling and storage of other hazardous or dangerous goods, will be strictly enforced.

The work area at the water intake site will include small storage and lay down areas, a site office, and fuel storage. Concrete reinforcing, explosives, and fuel supplies will be sourced from the main work area near the powerhouse. The borrow pit and aggregate processing work area will include sites for aggregate crushing, washing, screening, and stockpiling, as well as an aggregate wash water settling pond. First aid stations will be located on-site at each contractor's work area.

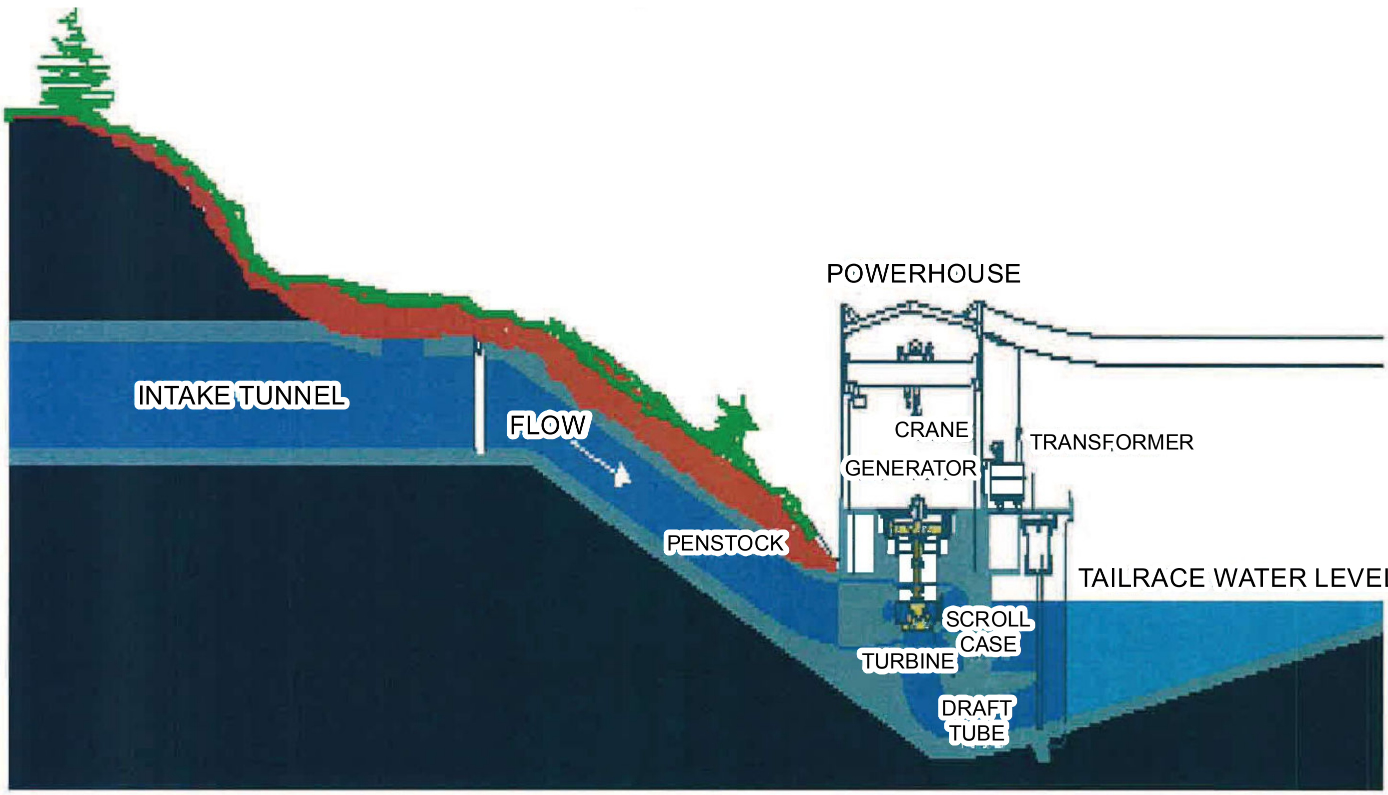
5.3.5 Powerhouse

The generating capacity of the Project is 50 MW (up to 190 m^3/s discharge rate). The Project will operate as a water diversion-type plant using approximately 36 m of gross head between Black Lake and Middle Lake. The Project's estimated, gross average annual generation will be approximately 400,000 megawatt hour (MWh) per year.

The Project will be managed so that minimum seasonal riparian flows will be maintained in the Fond du Lac River between the Black Lake outlet and the tailrace channel outlet. More specifically, the proposed minimum riparian flows would be managed to be higher (i.e., 70 m^3/s) during the spring spawning season and lower (i.e., 40 m^3/s) during the rest of the year. These values are simply minimum targets because river flows will exceed these values for most years. The minimum seasonal riparian flows represent flow levels that are anticipated to be sufficient for the maintenance of fish and fish populations within the Fond du Lac River.

The powerhouse will include two to four turbine generator units plus two or more flow bypass conduits. A multiple unit generating plant was selected because of its more flexible operation, ease of scheduling of maintenance outages as compared to a single unit power plant, and ability to maintain minimum riparian flows in the Fond du Lac River. The powerhouse and switchyard will be located in a deep cut in the bedrock and overburden and the top of all structures will be about 10 to 15 m below the surrounding terrain (Figure 5.3-1).

Hydroelectric facilities in Canada generally use Kaplan or Francis turbines for power generation (Canadian Electricity Association [CEA] 2001). A large proportion of the hydroelectric power generated in the United States also comes from hydroelectric facilities employing one of these turbine types (Becker et al. 2003; Odeh 1999). Kaplan style turbines have been selected for the Project; they are considered to be the more fish-friendly of the two turbine types. An example of a typical Kaplan turbine and generator installation layout is provided in Figure 5.3-2.



REFERENCE

PROCESS DIAGRAMS PROVIDED BY SASKPOWER

PROJECT

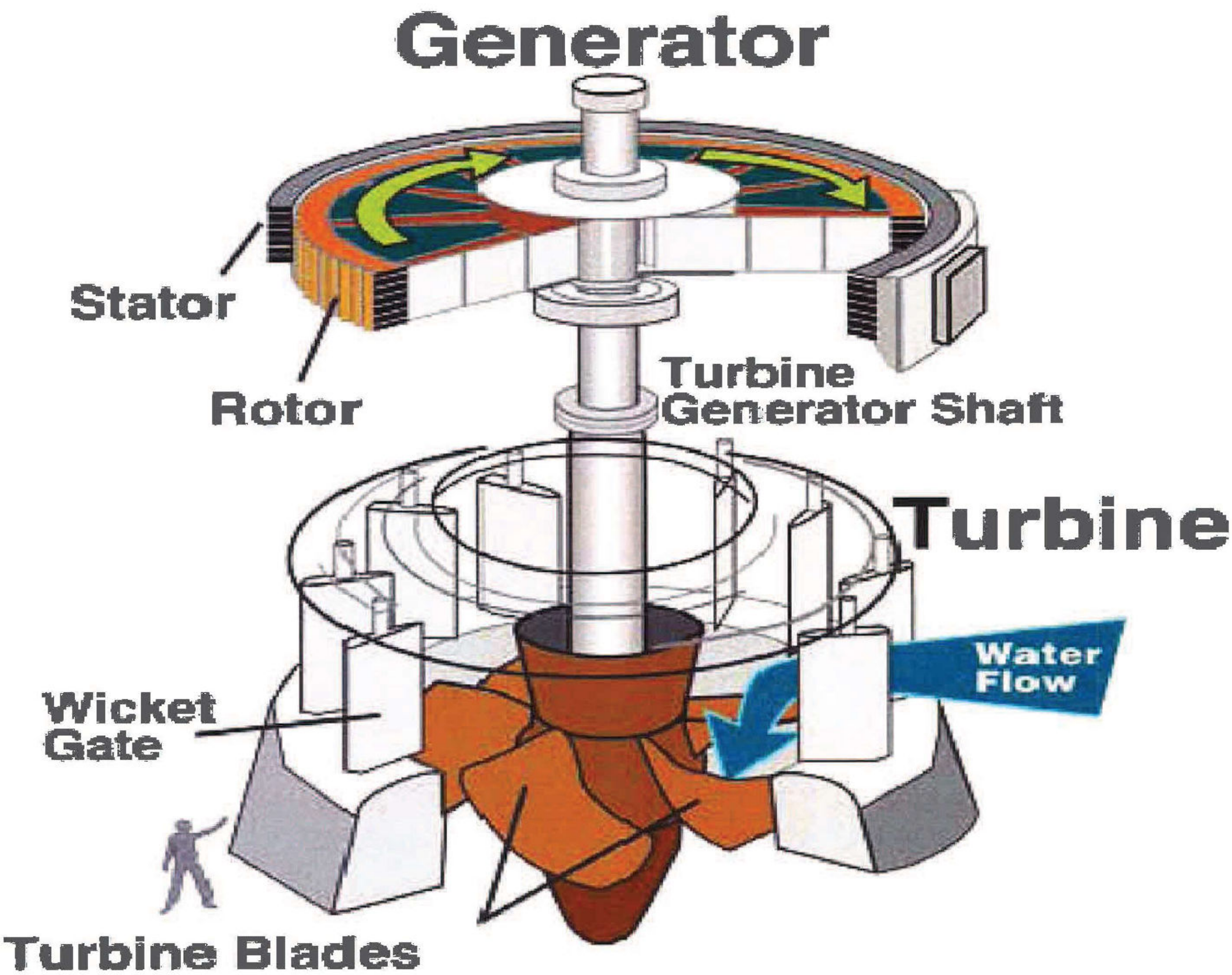
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

EXAMPLE POWERHOUSE PROCESS DIAGRAM

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN / REV. 0
GIS	SM	21/01/14	**FIGURE: 5.3-1**
CHECK	BC	21/01/14	
REVIEW	ML	21/01/14	



REFERENCE

PROCESS DIAGRAMS PROVIDED BY SASKPOWER

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

TYPICAL TURBINE LAYOUT

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	20/01/14	**FIGURE: 5.3-2**	
CHECK	MT	20/01/14		
REVIEW	BC	20/01/14		

A service bay, located immediately adjacent to the west side of the powerhouse, will serve as an area for assembly and maintenance of the larger turbine and generator components. Rooms for station control equipment, service and maintenance, storage areas, and toilets will be located along the southwest side of the service bay. A large overhead door and man door will be located in the southwest wall of the service bay.

A levelled area for manoeuvring large delivery vehicles and for parking will be located adjacent to the service bay. The switchyard, located on the southwest bank of the tailrace channel, will have concrete pads to support the main transformers. The switchyard will be connected, via a newly constructed SaskPower transmission line with the existing SaskPower Far North transmission line. A concrete slab and containment walls around the transformer pads will contain any possible leaks of transformer oil. Other auxiliary mechanical systems will include fire protection, service water, compressed air, and heating and ventilation.

5.3.6 Water Intake

The water intake will be located adjacent to a rock outcrop within bedrock 70 to 90 m from the shore of Black Lake, and will divert water from near the surface of the lake (i.e., water surface to about 5 m below the surface) into the power tunnel under controlled conditions. The streamlined water intake design will limit entrance turbulence reducing hydraulic losses (Figure 5.3-3). The water intake will be designed to draw the required power plant design discharge from Black Lake over the full range of anticipated lake levels.

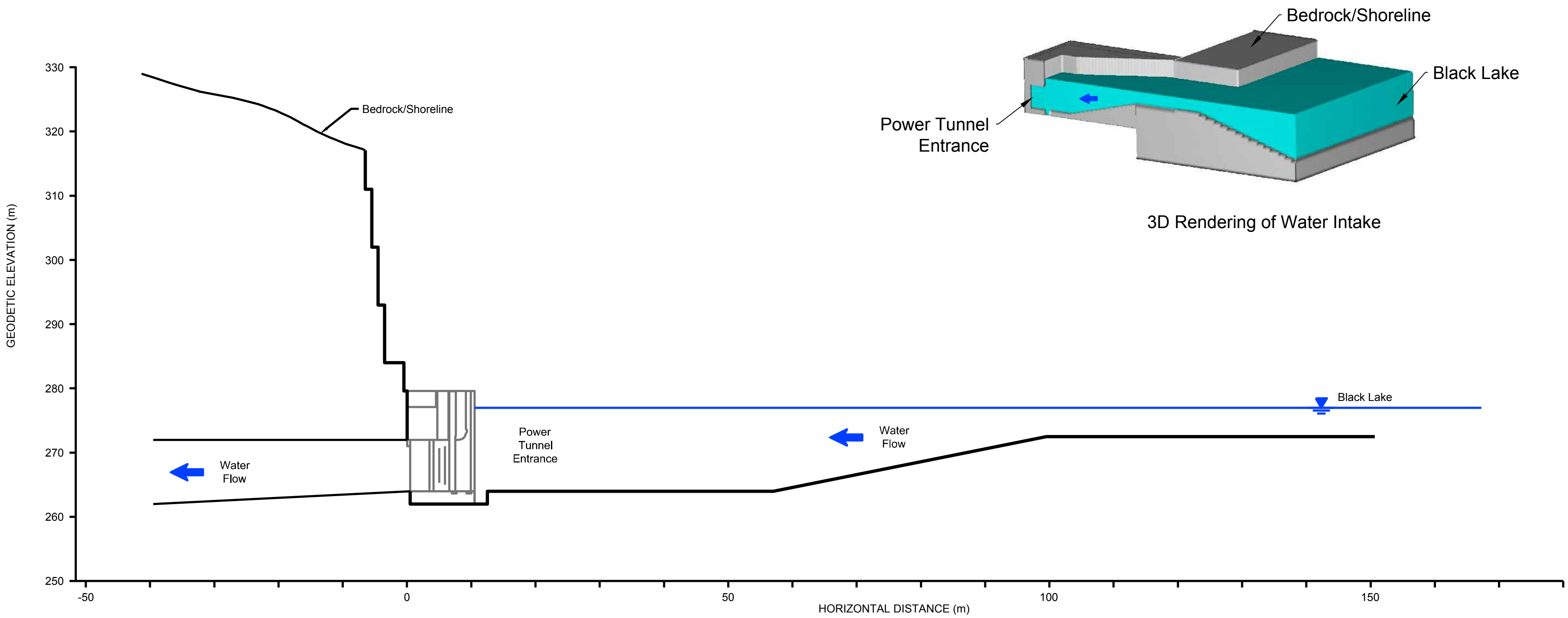
The size and shape of the water intake limits hydraulic losses, maintains similar intake flow water temperatures to natural outflows at the Black Lake outlet, and achieves compliance with industry and regulatory standards. The roof of the water intake will be submerged for the full range of anticipated Black Lake water levels, preventing entrainment of air into the power tunnel, which would interfere with the operation of the turbine generating units. A rock trap will be installed in the water intake upstream of the power tunnel entrance to reduce the risk of local bed material (e.g., cobbles and boulders) entering the units.

The water intake will be constructed of reinforced concrete with provisions for steel stoplogs and exclusion bar racks. The exclusion bar racks will prevent the entry debris and ice into the power tunnel, which could block the water intake and damage the powerhouse turbines. The stoplogs will be required for dewatering the water intake, power tunnel, and downstream water passageways for inspection and maintenance work. Materials that are clean and free of fine sediments and contaminants will be used for shoreline stabilization.

The construction area for the water intake and the outlet of the tailrace channel will be enclosed by a cofferdam or a rock plug (if feasible). The height of the cofferdam for the water intake will be based on the associated water level of Black Lake. The height of the cofferdam for the tailrace channel outlet will be based on the associated tailwater level in the Fond du Lac River. In-water works will be completed in accordance with conditions outlined in an authorization from DFO. For example, fish salvage activities will be completed before commencing in-water construction activities. Cofferdams or turbidity curtains will be used to contain sediment released during in-water construction and in-water work will be isolated from flowing water and adjacent lake or river habitats to reduce downstream or off-site effects. In addition, an Erosion and Sediment Control Plan and a Turbidity Monitoring Program will be developed and implemented at the Site.

Warning buoys and signage will be installed in front of the water intake and at the tailrace channel outlet into the Fond du Lac River to restrict boaters from the hazardous areas and to identify safe ice conditions on the lake in front of the intake during winter.

\\golder.gds\gal\Saskatoon\GGIS\CLIENTS\SASKPOWER\Elizabeth Falls Power Project\Figures\10-1365-0004 SaskPower Elizabeth Falls EA\25000 EIS Prep\S05_Proj Desc\10-1365-0004 Conceptual Profile and Rendering on the Water Intake.dwg 1/16/2014 12:05 PM



20 0 20

SCALE 1:1000 METRES

PROJECT	
TAZI TWÉ HYDROELECTRIC PROJECT	
TITLE	
CONCEPTUAL PROFILE AND RENDERING ON THE WATER INTAKE	

Tazi Twé Hydroelectric Project	PROJECT	10-1365-0004		FILE No.	
	DESIGN			SCALE AS SHOWN	REV. 0
	CADD	BDS	16/01/14	**FIGURE: 5.3-3**	
	CHECK	BC	21/01/14		
	REVIEW	MM	21/01/14		

REFERENCE

DRAWING PROVIDED BY KGS GROUP

Mitigation incorporated into the Project design to limit fish injury and mortality resulting from impingement or entrainment in the water intake include the following:

- selecting a water intake location away from sensitive fish habitat (i.e., areas where fish can congregate to spawn);
- constructing a shallow intake to reduce the entrainment of deep-water species such as lake trout (*Salvelinus namaycush*) and cisco (*Coregonus* sp.);
- sizing the intake opening so that water velocities in the approach channel are below burst speeds of resident fish, thereby promoting avoidance behavior;
- fitting the intake opening with an exclusion bar rack to reduce the potential for fish entrainment by presenting a visual barrier; and
- configuring the intake structure so that the soffit (ceiling) of the intake passage will be set low enough to prevent entrainment of air into the power tunnel and subsequently reduce the potential for gas bubble trauma in entrained fish.

5.3.7 Power Tunnel

The power tunnel dimensions will be optimized based on the rock quality encountered and hydraulic requirements, but is expected to be up to 11 m wide by 10 m high, with a horseshoe shaped (∩) cross-section. With the currently preferred tunnel alignment, the length of the power tunnel is 2.95 km. The power tunnel will be constructed using the drill-and-blast method. Approximately 430,000 cubic metres (m^3) of waste rock will be created by the tunnel excavation, assuming an overbreak of 0.5 m along the entire length of the tunnel.

The need for any pre-excavation grouting will be based on the assessed effects of groundwater inflows during the construction and the anticipated effect on adjacent structures, the environment, or on tunnel construction. Contact grouting will be used to fill any cavities left between concrete and rock during concrete operations at the intake, or during installation of the steel penstocks at the powerhouse end.

A Blasting Plan will be developed for the Project, which will describe the type of explosives used (e.g., ammonium nitrate/fuel oil [ANFO] and water-resistant explosives like Unimax® or similar) and the method of detonation (e.g., singular versus sequential blasting). At the present time, ANFO is expected to be used for the tunnel excavation. Tunnelling will be done from two active work faces, one originating at the water intake and the other from the power tunnel access adit located near the powerhouse. A blasting specialist will design all blasts using smooth wall blasting techniques that limit over-break, reduces disturbance to, and loosening of, the rock surrounding the power tunnel. The roof will be scaled (i.e., the removal of rock loosened from blasting, but still attached to the tunnel walls and roof) during or after mucking and the required rock support will be installed immediately. In very weak rock, a layer of shotcrete can be placed before mucking; in such cases, no scaling will be performed. Non-electric detonators with the appropriate number of interval delays will be used.

Venting of dust, gases, and fumes from inside the power tunnel will occur following blasting. Ventilation will be provided using forced air during power tunnel construction. Plastic coated textile ducts, treated to become fireproof, will be used as air conduits. The ventilation duct will have a diameter of 1 m; a silencer will reduce the noise of the fan. The power tunnel will be well-lighted with lamps hung from the crown of the power tunnel.

The tunnel is expected to be excavated from both sides, through the water intake and through the sloping inclined adit near powerhouse (which later becomes the surge shaft). The access for installation of the steel penstocks will be through the tunnel end that enters the upstream wall of the powerhouse excavation. The access to the tunnel for mucking and general traffic during construction from the Black Lake water intake end will be through the intake excavation. The waste rock will be transported to the nearest waste rock disposal area. Water pipes that are 50 mm in diameter will supply tunnel faces with water for drilling, flushing drill holes, cleaning rock surfaces, and watering muck piles for dust reduction. Water for most of the power tunnel excavation will be pumped from Black Lake.

Where possible, the power tunnel will be designed to drain by gravity to enable future access for inspections and maintenance during the operating life of the facility. The power tunnel portals will be located to avoid fault zones or closely fractured zones in the rock. The water intake portal rock cuts will be designed to resist structural instability mechanisms, such as rock wedge and rock slab instability, or toppling. The rock cuts will be supported using rock bolts, shotcrete, or wire mesh. The power tunnel eye will be reinforced and the first few tunnel rounds will be advanced using partial blasting rounds to control overbreak and fallout, until the tunnel heading is sufficiently advanced. A portal canopy (or alternate form of protection) could be required to protect workers from rock falls when entering the tunnel.

A surge facility/adit will be incorporated into the Project water conveyance system to control hydraulic transient pressures. The adit will limit the rise and fall of pressure when the turbine and generator units experience a load rejection by quickly reducing the water flow. The surge facility will limit the reduction in pressure when the units are started or when the load quickly increases. Due to the length of the power tunnel, the units will not maintain a constant speed while reacting to load changes if there was no surge facility.

The surge facility/adit will be an inclined tunnel branching off the power tunnel and emerging at the surface at an elevation sufficient to contain the highest water pressures during operation, which will be above the surface level of Black Lake. The surge facility will provide access to the power tunnel during construction. An alternate design option being considered uses a raised bore vertical shaft excavated in the rock to the surface above the level of Black Lake. The surge facility will connect to the power tunnel a short distance upstream of the powerhouse.

A rock trap will be designed to prevent entry of cobbles and boulders into the power tunnel and powerhouse, and will be designed to fulfill this function during filling of the power tunnel (i.e., when operating under partially full conditions), as well as when operating at full capacity (i.e., when the power tunnel is full and operating under pressure). The rock trap will be designed to provide safe access for personnel and for equipment used for inspection and maintenance. Long-term access to the power tunnel will be required to carry out tunnel inspections, tunnel cleaning, and cleaning of the rock trap. Access hatches, walking and travelling surfaces, and other facilities for safe future access of personnel and light excavation equipment for inspection, maintenance, and repairs of the tunnel will be provided.

The underground works will be performed in accordance with requirements of the *Occupational Health and Safety Act* of the Province of Saskatchewan. In addition to general safety regulations to be followed at a construction site, regulations for underground work activities will be followed including: handling of explosives, ventilation, fire proof ventilation ducts, proper illumination, electrical installations with backup generators, communication, radioactivity surveys, scaling of rock surfaces, and providing temporary rock support (e.g., shotcrete) where scaling is not possible due to weak rock conditions.

5.3.8 Tailrace Channel

After the water from Black Lake is used to generate power, the tailrace channel returns the water from the turbine discharge downstream of the powerhouse to the Fond du Lac River at a location upstream of Middle Lake (Figure 5.1-1). The proposed tailrace channel design has a length of approximately 800 m, a width of 25 m, and a depth of 5.5 m (the final design is subject to optimization). About 58,000 m^3 of overburden and 475,000 m^3 of waste rock will be removed during the excavation of the tailrace channel.

The tailrace alignment is along a rocky ridge to the northeast along the edge of the broad flat valley and allows the majority of the excavation to occur in bedrock, reducing the amount of overburden to be excavated. At the proposed tailrace channel outlet to the Fond du Lac River, an existing rock ridge will act as a rock plug preventing the migration of Fond du Lac River water into the excavation during construction. At its highest point, this ridge is approximately 7 m above the water level in the Fond du Lac River. To reduce effects on fish and fish habitat, the tailrace channel outlet will be situated upstream of important fish spawning habitat near the Fond du Lac River outflow to Middle Lake to maintain minimum required flows at this location.

The size of the tailrace channel has been designed to limit head loss, while considering the overall cost to excavate. As the power plant is expected to operate at full discharge capacity approximately 75% of the time, the design of the tailrace channel has been based on the full plant discharge. The proposed tailrace channel outlet has a designed water depth of 5.5 m and is expected to have an approximate flow velocity of 1.4 m/s based on a discharge rate of up to 190 cubic metres per second (m^3/s). The resultant hydraulic loss in the tailrace channel due to friction was estimated to be 0.21 m at the full plant discharge. The channel will be blasted into the bedrock or excavated in overburden and will have a relatively smooth, regular bottom with steeply sloping sides and exclude instream velocity refugia (e.g., slack water areas behind boulders or baffles).

Most of the channel excavation will be in bedrock. The bedrock is of good quality, permitting the excavation of near vertical sides (1 horizontal to 10 vertical [1H: 10V]). Some of the overburden is expected to consist of glaciofluvial material. This material will permit excavated side slopes through the overburden at approximately 3H: 1V. Slopes excavated in overburden will be protected with rock riprap excavated from the channel, or with other erosion control techniques. Erosion protection for the slopes will be optimized with the final design. The tailrace channel area will be fenced to prevent humans or wildlife from falling into the channel.

A rock and overburden plug will be left at the end of the tailrace channel outlet to exclude water from the Fond du Lac River from entering the active work area. A cofferdam in the river could be required if additional in-stream excavation is require to improve the existing river channel hydraulics at the tailrace channel outlet. The cofferdam would be constructed by placing the two rockfill sections first, then depositing semi-impervious material between them to minimize the release of fines into the river. The cofferdams will be removed following completion of the tailrace channel outlet excavation for hydraulic improvements at the river. Turbidity curtains will be used where possible during construction to minimize the amount of silt entering the river.

5.3.9 Submerged Weir at the Black Lake Outlet

A submerged weir spanning the width of the Fond du Lac River will be constructed at the natural outflow of Black Lake at Grayling Island to maintain historical water levels in Black Lake during Project operation (Figure 5.1-1). The Fond du Lac River is approximately 210 m wide at the location of the proposed weir, including the 35 m wide section of Grayling Island that the submerged weir will intersect. The length of weir to the west of Grayling Island will be approximately 90 m, while the length of weir to the east of the island is approximately 85 m. The mean elevation of the Fond du Lac River at this point will be identical to that of Black Lake at approximately 277 metres above sea level (m ASL).

The submerged weir will be completely underwater during the spring and early summer higher flow period and will be designed with a triangular cross section. It will have a 5H:1V slope on the upstream face and a 20H:1V slope on the downstream face. Thus, the fluvial distance or length of the weir will be approximately 50 m. The crest of the weir in each channel will be V-shaped, sloping to a mid-point notch to concentrated flows and facilitates fish passage during low flow periods. The weir will be constructed entirely of coarse rock fill, having an average diameter of 500 mm. As the weir is not required to act as a water retention structure, a central impervious core will not be required. This configuration of weir is designed to facilitate safe downstream passage for all fish species at the Black Lake outflow to the Fond du Lac River and at all lake levels and discharges. The crest of the weir (centre of notch) will be set at an elevation of 276.40 masl (i.e., less than the historical mean elevation of Black Lake).

The construction of the submerged weir will consist of advancement of clean rockfill material from the west shore of the Fond du Lac River towards Grayling Island, and from Grayling Island across the east channel. During advancement of the weir, the crest level of a temporary work pad groin in-line with the weir will be a minimum of 0.3 m above the lake level at the time of construction to enable the operation of heavy equipment to move and place the rock fill material without the equipment being in the water.

The submerged weir will be constructed at the end of the Project schedule once the powerhouse is operational. At this stage, spoil material will be readily available for use in weir construction, site access roads will be complete, and water will begin passing through the generating station. Construction of the weir prior to this would result in water levels in Black Lake increasing above natural levels.

The rock material used to construct the submerged weir be inspected and will be confirmed to have no potential or low potential for acid generation or radioactive materials. In addition, the rock materials used for shoreline stabilization and weir construction will be clean and free of fine sediments and contaminants. All in-water works will be completed in accordance with conditions outlined in a DFO authorization. An Erosion and Sediment Control Plan and a Turbidity Monitoring Program will be developed and implemented for the Project.

5.3.10 Settling Ponds

Three settling ponds have been included in the construction plan for the Project for the management and possible treatment of the Project's wastewater (other than site runoff and sewage and grey water; Figure 5.1-1). Water produced during construction or runoff through the site will be contained, tested, and treated, if necessary, before release in accordance with regulations.

One settling pond will be located near the water intake to collect the intake construction water along with a portion of the power tunnel dewatering flows and waste rock runoff from the waste rock disposal area south of the intake. A second settling pond will be located near the powerhouse excavation to collect the remainder of the tunnel and powerhouse dewatering. A third settling pond, beside the downstream end of the tailrace channel, will collect the tailrace channel dewatering and any runoff directed from the main waste rock piles to the northeast of the tailrace channel (Figure 5.1-1). At this preliminary design stage, each settling pond is anticipated to be approximately 43 m long by 11 m wide. The settling ponds in the powerhouse and tailrace excavations are expected to collect the majority of the estimated flow capacity of about 3,300 m^3/d and will have provision for secondary stored containment if the primary pond capacity is exceeded.

Water in the settling ponds will be pumped to the Fond du Lac River at one or both of two potential discharge locations (Figure 5.3-4) after the water has been tested and confirmed to meet appropriate discharge criteria. Construction and monitoring of settling ponds or water treatment areas will be included in the Site Water Management Plan.

5.4 Operations

The following section provides Project description information relating to the operations phase of the Project including power plant operations, site infrastructure, and supporting infrastructure during operations. This section describes industry standards, environmental design features, and mitigations that will be implemented during operations to reduce or eliminate potential effects on the environment.

5.4.1 Power Plant Operations

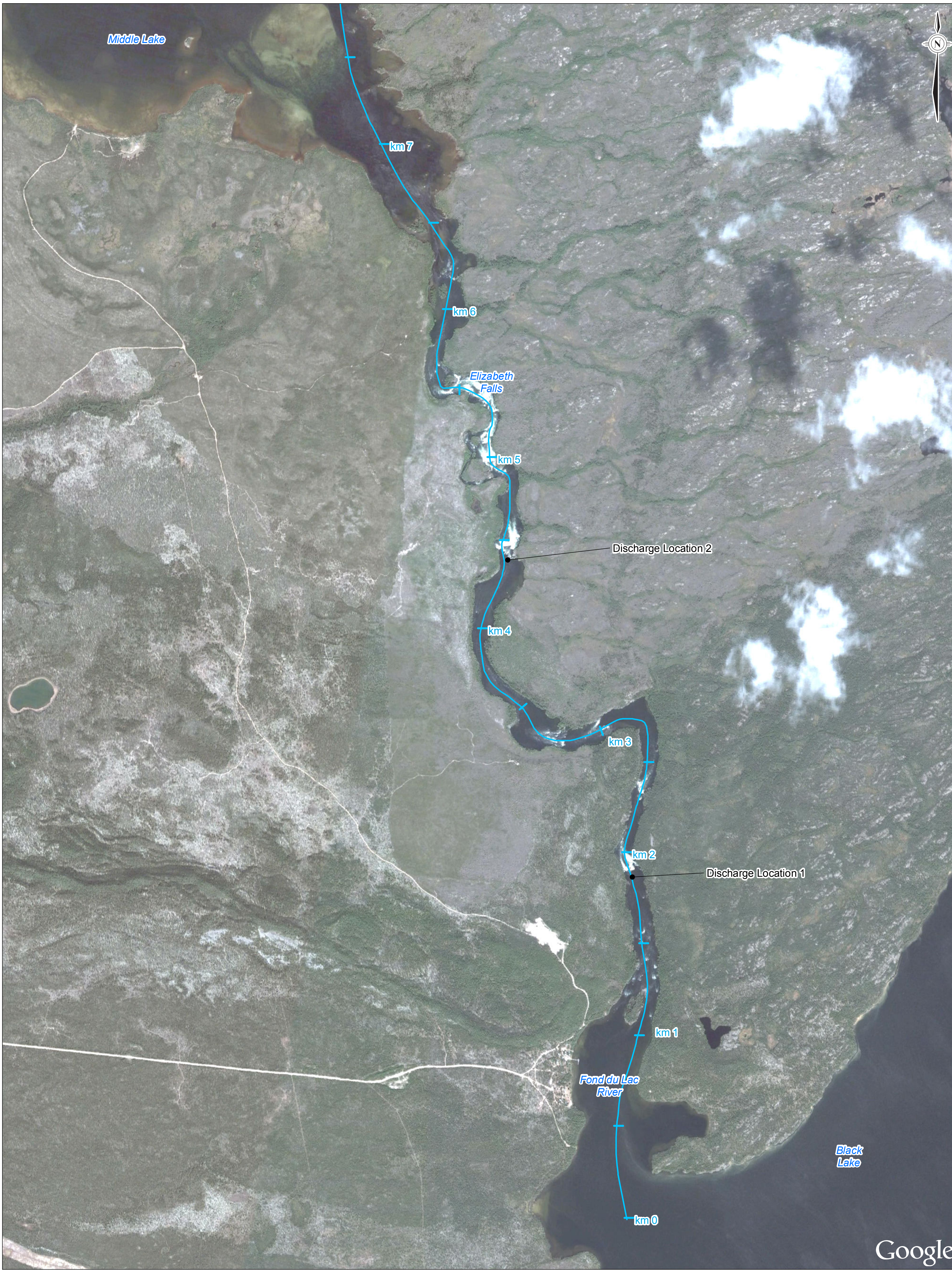
5.4.1.1 Normal Operating Conditions

The Fond du Lac River emerges in northeastern Saskatchewan and flows west-northwest to Lake Athabasca. The two main flow sources include Wollaston Lake to the east-southeast and Cree Lake to the south. Flows in the Fond du Lac River have been recorded since 1963 at Water Survey of Canada Gauging Station 07LE002, located at the outlet of Black Lake. The long-term average annual flow for the Fond du Lac River is 304 m^3/s (based on data from 1963 to 2011). The recorded minimum average monthly flow was 125 m^3/s in March 1982, and the recorded maximum average monthly flow was 786 m^3/s, which occurred in October 1997. The wettest year on record was 1977 with an average annual flow of 446 m^3/s. The driest year on record was 2011 with an average annual flow of 227 m^3/s. The maximum daily flow recorded was 860 m^3/s (in October 1997), and the minimum daily flow recorded was 122 m^3/s (in March 1982).

To produce 50 MW of power, a flow of up to 190 m^3/s would be required to pass through the power plant with the remaining 114 m^3/s (on average) passing through the natural Black Lake outlet into the Fond du Lac River. Powerhouse flows will be released into the Fond du Lac River upstream of Middle Lake, restoring the long-term annual outflow of 304 m^3/s entering Middle Lake and areas downstream of the tailrace channel outlet location.

The basis of the proposed design is that the plant will be operated such that total daily flows and water levels on Black Lake and Middle Lake during operation will remain very similar to the natural conditions observed prior to development. The Project will be also managed to meet minimum target seasonal riparian flows in the Fond du Lac River (between the Black Lake outlet and the tailrace channel outlet), including:

- 70 m^3/s for spring spawning season (i.e., May 1 to June 30); and
- 40 m^3/s for the over-wintering, summer and fall seasons (i.e., January 1 to April 30 and July 1 to December 31 for a given year).



LEGEND

DISTANCE CHAIN (0.5 KM INTERVAL)

400 0 400

SCALE 1:20,000 METRES

REFERENCE

GOOGLE EARTH IMAGE © 2010 DIGITAL GLOBE
NAD 83 UTM ZONE 13

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

POTENTIAL LOCATIONS OF SETTLING POND DISCHARGE TO THE FOND DU LAC RIVER

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	LR/SM	21/10/13	**FIGURE: 5.3-4**	
CHECK	LT	21/10/13		
REVIEW	BC	21/10/13		

These are the minimum target flows that will be released down the short section of the Fond du Lac River between Black Lake and the tailrace channel outlet during these periods. Most years the flows will exceed these values, particularly during the spring spawning period.

The power tunnel arrangement has the tunnel elevation sloping downwards from the water intake to the powerhouse at a uniform rate; therefore, the static pressure at the centreline elevation would increase uniformly from approximately 2.5 m of head at the centre of the intake water passage to 33 m of head at the inlet of the turbine. The pressure would then decrease by approximately 30.5 m of head as the water flows through the turbine generator units. The static pressure immediately downstream of the turbine is expected to be 2.5 m of head. As the centreline of the draft tube is followed, the pressure would increase to approximately 6.3 m of head at the centreline of the draft tube exit (which is nearly equal to the normal pressure in the tailrace channel at that depth).

A surge facility/adit will be incorporated into the Project water conveyance system to control hydraulic transient pressures. The control will limit the pressure rise and fall when the turbine and generator units experience a load rejection by quickly reducing the water flow. The control will limit the reduction in pressure when the units are started or when the load quickly increases. Due to the length of the power tunnel, the generator units would not be able to maintain a constant speed while reacting to load changes if there was no surge facility. The adit will tie into the power tunnel a short distance upstream of the powerhouse.

Pressure fluctuations will occur from transient effects caused by valve closures or changes in powerhouse output that will translate to water level fluctuations in the surge facility. In addition, the static pressure at the turbine inlet will increase by approximately 40% to 50% during load rejections. Following a load rejection, the pressure would fluctuate above and below the steady state value. These pressure fluctuations would last for several seconds.

An energy model was developed to simulate daily operation of the plant over the available historical flow record from 1963 to 2011. The headpond for the Project, Black Lake, will vary in elevation depending on overall inflow from its upstream watershed. The submerged weir at the lake outlet will be designed to maintain the historical water levels on Black Lake (1963 to 2011) and levels will vary as they did naturally prior to development of the Project.

The tailwater relationship for the plant is based on the estimated stage discharge relationship for Middle Lake. This relationship has been estimated based on recent bathymetric information obtained at the entrance and outlet of Middle Lake, together with available water level elevations collected as part of the field investigation. The large storage volume of Black Lake will give the powerhouse outflows a high thermal inertia, which likely will prevent ice cover forming over the tailrace channel.

The energy model assumed two or four turbine generator units. Hydraulic losses included losses at the water inlet, water intake structure, exclusion bar racks, power tunnel, transition/penstock bifurcation, butterfly valves, and tailrace channel. Several potential minimum riparian flow scenarios were modelled to determine the average annual net energy potential given various flow levels. A summary of the calculated average annual net energy potential as a function of the installed capacity and the assumed riparian flow scenario is shown in Table 5.4-1. The content of this table illustrates that power generation potential is sensitive to the value assumed for minimum riparian flow. The Project's estimated, average annual generation will be approximately 400,000 MWh per year.

Table 5.4-1: Average Annual Energy Potential

Minimum Riparian Flow Scenario	Average Annual Energy Potential (MWh) Installed Capacity 50 MW
Year Round IFR	
40 m^3/s	***407,000***
50 m^3/s	402,000
70 m^3/s	389,000
Spring [(a)] (Winter IFR = 40 m^3s)	
125 m^3/s	399,000
145 m^3/s	397,000
175 m^3/s	392,000

(a) Spring = My 1 to June 30

MWh = megawatt hours; MW = megawatt; m^3/s = cubic metres per second

5.4.1.2 Upset Conditions

When the generating station is in operation, there will be times (e.g., scheduled maintenance) when the plant must be slowed or shut down and the flow through the powerhouse must be reduced or stopped, turbine generator units in the powerhouse must be reduced or even stopped, and flows in the tailrace channel would be reduced . Annual inspections would be scheduled to avoid spawning periods and are expected to last for periods of up to two weeks. Only one unit would be shutdown at a time to limit the effect on water levels on Black Lake and Middle Lake and to maintain energy production. Maintenance shutdowns likely will be conducted during the winter or during other periods when there is less flow available to pass through the plant.

It is anticipated that each unit could be taken out of service once per month (on average), to perform minor adjustments, inspections, and maintenance. To accommodate the power tunnel inspections, the entire plant would be shut down for approximately 1.5 to 2 weeks every five years. The turbine generator units would receive major overhaul work every 30 years. It is expected that one unit at a time would be overhauled, with each overhaul lasting two to three months.

It is estimated that the power plant will undergo between 10 and 50 emergency shutdowns per year, with most of these occurring during the summer months (i.e., weather-related). The power plant will be shut down without advance notice if there is a load rejection in the transmission system due to transmission line failure. These unplanned shutdowns are expected to be relatively brief, typically from a few minutes to four or five hours. On occasions during the spring fish spawning and rearing period (May 15 to July 15), when the unplanned shutdown exceeds 15 minutes, the bypass conduit at the powerhouse will begin releasing flow to reduce drawdown effects on the Fond du Lac River below the tailrace channel outlet and upstream of Middle Lake. During these periods, flows through the natural outlet would slowly increase as water levels in Black Lake respond to reduced power tunnel outflows.

The turbine generator units for the proposed power plant will be equipped with turbine inlet valves (TIV) to handle the sudden requirement to stop the flow. These will act as the spigot at the end of the power tunnel and control the flow through the powerhouse. The TIVs will be designed to close at a rate that will avoid undesirable increases in water pressure in the power tunnel. The sudden curtailment or start up of flow within the power tunnel will trigger a pressure surge or transient condition within the power tunnel. Although the pressure will rise in the power tunnel as the pressure wave migrates upstream toward the water intake, it will dissipate rapidly once it reaches the open water of Black Lake. The pressure fluctuations in the tunnel will also be dampened by the open water surface of the surge facility located upstream of the powerhouse. Minor disturbances (e.g., small waves and local surging) are expected at the entrance, which will be confined to a small area near the intake structure. Due to the depth of the lake in this area, the increase in water level is expected to be local, extending in a radial pattern for approximately 50 to 100 m, and dissipating quickly in the open water.

Modelling has been completed to simulate a worst-case scenario when all turbine generator units suddenly shut down for an extended period. The modelling results suggest that the sudden shutdown of the units and subsequent bypass 80 m^3/s of power generation flows would subject Middle Lake to a maximum drop in water level of approximately 0.41 m. The maximum rate of water level drop was determined to be approximately 4.35 centimetres per hour (cm/h). The plant will be equipped with measures that allow flows to be bypassed through the plant when the turbine generator units are shutdown or cannot be connected to the transmission line grid, with the size of the bypass conduit selected to be in the order of 50% of the plant capacity.

To reduce the effects of shutdowns, the following environmental design features and mitigations are in place for the Project:

- schedule maintenance shutdowns annually on a unit-by-unit basis (estimated to last from a few days up to two weeks);
- remove one unit at a time from service for maintenance;
- time the maintenance shutdowns to limit downstream effects, for example during winter months, during other periods when there is less flow available to pass through the powerhouse, or during summer when sufficient in-river flows are available;
- take each unit out of service once per month, to perform minor adjustments, inspections, and maintenance; and
- maintain downstream flows by bypassing water around the turbine generator units using a bypass conduit for planned or unplanned shutdowns longer than 15 minutes duration during the spring spawning and rearing period (May 15 to July 15) and winter low flow periods.

5.4.2 Powerhouse

The powerhouse complex will be located in a rock excavation to the east of Elizabeth Falls. Adjacent to the powerhouse will be the parking and vehicle manoeuvring area, and the switchyard. The following powerhouse description, similar to descriptions of other Project components, is based on an initial design, and may be subject to change as the design is optimized.

5.4.2.1 Powerhouse Complex

A reinforced concrete powerhouse substructure will encase and support all the electrical and mechanical equipment associated with the turbine generator units in the central area of the main powerhouse floor level. Governor equipment used to control the generating units and other mechanical equipment would be installed beside the generator enclosures. Upstream of this, above the valve chambers, will be a gallery containing electrical equipment and covered hatches. A section of floor along the downstream side of the units at the service bay slab level will accommodate electrical panels and cubicles, and an oil-water separator near the service bay.

The steel penstock leading from the power tunnel will separate into two or four smaller penstocks (depending on the number of turbine units) that will pass through the upstream wall of the powerhouse where butterfly valves will be located to be used for emergency shut off of the flow to each unit. The steel penstock then leads to the turbine runner where the flow passes through the stay vanes, turbine inlet valves, and down through the turbines into the draft tubes. Having passed through the turbines, the water will be discharged into the tailrace channel where it re-enters the Fond du Lac River through the tailrace channel outlet downstream of Elizabeth Falls. When flow bypass is required, the 80 m^3s will be moved through the water conveyance system at the powerhouse, either by a discrete branchline diverting off of the penstock upstream of the powerhouse and dissipating into the tailrace through mechanical nozzles, or alternatively by passing through one or more of the turbines depending on the final design and equipment selection.

A dewatering and drainage sump will be located at the lowest elevation of the powerhouse. The dewatering system will consist of a set of pumps and associated controls that will operate to completely dewater the power tunnel, steel penstocks, turbine water passageways, and draft tubes for inspection. All drain and fill lines will be equipped with valves and connected to the service air system. Compressed air will be used to purge the drain lines of sediment prior to dewatering.

The generator cooling water strainers are designed for indoor operation with temperatures normally between 10ºC and 40ºC and inlet water temperature range from 1ºC to 25ºC. The service water pipes between the strainers and the generator enclosures will be insulated to prevent condensation. The generator cooling strainers will feed a service water header that will run the length of the powerhouse to supply the generators. The service water will be delivered to the generators at flanged outlets outside the generator enclosures. A branch line from the service water header will provide domestic water and shaft seal water. The shaft seal water filter system will be a filtered, pump-pressurized system and will supply water to the turbine shaft seals through distribution headers.

The powerhouse will be equipped with features so that a change in operation does not negatively affect downstream flows or water levels during a sudden change in turbine load (e.g., load rejection). The amount of flow that must be diverted will determine the type of equipment selected. If the ramping rate is moderate, it could be possible to use the turbines or an energy-dissipating valve. If larger bypass flows are required, a more complex system might be required, possibly employing multiple valves or specially designed units.

To reduce the effects of power generation activities the following environmental design features and mitigations are in place for the Project:

- locate the tailrace channel outlet upstream of important fish spawning habitat near the Fond du Lac River outflow to Middle Lake to maintain minimum required flows;
- maintain the historical range of water levels in Black Lake and in the uppermost section of the Fond du Lac River, for powerhouse operating flow conditions using a submerged weir on the Fond du Lac River at the outlet of Black Lake;
- time maintenance shutdowns to limit downstream effects, for example during winter months, during other periods when there is less flow available to pass through the powerhouse, or during summer when sufficient in-river flows are available; and

- maintain downstream flows during planned or unplanned shutdowns longer than 15 minutes duration during the spring spawning and rearing period (May 15 to July 15) and winter low flow periods, by bypassing water around the turbine generator units in the powerhouse using a bypass conduit.

5.4.2.2 Powerhouse Equipment

At each turbine generator unit, a turbine inlet valve will be positioned upstream of the turbine case. The valve will provide emergency closure capability to shut down the turbine if control of the generating unit is lost. The valve can be used to isolate the unit during dewatering. It will be hydraulically operated and provided with a counter-weight as a backup in the event of a hydraulic system failure. Each valve will have bypass piping to allow the hydraulic head across the valve to be balanced before operation.

Primary heating of the powerhouse structure will be accomplished by circulating the heat expelled from the generator equipment to the surrounding area. Heating, cooling, and ventilation of occupied spaces (i.e., control room, mechanical and electrical shops, communication and electronic rooms, lunchroom, and toilets) will be accomplished by mechanical heating and cooling units supplemented with exhaust ventilation to provide fume, humidity, and odour control. The number of air changes per hour will vary depending on the space, but will not be less than six changes per hour. Occupied spaces in the powerhouse (i.e., control room, communications and electronics rooms, lunchroom, and toilets) will be provided with heating and mechanical cooling (air conditioning) to maintain a temperature of 22°C. The air supply and exhaust system for the plant will shut down automatically in the event of a fire. A manual override will be located at the entrance to the plant so that emergency responders can activate the controls upon arrival.

5.4.2.3 Drainage Systems

Drainage from the rooftop will be collected in scuppers and drained by gravity through downspouts to the tailrace channel. Drainage within the powerhouse will be collected in a sump in the lower section of powerhouse. From there, float-operated pumps will transfer the drainage to an oil-water separator before it is released to the tailrace channel. The drainage system will be sized to handle the largest combination of drain loads, including fire protection discharges and rain, and will operate with temperatures normally between 10°C and 40°C. The oil-water separator storage area will have sufficient volume to hold the contents of the largest single oil container within the power station.

The pumped drainage system will be employed for collecting effluent drainage originating below the extreme maximum tailwater elevation with a network of floor drains. The pumped drainage system will collect sources of leakage through the concrete structure below the tailrace channel level. Sources of pumped drainage are hydraulic power unit trench drains, turbine pit liner and access drains, turbine case and draft tube access drains, dewatering gallery trench drains, and the dewatering sump drain. The pumped drainage system will not be linked to or collect any drainage from the sewage system. Generator cooling water will be discharged directly to the tailrace channel and will not be discharged into the pumped drainage system. The drainage sump will be equipped with an oil skimmer to remove oil from the collected water before it is transferred to the primary interceptor tank. This makes sure that oil is not emulsified with the water by the pumps.

The role of the primary interceptor tank is to act as a collection point for the pumped drainage system and the gravity drainage system to separate most of any oil from the water. The water then flows by gravity to the oil/water separator tank for further separation before passing to the tailrace channel. Oil is separated from the water, skimmed, and pumped into storage containers in the powerhouse. The disposal of the Project's hazardous waste is described in Section 5.7.2.

The gravity drainage system will be used where possible to collect the clear water and effluent drainage originating above the extreme maximum tailwater elevation. The gravity drainage system will collect sources of leakage through the concrete structure above the tailrace channel level. Assumed sources of gravity drainage are floor and trench drains from above tailwater level. Gravity drainage will be collected through a gravity drainage header and drain to the primary interceptor tank. The gravity drainage system roof drains will be individually piped to the tailrace channel. Drainage with the potential for containing oil will be directed to the primary interceptor and oil/water separator tanks.

Environmental issues associated with the new powerhouse drainage systems include oil containment and potential oil discharges to the river. The pumped drainage sump, primary interceptor chamber and the oil and water separation chamber will be equipped with oil detection equipment capable of detecting trace oils on the surface of the water. In the event of oil detection, the oil detector will alarm back to the main control room. To mitigate the risk of a drainage system failure flooding the powerhouse, the drainage sump will overflow into the dewatering sump, thereby providing significant additional pumping capacity.

5.4.3 Water Intake

The water intake will consist of a reinforced concrete structure with provision for steel stoplogs and exclusion bar racks, and a streamlined water passage to direct the flow to the power tunnel. The intake channel and structure will withdraw the required plant discharge from Black Lake over the full range of anticipated lake levels.

The water intake will divert water from near the surface of the lake (i.e., surface to about 5 m below the lake surface). The flow from the intake and power tunnel to the powerhouse is conveyed approximately 2.95 km through the rock-walled tunnel, transitioning to a single steel power tunnel liner that transitions into the penstocks to each of the turbine generator units, approximately 30 m inside the downstream power tunnel portal. The ceiling of the water passage will be set low enough to prevent entrainment of air into the power tunnel. The level of the water intake deck will be set so that it remains operational during periods of high water in Black Lake.

The design of the water intake will allow for a smooth and gradual acceleration of the flow that will limit the disturbance to the local fish habitat (i.e., adult large-bodied fish species likely to be present near the intake have burst swimming speeds in excess of the proposed exclusion bar rack approach velocity). The exclusion bar racks will consist of embedded horizontal steel beams that support assembled exclusion bar rack. The exclusion bar racks will consist of steel bars 10 mm thick by 150 mm deep. With an anticipated bar spacing of 80 to 160 mm on center, the clear opening would range from approximately 70 to 150 mm..

A central concrete pier will divide the upstream portion of the water passage into two bays. This will avoid placing an excessively long single span and its associated loads on the reinforced concrete base slab and roof and on the steel stoplogs and exclusion bar racks. The water passage will taper at its downstream end to match the width of the power tunnel.

Sectional stoplogs will be provided for the two openings at the water intake to isolate the power tunnel for inspection and repairs. The stoplog sections will only be installed or removed under balanced head conditions, which is when the power tunnel is full of water but not flowing, and with the butterfly valves and turbine inlet valves closed in the powerhouse. The water intake gate hoist will be an outdoor, self-supported monorail crane used to install and remove the water intake exclusion bar racks and stoplogs. The intake gate hoist will be provided with a follower equipped with an auto-tiller rope to handle the stoplogs. Stoplogs will be stored at the top of each check and off to one side if required. The deck of the water intake structure will be large enough to allow a mobile crane to be positioned adjacent to the stoplog and exclusion bar racks to facilitate handling. A small slide gate or embedded filling line will be provided in the water intake structure to allow for gradual filling of the power tunnel. A hatch will be provided immediately downstream of the stoplogs to gain access into the power tunnel for inspection and maintenance. Air intakes and vent pipes will be provided downstream of the stoplogs to stabilize air pressure in the power tunnel during dewatering and rewatering.

The deck of the water intake structure will be large enough to allow a mobile crane to be positioned adjacent to the stoplog and exclusion bar racks to facilitate handling. A permanent crane will be in place for removal and installation of stop logs.

The access road to the water intake will lead directly onto the deck and to the storage area. The concrete roof of the downstream portion of the water passage will be overlaid with compacted fill and road topping to bring it up to the same level as the access road.

To reduce the effects of the water intake, the following environmental design features and mitigations are in place for the Project:

- use an exclusion bar rack to prevent entry of debris into the power tunnel and to provide a visual deterrent for fish entrainment at the intake;
- operate a shallow water intake to reduce entrainment of deep water fishes;
- locate the water intake away from sensitive fish habitat;
- position the soffit (ceiling) of the water intake passage low enough to prevent entrainment of air into the power tunnel and reduce the potential for gas bubble trauma in entrained fish;
- size the water intake opening so that water velocities in the approach channel are below burst speeds of resident fish, thereby promoting avoidance behavior; and
- restrict access to the water intake and powerhouse structure, as well as the tailrace channel and any storage buildings with permanent fencing.

5.4.4 Switchyard

The switchyard for the Project will be located near the powerhouse. A grounding grid will be located underneath a layer of locally obtained crushed rock. The equipment within the switchyard will consist of the following items:

- two runs of 13.8 kilovolt (kV) 133% insulated XLPE TECK cable from the powerhouse entering the switchyard;
- each of the turbine generator units will connect to one generator step-up transformer located in the switchyard;
- 138 kV SF6 Circuit Breakers; and
- 138 kV Disconnect and Grounding Switches.

An access road will be built to bring equipment to the site and to facilitate future maintenance. A chain link fence with barbed wire will enclose the switchyard with gates for vehicles and pedestrian access.

5.5 General Project Activities

5.5.1 Site Water Management

Site wastewater will be of several types, including waste rock runoff, groundwater inflows during the construction of the power tunnel, general site runoff, and water collected in the settling ponds. Water collected within the three settling ponds for the Project will be composed of waste rock runoff and groundwater inflows during the construction of the power tunnel. Surface runoff will be diverted around and away from waste rock disposal areas as much as possible. The site will be properly graded and be surrounded by ditches and berms to capture runoff from the waste rock disposal areas.

At this preliminary design stage, each settling pond is anticipated to be approximately 43 m long by 11 m wide and have a flow capacity of about 3,300 m^3/d. Water collected in disturbed areas located away from the settling ponds will be pumped to these locations. Water collected in disturbed areas located away from the settling ponds will be pumped to these locations. Surface water diversions could be constructed to maintain natural drainage characteristics, whereas other structures could be designed to actively divert water away from its natural flow path to prevent the interaction with site infrastructure, potentially contaminated water, or areas sensitive to erosion. A Site Water Management Plan will be developed for the Project.

Water within the settling ponds will be tested and treated, if necessary, before release to the Fond du Lac River, in accordance with applicable regulations and licence requirements. Retention of Project-affected water in the settling ponds will allow suspended sediments and associated parameters (e.g., some metals) to settle out. Water in the settling ponds will be pumped to the Fond du Lac River at one or both of two potential discharge locations (Figure 5.3-3) after the water has been tested and confirmed to meet appropriate discharge criteria (if required). A Water Quality Monitoring Program will be implemented to determine the nature of potential changes to the water quality of the Fond du Lac River receiving discharge from the settling ponds. Contingency plans for off-site disposal of dewatered settling pond sludge will be included in an Environmental Protection Plan (EnvPP).

5.5.2 Waste Rock Management

Potential locations of the waste rock disposal areas are shown in Figure 5.1-1. While preliminary locations have been identified, waste rock disposal area locations and volumes will be defined as the Project design is finalized. The total potential disposal volume of waste rock and overburden after excavation will be approximately 1,192,000 m^3. This represents a volume for disposal consisting of approximately 118,000 m^3 of overburden and 1,074,000 m^3 of rock (Table 5.5-1). Predicted waste rock and overburden volumes have been purposely over-estimated for the environmental assessment. Total waste rock and overburden volumes are expected to decline as the Project design is optimized, thereby further reducing the footprint and possibly the height of waste rock disposal areas.

Table 5.5-1: Volume of Overburden and Waste Rock Removed from the Project

Material	Volume (m^3)
Overburden	
Powerhouse/Switchyard	0
Tailrace channel	58,000
Water Intake	60,000
Total Overburden	*118,000*
Rock	
Powerhouse	116,000
Tailrace channel	475,000
Water Intake	153,000
Power tunnel	330,000
Total Rock	*1,074,000*
Total Overburden + Rock	**1,192,000**

m^3 = cubic metres

Waste rock removed from excavations can be used in construction where these materials meet the applicable Project requirements and in concrete production. For example, a relatively small volume of the excavated rock can be used for road topping, for berm fill for riprap to armour the walls of portions of the water intake approach channel and tailrace channel excavated in overburden, and for construction of the submerged weir across the Fond du Lac River at the outlet of Black Lake. Similarly, portions of the overburden comprised of sand and gravel can be used as aggregate for the production of concrete, if suitable. The remaining excavated rock and overburden will be deposited in waste rock disposal areas.

Some portion of the waste rock excavated from the power tunnel could be acid-generating, have elevated concentrations of various metals, or contain uranium mineralization, particularly waste rock from the section of the power tunnel within, or near, the Black Lake Shear Zone. Previous geological testing has confirmed that radioactive waste rock is not likely to be encountered in the LSA (Hatch 2005, 2012). However, a Waste Rock Management Plan will be prepared for the Project that will outline methods to visually identify and classify waste rock including the rock type, waste unit designation, and ARD/ML potential. The rock will be segregated for special management if the bedrock materials are determined to be potentially acid-generating or contain metals. On-site geochemical characterization will be performed using simple visual techniques that can be learned and implemented by site personnel who have little or no geological background. It is anticipated that the waste rock will be classified into one of three materials types with respect to ARD potential or radioactivity: negligible, low, or uncertain potential.

The results of the on-site visual classification will be recorded along with the blast designation, the waste unit designation, and the disposal location. Representative samples of waste rock from within or near the Black Lake Shear Zone, or displaying evidence of uranium mineralization, will be screened using a scintillometer. Offsite confirmatory analyses will be carried out to confirm the visual classification. Confirmatory sampling of waste units with negligible or low potential for ARD or uranium will occur at a lower frequency than waste units with uncertain potential. In the event that drainage from specific portions of the waste rock disposal area cannot be monitored separately, or does not occur as a defined flow, field-monitoring bins could be constructed with leachate from the waste rock being sampled in the same manner as would occur with direct sampling of waste rock runoff. Regular visual inspections of the waste rock disposal areas will take place during active periods of power tunnel excavation. It is expected that a designated waste rock disposal area would be set aside to isolate materials deemed to be potentially ARD generating or that could contain uranium.

Any rock waste that is found to be radioactive will be disposed of according to provincial and federal guidelines. Environmental design features will be required to limit seepage from the waste rock disposal areas. A containment system will be designed to control seepage from the waste rock disposal areas to groundwater or underlying aquifers. The design will control shallow horizontal migration. Potentially contaminated wastewater from waste rock disposal areas run-off will be collected in on-site settling ponds. Once wastewater is collected, it will be tested and treated, if required, prior to discharge. Wastewater will meet applicable water quality guidelines (e.g., CCME) prior to being released into a the Fond du Lac River.

If no adverse characteristics are identified in the waste rock, this material can be used as aggregate for road construction and concrete production. It can be used as riprap to armour the walls of the tailrace channel or to construct the weir across the Fond du Lac River at Grayling Island. Re-use of clean waste rock at the Project site will reduce the overall volume stored in the waste rock disposal areas.

With the proposed life of the Project being approximately 90 years, there is potential for long-term contaminant transport from the waste rock disposal areas that could affect groundwater quality. To mitigate the potential for long-term contaminant transport, the potentially ARD/ML or radioactive waste rock disposal areas will be placed on engineered pads that will limit infiltration. Furthermore, recharge of groundwater to bedrock aquifer systems typically is limited to fracture networks. Therefore, a release of contaminants from the waste rock disposal areas is more likely to occur in the downstream surface water environment and not in the groundwater system. Ongoing monitoring requirements outside of those specified within the Project license would default to terms outlined within the relevant federal and provincial acts, regulations, and standards applicable at the time.

5.5.3 Domestic and Industrial Waste Management

Non-hazardous waste at the Project consists of domestic waste (e.g., kitchen waste and office waste) and construction material waste (e.g., plastics, wood, metal, and other inert materials). Domestic waste produced during the construction and operation phase of the Project, including food refuse and similar material, will be managed with bear-proof storage containers and will be hauled off-site to an existing permitted waste disposal facility. During construction, about 4 m^3/d of solid waste will be produced, varying in volume at different times of the year. There will be about one load per day of camp and kitchen waste and a larger load of construction waste every few weeks. If solid waste is hauled to Black Lake for disposal, it will be subject to the Indian Reserve Waste Disposal Regulations contained in the *Indian Act* (1985). Some recycling will take place at the construction camp with the recyclable materials hauled to southern facilities.

5.5.4 Hazardous Substances

Hazardous substances used at the Project during construction will include fuels and other petroleum hydrocarbons (e.g., diesel fuel, light or medium oils, hydraulic fluid, and lubricants), pressurized gases (i.e., oxygen, acetylene, propane, and compressed air) and chemical additives. Fuel will be stored in a dedicated, secured staging area adjacent to the maintenance facility on the east side of the river near the powerhouse, complete with appropriate spill-proof equipment (including secondary containment) and documentation. Explosives will be stored in licensed magazines provided by the explosive manufacturer. They will be located on the project site in accordance with Transport Canada guidelines. No explosives will be manufactured at site. Some equipment used during Project construction will be powered by propane. In addition to the federal *Propane Storage and Handling Code*, the SaskPower code of practice for propane handling will apply.

Hazardous industrial waste expected to be generated at the site during construction and operations includes waste hydrocarbons, chemicals, glycols, solvents, antifreeze, and batteries. The management of hazardous wastes will include collecting the wastes in suitable containers and storing them for shipment off-site via a licensed contractor to recycling or disposal facilities. Where suppliers will accept them, empty containers used to ship these materials to site will be returned to the supplier. Those that cannot be returned will be shipped to recycle or disposal facilities. All storage and handling of hazardous materials and hazardous waste will meet the requirements of the *Hazardous Substances and Waste Dangerous Goods Act and Regulations* and *Transportation of Dangerous Goods Act and Regulations*, including employee training, storage facility design and operation, labelling and material control (e.g., Workplace Hazardous Materials Information System [WHMIS]).

5.6 Supporting Infrastructure and Services

The Project's site infrastructure includes the powerhouse, water intake, power tunnel, tailrace channel, submerged weir at the Black Lake outlet, transmission line, construction camp, contractor's work area, and settling ponds. The following major equipment will be included in the Project:

- turbine generator units located within the powerhouse;
- generator step-up transformers located in a switchyard near the powerhouse;
- supply air fans for powerhouse ventilation located inside the powerhouse;
- hydraulic power units (for turbine control) located inside the powerhouse;
- two air compressors located inside the powerhouse;
- exhaust fans and small heating, ventilation, and air conditioning (HVAC) units located inside the powerhouse;
- dewatering pumps;
- drainage pumps - submersible pumps;
- powerhouse crane;
- draft tube gauge and intake gate hoists;
- permanent diesel-powered generators for backup power supply;
- fire pumps located inside the powerhouse; and
- energy dissipating bypass valves.

5.6.1.1 Power

Diesel-powered generators and 25 kV power from the SaskPower electrical grid are the only options available for initial Project construction power. Diesel-powered generators will be used as a temporary means of providing construction power and as backup power if the SaskPower grid is out of service.

Within a few months of construction startup, construction power will be supplied to the site from the SaskPower electrical grid using a permanent 25 kV distribution line that will travel along the new access road to the powerhouse and water intake structure. Temporary lines will be sent out from the permanent line to the construction camp, contractor's work areas, and certain construction facilities within the Project site. The temporary pole line distributing power throughout the Project site will provide mounting for camp and construction services. Power supplied to the site from the SaskPower grid will be backed up by diesel-powered generator sets.

A transmission line will be required to connect the Project to the existing northern Saskatchewan electrical grid through the existing Stony Rapids Switching Station (approximately 3 km south of the Northern Hamlet of Stony Rapids) or, potentially, a new switching station in the area. This transmission line will be a separate project and SaskPower will be the proponent of any environmental assessment required for providing the new power line to the Project. Factors taken into account for determining the most appropriate routing for the power line will include environmental constraints, community feedback, cost, and technical constraints.

The station service system will provide power for all station services and equipment heating, lighting, motors, and generation equipment. This power will be provided by two transformers, one 13.8 kV/600 V connected to the generator switchgear lineup and complete with an on-load tap changer and one connected to SaskPower's 25 kV distribution network. Backup power for the station service will be provided by a permanent diesel-powered generator. The station service system will be designed to allow isolation of components so that routine maintenance can be performed on equipment, which is isolated in accordance with SaskPower standards.

5.6.1.2 Communications

SaskPower will coordinate with SaskTel for the installation of communication infrastructure to support the construction requirements. The construction site will have a satellite phone connection for a backup system.

A telecommunication system will be required for construction of the Project, as well as for the eventual management and integration of the energy produced by the Project into the SaskPower grid system. Given the remote location of the proposed Project, telecommunications is one of the key aspects of the Project. Permanent communications for the Project will be provided by fibre optic connection, which will provide the communications link for IT and corporate LAN (including a voice over internet protocol based system [VOIP]) and security systems. Other communication infrastructure will include a satellite phone connection to the plant.

The powerhouse will be built with a modern control system and switching station configuration. Data will be communicated through Internet Protocol (IP) based technology, reducing the amount of wiring and conduits inside the powerhouse and switching station.

5.6.1.3 Water Supply

The withdrawal of water for domestic and industrial purposes will be required during Project construction and operation. Water usage will vary depending on the number of workers on-site and is expected to be greatest during the construction phase of the Project when up to 250 people are expected to be on-site. Water requirements for the construction phase can reach up to 4,700,000 litres (L) per year (i.e., approximately 13 m^3/d) for industrial water and potable water use is expected to be between and 30,000 and 45,000 litres/day). Potable water for the construction camp is anticipated to be sourced from one or more new wells located near the camp, although this water could be drawn from either Black Lake or the Fond du Lac

River. Pump intakes would be screened to prevent entrainment of fish in accordance with the "Freshwater Intake End-of-Pipe Fish Screen Guideline" (DFO 1995).

During operations, approximately 365,000 L/year (i.e., 1 m^3/d) of water will be required for the Project. Potable water will be drawn from the penstock and treated for use. A water treatment facility will be constructed on-site to meet daily water consumption requirements. The water treatment facility will meet provincial drinking water quality and safety standards and will be licensed under *The Water Regulations* (2002). Industrial water (i.e., used for fire suppression, preparing concrete, and controlling road dust) will be taken from Black Lake (i.e., intake location) and the Fond du Lac River (i.e., bridge location). Pump intakes would be screened to prevent entrainment of fish in accordance with the "Freshwater Intake End-of-Pipe Fish Screen Guideline" (DFO 1995).

A supply of industrial water will be required for dust suppression and fire-protection during Project operation. The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail. Each pump will be sized to meet the full demand of the largest component of the system with the addition of 31.5 litres per second (L/s) for hose demand. There is no treatment required for industrial water.

The areas to be protected by the automatic fire protection system include the following:

- generator step-up transformers;
- oil storage room;
- electrical equipment rooms;
- mechanical equipment rooms;
- generator deluge system;
- hydraulic systems; and
- storage of supplies and spares room.

Water is supplied from the fire protection header in these areas. Sprinklers will be activated when the ambient temperature reaches the preselected operating temperature of the actuating element in the sprinkler. Once activated, water will be discharged until the system is manually isolated or all activated sprinklers are replaced. A flow switch will be installed in the system supply line to provide a system activated signal to the main fire alarm panel on detecting flow through one or more sprinklers.

Industrial water will be diverted from power generation flows passing through the power station. Storage tanks will provide the appropriate storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (2 hours of available water at 750 US gallons per minute). The industrial water (i.e., used for fire suppression, preparing concrete, and controlling road dust) will be taken from Black Lake (i.e., intake location) and the Fond du Lac River (i.e., bridge location). Pump intakes will be screened appropriately to prevent entrainment of fish.

5.6.1.4 Sewage and Grey Water

Sewage and grey water from the Project will be transported to the Black Lake lagoon for disposal. The amount of sewage and grey water produced at the site during Project construction and operation will be dependent upon the number of workers on site. The exact number of people employed will be determined when the design of the generating station is finalized. During the peak construction period, it is expected that the workers will produce about 30,000 L/day of sewage and grey water (e.g., the equivalent of two truckloads a day). Based on similar facilities located in remote northern regions, it is anticipated that between six and eight people could be required to operate the power plant. Therefore, during the operational phase it is estimated that the Project will produce approximately 1,400 L of wastewater per day. Sewage and grey water from plumbing fixtures will be directed to the sanitary system and pumped to an outdoor buried fiberglass sewage-holding tank. The sewage-holding tank will be pumped out as required (about once a week) and disposed of at the Black Lake lagoon.

The Black Lake Lagoon was completed in 2009, and at the time of design had a design horizon to 2018 (Lukey 2013, pers. comm.). The lagoon will have the capacity to accommodate the peak Project camp requirements (Lukey 2013, pers. comm.). The storage cell at the lagoon has a volume of 165,500 m^3, while the primary cell has a volume of approximately 100,000 m^3 (Keleman 2013, pers. comm.). Treated water is released to the west of the Black Lake Lagoon into 180 day retention lagoon in a wetland/swamp area once every six months (in spring and in fall). Prior to release, the treated water must meet applicable water quality criteria as per Wastewater Systems Effluent Regulations (Government of Canada 2013).

5.6.1.5 Compressed Air

Compressed air uses at the Project include generator brakes, service air stations for use of hand-operated tools for maintenance (maximum of 10 users at a time), blowdown of unit dewatering piping, and arc air gouging. The compressed air system equipment will consist of two air compressors, air receiver, and airflow controller. Each compressor will be sized for 50% of the peak air requirement (115 standard cubic feet per minute [scfm] each) at a delivery pressure of 125 pounds per square inch gauge (psig) and will be arranged so a single compressor can be taken out of service without affecting the system. The air receiver will be of sufficient size to provide an emergency reserve volume of compressed air for function of critical services during a compressor outage. An airflow controller will be provided on the downstream side of the air receiver to maintain the demand side of the system at a constant operating pressure of 100 psig. The airflow controller will be equipped with a manual bypass valve. The compressed air piping system will be designed for a nominal operating pressure of 100 psig and maximum design pressure of 150 psig and will include service air stations at strategic locations throughout the powerhouse.

5.6.1.6 Security

Due to health and safety concerns, the Project site on the east side of the Fond du Lac River will be restricted during the construction period. Access restrictions to Project components on the west side of the river will also be implemented during construction, although special considerations will be made for local residents. For health and safety reasons, access to some Project infrastructure on the east side of the Fond du Lac River will also be restricted during the operations phase of the Project. This includes the powerhouse, switching station, water intake structure, and the tailrace channel.

An Access Management Plan will be developed by the Proponent to address overall access to the Project site during construction and operation, with consideration given to land-based and water and ice-based travel. This will include effective and timely communication with resource users (including members of BLFN, residents of Stony Rapids, and the owner of Camp Grayling) about Project activities and any restrictions that will be put in place for overall public safety. In addition, the Plan will include the development of a "no hunting, trapping, harvesting, or fishing policy" for Project employees. No firearms will be allowed on the Project site. A "no hunting" zone will be imposed for the Project, and will include a 500 m buffer around the Project footprint and access road right-of-ways. The no hunting zone will be developed in consultation with the BLFN. Unauthorized public visits to the construction camp and associated facilities will be restricted. All access to the construction, laydown, and camp areas will be restricted to the public until Project construction is completed. The use of recreational all-terrain vehicles will also be prohibited at the site.

5.7 Closure

A Decommissioning and Reclamation Plan (D&R) Plan will be developed with the objective of returning lands disturbed by Project activities to a condition that is physically stable, safe, and environmentally sustaining in keeping with the land use and landscape of the day. Detailed plans for decommissioning, reclamation, and abandonment will be developed in consultation with regulatory agencies during licensing.

The D&R Plan will follow a process of progressive reclamation where any disturbed area that is no longer in use after construction is complete will be reclaimed as soon as practical. Reclamation activities can occur throughout the operational life of the Project although they will be concentrated during and immediately following construction. The operational life of the Project is expected to extend to 90 years or more. The exact life expectancy of the Project cannot be determined at this time as hydroelectric projects of this type can operate almost indefinitely with ongoing equipment maintenance and upgrades. It is anticipated that final closure of the Project will take approximately two years following cessation of power production operations.

The D&R Plan will outline the monitoring programs for testing the effectiveness of mitigation and reclamation techniques employed. To be successful, the D&R Plan should adopt the approach of "beginning with the end in mind" by "designing for closure." The careful application of this concept will lead to the protection of the environment over the long-term and benefit the Project financially. General reclamation procedures include the following:

- clean-up, remediation, and disposal of any waste material to meet regulatory requirements;
- progressively reclaim disturbed areas no longer required for construction or operation as soon as reasonably possible;
- re-contour and reclaim areas to be compatible with end land uses and ecological structure and function, including provision of proper drainage, stability, and erosion control; and
- create, to the extent practical, an aesthetically pleasing landscape that is consistent with pre-development activities.

The following subsections provide preliminary information on decommissioning and reclamation activities during construction and closure.

5.7.1 Decommissioning and Reclamation Activities Implemented following Construction

The construction phase of the Project is expected to be relatively short (i.e., about three years) compared to the operational life of the Project, which could extend to 90 years or more. The D&R Plan will follow a process of progressive reclamation where any disturbed area that is no longer in use after construction is complete will be reclaimed as soon as practical. Reclamation activities can occur throughout the operational life of the Project although they will be concentrated during and immediately following construction.

Decommissioning and removal of portions of the temporary construction infrastructure not required during the operation of the Project includes the construction camp, contractor’s work areas, and access roads to these areas. Decommissioning activities for the temporary construction infrastructure will include the following activities:

- decommissioning of the camp and work areas will consist of removing all temporary construction buildings and infrastructure; clearing any debris, construction waste and other solid waste; and removing electrical services and storage areas;
- dismantling electrical services that were set up for the contractor's work areas, including removal of power lines, poles, and transformers;
- dismantling of buildings will include disconnecting all services, packing furniture as necessary, hauling refuse, and preparing the buildings for transportation to their next destination;
- any non-hazardous waste materials that are not salvageable from decommissioning the contractor’s work areas and infrastructure will be disposed of in existing disposal areas near the Project site;
- Project-affected soils containing elevated metals or salts concentrations will be removed and disposed of in an approved landfill or waste management facility; and
- hazardous materials will be picked up directly by licensed companies that specialize in handling of such materials.

The objective of a Reclamation Plan is to return lands disturbed by Project activities to a condition that is physically stable, safe, and environmentally sustaining in keeping with the land use and landscape of the day. At the end of the construction period, the following procedures will be undertaken to reclaim the Project site:

- road subgrades and applicable Project area surfaces that are being reclaimed will be deep-ripped, as required, to alleviate compaction:
  - if soils are excessively wet or frozen, ripping operations will be postponed until conditions are favourable;
  - grading, discing, and plowing can be used to remove ruts caused by rubber-tired and tracked vehicles;
  - areas to be reclaimed will be contoured to blend with the surrounding landscape; and
  - if any topsoil was available to be salvaged, it will be placed evenly over the disturbed site once all initial ripping, grading, and contouring is completed.

- topsoil replacement will be postponed when soils are excessively wet, frozen, or during high winds to prevent soil structure damage or topsoil loss through erosion; and
- noxious weeds or invasive plant species will be controlled through plowing or spraying and a weed management strategy will be established and implemented with standards that include:
  - limiting soil disturbance to only those areas required for construction and operation of the Project;
  - cleaning equipment and vehicles so that they are free of weed species plant seeds and plant parts before arriving on-site;
  - using certified seed for re-vegetation activities where required; and
  - rapidly responding to weed infestations on Project development areas.

The objectives of a reclamation monitoring program are to evaluate the success of reclamation methods and procedures over time, and to adjust or modify practices where necessary. Specifically, monitoring will be designed to provide information for evaluating the effectiveness of the following elements:

- topsoil replacement on contoured surfaces is adequate to meet regulatory reclamation objectives;
- erosion control and slope stability;
- establishment of sustainable revegetation on all disturbed areas;
- weedy and invasive plant species control; and
- re-establishment of an equivalent ecological structure and function as the surrounding environment of the same type, region, and period.

These objectives will be met through regular site inspections, evaluation of the monitoring program results on all reclaimed areas, implementation of corrective actions, implementation of additional reclamation procedures over time (if necessary), and incorporation of findings from other reclamation efforts conducted in northern Saskatchewan.

5.7.2 Decommissioning and Reclamation Activities Implemented during Closure

It is anticipated that final closure of the Project will take approximately two years following cessation of power production operations. Final decommissioning, when it occurs, will be done in compliance with federal and provincial acts, regulations, and standards applicable at the time, and in consultation with the BLFN. Abandoned properties will be left in a condition that meets or exceeds regulatory requirements. In general, it is anticipated that equipment and material that would no longer be viable would be removed from the site or disposed of in an approved manner. It is anticipated that usable materials and equipment will be removed from the site and returned to central stores or used at other power generation facilities. Alternatively, some reusable material and equipment could be made available for acquisition by the local communities. In general, site access roads and the bridge would remain in place unless requested otherwise by the BLFN.

The following provides conceptual details on the activities required to decommission the final components of the Project:

- During the final closure period, prior to demolition, all buildings and equipment will be inspected for contamination so that potentially hazardous materials are identified for appropriate removal and disposal. All buildings will be demolished to grade.
- Equipment and materials will be removed from the site and either salvaged for other use, recycled, or disposed of in an approved facility.
- Exposed portions of the penstock would be removed and sold as scrap.
- The concrete powerhouse substructure likely would remain in place below the natural ground elevation and potentially be backfilled.
- Concrete foundations and pilings will be removed to one metre below grade. Concrete will be recycled or disposed of at a licenced landfill.
- The submerged weir at the outlet of Black Lake will be removed to allow re-establishment of natural pre-development flow regimes down the Fond du Lac River.
- The power tunnel would not be infilled other than possibly at the extreme upstream and downstream ends to prevent access, and the potential placement of a series of internal concrete bulkheads. The plugs at the upstream and downstream ends would likely be constructed of concrete.
- The tailrace channel will be decommissioned by contouring it so it is safe for wildlife. If there are concerns about leaving the tailrace channel open once the plant is decommissioned, the waste rock and overburden could be used to fill in the channel.
- Waste rock disposal areas will remain in place without further remediation. Monitoring of runoff for water quality in the future could be warranted.
- The disturbed landscape will be restored to approximately its original contour. This includes stabilisation of the landscape to prevent erosion, re-vegetation with plant species native to the region, and control of invasive plant species. Reclamation success will be monitored through the implementation of the Reclamation Plan and associated monitoring program (see Section 5.7.1).

With the Project shut down for final decommissioning, the power tunnel void could create a directly interconnected flow path for groundwater from the Black Lake area to the Fond Du Lac River to the west. While this will not alter the estimated natural groundwater general flow direction, it is possible that the tunnel would provide a conduit for enhanced groundwater mixing or result in a reduced residence time for mineralized groundwater flows to natural discharge areas. Based on the proposed elevation of the Project tunnel, in a natural condition the tunnel is anticipated to be below the groundwater table, and as such would be “flooded” in the long term, following decommissioning of the Project.

To mitigate the possible enhancement for flows of mineralized groundwater to discharge from the power tunnel, it is expected that a series of concrete bulkheads would be placed in the tunnel at the intake and powerhouse areas, but also at other possible locations within the tunnel to isolate mineralized bedrock zones discovered and mapped during tunnel construction. A valved discharge pipe or pipe structure could be constructed within the downstream concrete bulkhead, to allow for long-term monitoring and sampling of tunnel groundwater quality, if required.

Ongoing monitoring of surface water runoff from waste rock piles for ARD/ML and possibly other environmental parameters will continue during the operational phase, if required, with a schedule and list of parameters required for ongoing monitoring determined by the site geological characteristics, and as defined during the Project environmental licensing process. Monitoring and sampling programs for waste rock runoff during construction and operational Project phases often are adaptive and tailored for the potential level of risk for the site's waste rock materials to generate ARD/ML. As well, the frequency and timing of monitoring often are designed to capture runoff quality conditions at key times of the year (i.e., during spring freshet events and late in the year prior to winter freeze-up).

It is conceivable that any onset of possible ARD/ML or radioactivity issues associated with the waste rock will have been quantified over decades of Project operations and associated environmental monitoring prior to final decommissioning of the Project. Depending on the terms within the Project license, any ARD/ML issues could have been handled during the Project operational stage as a license condition or by applying license-specific contingency plans to mitigate possible ARD/ML issues. By the end of the serviceable life of the Project, it is possible that any ARD/ML condition will have "run its course" to completion or will have been mitigated, with discharge surface water characteristics within the allowable parameters specified within the Project license. It also is possible that long-term Project waste rock disposal will result in no ARD/ML discharge conditions or radioactivity issues. In these cases, the license for the Project with respect to continued ARD/ML or radioactivity monitoring would be followed, modified, or ceased, according to the license terms. Ongoing monitoring requirements outside of those specified within the Project license would default to terms outlined within the relevant federal and provincial acts, regulations, and standards applicable at the time.

5.8 Human Resources

It is anticipated that construction of the Project will occur under the direction of a single general contractor. Due to the specialized and diverse nature of the work associated with constructing a hydroelectric power facility, some specific activities will need to be completed by sub-contractors with expertise in areas. Tasks include the construction of the water intake structure and potential installation of cofferdams, power tunnel excavation, powerhouse structural, mechanical, and electrical installation, installation and commissioning of turbine and power generation equipment, excavation of the tailrace channel, and construction of access roads and the bridge.

There is the potential for several components of the construction to be sourced locally, including using local businesses and labour. Training for these positions would occur on the job or would be scheduled leading up to the operations of the Project.

Specific workforce estimates are difficult to formulate for hydroelectric projects of this size prior to the award of construction contracts. To achieve accurate results, planning estimates must be verified with contractor estimates to make sure that current market forces are reflected. At this time, the total number of jobs created by the Project has not yet been determined, although it is estimated that during the peak construction period, the Project will create approximately 250 to 300 jobs and the camp population could be up to 250 workers. The estimated Project employment for the construction of the Project is shown in Table 5.8-1. Worker rotation systems and schedules will be implemented similar to what is employed for other industrial activities in Northern Saskatchewan (i.e., two-week work rotations). Most workers will work 10 to 12 hour days, 7 days a week with 14 days on shift, and have 7 days off between shifts.

Table 5.8-1: Tazi Twé Estimated Project Employment for the Construction Phase

Position Type	Job Description	2014 (Q4 Only)	2015	2016	2017
Field Positions	CAT 769/773 operator	0	15	15	6
	Truck Driver (concrete, transport)	2	6	6	2
	Loader Operators	1	4	4	2
	Back Hoe Operator	2	8	8	4
	Dozer, Grader Operators	1	4	4	4
	Crane Operator	1	3	3	3
	Boom Truck Operator	1	2	2	1
	Labourer	4	30	30	10
	Concrete Finisher	0	2	3	3
	First Aid Attendant	2	6	6	2
	Carpenter	4	20	20	10
	Electrician	0	2	6	6
	Millwright	0	0	6	6
	Batch Plant	1	2	2	2
	Surveyor	1	6	6	6
	Surveyor Rodman	1	6	6	6
	Mechanic	3	6	6	6
	Lube Person	2	4	4	4
	Driller	6	12	12	6
	Blaster (Surface)	3	3	3	3
	Powder Men (Surface)	3	3	3	3
Clerical	Reception	1	1	1	1
	Office Clerk	1	1	1	1
	Engineer Student	2	2	2	2
Subcontractor Positions	Cooks	2	4	4	4
	Housekeeping	4	6	6	6
	Jumbo Driller	6	6	6	6
	Blaster (underground)	3	3	3	3
	Powder Men (Underground)	3	3	3	3
	Rig Welder	0	0	2	2
	CAT 769/773 operator	4	4	4	4
	Back Hoe Operator	1	1	1	1
	Dozer, Grader Operators	1	1	1	1
	Electrician	0	0	8	8
	Rebar Placer	0	20	10	0
Total Craft Positions		***66***	***196***	***207***	***137***
Total Craft and Supervisory (4:1)		***83***	***245***	***259***	***171***

Table 5.8-1: Tazi Twé Estimated Project Employment for the Construction Phase (continued)

Quarterly Workforce Estimates	2014 (Q4 Only)	2015	2016	2017
Q2 and Q3 (peak workforce)	n/a	245	259	171
Q1 and Q4 (off-season)	33	98	104	69

n/a = not applicable

The work force will fluctuate based on the season, with the lowest numbers in winter (Q1 and Q4) and peaks in summer (Q2 and Q3). Peak workforce numbers will be associated with construction activities in the summers of 2015, 2016, and 2017. The workforce estimates represent the maximum on-site workforce for the periods shown. The quarterly workforce estimates are based on estimates for the total number of craft positions required for the various activities on the Project plus supervisory positions (managers, engineers, superintendents, and foremen), which are calculated at a 4:1 ratio (craft position to supervisor).

The exact number of people employed during operations will be determined once the design of the power plant is finalized. However, based on similar facilities located in remote, northern regions, it is anticipated that between six and eight people could be required to operate the plant and additional staff could be required during special projects such as maintenance and monitoring procedures.

Once the Project is in the operation phase, it is expected to require the following staff:

- one foreman (i.e., journeyman electrician or electrical engineering technologist);
- two journeyman electricians;
- two journeyman millwrights (i.e., industrial mechanics); and
- one utility person (i.e., general labourer, storekeeper, and heavy equipment operator).

It is the intent of the Proponent (BLFN and SaskPower) to train and employ people from the local community to maintain and operate the plant once it is commissioned.

The BLFN facilities at Black Lake will be used for pre-employment training and the Northlands College facilities (i.e., La Ronge campus) will be used for the more advanced trades training and education upgrading.

5.9 Environment, Health, and Safety Management System

SaskPower and BLFN (as the Project proponent) through the Project Manager will make sure that all contractors comply with current provincial and federal Health and Safety regulations, as well as SaskPower's ISO 18001 safety system. The SaskPower Safety Management Policy applies to all SaskPower facilities and operations, employees, contractors, and visitors. The policy states that SaskPower is committed to maintaining a workplace in which safety is part of everything that is done and equally important as anything else done by the corporation.

Occupational Health and Safety PlanDuring construction, the General Contractor will be responsible for providing health and safety materials to personnel. Areas will be set aside as designated first aid stations so that a basic level of emergency response and health care will be provided on-site during construction. For example, first aid stations will be located on-site at each contractors work area and the Project will meet the requirements of the *Saskatchewan Occupational Health and Safety Act of Saskatchewan (1993) and Occupational Health and Safety Regulations* (1996).

According to the *Saskatchewan Occupational Health and Safety Regulations* (1996), since the nearest health care facility is less than 30 minutes away and the Project will employ more than 100 employees, the first aid requirements include a first aid box containing standard supplies, a manual, a register, and emergency information plus two Class A7 attendants and supplies. There must be a means of transportation for injured workers to the nearest health care facility (Athabasca Health Authority [AHA] health facility). Patients requiring emergency services that are unavailable at the AHA health facility will usually be flown from the Stony Rapids Airport to La Ronge, Prince Albert, or Saskatoon, depending on their needs.

5.9.1 Environmental Protection Plan

An EnvPP will be developed by the contractor before the start of construction. The EnvPP will include information relating to general Project activities such as site water management waste rock management, domestic and industrial waste management, and management of hazardous substance (as indicated above in Section 5.6). Other plans developed as part of the overall EnvPP include a Weed Management Plan and an Emergency Response Plan (ERP).

The ERP will outline specific spill prevention and clean-up procedures. A Spill Response and Remediation Plan will be kept in the engineering office, and with emergency response personnel. Any potentially toxic or hazardous liquid waste, such as oils and lubricating fluids, will be identified in a Waste Management Plan. The Waste Management Plan will include any specialized management measures required for the collection, treatment, storage, and disposal of any toxic or hazardous wastes generated from Project construction.

Prior to the development of the Waste Management Plan, the specific hazardous industrial wastes that are expected to be generated and the sources of those hazardous wastes must be identified. In addition to suggested hazardous waste storage and handling practices, hazardous waste management and recycling practices that will be incorporated into the Waste Management Plan include the following:

- collecting hazardous waste in appropriate containers for storage prior to shipment off-site to appropriate recycle or disposal facilities using a licensed contractor. Where suppliers will accept them, empty containers used to ship hazardous materials to site can be returned to the supplier. T-hose that cannot be returned will be shipped to appropriate recycling or disposal facilities;
- recycling batteries using by a provincially recognized recycler;
- establishing an appropriate spill plan so if a major spill occurs, the clean-up, treatment, and disposal of the contaminated waste and soil will be handled by a specialized subcontractor who is certified to dispose of the spilled substance; and
- maintaining good housekeeping practices during all phases of construction and operation.

Properly handling waste produced by the Project prevents potential effects on humans and wildlife.

5.9.2 Emergency Response and Contingency Plans

Existing SaskPower procedures and codes of practice cover emergency preparedness, environmental management, workplace safety, public access safety, and spill response. The SaskPower Emergency Response Planning Policy indicates that written plans to respond to health and safety emergencies will be developed, maintained, and tested. The purpose of the policy is to make sure that SaskPower employees:

- prepare for and respond effectively to health and safety emergencies through the appropriate use of SaskPower resources;
- develop and maintain a framework for sustaining operations in the event of a health and safety emergency;
- develop and maintain health and safety ERP that will integrate with SaskPower's corporate emergency response and business continuity management program; and
- maintain the health and safety of the employees and the public and of the emergency responders.

Additional SaskPower policies and standards that are applicable to emergency response, workplace accidents, and injury include:

- Emergency Response Standard - supports the Emergency Response Planning Policy and specifies the requirements for managing emergency events at SaskPower.
- Emergency Response Testing Protocol Standard - supports the Emergency Response Planning Policy and specifies the requirements for testing of emergency response plans at SaskPower.

During construction, the General Contractor will be responsible for developing and enforcing site-specific safety procedures and emergency response plans for all operational activities as required.

5.10 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events can occur on an industrial site. Execution of the SaskPower Safety Management Policy for the Project will work towards preventing and mitigating accidents and malfunctions. For example, within the ERP, procedures will be established for emergency response and rescue, power plant evacuation, first aid, fire protection, firefighting (including forest fires), and spill response. The Environment, Health, and Safety Management programs are described in Section 5.6.

This section presents the methods and results of a risk assessment of potential accidents, malfunctions, and unplanned events for the Project, as well as the mitigation, potential environmental effects, and an estimate of the risk associated with the accident or malfunction.

The frequency index for the Project has been defined in four order-of-magnitude levels as shown in Table 5.10-1.

Table 5.10-1: Frequency Index

Frequency Index	Frequency (Probability)
Highly likely	at least one chance of occurring within a year (100% probability of occurrence per year)
Likely	at least one chance of occurring within 10 years, but less than once a year (>10% to <100% probability of occurrence per year)
Possible	at least one chance of occurring within 100 years, but less than once in 10 years (1% to 10% probability of occurrence per year)
Unlikely	less than one chance of occurring in 100 years (<1% probability of occurrence per year)

Note: The potential life of the Project is 90 years.
% = percent; <= less than; >= greater than.

Consequences have been divided into four severity levels as shown in Table 5.10-2.

Table 5.10-2: Consequence Severity Index

Negligible	Low	Moderate	High
A consequence that is contained, controlled, or cleaned up with no measurable impact to the environment	A consequence that is contained, controlled, and cleaned up through normal environmental management in the short term, but could negatively affect organisms present at the location of the accident or malfunction	A consequence that is uncontained and results in localized reversible environmental damage (e.g., the loss of plant, wildlife or aquatic communities within the local study area over the medium term)	A consequence that results in a negative effect of high magnitude (effect at the population level) over the medium- to long-term

Risk is defined as the product of frequency (or probability) of occurrence and severity of consequence (i.e., Risk = Probability X Consequence). Risk levels were determined for the Project based on frequency and consequence, as illustrated in Table 5.10-3. Risk levels, frequency, and consequence severity were determined according to professional judgement.

Table 5.10-3: Example Risk Matrix

Frequency Index	Consequence Severity Index			
	Negligible	Low	Moderate	High
Highly Likely				
Likely				
Possible				
Unlikely				

Risk Level	
	High Risk
	Moderate Risk
	Low Risk
	Negligible Risk

The risk matrix for the Project is shown in Table 5.10-4. Accidents, malfunctions, and unplanned events in the matrix include the following:

- improper inspection of construction equipment;
- hazardous chemical spills;
- fuel storage loss of containment;
- failure of embankment dykes around the settling ponds; and
- failure of emission control systems.

Risks associated with these accidents, malfunctions, and unplanned events were assessed as ranging from negligible to low given implementation of appropriate Environment, Health, and Safety Management programs, environmental design features, and mitigation practices, as described in Table 5.10-4.

Table 5.10-4: Accident, Malfunctions, and Unplanned Events Risk Matrix for the Project

Description of Accident or Malfunction	Potential Environmental Effect	Mitigation	Risk Level (Considering Mitigation)
■ Emergency shutdowns of power generation activities	■ Emergency shutdowns of power generation activities can change surface hydrology, which can affect soils, vegetation, wildlife, wildlife habitat, fish, fish habitat, and human activities.	■ Planned or unplanned shutdowns longer than 15 minutes during the spring spawning and rearing period (May 15 to July 15) and winter low flow period, the bypass conduit at the powerhouse will begin releasing flow to reduce drawdown effects on the Fond du Lac River below the tailrace channel outlet and upstream of Middle Lake.	■ Risk: low ■ Consequence: low ■ Frequency: highly likely
■ Improper inspection of construction equipment	■ Invasion of Project site by noxious weeds.	■ Inspection of equipment required before entering Project site. ■ Basic, core, and specific training of workers.	■ Risk: negligible ■ Consequence: negligible ■ Frequency: likely
■ Release or spills of hazardous substances	■ Release or spills of hazardous substances can change groundwater, surface water, soil, and vegetation quality, which can affect fish and wildlife habitat, and human activities.	■ Individuals working on-site and handling hazardous materials will be trained in Workplace Hazardous Materials Information Systems (WHMIS) and Transportation of Dangerous Goods (TDG). ■ Controlled products will not be allowed on-site unless accompanied by approved labels and Material Safety Data Sheets (MSDS). ■ All fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard; a lined and dyked containment area around these tanks will be provided to contain any potential fuel spills. The design of the containment area will be based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm.	■ Risk: negligible ■ Consequence: negligible ■ Frequency: likely

Table 5.10-4: Accident and Malfunction Risk Matrix for the Project (continued)

Description of Accident or Malfunction	Potential Environmental Effect	Mitigation	Risk Level (Considering Mitigation)
■ Release or spills of hazardous substances	■ Release or spills of hazardous substances can change groundwater, surface water, soil, and vegetation quality, which can affect fish and wildlife habitat, and human activities	■ The storage containers will be regularly inspected for leaks or damage, and replaced when necessary. ■ Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled, and located in lined and bermed containment areas. ■ Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers. ■ Regular maintenance of construction equipment. ■ Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. ■ Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills of fuel would flow to the sump, which would be pumped out to a container for shipment off-site. ■ An Emergency Response Plan will be developed. ■ Spill response material (e.g., sorbent pads) will be stored on-site in designated areas and in vehicles.	■ Risk: negligible ■ Consequence: negligible ■ Frequency: likely

Table 5.10-4: Accident and Malfunction Risk Matrix for the Project (continued)

Description of Accident or Malfunction	Potential Environmental Effect	Mitigation	Risk Level (Considering Mitigation)
■ Increased traffic and potential for collisions.	■ Increased traffic and degradation of transportation infrastructure can increase the potential for vehicle-to-vehicle and vehicle-wildlife collisions, which can cause injury or mortality to people and/or wildlife	■ Speed limits will be clearly posted on construction roads and enforced to militate against potential road mortalities during construction. ■ Vegetation along the roadside will be mowed and cut to increase visibility of wildlife passing through or using the roadsides or ditches. ■ Unpaved roads within the limits of the Project will be regularly graded and maintained to avoid washboarding and rutting. ■ Safety policies will be developed by SaskPower and the general contractor will address safe driving practices for all construction personnel on public roads. SaskPower and the general contractor will monitor all reported incidents of speed violations and provide appropriate disciplinary measures, where necessary. ■ Shuttle vehicles will be used by the contractor to transport workers between the construction site and the Stony Rapids airport to reduce the use of personal vehicles.	■ Risk: moderate ■ Consequence: high ■ Frequency: possible
■ Physical hazards	■ Physical hazards (e.g., blasting activities, tailrace channel, buildings, waste rock disposal areas) from the Project that can cause injury or mortality to people and/or wildlife.	■ Open trenches or pits will be fenced to exclude wildlife or one of the ends and sides will be sloped to allow escape. ■ The water intake, powerhouse structures, and tailrace channel will be fenced to prevent wildlife from entering this area and falling into channel. ■ During winter construction periods, gaps will be left in some snow windrows along access roads and around the site to allow escape routes for mid to large sized wildlife. ■ Good housekeeping will be practiced to prevent wildlife from becoming entangled with or injured by on-site material.	■ Risk: low ■ Consequence: moderate ■ Frequency: unlikely

Table 5.10-4: Accident and Malfunction Risk Matrix for the Project (continued)

Description of Accident or Malfunction	Potential Environmental Effect	Mitigation	Risk Level (Considering Mitigation)
■ Physical hazards	■ Physical hazards (e.g., blasting activities, tailrace channel, buildings, waste rock disposal areas) from the Project that can cause injury or mortality to people and/or wildlife.	■ A detailed Blasting Plan will be developed for the Project and distance during blasting of the water intake foundation, powerhouse foundation, and tailrace channel will be included as part of this plan. ■ Surface blasting will be temporarily suspended if large mammals are observed within the danger zone identified by the blast supervisor. ■ Waste rock excavated from the power tunnel will be checked for the potential to generate acid rock drainage (ARD) and metals leaching (ML) prior to placing in a permanent waste rock disposal area. If necessary, this waste rock could be contained in a lined waste rock pile.	■ Risk: low ■ Consequence: moderate ■ Frequency: unlikely
■ Failure of embankment dykes around the settling ponds	■ Failure of the embankment dykes around the settling ponds can change groundwater, surface water, soil, and vegetation quality, which can affect fish and wildlife habitat, and human activities.	■ Fill material used for constructing the embankment dykes around the settling pond will be clean mineral soil with sufficient moisture to allow for proper compaction. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap as soon as practical following construction. ■ Water produced during construction or runoff through the site will be contained, tested and treated if required before release in accordance with the regulations.	■ Risk: low ■ Consequence: moderate ■ Frequency: unlikely

Table 5.10-4: Accident and Malfunction Risk Matrix for the Project (continued)

Description of Accident or Malfunction	Potential Environmental Effect	Mitigation	Risk Level (Considering Mitigation)
■ Failure of embankment dykes around the settling ponds	■ Failure of the embankment dykes around the settling ponds can change groundwater, surface water, soil, and vegetation quality, which can affect fish and wildlife habitat, and human activities.	■ The settling ponds will be engineered to provide adequate storage of wastewater streams under normal and extreme operating conditions (e.g., settling ponds will be designed to contain the 1:100 year storm event). In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling ponds would be provided by the inclusion of an overflow spillway in the embankment. ■ The settling ponds will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. ■ During the detailed design stage, additional mitigation could be identified and included as part of the Environmental Protection Plan and the Emergency Response Plan.	■ Risk: low ■ Consequence: moderate ■ Frequency: unlikely

Table 5.10-4: Accident and Malfunction Risk Matrix for the Project (continued)

Description of Accident or Malfunction	Potential Environmental Effect	Mitigation	Risk Level (Considering Mitigation)
■ Fire	■ Increased risk to the health and safety of employees ■ Damage to site infrastructure and equipment ■ Regulatory and Legal consequences ■ Short- term air emissions exceedances can cause changes to air quality ■ Loss of traditional and non-traditional use land	■ The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail. ■ Each pump will be sized to meet the full demand of the largest component of the system with the addition of 31.5 litres per second (L/s) for hose demand. ■ Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. ■ Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute). ■ Fire safety measures and response will be reviewed with the community of Black Lake and Stony Rapids. ■ Personnel will be trained in fire prevention and response procedures. ■ Firefighting equipment will be available on site.	■ Risk: low ■ Consequence: moderate ■ Frequency: unlikely

mm = millimetres

5.11 Effects of the Environment on the Project

The local environmental setting can affect the construction, operation, and closure phases of the Project. This section of the EIS examines the interactions between the surrounding environment and the Project, to identify the main environmental conditions that can affect the Project. These environmental conditions are examined to determine their local severity, probability, and/or frequency. Mitigation, contingency plans, and designs for each are designed and monitored to confirm that risks to the Project are sufficiently reduced.

The environmental conditions that may affect the Project can be categorized based on the time over which they occur.

- Short-term events: these events are high intensity events that occur over a short time scale (e.g., storm events; temperature extremes). Mitigation for these events cannot generally be responsive due to the intense nature and short time period over which they occur.
- Seasonal events: These events can last weeks or months and can feature similar conditions to the short-term events (i.e., high precipitation), but will not necessarily include large extreme events. The effects would be cumulative in nature.
- Long-term events: These events can develop over a period of years. This category involves long-term variations in the environmental setting surrounding the Project.

A summary of the short-term and seasonal events that can occur near the Project, the potential environmental or Project effects and the mitigation strategies that will be employed to help reduce effects is shown in Table 5.11-1. While some of the short-term events could affect the Project or environmental interactions negatively, the likelihood of them occurring or the magnitude of their effects is sufficiently reduced through mitigation strategies.

Table 5.11-1: Summary of Potential Environmental Effects from Short-term and Seasonal on the Project and Associated Mitigation

Event	Potential Effect	Mitigation Strategies
Short-term Events		
Storms	Intense rain can cause erosion, which can compromise the integrity of site infrastructure.	Site will be graded and will include stable slopes, and will be landscaped to include armouring or vegetation where necessary according to the Erosion and Sediment Control Plan.
	Storm events can damage site infrastructure and interrupt site operations.	Site infrastructure will be designed according to NBC standards.
	High rainfall events can cause overtopping of site drainage structures and can limit access to site or ability to travel on site.	Road crossing structures will be designed to sufficient design standards for seasonal flood events, which are considerably higher than short-term rain events.
	Storm events can introduce dangerous working conditions.	The SaskPower Safety Rulebook explains all relevant safe work practices, and complies with current provincial and federal Health and Safety regulations, and the SaskPower ISO 18001 safety system.
	Electrical storms could cause a power outage.	Power will be generated on site and the site will be connected to the SaskPower grid; backup power for the station service will be provided by a permanent diesel-powered generator.

Table 5.11-1: Summary of Potential Environmental Effects from Short-term and Seasonal on the Project and Associated Mitigation (continued)

Event	Potential Effect	Mitigation Strategies
Storms (continued)	Lightning strike could start a forest fire.	An emergency plan will be developed to prevent and respond to fires and equipment will be available. The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail.
		The SaskPower Safety Rulebook explains all relevant safe work practices and complies with current provincial and federal Health and Safety regulations, and the SaskPower ISO 18001 safety system.
Extreme Snowfall	Snow drifts and ice on roads surrounding and on site can affect driving safety.	The SaskPower Safety Rulebook explains all relevant safe work practices, and complies with current provincial and federal Health and Safety regulations, and the SaskPower ISO 18001 safety system.
	Poor visibility or deep snow can affect worker safety.	
Extreme Temperatures	Extreme temperatures can introduce unsafe working conditions.	
	Extreme temperatures can affect the performance of equipment and interrupt operations.	Procedures will be developed for maintaining the use of equipment during extreme temperature (e.g., storage and usage limits).
High Winds	High winds can introduce unsafe working conditions.	The SaskPower Safety Rulebook explains all relevant safe work practices, and complies with current provincial and federal Health and Safety regulations, and the SaskPower ISO 18001 safety system.
	High winds can damage site infrastructure or equipment and interrupt operations.	Site infrastructure will be designed according to NBC standards.
Fires	Fires can damage site infrastructure and interrupt operations.	An emergency plan will be developed to prevent and respond to fires and equipment will be available. The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail.
	Forest fires can introduce unsafe working conditions.	The SaskPower Safety Rulebook explains all relevant safe work practices, and complies with current provincial and federal Health and Safety regulations, and the SaskPower ISO 18001 safety system.
Seismic Events	Seismic activity can damage buildings, injure occupants, and interrupt operations.	Site infrastructure will be designed according to NBC standards

Table 5.11-1: Summary of Potential Environmental Effects from Short-term and Seasonal on the Project and Associated Mitigation (continued)

Event	Potential Effect	Mitigation Strategies
Seasonal Events		
Low Precipitation	Dry events can increase the likelihood of fires	Water required for fire suppression will be obtained from Black Lake or the Fond du Lac River.
	Drought conditions can affect the quantity of water available for tunnel operations	The Water Management Plan for the Project outlines a detailed water management strategy that will allow maximum facility efficiency to be attained while maintaining minimum riparian flow in the Fond du Lac River.
	Drought conditions can affect the quantity of water available for domestic and industrial water supply	The proponent will retrieve its water supply from local groundwater wells or directly from the Fond du Lac River or Black Lake, which all have sufficient water to supply the site even during extreme droughts (Section 9.0; Section 10.0).
High Precipitation	High seasonal precipitation or a rapid spring melt can cause flood conditions which can affect site infrastructure.	Drainage structures will be designed for flood events greater than that produced by snowmelt; culverts will be monitored and ice blockages will be removed, if required.
		Site buildings will be designed according to NBC standards and will be located well above high water levels.

Climate change can affect the Project by increasing the frequency and intensity of short-term events. While the changes to the frequency and intensity of short-term events are difficult to predict and the climate change models used in this assessment do not estimate how these events will change. The longer summers and warmer temperatures suggest more energy in the climate system and likely an increase in frequency and intensity of short-term events (i.e., storms, high temperature extremes, wind extremes, and fires). While the magnitude of these changes is currently unknown, appropriate conservatism has been incorporated into the Project design to address these potential issues. For example, cross drainage structures will be designed for infrequent flood events. Additionally, conservatism incorporated into the design criteria help to address potential long-term changes in the intensity of short-term events.

Climate change can affect the Project by increasing the frequency and/or intensity of seasonal events. While an increase in radiation, wind, and temperature can increase evaporation from waterbody surfaces, this is unlikely to offset the increase in total precipitation and can result in a net increase in runoff. An increase in water levels and flow rates is not expected to affect the Project beyond the potential effects described in Table 5.11-1. Appendix 5.2 provides additional information on the interaction of these environmental considerations with the Project.

5.12 References

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5.13 List of Acronyms

Term	Definition
AHA	Athabasca Health Region
ANFO	ammonium nitrate/fuel oil
ARD	Acid Rock Drainage
BLFN	Black Lake First Nation
BMP	Best Management Practices
CCME	Canadian Council of Ministers of the Environment
CDA	Canadian Dam Association
CEA	Canadian Electricity Association
D&R	Decommissioning and Reclamation
DFO	Fisheries and Oceans Canada
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EnvPP	Environmental Protection Plan
ERP	Emergency Response Plan
HVAC	Heating, Ventilation, And Air Conditioning
IP	Internet Protocol
ML	Metals Leaching
MOE	Saskatchewan Ministry of Environment
MSDS	Material Safety Data Sheet
Project	Tazi Twé Hydroelectric Project
TDG	Transportation of Dangerous Goods
VOIP	Voice Over Internet Protocol
WHMIS	Workplace Hazardous Materials Information System

5.14 List of Units

Term	Definition
%	percent
°C	degree Celsius
cm/hr	centimetres per hour
ha	hectare
kV	kilovolt
km	kilometre
km^2	square kilometres
L	litre
L/day	litres per day
L/s	litres per sec
m	metre
m/s	metres per second
m^2	square metre
m^3	cubic metre
m^3/d	cubic metres per day
m^3/s	cubic metres per second
masl	metres above sea level
mm	millimetre
mW	megaWatt
mWh	megaWatt hours
ppm	parts per million
psig	pounds per square inch gage
scfm	standard cubic feet per minute

6.0 ENGAGEMENT AND DUTY TO CONSULT

6.1 Introduction

Stakeholder engagement and Duty to Consult are separate processes that are both important components of the environmental assessment process. This section of the Environmental Impact Statement (EIS) for the Tazi Twé Hydroelectric Project (the Project) outlines both the engagement and the Duty to Consult processes completed for the Project.

6.2 Engagement

Engagement refers to the activities and processes of interaction and information sharing between a company (i.e., proponent) and the stakeholders who could be affected by a project that the company is undertaking. Engagement is an inclusive process that strives to reach any stakeholders who wish to find out more about a project or to become more involved in a project (International Finance Corporation [IFC] 2007). Engagement activities can be concentrated at the beginning of a project, but generally extend in some form throughout the life of a project. Engagement activities are typically the responsibility of the Project proponent. Engagement can include a combination of the following activities:

- social media (e.g., website, blog, and Twitter);
- printed media (e.g., letters, newsletters, news releases/articles, and brochures); and
- direct communication (e.g., community sessions, workshops, and one on one targeted meetings).

6.2.1 Engagement Approach

The approach to engagement for the Project has been developed based on the nature of the Project, knowledge of the communities and stakeholders near the Project, and professional experience. The purpose of the Project engagement program is to inform stakeholders about the Project; and to provide an opportunity for the stakeholders to ask questions and share their concerns about the Project and the environmental assessment process. Early engagement is important to identify specific issues that may be of interest locally so that appropriate technical studies, materials and preparations can be completed to address the issues/risks identified.

Factors that were taken into consideration in developing an engagement program are listed below:

- The Project is a partnership between SaskPower and the Black Lake First Nation (BLFN).
- The Project is located in northern Saskatchewan and more specifically, the Project is located within the Chicken Indian Reserve No. 224, near the communities of Black Lake and Stony Rapids.
- A large portion of the local population is First Nation or Métis; however, there also are non-Aboriginal community members in the area.
- The Project, in general terms, has been discussed for several decades. This means the surrounding communities already have some ideas about the Project, but there could be inaccurate information circulating about the Project.

The proponent identified stakeholders as those who live near the Project or who could be interested or potentially affected by the Project. The engagement process began by identifying the stakeholders and determining the most appropriate engagement activities for each type of stakeholder. The three main stakeholder types were identified as: First Nations and Métis, Public, and Regulatory Agencies.

A variety of methods have been used to inform identified stakeholders about the Project including:

- general distribution of Project information (e.g., website, specific letters of introduction, community newsletters, news articles and press releases);
- community information meetings; and
- targeted meetings.

The last two methods also allowed for direct feedback about the Project to be collected and used in the engineering design and environmental assessment processes.

Documentation of stakeholder engagement activities for the purposes of the environmental assessment began in 2010. All engagement activities (i.e., events and communications with stakeholders) were recorded using Stake Tracker (i.e., a software system designed for engagement and consultation data storage) along with questions, comments, or concerns any group or individual has relating to the Project. The proponent maintained a strong focus on the engagement of Aboriginal people, in particular those residents in the Athabasca Region of northern Saskatchewan. It is important to note that the population of this region of northern Saskatchewan is more than 90% aboriginal, so many of the engagement activities had a strong aboriginal representation.

6.2.2 Identification of Stakeholders

Within each of the three categories of stakeholders, a number of individual stakeholders were identified.

First Nations and Métis

A number of First Nation and Métis communities have been identified as stakeholders for inclusion in engagement activities. Some groups were identified based on proximity to the Project location, while others were identified for consistency with the federal government's Duty to Consult process. The First Nation and Métis communities identified as stakeholders for the Project include:

- Black Lake Denésuline First Nation;
- Resident of Cabin on Middle Lake;
- Fond du Lac Denésuline First Nation;
- Hatchet Lake Denésuline First Nation;
- Métis Nation Saskatchewan Stony Rapids, Local # 80;
- Métis Nation Saskatchewan Camsell Portage, Local # 79; and
- Métis Nation Saskatchewan Uranium City, Local # 50.

Public

The Northern Hamlet of Stony Rapids has been identified as the main non-reserve community for inclusion in engagement activities. In addition, agencies, organizations, and groups identified as stakeholders potentially having an interest in the Project, and for which engagement has been offered, include:

- Camp Grayling;
- Mayor and Council Northern Hamlet of Stony Rapids;
- Prince Albert Grand Council – Athabasca Region;
- Athabasca Health Authority;
- New North;
- Northern Labour Market Committee (NLMC);
- Athabasca Basin Development - Board of Directors;
- Athabasca Keepers of the Water;
- Canadian Parks and Wilderness Society, Saskatchewan (CPAWS);
- Saskatchewan Environmental Society (SES);
- regional suppliers;
- local outfitters and resource users;
- uranium industry; and
- regional educations and training institutes.

Regulatory Agencies

As part of the environmental assessment approvals process, a number of federal and provincial regulatory agencies will be reviewing the EIS. Agencies were included in the Project engagement program to gain an early understanding of the concerns and comments these agencies may have about the Project. This Project is undergoing both a federal and provincial environmental assessment review process. As such, both the Canadian Environmental Assessment Agency (the Agency) and Saskatchewan Ministry of the Environment (MOE) Environmental Assessment Branch (EAB) are the lead agencies for these processes and both have played a large role in the engagement process. Due to the nature of the Project, the following agencies have also been included in the engagement program:

- Aboriginal Affairs and Northern Development Canada (AANDC) (previously known as Indian and Northern Affairs Canada [INAC]);
- Department of Fisheries and Oceans (DFO);
- Natural Resources Canada (NRCan); and
- MOE Fish and Wildlife Branch (MOE FWB).

Other federal and provincial regulators identified as having a key role or interest in the Project include:

- Transport Canada (TC);
- Health Canada (HC);
- Environment Canada;
- Canadian Wildlife Service (CWS);
- Ministry of Government Relations - First Nations, Métis and Northern Affairs (FNMNA);
- Ministry of Highways and Infrastructure;
- Ministry of Economy (previously known as Ministry of Industry and Resources); and
- Water Security Agency (WSA; previously known as Saskatchewan Watershed Authority).

6.2.3 Engagement Activities Completed to Date

Specific engagement activities for the Project include distribution of information through social media (i.e., website), print media (i.e., letters of introduction, newsletters, news articles and press releases), and direct communication (i.e., community sessions, workshops, and meetings). Stakeholders were encouraged to respond with questions, concerns, and comments through all the methods used. Details of these engagement activities are described below.

Website

A Project website is located at www.tthp.ca. The purpose of this website is to provide the public and stakeholders with a forum to learn more about the Project, the regulatory process and approvals, and employment and training opportunities. The website contains press releases, dates of public presentations, presentation material, and contact information. To date the Project has not received any comments or questions directly through the website.

Newsletters, News Articles and Press Releases

In addition to the website, general promotion of the Project has been completed through:

- Press Release from BLFN;
- Missinipi Broadcasting Corporation Interview with Chief Rick Robillard;
- newsletter to provide Project updates, information on the economic opportunities, and the environmental assessment and approval process was distributed to the community of Black Lake and posted on the website; and
- articles discussing the Project were featured in Water Power Magazine, Prince Albert Grand Council Tribune, and Opportunities North.

Copies of these publications are provided in Appendix 6.1.

Letters

Letters of Introduction were distributed to various public stakeholders. These letters provided an overview of purpose of the Project and information about the environmental assessment process. Copies of these letters are provided included in Appendix 6.2. The Letters of Introduction were distributed to the following groups:

- Athabasca Health Authority;
- New North;
- Athabasca Keepers of the Water;
- CPAWS;
- SES;
- Cree River Lodge;
- Blackmur's Athabasca Fishing Lodge;
- AREVA Resources; and
- Cameco Corporation.

To date no questions or comments have been received from these stakeholders.

Meetings

A number of meetings with various stakeholders have been held over the past years to discuss the Project. Most meetings have been specific to the Project, while a few have had Project representatives provide an update of the Project in another organization's regularly scheduled meeting. As presented in Table 6.2-1, meetings have taken place with community leadership, organizations, specific resources users, and regulatory agencies.

Table 6.2-1: Record of Stakeholder Meetings

Stakeholder Type	Meeting Date	Location	Stakeholder in Attendance	Purpose/Objective of Meeting
First Nations and Métis	Dec 2/13	Fond du Lac First Nation	Chief and Council	Provide information on the Tazi Twé Project and to solicit feedback with respect to potential impacts on Treaty and Aboriginal Rights.
	Jul 31/13	Wollaston Lake	Hatchet Lake First Nation Chief and Council	Presentation to the Chief and Council of the Hatchet Lake First Nation
	Jun 25/13	Father Porte Memorial Dené School	Prince Albert Grand Council – Dene Sector	Presentation to the Prince Albert Grand Council
	Jun 12/13	Black Lake Youth Centre	Black Lake First Nation	SaskPower presented information on the proposed interconnection facilities to service the Project. Representatives of the Tazi Twé Project were in attendance to answer questions specifically about the Project. The proposed interconnection facilities are considered a separate (but related) project.

Table 6.2-1: Record of Stakeholder Meetings (continued)

Stakeholder Type	Meeting Date	Location	Stakeholder in Attendance	Purpose/Objective of Meeting
First Nations and Métis (continued)	Nov 5/10	Black Lake First Nation	Black Lake First Nation Leadership and Fishers and Trappers	Present the Project and discuss the Media Kit.
	Apr 8/13	Middle Lake	Cabin owner of Middle Lake	In person invitation to attend workshop. Informal discussions.
	Apr 10/13	Middle Lake	Cabin owner of Middle Lake	Met with cabin owner to discuss any concerns or questions the cabin owner had.
	Oct 16/12	Black Lake Administration Building	Black Lake First Nation Leadership	Meeting to introduce key members of team to Black Lake First Nation Leadership.
Public Stakeholders	Nov 21/13	N/A	Northern Labour Market Committee	Provided an update on the Project. Minutes are not yet available.
	Oct 10/13	Camp Grayling	Owner of Camp Grayling	Introduce Regulator representatives to the owner of Camp Grayling and give the owner an opportunity to discuss his issues concern with the Regulator.
	Jul 2/13	Prince Albert	Athabasca Basin Development Limited Partnership	Provided presentation on the Project to the Board of Directors of the Athabasca Basin Development Limited Partnership.
	Jun 13/13	Waterfront Inn	Stony Rapids	SaskPower presented information on the proposed interconnection facilities to service the Project. Representatives of the Project were in attendance to answer questions specifically about the Project, as the proposed interconnection facilities are considered a separate (but related) project.
	Jun 5 & 6/13	N/A	Northern Labour Market Committee	Provided an update on the Project focusing on Employment and Training Charter and first phases of training programs.
	Apr 24/13	Camp Grayling	Owner of Camp Grayling	SaskPower met with the owner of Camp Grayling to discuss his concerns regarding the Project.
	Apr 8/13	Camp Grayling	Owner of Camp Grayling	SaskPower met with the owner of Camp Grayling to discuss his concerns about the Project. It was agreed that SaskPower would provide owner of Camp Grayling with all materials presented at future community sessions.
	Mar 6 & 7/13	N/A	Northern Labour Market Committee	Provide a presentation on the Project.
	Nov 24/10	Northern Hamlet Office	Stony Rapids Council	Introduce the Project team members to the council and provide a brief overview of the Project.
Regulatory Agencies	Nov 22/13	Conference Call	DFO	Discuss potential Project effects on fish and fish habitat and the Offsetting Plan.
	Nov 8/13	Conference Call	DFO	Discuss potential Project effects on fish and fish habitat and the Offsetting Plan.

Table 6.2-1: Record of Stakeholder Meetings (continued)

Stakeholder Type	Meeting Date	Location	Stakeholder in Attendance	Purpose/Objective of Meeting
Regulatory Agencies (continued)	Oct 24/13	Conference Call	CEAA MOE	Discuss EIS public review and timelines and harmonizing of federal and provincial review processes.
	Oct 9 & 10/13	Site Visit	DFO MOE FWB	Trip to the Project site to familiarize DFO and MOE FWB personnel with the Project site. Discussions with owner of Camp Grayling.
	Oct 1/13	Prince Albert	MOE FWB	Update the MOE FWB on the Project status and assessment approach.
	Sep 5/13	Golder Office, Saskatoon	DFO	Update DFO with all aspects of the Project in terms of potential effects to fish and fish habitat and surface water quality. Provide answers to questions previously raised by DFO so they can be addressed in the final EIS document.
	Jul 30/13	Conference Call	CEAA NRCan	Update on the hydrogeology and geochemistry technical approach for the environmental assessment.
	May 2/13	Regina	CEAA AANDC MOE EAB	Provide a Project summary and update to the Agency staff new to the Project and get a better understanding of the *CEAA* process and new timelines.
	Apr 30/13	DFO Office, Winnipeg	DFO	Provide a Project summary and update to DFO staff new to the Project, and to present the proposed HSI modelling approach.
	Mar 24/13	EAB Office	MOE EAB	To discuss preparing the TOR for the provincial EIA.
	Mar 21/13	Conference Call	CEAA	To discuss the *CEAA* draft Guidelines for the federal EIA.
	Mar 14/13	MOE EAB Regina Office	MOE EAB	Determine provincial environmental assessment process and harmonization with the *CEAA*. Address various small questions of comments on the Project Description.
	Nov 20/12	Conference Call	CEAA DFO MOE EAB	To discuss the Project Description comments received from the Agency and to provide an update on Project status.
	Jun 8/11	DFO Office, Prince Albert, Saskatchewan	DFO MOE FWB AANDC	To discuss potential Project effects on fish and fish habitat.
	Apr 11/11	Conference Call	DFO	To discuss the technical memo prepared by Golder Associated Ltd. including: whether future fish recapture surveys are required to establish Arctic grayling populations and whether fish habitat preference curves will be required for all of the fish identified in the draft TOR.

Table 6.2-1: Record of Stakeholder Meetings (continued)

Stakeholder Type	Meeting Date	Location	Stakeholder in Attendance	Purpose/Objective of Meeting
Regulatory Agencies (continued)	Jan 7/11	Golder Office, Saskatoon	DFO MOE FWB	To provide an update on 2010 field program results.
	Dec 3/10	DFO Office, Prince Albert, Saskatchewan	DFO	To discuss environmental assessment activities and potential effects and concerns regarding fish habitat.
	Jun 24/10	Ramada Hotel, Regina Saskatchewan	CEAA DFO AANDC MOE FWB	To review the environmental baseline surveys completed for the Project and discuss the draft Guidelines provided by the Agency.

Jan = January; Feb = February; Mar = March; Apr = April; Jun = June; Jul = July; Sep = September; Oct = October; Nov = November; Dec = December; CEAA = *Canadian Environmental Assessment Act*; the Agency = Canadian Environmental Assessment Agency; TOR = Terms of Reference; DFO = Fisheries and Oceans Canada; AANDC = Aboriginal Affairs and Northern Development Canada; MOE = Ministry of Environment; EAB = Environmental Assessment Branch; FWB = Fish and Wildlife Branch; EIA = Environmental Impact Assessment; NRCan = Natural Resources Canada; N/A = not applicable.

Community Sessions

The engagement program focussed considerable effort on a number of community sessions to reach as many local residents as possible. The purpose of these sessions was to provide local residents with updated information about the Project, and to answer questions and receive feedback to incorporate into the Project planning process.

Community sessions began in 2010 as baseline studies were taking place. Nine community sessions have taken place to date (Table 6.2-2) with additional sessions expected to be held in 2014. The 2014 sessions are expected to coincide with the submission of the EIS. Community sessions were held in the communities closest to the Project location (i.e., communities of Black Lake and Stony Rapids) with additional sessions held in Fond du Lac.

Multiple methods of advertising were used to promote the events. Advertisements were broadcasted over the radio through the Missinipi Broadcasting Corporation in both Denésuline and English. Posters advertising the events were posted at local businesses, schools and town offices. Invitations were sent to various groups such as Métis Nation Saskatchewan – Northern Region 1, Local # 80, Black Lake Elders, Black Lake Teachers, Black Lake Students, Stony Rapids Village Council, Athabasca Health Authority, Athabasca Denésuline Child and Family Services Inc., Mining Industry Community Liaison, and Fond du Lac First Nation.

The format of the sessions varied, but included elements of formal presentations, posters stations with subject matter experts, and formal and informal question periods. Translation services were provided at the Black Lake Community Sessions. Materials presented at each community session are provided in Appendix 6.3. One community session held in Black Lake (April 9, 2013) was completed as a workshop, with the specific purpose of receiving feedback from local residents on various aspects of the Project (e.g., water intake; submerged weir; riverscape (changes to the river); valued components selected for the assessment; road, bridge and camp locations; and how it works). It was expected that 40 people would attend the event based on the invitation list. The attendance exceeded expectations with 73 people attending the event.

Table 6.2-2: Record of Community Sessions

Community	Meeting Date	Location	Attendance	Purpose of Meeting
Black Lake First Nation	Oct 29/13	Joe Cook Memorial Youth Centre	73	**Purpose:** Provide an update on the Project details. Create an opportunity to hear concerns and answer questions about the Project. **Format:** Opening, Presentation, Informal Question Period at Poster Stations, Formal Question Period, Closing. **Material Topics:** Update on technical design details; potential effects of the Project on Black Lake and Middle Lake water levels, waste rock management, Fond du Lake River water levels, and fish; and next steps.
	Apr 9/13	Joe Cook Memorial Youth Centre	73	**Purpose:** Address concerns raised at Community Sessions in February 2013. Gather specific feedback to be used to advance the design of the Project and the environmental assessment. **Format:** Presentation, Circulation through 6 workstations. **Material Topics:** Main topics for discussion and feedback at stations included water intake; submerged weir; changes to the river; valued components; road, bridge and camp locations; and how it the Project works.
	Feb 20/13	Joe Cook Memorial Youth Centre	68	**Purpose:** Provide an update on the Project details. Create an opportunity hear concerns and answer questions about the Project. **Format**: Opening, Presentation, Formal Questions Period, Closing. **Material Topics:** Need for Project; Key Features; Construction Process; Overview of environmental studies; Next Steps; and Benefits to Community.
	Dec 6/10	Father Porte Memorial School	76	**Purpose:** Provide an update on the Project details. Create an opportunity hear concerns and answer questions about the Project. **Format**: Poster Viewing and Informal Questions Period, Presentation. **Material Topics:** Project Details; and Environmental Assessment Process.
Fond du Lac First Nation	2-Dec-13	Band Hall	47	**Purpose:** Provide an update on the Project details. Create an opportunity to hear concerns and answer questions about the Project. **Format:** This event was planned as an open house; however due to delays in the meeting with Chief and Council, full resources were not available to facilitate the open house format at the appointed start time. To manage the assembled crowd and disseminate information in a timely manner an oral presentation was given based upon the slides prepared for the Round 2 meetings held in Black Lake and Stony Rapids on October 29 & 30, 2013. **Material Topics:** Update on technical design details; potential effects of the Project on Black Lake and Middle Lake water levels, waste rock management, Fond du Lake River water levels, and fish; and next steps.
	27-Feb-13	Father Gamache Memorial School	30	**Purpose:** Provide an update on the Project details. Create an opportunity hear concerns and answer questions about the Project. **Format**: Opening, Presentation, Formal Questions Period, Closing. **Material Topics**: Need for Project; Key Features; Construction Process; Overview of Environmental Studies; Next Steps; and Benefits to Community.

Table 6.2-2: Record of Community Sessions (continued)

Community	Meeting Date	Location	Attendance	Purpose of Meeting
Fond du Lac First Nation (continued)	27-Feb-13	Father Gamache Memorial School	30	**Purpose:** Provide an update on the Project details. Create an opportunity hear concerns and answer questions about the Project. **Format**: Opening, Presentation, Formal Questions Period, Closing. **Material Topics**: Need for Project; Key Features; Construction Process; Overview of Environmental Studies; Next Steps; and Benefits to Community.
Stony Rapids	Oct 30/13	Waterfront Inn	18	**Purpose:** Provide an update on the Project details. Create an opportunity hear concerns and answer questions about the Project. **Format:** Opening, Presentation, Informal Question Period at Poster Stations, Formal Question Period, Closing. **Material Topics**: Update on technical design details; potential effects of Project on Black Lake and Middle Lake water levels, waste rock management, Fond du Lake River water levels, and fish; and Next Steps.
	Feb 21/13	Waterfront Inn	12	**Purpose:** Provide an update on the Project details. Create an opportunity hear concerns and answer questions about the Project. **Format**: Opening, Presentation, Formal Questions Period, Closing. **Material Topics**: Need for Project; Key Features; Construction Process; Overview of Environmental Studies; Next Steps; and Benefits to Community.
	Dec 7/10	Waterfront Inn	6	**Purpose:** Provide an update on the Project details. Create an opportunity hear concerns and answer questions about the Project. **Format**: Poster Viewing and Informal Questions Period, Presentation. **Material Topics:** Project Details; and Environmental Assessment Process.

Feb = February; Apr = April; Oct = October; Nov = November; Dec = December; N/A = not available.

Feedback Results

Stakeholders have been interested in the Project and have had the opportunity to ask numerous questions. A total of 218 pieces of feedback (i.e., question and concerns) have been recorded from both meeting (not including meetings with regulatory agencies) and the community sessions. The feedback has been divided into four categories: Environmental Aspects; Social Aspects; Project Details; and Regulatory Process (Table 6.2-3); each category has further been divided into subcategories. A wide range of feedback topics have been generated with the most frequently asked questions being about the infrastructure of the Project, potential effects to water, potential effects to fish, and workforce/employment and the Partnership agreement. A complete list of feedback questions and the responses can be found in Appendix 6.4.

Table 6.2-3: Topics of Discussion from Engagement Activities

Category	Subcategory	Number of Recorded Comments
Environmental Aspects	Water	28
	Fish	24
	Rock	9
	General	7
	Aesthetics	4
	Noise	3
	Plants	2
	Heritage	2
	Total	**76**
Social Aspects	Partnership Agreement	20
	Workforce, Employment	20
	Power Rates	14
	Economic Benefit	9
	Education	7
	Housing	1
	Total	**71**
Project Details	Infrastructure	29
	How it Works	15
	General	7
	Need	4
	Schedule	3
	Total	**58**
Regulatory Process	Translation	3
	Consultation	4
	Federal/Provincial Process	3
	Total	**7**
Total		**218**

6.2.4 Future Engagement Activities

To date the engagement program has been focussed on the planning and environmental assessment phase of the Project. Future engagement activities related to this phase of the Project will include the continued dissemination of information through the web page, newsletters, and additional community sessions. A community session in the community of Fond du Lac First Nation was held in December 2013 and additional sessions with the communities of Black Lake First Nations and Stony Rapids are planned for early 2014. As the Project progresses, the engagement program will be altered to coincide with the next phases of the Project.

6.3 Duty to Consult

In Canada, the Supreme Court of Canada has ruled that the Crown has a legal Duty to Consult with and, where appropriate, accommodate, First Nations and Métis on matters that can affect Aboriginal claims or rights (CEAA 2013a; Ceballos 2010). This includes permitting, changes in tenure, and approval of developments on and off reserve lands. The purpose of Duty to Consult is to identify different values and concerns existing between Aboriginal groups and the Government of Canada, and to address questions and concerns so that they arrive at a result that meets the needs of all interested parties (Ceballos 2010).

Governments in Canada, at the federal and provincial level, have a duty to consult with Aboriginal groups when making decisions that could affect lands and resources subject to aboriginal claims. The federal and provincial Duty to Consult requirements for the Project are described below.

6.3.1 Federal Requirements

The *CEAA* 2012 provides for environmental assessment of designated projects by a responsible authority, and also promotes communication and cooperation with aboriginal peoples. The Agency acts as consultation coordinator to integrate the Government of Canada's Aboriginal consultation activities into the environmental assessment process to the greatest extent possible (CEAA 2013a). This applies to all environmental assessments for which the Agency is the responsible authority.

The Agency's Duty to Consult responsibilities include following:

- identify Aboriginal groups whose potential or established Aboriginal or Treaty rights may be adversely affected by the proposed project;
- invite identified Aboriginal groups to provide comments in relation to the environmental assessment;
- provide Aboriginal groups with information about the proposed project and the environmental assessment process;
- provide funding to assist eligible Aboriginal groups in preparing for and participating in consultation activities through the Agency's Participant Funding Program;
- consider the feedback provided by Aboriginal groups during the consultation process, including any concerns or issues raised, prior to any decisions being final; and
- identify mitigation and accommodation measures that may be required to address issues raised during the consultation process (CEAA 2013a).

The nature and level of consultation activities undertaken by the Agency will vary on a project-by-project basis and are dependent on the nature of the potential or established Aboriginal or Treaty rights, and the extent and severity of the potential adverse impacts of the proposed project on those rights (CEAA 2013a). The proponent can contribute to fulfilling the Crown's legal Duty to Consult by involving First Nations and Métis people in the engagement process for an environmental assessment. However, the public participation process might not be sufficient to meet fully the Crown's legal Duty to Consult with Aboriginal peoples (CEAA 2013b).

The following is a complete list of all Aboriginal groups who have been identified by the federal officials for consultation related to the environmental assessment on the basis that potential or established Aboriginal or Treaty rights and interests may be affected by the Project:

- Black Lake Denésuline First Nation;
- Fond du Lac Denésuline First Nation;

- Hatchet Lake Denésuline First Nation;
- Métis Nation Saskatchewan Camsell Portage Local 79;
- Métis Nation Saskatchewan Stony Rapids Local 80; and
- Métis Nation Saskatchewan Uranium City Local 50.

The Agency is responsible for completing all the requirements of the federal Duty to Consult process. While the Proponent has moved forward with an engagement program, the Proponent has not conducted any specific activities related to the federal Duty to Consult process.

6.3.2 Provincial Requirements

Based on the Project information provided in the Project Description (Golder 2012) and the Terms of Reference (Golder 2013), it is the responsibility of the MOE EAB to determine if the Project will trigger a Duty to Consult. In determining if the Duty to Consult will be triggered, the EAB will consider if:

- the proposed Project is a "development" under the *Environmental Assessment Act* (2010) and the Minister must decide whether the project will be approved;
- the proposed Project has the potential for adverse environmental effects on the resources that First Nations and Métis people use to exercise their Treaty and Aboriginal rights and traditional uses; and/or
- the proposed Project has the potential to limit First Nations and Métis right of access to those resources (MOE 2012).

On April 19, 2013 the MOE EAB determined that the Project has the potential to adversely affect the exercise and Treaty and Aboriginal rights or traditional uses as described in the provinces First Nation and Métis Consultation Policy Framework (Appendix 6.5, Appendix A). Although the legal Duty to Consult ultimately resides with the Crown, and not with the proponent, MOE delegated certain procedural aspects to the proponent of the Project as they are in the best position to describe accurately the Project and any potential effects on the environment. The MOE EAB identified the communities to which the Proponent were to provide Project-specific information and solicit feedback with respect to potential impacts on Treaty and Aboriginal rights. The communities identified by the MOE EAB included:

- Fond du Lac Denésuline First Nation; and
- Métis Nation Saskatchewan – Northern Region I, Local # 80.

The primary objective of the Project proponent is to assist MOE in meeting its Duty to Consult. The Proponent works with potentially affected First Nation and Métis communities in assessing potential environmental and social-economic impacts, and developing the EIS. Meetings to fulfill MOE's Duty to Consult requirements are carried out in accordance with requirements specific to MOE's letter of April 19, 2013 and as described in the First Nation and Métis Duty to Consult Plan for the Tazi Twé Hydroelectric Project – Saskatchewan Ministry of Environment (Appendix 6.5).

Through the implementation of the Duty to Consult program, the proponent provides the identified First Nations and Métis communities with specific information about predicted effects from the Project in the Fond du Lac River between Black Lake and Middle Lake and how that might affect fish species. Information will be gathered from the First Nations and Métis communities regarding how these potential effects might affect their ability to pursue their traditional activities along the Fond du Lac River (e.g., hunting, fishing, trapping, or other traditional activities). Documentation of these activities as of December 31, 2013 is presented in Appendix 6.5, Appendix B.

6.4 References

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6.5 List of Acronyms

Term	Definition
AANDC	Aboriginal Affairs and Northern Development Canada
BLFN	Black Lake First Nation
CEAA	*Canadian Environmental Assessment Act*
CPAWS	Canadian Parks and Wilderness Society
CWS	Canadian Wildlife Service
DFO	Fisheries and Oceans Canada
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
FNMNA	First Nations, Métis and Northern Affairs
FWB	Fish and Wildlife Branch
HC	Health Canada
IFC	International Finance Corporation
INAC	Indian and Northern Affairs Canada
MOE	Ministry of Environment
MOE EAB	Ministry of Environment Environmental Assessment Branch
NLMC	Northern Labour market Committee
NRCan	Natural Resources Canada
Project	Tazi Twé Hydroelectric Project
SES	Saskatchewan Environmental Society
SWA	Saskatchewan Watershed Authority
TC	Transport Canada
the Agency	Canadian Environmental Assessment Agency
TOR	Terms of Reference
WSA	Water Security Agency

7.0 ENVIRONMENTAL ASSESSMENT APPROACH

7.1 Introduction

This environmental assessment will be used as a tool to integrate environmental and social factors into the Tazi Twé Hydroelectric Project (Project) planning and encourage decision makers to take actions that promote sustainable development. The goal of this approach is to promote sustainable development, engage First Nations and Métis, government agencies, local communities, interest groups and the public, and limit the overall environmental, economic, social, heritage, and health effects of the Project.

7.2 Steps in the Effects Assessment

The environmental assessment process considers a number of components, including issue scoping, baseline studies, effects predictions, and recommended monitoring and follow-up programs. Although the EIS will evaluate all potential Project-environment interactions, the intent is to focus the effects assessment on those interactions with the greatest potential to result in significant residual effects on valued components (VCs) of the biophysical and socio-economic environments.

This section describes the approach that will be used in the EIS for analyzing effects, classifying residual effects, and determining the significance of residual effects from the Project (incremental) and other developments (cumulative) on the biophysical and socio-economic components. The approach will be applied to the analysis and assessment of the effects from the Project using information from the Project Description (Section 5.0) and existing (baseline) conditions in the Project study areas. Each section of the EIS will use the following key elements for assessing effects on VCs of the biophysical and socio-economic components:

- define the spatial and temporal boundaries;
- provide a summary of the existing environment;
- complete a screening level assessment of Project interactions and mitigation;
- provide methods and results of residual effects analysis (incremental and cumulative);
- explain the approach for managing uncertainty;
- provide methods and results for determining significance; and
- summarize expected environmental management, monitoring, and follow-up programs.

The assessment approach presented here is based on ecological, cultural, and socio-economic principles, and environmental assessment best practice. Several elements of the approach can be consistently applied to all biophysical and socio-economic components. Alternately, certain elements of the assessment approach may have to be modified for some components. For example, there is general consistency in the approach for identifying interactions that link the Project to potential effects on VCs of the biophysical and socio-economic environments. Likewise, the approach to determining the spatial boundaries for the effects analysis and assessment is similar across biophysical and human environment components.

In contrast, the methods for analyzing effects, classifying residual effects (e.g., direction, magnitude, and duration), and predicting environmental significance can differ between biophysical and socio-economic components. For example, human effects of a specific project are difficult to isolate from the ongoing processes of interdependent social, cultural, and economic change. Evolving social trends, government policy and programming decisions, and individual choice all have effects that will be concurrent with potential Project effects. Biophysical components also are influenced simultaneously by natural and human-related factors; however, for many disciplines, Project-specific effects can be quantified (e.g., incremental changes to groundwater and surface water supply, air quality, soil, and wildlife habitat). The socio-economic status of different communities, subpopulations, and individuals may vary; as such, the socio-economic effect may have both positive and negative aspects.

7.2.1 Valued Components

Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples and the public. The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. The inter-relationships between components of the biophysical and human environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). Examples of physical properties that may be considered VCs include air quality, groundwater, hydrology, and soil. Aquatic and terrestrial biota populations represent biological properties that may be considered VCs. Traditional and non-traditional uses of plants and wildlife and other biophysical properties (e.g., ecological services or resources) can be VCs of the cultural and socio-economic environment. The EIS integrates Project-related effects on biophysical, cultural, and socio-economic VCs for the people who may be directly or indirectly influenced by the Project.

7.2.1.1 Selection of Valued Components

The selection of VCs is a process that reflects a balanced and knowledgeable synthesis of a wide range of information including the design of the Project, the environmental setting where the Project is located, and an understanding of concerns and issues associated with the development of the Project. A preliminary evaluation was completed at the Project concept stage to identify key interactions between the Project and various components of the biophysical and socio-economic environments. This evaluation identified key issues to support the initial VC selection process. This preliminary evaluation also provided a basis for understanding the interactions that are present for each of the major phases of the Project (i.e., construction, operations, and closure, as well as accidents and malfunctions) and how anticipated events can be mitigated.

The identification of the key Project-environment interactions and the initial selection of VCs built on the preliminary Project scoping meetings with government, public, and First Nations and Métis, and considered the following:

- presence, abundance, and distribution within, or relevance to, the area associated with the Project;
- potential for interaction with the Project;
- conservation status or concern;
- ecological and socio-economic value;
- identified importance to interested public, First Nations, Métis, government agencies, the scientific community, or the proponent;
- the public, economics, and social conditions; and

- sensitivity to potential Project effects.

Resilience to change was also considered when selecting VCs. Resilience includes the ability of the population to adapt to change (e.g., rate and degree of fluctuation in population abundance and distribution after a disturbance). Properties of the environment that are considered to be sensitive due to limited resilience (e.g., fish populations that are restricted in distribution, listed species, and sensitive ecosystems), and that have the potential to be affected by the Project were specifically considered during the selection of VCs. In some cases, a VC (e.g., wildlife) may be assessed using representative species (e.g., beaver [*Castor canadensis*], American marten [*Martes americana*], and moose [*Alces alces*]) because an interaction with that species has been demonstrated, sufficient suitable information to make effects predictions is available, and that species may represent a limiting condition for effects.

The identification of key Project-environment interactions and the initial VC selection process were used to guide the design of scientifically robust environmental baseline programs. Environmental baseline studies were completed to document existing conditions in the surrounding area. Observations collected during baseline studies represent part of the range of variation in the ecological and socio-economic systems produced by historical and current environmental selection pressures (i.e., human and natural). As such, baseline conditions represent the cumulative effects from previous and existing land use practices and natural processes that have shaped the biophysical, cultural, and socio-economic components during the period of human settlement. Results of the baseline studies were used to support the final VC selection. The final VC selection considered feedback from ongoing regulatory, public, First Nations and Métis engagement activities, professional judgment and experience, and current environmental assessment practices. The final list of VCs for the Project is identified in Table 7.2-1 and rationale for the selection of these VCs is provided.

Table 7.2-1: Rationale for Selection of Valued Components

Valued Component	Rationale
Atmospheric Environment	■ Close link between air quality and other VCs (i.e., surface water quality, fish habitat, soils, vegetation, wildlife, and people). ■ Changes in noise levels can affect fish and wildlife. ■ Changes in air quality or noise levels can affect the quality of life of people living near the Project. ■ Local communities and residents have identified air and noise as a concern.
Groundwater	■ Changes to groundwater can affect quantity and quality of surface water, which can subsequently affect the aquatic and terrestrial environments and people that use these resources. ■ Changes to groundwater was identified as a concern by the public, First Nations and Métis, and regulatory agencies in the Project region.
Surface Hydrology	■ Availability of surface water to sustain aquatic life was identified as a concern by the public, First Nations and Métis, and regulatory agencies in the Project region. ■ Natural and human-related disturbances can alter the timing and nature of the interaction between physical and biological components of the surface water environment. ■ Changes to surface water quantity can influence components of the terrestrial environment and the availability of natural resources for traditional and non-traditional human use.

Table 7.2-1: Rationale for Selection of Valued Components (continued)

Valued Component	Rationale
Surface Water Quality	■ Surface water quality is important to community members, First Nations and Métis, and provincial and federal government regulators. ■ Changes to surface water quality can affect other biophysical and socio-economic VCs that depend on suitable surface water quality.
Fish and Fish Habitat	■ Local Aboriginal people from the Black Lake First Nation, and the outfitter at Camp Grayling identified a number of important fish species in Black Lake, Fond du Lac River, and Middle Lake that are used for traditional and economic purposes. These selected fish VCs are as follows: ▪ Black Lake fish species: Arctic grayling (*Thymallus arcticus*), cisco species (*Coregonus* spp.), lake trout (*Salvelinus namaycush*), lake whitefish (*Coregonus clupeaformis*), longnose sucker (*Catostomus catostomus*), northern pike (*Esox lucius*), walleye (*Sander vitreus*), and white sucker (*Catostomus commersonii*); ▪ Fond du Lac River: Arctic grayling (three populations); and ▪ Middle Lake: Arctic grayling, lake whitefish, longnose sucker, northern pike, walleye, and white sucker. ■ Fish have been a vital part of traditional life in the region and continue to be prepared for consumption based on local cultural practices. ■ Fish habitat is critical to the growth and development of the various life stages of fish species. ■ Effects on fish and fish habitat and effects on aquatic species as defined in *SARA* are areas of federal jurisdiction, and therefore, pursuant to Section 5 of *CEAA* 2012.
Soils	■ Close links among soils and other VCs (i.e., vegetation, wildlife, wildlife habitat, and surface water quality). ■ Natural and human-related disturbances can change the interactions between the soil and other VCs. ■ Changes in soils and other VCs can influence the opportunity for traditional and non-traditional human use of natural resources (e.g., gathering, hunting, trapping, and fishing).
Vegetation	■ Plant populations and communities provide food and habitat for wildlife. ■ Protection of listed (rare) plant species designated by federal and provincial legislation. ■ In recent interviews with the local Aboriginal people, several plant species were identified and are considered to be VCs by for traditional and economic purposes, including blueberries (*Vaccinium* spp.), bog cranberries (*Vaccinium* spp.), moss berries (*Vaccinium* spp.), and strawberries (*Fragaria virginiana*), as well as other edible vegetation, such as mushrooms, when available.
Wildlife	■ Protection of listed wildlife species is designated by federal and provincial legislation. ■ Selected wildlife species were chosen for their potential for interaction with the Project, socio-economic and cultural importance (e.g., hunting, trapping), sensitivity (i.e., listed species), knowledge of the species, life history, and ecological importance.
	■ Given the large number of species that could potentially interact with the Project, it is neither possible, nor necessary to attempt to measure effects on all possible receptors. Thus, wildlife VCs are identified as surrogates to focus or structure the environmental effects assessment, with the understanding that effects on other components of the environment would be similar. For example, assessing the effects from the Project on increases in harvest pressure on furbearer populations using American marten is expected to provide similar results for black bear, wolverine, and lynx occupying the study area(s). Selected wildlife VCs include the following:

Table 7.2-1: Rationale for Selection of Valued Components (continued)

Valued Component	Rationale
Wildlife (continued)	▪ moose (*Alces alces):* large home range; important subsistence and cultural species; prey species for large carnivores. ▪ woodland caribou (*Rangifer tarandus caribou)*: important subsistence, cultural and economic species; migratory species with extensive range requirements; primary prey species for large carnivores in northern environments; considered “rare to uncommon” in Saskatchewan, and ranked as “threatened” by COSEWIC and *SARA.* ▪ barren-ground caribou (*Rangifer tarandus groenlandicus)*: important subsistence, cultural and economic species; migratory species with extensive range requirements; primary prey species for large carnivores in northern environments; considered “rare to uncommon” in Saskatchewan. ▪ beaver (*Castor canadensis):* prey species for many carnivores in northern environments; tolerant of human activities but may be affected by habitat loss; may be affected by changes to water levels; commonly harvested furbearer (valued economic species). ▪ American marten (*Martes americana):* most commonly harvested furbearer (valued economic species); mid-trophic predator in boreal ecosystems. ▪ upland breeding birds: have a small territory size and high bird density so large numbers of upland birds may be affected by habitat loss; migratory birds are susceptible to population declines as a result of changing environmental conditions on breeding and overwintering habitats; some species are tracked in Saskatchewan, and listed as “special concern” and “threatened” federally. ▪ waterbirds (ducks, loons, and grebes): can be affected by loss of shoreline habitat for breeding; important staging habitat may also be lost; can be sensitive to noise disturbance and human activity; some species are important for subsistence, some species can be protected migratory birds; some species are tracked in Saskatchewan, and are listed as “special concern” federally. ▪ bald eagle (*Haliaeetus leucocephalus*): breeding habitat is limited; can be sensitive to noise disturbance and human activity during nesting; May be affected by changes to water levels as species is piscivorous; tracked species in Saskatchewan.
Heritage Resources	▪ Heritage resources are important for revealing past and present land use, cultural identity, and relationships with other cultures and the social and biophysical environments. ▪ Potential alteration or loss of heritage resources may have an effect on Aboriginal people. ▪ Several known heritage sites exist near the Project including a historic Dené cemetery.

Table 7.2-1: Rationale for Selection of Valued Components (continued)

Valued Component	Rationale
Land and Resource Use	■ Pursuant to Section 5 of the *CEAA* 2012, the potential to affect the ability of Aboriginal people to maintain traditional land and resource use must be evaluated. ■ Several fish, plant, and wildlife species are considered to be VCs by local Aboriginal people for hunting, trapping, fishing, and gathering for domestic and commercial use. ▪ Fish species include Arctic grayling, cisco species, lake trout, lake whitefish, longnose sucker, northern pike, walleye, and white sucker. ▪ Plant species include blueberries, bog cranberries, moss berries, and strawberries, as well as other edible vegetation, such as mushrooms, when available. ▪ Wildlife species include black bear, wolf, coyote, red fox, arctic fox, lynx, wolverine, fisher, American marten, weasel species, mink, beaver, muskrat, river otter, red squirrel, and waterbirds (e.g., snow geese, Canada geese, and ptarmigan). ■ Increased access to the Project area is a topic of interest for Aboriginal groups.
Economy	■ During engagement sessions, local Aboriginal groups and community members expressed interest in economic and employment opportunities that will be generated by the Project. ■ Changes on the local, regional, and provincial economy, and the potential effects of these changes on Aboriginal people must be evaluated pursuant to Section 5 of the *CEAA* 2012.
Infrastructure and Community Services	■ Increased traffic volume on local access roads is a topic of interest for Aboriginal groups. ■ Increased employment and economy can cause increased demands on community services and infrastructure, and the potential effect of these changes on Aboriginal people must be evaluated pursuant to Section 5 of the *CEAA* 2012.
Human Population and Health	■ The livability of the environment during construction and throughout operations is a concern of residents located closest to the Project. ■ Local residents identified aesthetics as an issue that would affect the quality of life of residents near the Project. ■ Increased household incomes may influence patterns of family life.

VC = valued components; Project = Tazi Twé Hydroelectric Project; *SARA = Species at Risk Act*; COSEWIC; Committee on the Status of Endangered Wildlife in Canada

7.2.1.2 Assessment and Measurement Endpoints

The definitions of the aspect or key properties of the VC that requires protection to be sustainable (i.e., assessment endpoint) and the measurable indicators of change (i.e., measurement endpoint), help to focus baseline studies, but are also important for predicting the significance of residual effects and for monitoring and managing these effects (Noble 2010). Assessment endpoints are typically qualitative expressions used to assess effects on VCs (e.g., ability of a wildlife VC to remain self-sustaining and ecologically effective). Assessment endpoints are general statements about what is being protected and represent the key properties of the VC that reflect its ecological status or societal value. An assessment endpoint may or may not be measurable. Identification of assessment endpoints for VCs in the EIS was determined partially from the outcome of the public, First Nations, and Métis engagement process.

Measurement endpoints (biophysical or socio-economic indicators) represent properties of the environment, population, or system that, when changed, could result in, or contribute to, an effect on an assessment endpoint.

Measurement endpoints may be quantitative (e.g., concentrations of metals in surface water) or qualitative (e.g., movement and behaviour of wildlife from disturbance). Effects on long-term social, cultural, and economic values are predicted through analysis of changes to measurement endpoints such as employment and income, education and training, and capacity for, traditional, agricultural, and recreational land use. Measurement endpoints also provide the primary factors for discussions concerning the uncertainty of effects on VCs, and subsequently, are the key variables for study in monitoring and follow-up programs. For some disciplines (i.e., air quality, noise levels, groundwater, surface hydrology, and soils) the VCs are strictly considered as measurement endpoints for other VCs, and do not have an independent assessment endpoint. For example, changes in air quality may result in effects on the maintenance of self-sustaining plant communities and populations. Consequently, not every environmental component is carried through the residual effects classification and determination of significance; rather the results of the residual effects analyses are provided to support the effects assessment for other VCs.

The significance of effects from the Project on VCs is evaluated by linking changes in measurement endpoints to effects on an assessment endpoint. For example, changes in habitat quantity and quality (measurement endpoints) are used to assess the significance of effects from the Project on the ability of a wildlife population to remain self-sustaining and ecologically effective (an assessment endpoint). Valued components, assessment endpoints, and measurement endpoints that will be used in this EIS are presented in Table 7.2-2.

Table 7.2-2: Valued Components and Associated Assessment and Measurement Endpoints

Valued Components	Assessment Endpoint	Measurement Endpoint
Atmospheric Environment	■ No assessment endpoint. Results of the assessment are used in the effects analysis for other VCs.	■ particulate matter ($PM_{2.5}$, PM_{10}) and total suspended particulates ■ carbon monoxide, sulphur dioxide, nitrogen oxides ■ deposition rates ■ noise levels
Groundwater	■ No assessment endpoint. Results of the assessment are used in the effects analysis for other VCs.	■ changes to groundwater levels and amount available for human use ■ physical analytes (e.g., pH, conductivity, turbidity) ■ major ions and nutrients ■ total and dissolved metals
Surface Hydrology	■ No assessment endpoint. Results of the assessment are used in the effects analysis for other VCs.	■ flow rate and the spatial and temporal distribution of water ■ surface topography, drainage boundaries, and waterbodies (e.g., streams, lakes, and drainages) ■ water level, waterbody volume, flow rates, and watershed area

Table 7.2-2: Valued Components and Associated Assessment and Measurement Endpoints (continued)

Valued Components	Assessment Endpoint	Measurement Endpoint
Surface Water Quality	■ Protection of surface water quality for aquatic and terrestrial ecosystems, and human use.	■ physical analytes (e.g., pH, conductivity, turbidity, sediment quality) ■ major ions and nutrients ■ total and dissolved metals
Fish and Fish Habitat	■ Maintenance of self-sustaining fish populations (including listed species).	■ habitat quantity ■ habitat quality ■ relative abundance and distribution of fish species ■ survival and reproduction
Soils	■ No assessment endpoint. Results of the assessment are used in the effects analysis for other VCs.	■ terrain and slope stability ■ soil quality, quantity, and distribution ■ permafrost distribution
Vegetation	■ Maintenance of a self-sustaining plant population and community (including listed species).	■ plant community diversity ■ plant community health ■ relative abundance and distribution of plant species ■ habitat fragmentation
Wildlife	■ Maintenance of self-sustaining wildlife populations (including listed species).	■ changes in habitat quality and quantity ■ habitat fragmentation ■ movement and behaviour ■ relative abundance and distribution of wildlife species ■ survival and reproduction
Heritage Resources	■ Protection and preservation of heritage resources.	■ value and quantity of archaeological and sacred sites
Land and Resource Use	■ Continued opportunity for traditional and non-traditional activities such as hunting, fishing, trapping, and plant and berry gathering.	■ relative abundance and distribution of fish species ■ relative abundance and distribution of plant species ■ relative abundance and distribution of wildlife species ■ capacity for traditional and recreational land use
Economy	■ Continued opportunity for employment.	■ employment and income ■ education, training, and opportunities for youth ■ capacity of labour pool ■ tourism potential

Table 7.2-2: Valued Components and Associated Assessment and Measurement Endpoints (continued)

Valued Components	Assessment Endpoint	Measurement Endpoint
Infrastructure and Community Services	■ Continued access to health care, family services, education, and recreation.	■ health care services and facilities ■ child care services and facilities ■ education facilities ■ traffic volume ■ quality and development of infrastructure and community services
Human Population and Health	■ Protection of human health and maintenance of quality of life.	■ population demographics ■ substance abuse ■ crime rates ■ health care ■ child care ■ education ■ family and community cohesion ■ livability of the environment (e.g., effects on people from Project-related changes to air and water quality, noise levels, and aesthetics of the environment) ■ long-term social, cultural, and economic sustainability

VC = valued components; PM_{10} = particulate matter concentrations less than 10 micrometres; $PM_{2.5}$ = particulate matter concentrations less than 2.5 micrometres

7.2.2 Environmental Assessment Boundaries

To facilitate the assessment of Project effects, it is necessary to establish relevant spatial and temporal boundaries within which potential effects are to be evaluated. Individuals, populations, and communities function within the environment at different spatial and temporal scales. In addition, the response of physical, chemical, and biological processes to changes in the environment can occur across a number of spatial scales at the same time (Holling 1992; Levin 1992). As a result, the scale of an investigation will determine the range of patterns and processes that can be observed and predicted with certainty (Wiens 1989; Harris et al. 1996). Spatial and temporal boundaries of the assessment can be VC-specific, which provides ecologically relevant assessment predictions.

7.2.2.1 Spatial Boundaries

Effects from Project interactions on VCs are typically stronger at the local scale, and larger scale effects are more likely to result from other ecological factors and human activities. For example, effects from the Project on VCs with limited movement (e.g., soil and vegetation) will likely be limited to local changes from the Project footprint. Similarly, for species with small home ranges (e.g., upland breeding birds), any effects from Project interactions on a local population will likely not be transferred to other local populations in the region. Depending on the species, an increase in distance among local populations can decrease effective dispersal and result in subpopulations that fluctuate independently (Schlosser 1995; Steen et al. 1996; Sutcliffe et al. 1996; Ranta et al. 1997; Bjørnstad et al. 1999), and act more like larger (or actual) populations (Berryman 2002). In other words, changes in the number of individuals within populations over time are more related to factors that influence reproduction and survival rates than to the movement of individuals between populations.

For VCs with more extensive distributions, such as wildlife species with large home ranges, effects from Project interactions have a higher likelihood of combining with effects from other human developments and activities. For example, larger wildlife species (e.g., moose) that are influenced by the Project may encounter other human activities and developments in their daily movements. Consequently, effects from the Project could combine with influences from other developments, which can result in cumulative effects on the VC.

The purpose of the examples above is to emphasize the different levels of organization in natural systems, and the corresponding need to analyze and predict Project effects at the appropriate spatial scales. For this EIS, the spatial scales were defined to capture the processes and activities that influence the geographic distribution and movement patterns specific to each VC. Accordingly, the EIS has adopted a multi-scale approach for describing baseline conditions and predicting residual effects from the Project on VCs.

For the EIS, the spatial boundaries defined for VCs (where applicable) include a local study area (LSA) and regional study area (RSA). The LSAs were designed to measure baseline environmental conditions and to assess direct effects from the Project on the VCs. The LSAs were also defined to assess small-scale indirect effects from Project activities on VCs, such as changes to soil, vegetation, and surface water quality from air and dust emissions.

The boundaries for the RSAs were designed to quantify baseline conditions at a scale that is large enough to assess the maximum predicted geographic extent (i.e., maximum zone of influence) of direct and indirect effects from the Project on VCs. Project-related effects at the regional scale may include potential changes to downstream water quantity or changes to regional employment and incomes. Cumulative effects typically are assessed at a regional scale and, where relevant, can consider influences that extend beyond the RSA.

7.2.2.2 Temporal Boundaries

Spatial and temporal boundaries are tightly correlated because processes that operate on large spatial scales typically occur at slower rates and have longer time lags than processes that operate on smaller spatial scales (Wiens 1989; Chapin et al. 2004; Folke et al. 2004). An example of a large spatial scale process that occurs at a slow rate is the change in the northern and southern extent of the boreal forest. In this EIS, the temporal boundary for each VC is defined as the amount of time between the start and end of a relevant Project activity, which is related to development phases. The temporal boundary of the assessment encompasses all Project phases including: Project construction (3 years), operations (for the purpose of the Environmental Impact Assessment (EIA) the operating period is assumed to be 90 years), and closure (2 years).

7.2.3 Screening of Project Interactions and Mitigation

Interactions or linkages between Project components or activities, and the corresponding potential changes to measurement endpoints (indicators of change) of the environment are identified through a screening process. This screening step is largely a qualitative assessment, intended to focus the residual effects analysis on interactions that will require a more comprehensive assessment of effects on VCs (i.e., those interactions that may result in significant residual effects after mitigation).

Potential interactions through which the Project could affect VCs were identified from a number of sources including the following:

- a review of the Project Description and scoping of potential interactions and mitigation by the environmental and engineering teams for the Project;
- scientific knowledge and experience with other similar projects in Canada; and
- engagement with the public, First Nations and Métis communities, and government.

The screening process is completed to systematically remove Project interactions that are predicted to have no residual effect or are expected to result in minor changes to measurement endpoints and a negligible effect on the assessment endpoint, after applying mitigation. Interactions are evaluated using scientific knowledge, logic, experience with similar developments, and the effectiveness of mitigation. This screening step is intended to focus the residual effects analysis on Project interactions that have potential to lead to significant residual effects on VCs.

The first part of the screening step is to produce a list of all potential interactions for the Project. Each interaction is initially considered to have a linkage to potential effects on environmental components. This step is followed by the development of environmental design features and mitigation that can be incorporated into the Project to remove an interaction or limit (mitigate) the effects on environmental components. Environmental design features include Project design elements, environmental best practices, management policies and procedures, and social programs. Environmental design features are developed through an iterative process between the Project's engineering and environmental teams to avoid or mitigate effects.

Knowledge of the environmental design features and mitigation is then applied to each of the interactions to determine the expected amount of Project-related changes to the environment and the associated residual effects (i.e., effects after mitigation) on VCs. Changes to the environment can alter physical measurement endpoints (e.g., water and soil chemistry, and amount of habitat) and biological measurement endpoints (e.g., animal behaviour, movement, and survival). For a residual effect to occur there has to be a source (Project component or activity) that results in a measurable environmental change and a correspondent residual effect on VCs.

Project activity → measurable environmental change → residual effect on a VC

Interactions will be determined to be primary, secondary (minor), or as having no linkage using scientific knowledge, logic, and experience with similar developments and environmental design features. Each potential interaction will be assessed and described as follows:

- no linkage – interaction is removed by environmental design features and mitigation so that the Project results in no detectable (measurable) change and no residual effect on a VC relative to baseline or guideline values;
- secondary - interaction could result in a minor change, but would have a negligible residual effect on a VC relative to baseline or guideline values and is not expected to contribute to effects of other existing or reasonably foreseeable projects to cause a significant effect; or

- primary - interaction is likely to result in a measurable change that could contribute to significant residual effects on a VC relative to baseline or guideline values.

Primary interactions are anticipated to result in a residual effect on the assessment endpoint, and therefore require further analysis (residual effects analysis), a classification of the residual effect, and a determination of the significance of the residual effect. For those VCs with no assessment endpoints, the classification of residual effects and the determination of the significance are not completed. Interactions with no linkage to a change or changes that are considered minor (secondary) will not be analyzed further or classified in the EIS because environmental design features will remove the interaction (no linkage) or residual effects can be determined to be negligible through a simple qualitative or quantitative evaluation. Interactions determined to have no linkage to VCs or those that are considered secondary are not predicted to result in significant effects on VCs.

7.2.4 Residual Effects Analysis

In the EIS, the residual effects analysis considers all primary Project interactions that will likely result in measurable environmental changes and residual effects on VCs (i.e., after implementing environmental design features and mitigation). This section will provide the general approach to analyzing Project-specific and cumulative effects for biophysical and socio-economic components.

Assessment cases are defined for the effects analysis and included the baseline case, application (Project) case and future case (if applicable) (Table 7.2-3). The baseline case considers the current conditions in the RSA such as natural disturbances (e.g., fire) and previous and existing human developments and activities. The regional area surrounding the Project has experienced little industrial human development and activity. Previous activity includes exploration work for the Nisto uranium deposit (mineral property #1621), which is located on the west shore of Black Lake, approximately 23 km east of the Northern Hamlet of Stony Rapids (Government of Saskatchewan 2013). In 1950, two adits were driven and lateral work was completed. Ore was mined from the shoots accessible from the northeast adit in 1959, but only exploration work has been completed in the area since 1959. Existing human-related disturbance includes trails, roads, cabins, the Black Lake sewage lagoon, and the communities of Black Lake and Stony Rapids. Populations and communities in aquatic and terrestrial ecosystems have likely adapted to the low level of human industrial activity over the previous 50 to 60 years. Therefore, current (baseline) conditions in the RSA are expected to reflect the cumulative influence of previous and existing human industrial activities on aquatic and terrestrial ecosystems relative to reference conditions. Reference conditions represent no to little human development, except for First Nation communities, which are assumed part of the historical natural ecosystems.

Table 7.2-3: Contents of Each Assessment Case

Conditions from all previous and existing developments prior to the Project.	Baseline case plus the Project.	Application case plus reasonably foreseeable developments.

The application case occurs during the start of construction of the Project through closure, and the associated duration of predicted effects (i.e., until effects are reversed or are deemed irreversible). The magnitudes of effects from the Project are expected to be greatest during construction and the initial period of operation. For example, the magnitude of some effects, such as the changes from blasting activities to existing noise levels and dust deposition are expected to be strongest during construction, and the duration of these effects will likely end within the initial period of operation. Physical disturbance to the terrestrial environment is expected to occur only at the beginning of construction and the majority of the area disturbed will be reclaimed immediately following construction. Reclamation activities following construction will include the removal of portions of the temporary construction infrastructure not required during operation. Temporary infrastructure includes the construction camp, contractor's work areas, and waste rock disposal areas.

The duration of some effects from the Project have the potential to last over the 90-year operation period. For example, the presence of the water intake structure in Black Lake may have long-term effects on the habitat suitability for fish or wildlife species that may use this area. The presence of the main access road and tailrace channel for the 90-year period could present long-term physical barriers or sensory effects on wildlife, but the magnitude and geographic extent of these effects should be much smaller than similar effects during construction. Because the differences in the magnitude and geographic extent of effects are expected to be measurable between construction and operation, the analysis examined both phases. Analyses were quantitative where possible and qualitative where necessary.

There is potential for this Project to operate beyond the expected 90-year operational period; however, increasing the duration of the operation phase of the Project would have little influence on effects predictions. Most of the physical changes to habitat from the operations footprint are considered permanent because of the length of operations (i.e., the duration of the change will be well beyond the temporal boundary of the assessment). The outcome of reclamation activities with respect to the operation footprint is highly uncertain, particularly in an environment where natural succession processes are slow, and plant community trajectories can be altered by a number of factors (e.g., climate change, fire, and unforeseeable human development).

Closure is when power production operations end, and decommissioning and reclamation of the final infrastructure (i.e., powerhouse, intake, power tunnel, tailrace channel, switchyard, access roads, and distribution line) is completed.

The future case includes the baseline case, application case, and reasonably foreseeable developments (if applicable). Reasonably foreseeable developments or designated projects that would be included in the EIS are activities or projects that:

- would be developed in the spatial and temporal boundaries of the Project;
- have been proposed and scoped to a reasonable level of detail;
- may be induced by the Project;
- are currently undergoing regulatory review; and
- have the potential to change the Project or the effects predictions.

Both incremental and cumulative effects from the Project and other developments, if applicable, will be analyzed in this section. Results for predicted Project-specific (incremental) and cumulative effects will be concisely and clearly presented with appropriate tables and figures.

7.2.4.1 Project-specific Effects

For each VC, the effects analysis considers all primary Project interactions that likely result in measurable environmental changes and residual effects on VCs (i.e., after implementing environmental design features and mitigation). Thus, the analysis is based on residual Project-specific (incremental) effects that are verified to be primary in the screening level assessment of Project interactions. The methods and results for determining numerical or qualitative changes to each measurement endpoint (e.g., lake levels, soil chemistry, and habitat quality) that are influenced by a primary Project interactions are provided, followed by the predicted residual effects on the VC.

If necessary, detailed methods and technical details, where required, will be provided in an appendix with a summary in the residual effects section. The summary will contain adequate detail so that it will be sufficient for most readers to understand how the results were generated. Assumptions and other details needed to reproduce any modeling, as well as approaches and procedures used to decrease uncertainties (if they exist) in the analysis and models (e.g., conservative estimates) are described.

Where possible and appropriate, the analyses are quantitative, and may include data from field studies, modeling results, scientific literature, government publications, effects monitoring reports, and personal communications. Available traditional knowledge and community information are incorporated into the analysis and results. Due to the amount and type of data available, some analyses are qualitative and include professional judgement or experienced opinion.

7.2.4.2 Cumulative Effects

Cumulative effects are those that are likely from a reviewable project, combined with the effects from prior development, existing activities, and reasonably foreseeable future developments that are sufficiently certain to proceed. Cumulative effects represent the sum of all natural and human-induced influences on the physical, biological, cultural, and economic components of the environment through time and across space. Some changes may be human-related, such as increasing industrial and mineral development, and some changes may be associated with natural phenomena such as extreme rainfall events, and periodic forest fires. It is the goal of the cumulative effects assessment to estimate the contribution of residual effects from the Project and other developments on environmental components, in context of natural changes in the system.

Not every environmental component requires an analysis of cumulative effects. The key is to determine if the effects from the Project and one or more additional developments and activities overlap (or interact) with the temporal or spatial distribution of the environmental component. For some environmental components, Project-specific effects are important and there is little or no potential for cumulative effects, because there is little or no overlap with other developments (e.g., soils). For other environmental components that are distributed or travel over large areas and can be influenced by a number of developments (e.g., wildlife) the analysis of cumulative effects can be necessary and important. Socio-economic components also must consider the potential cumulative effects of the Project and other developments and human activities.

7.2.5 Management of Uncertainty

Ecosystems are complex and interactions among abiotic and biotic components of the ecosystem occur across multiple scales and are typically nonlinear (Boyce 1992; Holling 1992; Levin 1992; Wu and Marceau 2002). These characteristics can confound our understanding of ecosystem processes and limit our capacity to make predictions. Like all scientific results and inference, residual effects predictions have uncertainty associated with the data and current knowledge of the system. The confidence in residual effect predictions is related to the following:

- adequacy of baseline data for understanding conditions in the Project study areas;
- the understanding of Project-related residual effects on the system; and

- knowledge of the effectiveness of environmental design features and mitigation at limiting effects on VCs.

Most assessments of effects embody some degree of uncertainty. The uncertainty section of the EIS will identify the key sources of uncertainty and discuss how uncertainty was addressed to increase the level of confidence that residual effects will not be worse than predicted. Where possible, a strong attempt was made to reduce uncertainty in the EIS to increase the level of confidence in effects predictions. Where appropriate, uncertainty may also be addressed by additional mitigation, which would be implemented as required. Each discipline section will include a discussion of how uncertainty has been addressed and provide a qualitative evaluation of the resulting level of confidence in the residual effects analyses and determination of significance.

7.2.6 Determination of Significance

The classification of residual adverse effects on the primary interactions provides the foundation for determining environmental significance from the Project and other developments on VC assessment endpoints. Generic definitions for residual effects criteria are provided below, as well as an overview of the approach and method used to classify residual effects and predict significance.

7.2.6.1 Residual Effects Criteria and Classification

The purpose of the residual effects classification is to describe the residual incremental and cumulative (if applicable) effects from the Project and other developments on VCs using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment. It is difficult to provide specific definitions for all residual effects criteria (e.g., magnitude and geographic extent) and significance that are universally applicable to each VC assessment endpoint. Consequently, specific definitions will be provided for each VC within each section of the EIS. The following criteria will be used to classify the residual effects from the Project in the EIS.

- direction;
- magnitude;
- geographic extent;
- duration;
- reversibility;
- frequency; and
- likelihood.

Generic definitions for each of the criteria for the classification of residual effects and the determination of significance used in this assessment are provided below.

Direction - Direction indicates whether the residual effect on a VC is negative (i.e., less favourable), positive (i.e., improvement), or neutral (i.e., no change). While the main focus of the residual effects assessment is to predict whether the development is likely to cause significant negative residual effects on a VC or cause public concern, the positive changes associated with the Project also are reported. Neutral changes are not assessed.

Magnitude - Magnitude is a measure of the intensity of a residual effect, or the degree of change caused by the Project relative to baseline conditions or a guideline value. It is classified into three scales: negligible to low, moderate, and high. The definition of magnitude of effects is typically VC specific. Magnitude can relate to relative or absolute changes that are above or below baseline, guideline, or threshold values. Where possible, magnitude is reported in absolute and in relative terms.

Geographic Extent – refers to the spatial extent of the effect, and is different from the spatial boundary (i.e., study area) for the effects analysis. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution and movement of VCs. However, the geographic extent of effects can occur on a number of scales within the spatial boundary of the assessment (i.e., effects study area). Geographic extent refers to the area affected, and is categorized into three scales of local, regional, and beyond regional. Effects at the local scale are largely associated with the predicted maximum spatial extent of combined direct and indirect changes from the Project. Effects at the regional scale are associated with incremental and cumulative changes from the Project and other developments. The beyond regional scale includes cumulative residual effects from the Project and other developments that extend beyond the RSA. The principle applied when using geographic extent to understand magnitude is that local effects from the Project are less severe than effects that extend to the regional or beyond regional scales.

Duration – Duration is defined as the amount of time (usually in years) from the beginning of an effect to when the effect on a VC is reversed, and is expressed relative to Project phases. Duration has two components. It is the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases), plus the time required for the effect to be reversible. Essentially, duration is a function of the length of time that VCs are exposed to Project activities and reversibility.

Both the duration of individual events and the overall time frame during which the residual effect may occur are considered. Some residual effects may be reversible soon after the effect has ceased, while other residual effects may take longer to be reversed. By definition, residual effects that are short-term, medium-term, or long-term in duration are reversible.

In some cases, available scientific information and professional judgment may predict that the residual effect is irreversible. Alternately, the duration of the residual effect may not be known, except that it is expected to be extremely long and well beyond the temporal boundary of the assessment (95 years). As such, any number of factors could cause a VC to never return to a state that is unaffected by the Project. In other words, science and logic predict that the likelihood of reversibility is so low that the residual effect is classified as irreversible.

Reversibility - After removal of the Project activity or stressor, reversibility is the likelihood that the Project will no longer influence a VC in a future predicted period of time. This term usually has only one alternative: reversible or irreversible. The period is provided for reversibility (i.e., duration) if a residual effect is reversible. Permanent residual effects are considered irreversible.

Frequency - Frequency refers to how often a residual effect will occur and is expressed as isolated (confined to a discrete period), periodic (occurs intermittently, but repeatedly over the temporal boundary of the assessment), or continuous (occurs continuously over the temporal boundary of the assessment). Frequency is explained more fully by identifying when the residual effect occurs (e.g., once at the beginning of the Project and quickly reversed). If the frequency is periodic, then the length of time between occurrences, and the seasonality of occurrences (if present) is discussed.

Likelihood - Likelihood is the probability of an effect occurring and is described in parallel with uncertainty. Four categories are used: unlikely (residual effect is possible, but unlikely to occur within the temporal boundary of the assessment [95 years; less than 10% chance of occurring]), possible (residual effect is possible within a year, or a chance of occurring within the temporal boundary of the assessment [95 years], but is not certain), likely (residual effect is likely to occur or probable within a year, or at least a chance of occurring in the next 10 years, and has a greater than 80% chance of occurring), and highly likely (the residual effect is certain).

7.2.6.2 Significance of Residual Effects

The classification of residual adverse effects on the primary interactions provides the foundation for determining environmental significance from the Project and other developments on VC assessment endpoints. Magnitude, geographic extent, and duration (which include reversibility) are the principal criteria used to predict significance (FEARO 1994). Other criteria, such as frequency and likelihood, may be used as modifiers (where applicable) in the determination of significance. The key sources of uncertainty related to the effects assessment are identified and discussed to present how uncertainty is addressed to increase the level of confidence that effects will not be worse than predicted.

The determination of significance considers all primary interactions that are expected to result in residual effects on the assessment endpoint of a VC. The relative contribution of each interaction is then used to determine the significance of the Project on assessment endpoints. For example, a primary interaction with a high magnitude, large geographic extent, and long-term duration would be given more weight in determining significance relative to interactions with smaller scale effects. The relative effect from each interaction is discussed; however, interactions that are predicted to have the greatest influence on changes to assessment endpoints would also be assumed to contribute the most to the determination of environmental significance. Significance is determined for the residual effect of the Project overall, as well as for the cumulative residual effects from the Project and previous, existing, and reasonably foreseeable developments or designated projects.

A significant residual effect is predicted to have sufficient magnitude, duration, and geographic extent to cause fundamental changes to the population and/or community processes (e.g., demographic rates) and properties (e.g., resilience and stability) of the VC. The evaluation of significance uses ecological and socio-economic principles, to the extent possible, but also involves professional judgment and experienced opinion.

For example, although difficult to measure, resilience is the capacity of the system to absorb disturbance, and reorganize and retain the same structure, function, and feedback responses (i.e., properties of the social-ecological system) (Holling 1973; Walker et al. 2004; Folke 2006). Resilience includes resistance, capability to adapt to change, and how close the system is to a threshold before shifting states (i.e., precariousness). Highly resistant systems require stronger disturbances over a longer duration and larger geographic area to change the system's current path or trajectory, even if it is close to a threshold. In contrast, a similar system with lower resistance would be less resilient to a weaker disturbance, and may generate a change in state or a regime shift with a subsequent impact on the ecosystem and society (Folke et al. 2004; Walker et al. 2004).

The adaptive capability of a system is related to the evolutionary history and adaptations accumulated by communities, species, and populations while experiencing a range of disturbances and fluctuations through space and time (Holling 1973; Gunderson 2000). If the frequency, duration, geographic extent, and/or intensity (magnitude) of a disturbance are beyond that historically encountered by the system, and outside the adaptive capability of species, then the likelihood of a regime shift increases. Regime shifts and changes in state of the population or social-ecosystem can be reversible or irreversible.

Reversibility is the likelihood that the system will recover at a future time following removal of the stressor, and is a function of resilience. Due to the complex relationships among biophysical components and unpredictable events, the recovery of the system following disturbance can result in the same or altered state (Gunderson 2000; Folke 2006). In other words, the effect from disturbance may be reversible, but the exact nature of ecosystem properties and services, and human uses are different. In some cases, the shift in ecological properties and services may not be reversible and will have a consequence to socio-economics and land use (Gunderson 2000; Scheffer and Carpenter 2003; Folke et al. 2004; Carpenter and Brock 2006).

In summary, the following information is used in the evaluation of the significance of residual effects from the Project on a VC:

- results from the residual effect classification;
- magnitude, geographic extent, and duration of the effect as principal criteria, with frequency and likelihood as modifiers;
- application of professional judgment and ecological and socio-economic principles, such as resilience, to predict the duration and associated reversibility of residual effects.

7.2.7 Environmental Management, Monitoring, and Follow-up

This section will provide an overview of the monitoring and follow-up programs proposed to verify the accuracy of the effects assessment and to determine the effectiveness of mitigation and environmental design features. Monitoring programs will be designed to incorporate baseline data, compliance data (e.g., regulatory documents, standards, or guidelines), and real time data. These programs will also include any contingency procedures/plans or other adaptive management provisions as a means of addressing unforeseen effects or correcting exceedances, as required, complying or conforming to benchmarks, regulatory standards, or guidelines. Monitoring will be completed by qualified individuals and typically includes one or more of the following categories, which may be applied during the Project.

- Compliance monitoring - Confirms compliance to regulatory requirements, company commitments, and the implementation of approved design standards and mitigation. Compliance inspections will be undertaken as part of a comprehensive Environmental Protection Plan (EnvPP).
- Environmental monitoring - Completed to track conditions or issues during the Project lifespan, and is a key component of adaptive management (e.g., monitoring for soil erosion and rare (listed) plant species during construction, monitoring water quality and discharge volumes), and for continuous improvement of the Project-specific EnvPP. Information obtained during environmental monitoring programs can be used to implement further mitigation as required.
- Follow-up monitoring - Follow-up monitoring is designed to verify the accuracy of effects predictions, reduce uncertainty, determine the effectiveness of environmental design features and mitigation, and provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices.

If monitoring detects effects that are different from predicted effects or the need for improved or modified design features, then adaptive management will be implemented. Details regarding the monitoring plans will be discussed in the EIS. This may include increased monitoring, changes in monitoring plans, or additional mitigation.

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7.4 List of Acronyms

Acronym	Definition
CEAA	*Canadian Environmental Assessment Act*
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
EIS	Environmental Impact Statement
EnvPP	Environmental Protection Plan
FEARO	Federal Environmental Assessment and Review Office
LSA	local study area
Project	Tazi Twé Hydroelectric Project
RSA	regional study area
SARA	*Species at Risk Act*
VC	valued components

7.5 List of Units

Unit	Definition
%	percent
PM_{10}	particulate matter concentrations less than 10 micrometres
$PM_{2.5}$	particulate matter concentrations less than 2.5 micrometres

8.0 ATMOSPHERIC ENVIRONMENT

8.1 Introduction

The purpose of the atmospheric environment section is to describe the existing air quality and acoustic environment that could be affected by the Tazi Twé Hydroelectric Project (Project) and to assess the effects on the atmospheric environment. The scope of the atmospheric environment section includes an analysis of Project-related changes to air quality and noise levels during construction, operation, and closure, and considers accidents, malfunctions, and unplanned events. The overall residual effects from the Project and potential for cumulative residual effects from the Project and previous, existing, and reasonably foreseeable developments on the atmospheric environment are also assessed.

Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples and the public. The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development, and are therefore used to predict the effects of the Project on all environmental components. Rationale for selection of the atmospheric environment as a VC is as follows:

- close link between air quality and other VCs (i.e., surface water quality, fish habitat, soils, vegetation, wildlife, and people);
- changes in noise levels can affect fish and wildlife;
- changes in air quality or noise levels can affect the quality of life of people living near the Project; and
- local communities and residents have identified air and noise as a concern.

The assessment endpoint is the key property that should be protected for use by future human generations and although the atmospheric environment was selected as a VC, it does not have an assessment endpoint. The results of this assessment are instead used in the effects analysis for other VCs (e.g., water quality, soils, vegetation, and human health). The measurement endpoints are quantifiable and qualitative expressions of change, and for the atmospheric environment include particulate matter ($PM_{2.5}$) and total suspended particulates (TSP), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_x), dust deposition rates, and noise levels.

There are no provincial noise requirements or standard methods for completing assessments of the acoustic environment in Saskatchewan. For the purpose of this Project, Alberta Utility Commission (AUC) Rule 012: Noise Control Directive (AUC 2013) will be used; hereafter referred to as Rule 012. However, Rule 012 does not require a quantitative assessment of potential noise effects from energy industry facilities under construction, and AUC does not provide any specific criterion thresholds to assess the construction noise for the Project. Rule 012 is commonly used for the noise assessment of Saskatchewan energy industry facilities during their operation. The noise assessment based on Rule 012 determines changes to the existing Ambient Sound Levels (ASL) from operation of the Project and compares those results with noise regulations and guidelines from AUC. Rule 012 requires the total noise levels at receptors during Project operation to be compared with mandated Permissible Sound Level (PSL) values for the receptors.

Because Rule 012 does not require a quantitative assessment of potential noise effects during Project construction, the assessment of potential noise effects associated with the Project construction uses guidance taken from Health Canada. Health Canada's guidance includes specific and explicit thresholds for the assessment of environmental noise in the document *Useful Information for Environmental Assessments* (Health Canada 2010); hereafter referred to as the HC Guidance.

Guidance for completing the assessment for blasting activities during construction of the Project was obtained from the Ontario Ministry of Environment (Ontario MOE) limits contained in Noise Pollution Control (NPC) publication 119 of the Municipal Noise Control By-law, dated August 1978, published by the Ontario MOE (Ontario MOE 1978), later referred to as NPC 119. Additional guidance for the Project blasting limits was obtained from the Ontario Provincial Standard Specification (OPSS) in the document OPSS 120 – General Specification for Use of Explosives, later referred to as OPSS 120 (OPSS 2008). The Project will follow industry standard Best Management Practices, applicable federal regulations, and DFO guidelines for use of explosives.

8.2 Spatial Boundaries

To quantify baseline conditions and evaluate potential environmental effects on the atmospheric environment, an air quality study area and a noise study area were defined.

8.2.1.1 Air Quality

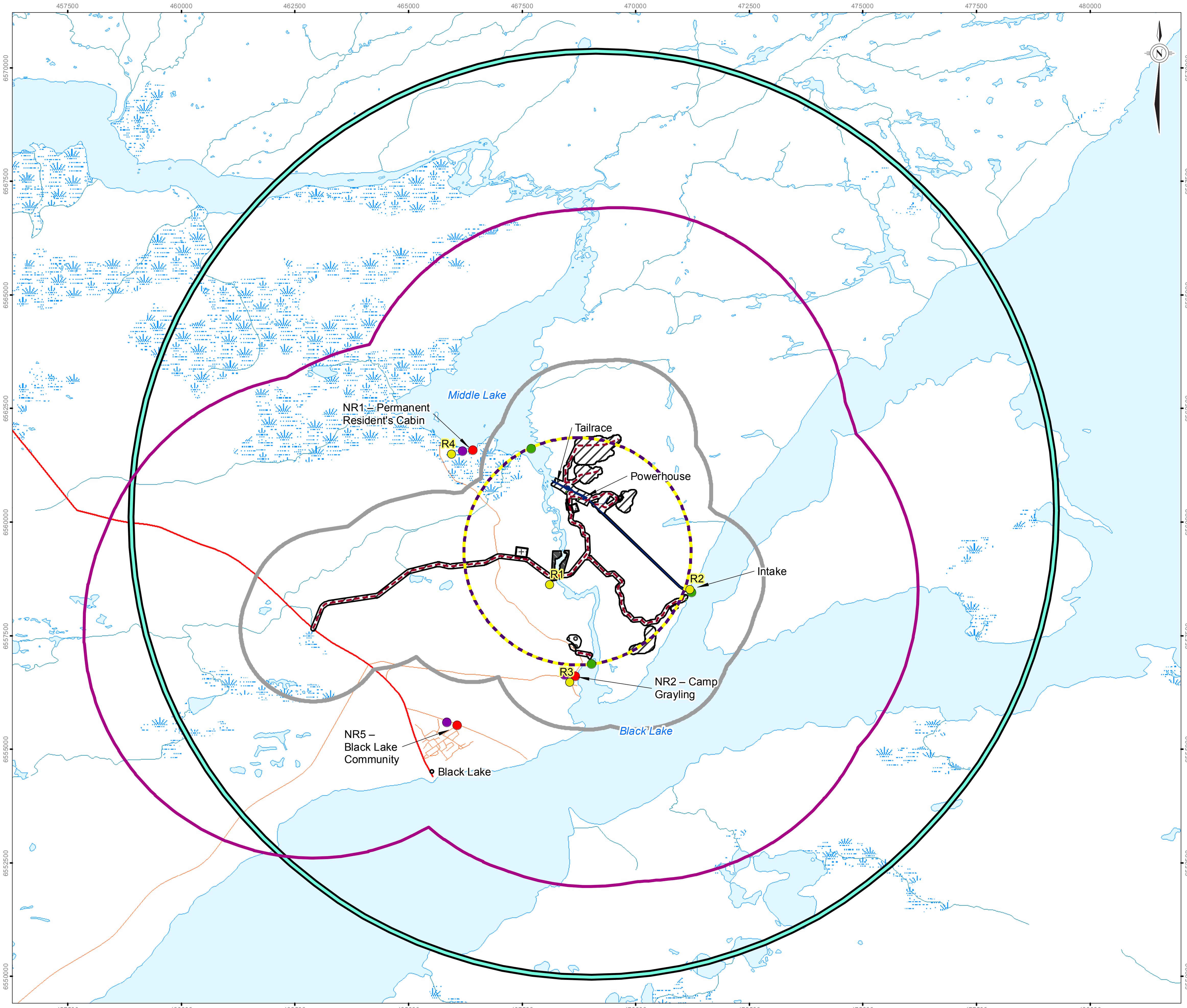
A single study area was selected for the air quality assessment of the Project. The air quality study area is expected to be large enough to capture the maximum predicted spatial extent of combined direct and indirect environmental effects from the Project on air quality. The study area defined for the completion of predictive modelling on changes to air quality was defined by a 10 kilometre (km) radius area centered on the powerhouse (Figure 8.2-1).

In this assessment Project related effects on air quality are assessed using an air quality screening model. Project emissions within the model can be described as point sources or area sources prescribed as a simple geometric shape (i.e., circle or rectangle), therefore an emissions source area is defined as a 2.5 km radius circle centered on the construction footprint with an area of 1,960 hectares (ha; Figure 8.2-1).

8.2.1.2 Noise

The noise study area was selected to include a region within the expected zone of influence of the Project. For the Project operation, the noise study area was defined by a 5 km boundary around the Project operation footprint. This area will also be large enough to capture potential changes to noise from construction and blasting activities. The noise study area and operation footprint for the Project is shown in Figure 8.2-1.

A noise assessment boundary is defined by Rule 012 (AUC 2013) as a 1.5 km buffer boundary around the Project boundary, hereafter referred to as the 1.5 km Buffer. For the Project operation, the AUC noise assessment boundary is defined as a 1.5 km boundary of the Project operation footprint. There is no specific noise assessment boundary defined by HC Guidance. The approach advised by Health Canada for the noise assessment is based on the relative changes in noise levels from baseline from the implementation of the Project on potential noise-sensitive receptors.



LEGEND

- VILLAGE
- HIGHWAY
- ROAD
- RIVER
- WETLAND
- WATERBODY
- NOISE RECEPTOR (NR)
- ATMOSPHERIC DEPOSITION RECEPTORS
- AMBIENT AIR QUALITY RECEPTOR
- AIR QUALITY STUDY AREA
- NOISE STUDY AREA
- NOISE ASSESSMENT BOUNDARY (1.5 km BUFFER)
- AIR EMISSIONS SOURCE AREA

SPECIFIC CONSTRUCTION SITES

- POTENTIAL BRIDGE ALIGNMENT
- PERMANENT ROAD
- CONTRACTOR CAMP / LAYDOWN AREA
- BORROW AREA
- POTENTIAL BRIDGE ALIGNMENT AREA
- TUNNEL AND TAILRACE ALIGNMENT
- SETTLING POND
- OPERATIONS FOOTPRINT

REFERENCE

DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEET: 74P/03, 04

1.5 0 1.5

SCALE 1:85,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

PROJECT SITE AND AIR AND NOISE STUDY AREA

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	09/01/14	**FIGURE: 8.2-1**	
CHECK	VS	09/01/14		
REVIEW	CM	09/01/14		

The AUC considers noise sensitive receptors to be any permanent residences or seasonally occupied dwellings used for at least six weeks of the year within 1.5 km Buffer of the Project (i.e., within the AUC noise assessment boundary). According to the definition of noise receptors based on AUC, there is only one permanent or seasonally occupied dwelling within the 1.5 km Buffer, which is Camp Grayling (Figure 8.2-1). The HC Guidance expands the definition of noise sensitive receptors to also include any daycares, schools, hospitals, places of worship, nursing homes, and First Nations and Inuit communities that could potentially be impacted by noise from the Project. Both the community of Black Lake and a permanent resident's cabin are located within the noise study area, but outside of the 1.5 km Buffer (Figure 8.2-1). This community and permanent resident's cabin are treated as the area that potentially may be impacted by noise from the Project according to the definition of noise receptors by HC Guidance. Both of the permanent resident's cabin and Camp Grayling are hunting and fishing camp locations. The closest dwelling within the community of Black Lake to the Project is taken as representative of the whole community in the noise assessment. The description and coordinates of noise assessment receptors are presented in Table 8.2-1.

Table 8.2-1: Coordinates for Noise Assessment Receptors

Noise Receptors	Description	Easting[a] (m)	Northing[a] (m)
NR1 – Permanent Resident's Cabin	Hunting/fishing camp on Middle Lake	468667	6556614
NR2 – Camp Grayling	Hunting/fishing camp on Black Lake	466417	6561584
NR5 – Black Lake Community	The closest dwelling within the Black Lake Community	465825	6554908

[a] Locations based on datum NAD83 and coordinate system Universal Transverse Mercator (UTM) Zone 13.
m = metres

8.3 Existing Environment

The purpose of this section is to describe the current environmental conditions related to climate, air quality, and noise in the study areas, as a basis to assess the potential Project-specific effects on the atmospheric environment. The detailed methods and results for the baseline surveys are located in Annex I.

8.3.1 Climate and Meteorology

The Project will occur within the context of the prevailing climate of northern Saskatchewan, a region characterized by a subarctic continental climate experiencing long, cold winters, and short cool summers. Climate, which is the long-term record and pattern of weather in an area, influences many aspects of the Project. There are strong links between climate and other environmental disciplines. Climate greatly influences terrestrial and aquatic ecosystems through its continual influence on air, surface water, and terrestrial environments. For example, climate, in part, determines the plant and wildlife communities that are present in the area, and has a direct effect on the availability of water in terms of total volume and the timing of that availability.

Seasonal and daily air temperatures can range by tens of degrees, while the underlying processes of energy exchange and transformation occur within and between air, soil, the snow pack, and waterbodies. Precipitation (including snowfall) and evaporation (including evapotranspiration and sublimation) govern the availability of moisture in the environment. Wind influences microclimate over the landscape, and enhances evaporation and blowing snow. Climate has a continual influence on most of the existing biophysical and socio-economic components of the environment.

8.3.1.1 Methods

There are four Environment Canada meteorology stations within 225 km of the Project with long-term climate records: Cree Lake, Collins Bay, Key Lake, and Stony Rapids (see Annex I; Figure 2.2-1). The Key Lake station is the primary meteorology station within the Northern Air Dispersion Modelling Zone, whereas the Stony Rapids station is the alternative meteorology station in the zone (Saskatchewan Ministry of Environment [MOE] 2012). Statistics for basic meteorological parameters including temperature, precipitation, wind speed and direction, and relative humidity were analyzed for the 1971 to 2000 time period to provide historical climate context for the study area (Annex I).

Evaporation is also an important factor for consideration in water balance estimates as it is a function of climatic conditions, including temperature, precipitation, relative humidity, wind speed, net radiation, and available energy and water body characteristics. Natural Resources Canada (NRC) provides approximate mean values for pan evaporation across Canada (NRC 1978), and Environment Canada (2012) provides an estimate for lake evaporation rates for four locations within 250 km of the Project. These evaporation rates were also used to inform the assessment (Annex I).

8.3.1.2 Results

Figure 8.3-1 illustrates the extreme seasonal temperature variations observed in the study area between 1971 and 2000. The summertime mean highs are 22.7 degrees Celsius (°C) with extremes to 36.7°C. Winter lows average -30.0°C with extreme lows down to -50.6°C. These seasonal differences of more than 50°C to 80°C between the warmest summer days and the coldest winter nights, which are characteristic of continental climate types.

Mean annual precipitation over the 1986-2010 time period at Stony Rapids is 424 millimetres (mm) with 66 percent (%) of the precipitation occurring as rainfall during the spring, summer and fall (Figure 8.3-2). Precipitation for the Project's location is similar to that of Cree Lake (446 mm), but drier than the Key Lake (481 mm) or Collins Bay (552 mm) locations. The highest daily rainfall event occurred in August at 69.9 mm while the highest daily snowfall event occurred in March with 31.0 centimetres (cm) of snow. Extreme precipitation records for Stony Rapids (1960 to 2007) and intensity duration and frequency rainfall statistics are summarized in Annex I.

Hourly average wind speed (kilometre per hour [km/h]) and direction (10^{o} bins) are available for the Stony Rapids weather station from July 1986 to February 2010 (Environment Canada 2012). Figure 8.3-3 presents the annual distribution of wind speed and direction. The average wind speed is 16.8 km/h with a standard deviation of 9.5 km/h, and the wind direction is most commonly from the northwest or the southeast. Seasonal distributions of wind speed and direction can be found in Annex I.

Relative humidity was measured hourly at the Stony Rapids meteorology station from July 1986 to February 2010 (Environment Canada 2012). Monthly relative humidity is typically lowest during the spring, with a median value in May of 62%, and highest in the early winter, with a median value in November of 82%. Although mean monthly relative humidity can vary considerably, all mean monthly values are between 50% and 88% (Annex I).

While annual lake evaporation in the region can range between 55 mm/year and 600 mm/year, the average lake evaporation rate is 377 mm/year (Annex I). The evaporation is largely distributed during the open water season of May through September, with the highest evaporation rates in June or July.

Figure 8.3-1: Annual Daily Average Air Temperatures at Stony Rapids, Collins Bay, Cree Lake, and Key Lake

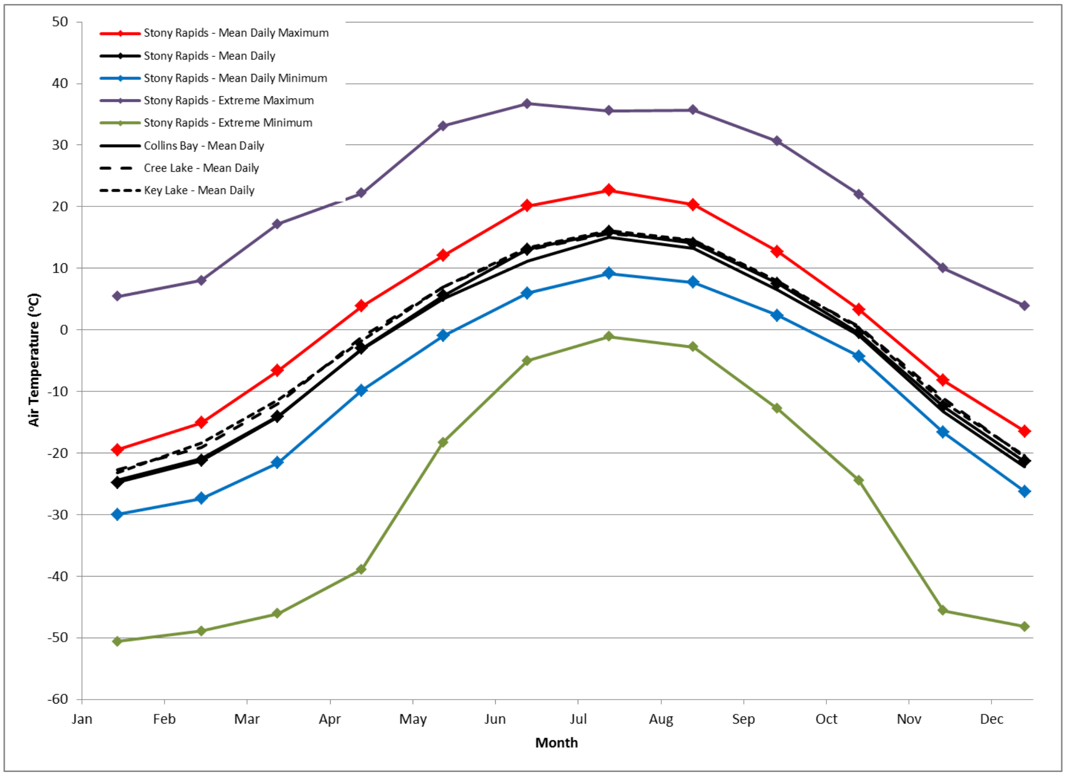


Figure 8.3-2: Annual Precipitation at Stony Rapids, Collins Bay, Cree Lake, and Key Lake

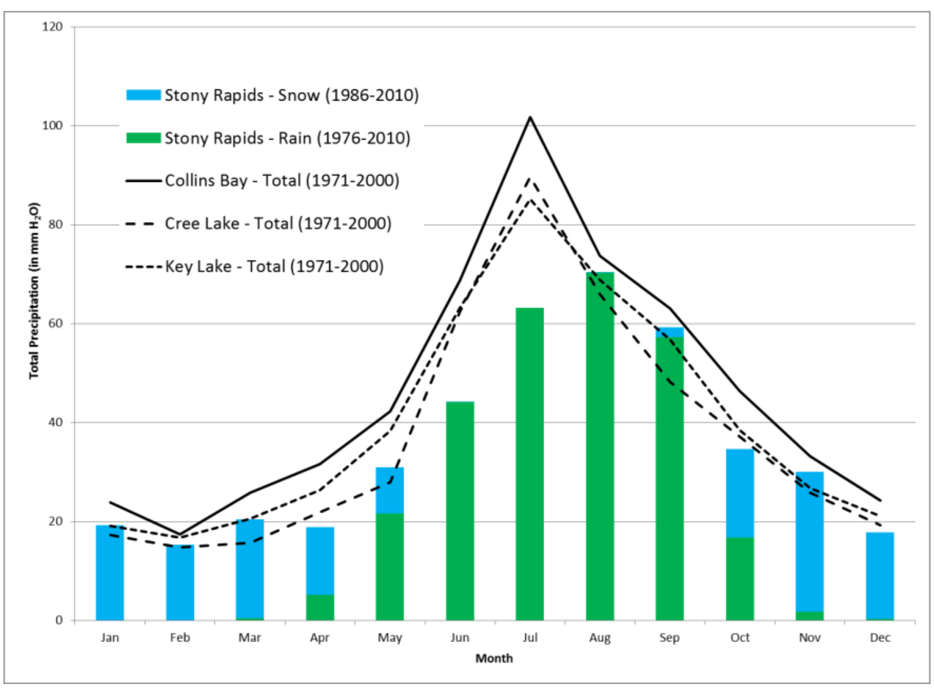
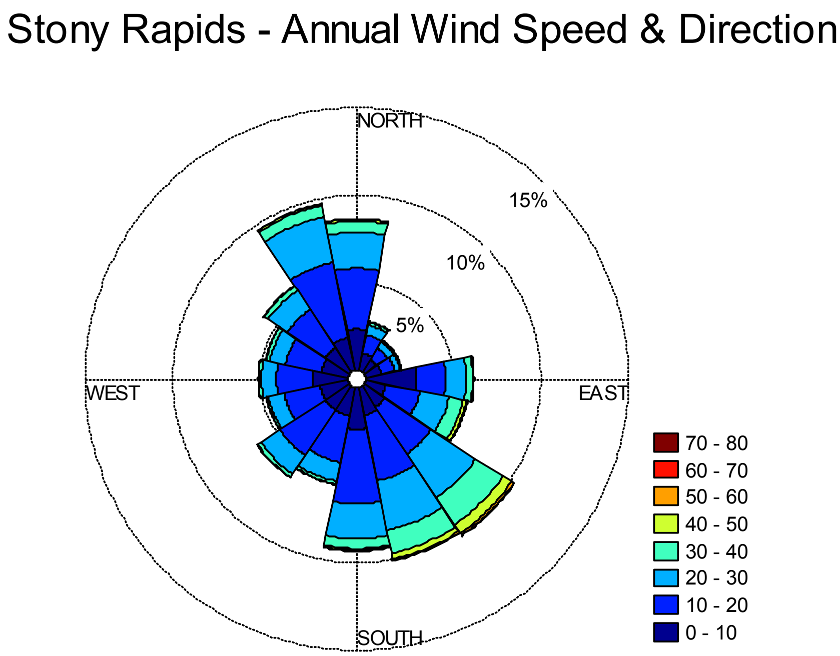


Figure 8.3-3: Annual, Hourly Averaged Wind Speed (km/hr) and Direction for the Stony Rapids Climate Station (1986 to 2010)



Source: Environment Canada 2012

8.3.2 Air Quality

The Project is located in the remote boreal forest, more than 200 km northeast of the nearest large industrial sources of air pollution, uranium mining and milling in Saskatchewan's Athabasca Basin, and more than 400 km northeast of the oil sands mining and upgrading activities near Fort McKay and Fort McMurray, Alberta. Despite its remoteness, northern Saskatchewan is subject to seasonal variations in air quality due to emissions from boreal forest fires (Amiro et al. 2001), and the long-range transport of air pollution (e.g., the Arctic Haze phenomenon [Shaw 1995]).

Air quality predictions, including the ground level concentrations and deposition rates of trace gases and particulate matter, are linked closely to other environmental assessment disciplines, such as surface water quality, fish habitat, soils, vegetation, and wildlife habitat.

8.3.2.1 Methods

From 2008 until 2011 MOE collected ambient air quality measurements at La Loche, Saskatchewan. The MOE monitored concentrations of nitrogen oxide (NO), nitrogen dioxide (NO_2), SO_2, ozone (O_3) and particulate matter larger than 2.5 micrometres (μm) in aerodynamic diameter ($PM_{2.5}$). Although La Loche is located approximately 375 km southwest of the Project, it is the only MOE air quality monitoring station in Saskatchewan's Northern Region airshed (Annex I; Figure 2.2-1). The MOE is the primary source of air quality data used in this assessment.

During the 2007/2008 International Polar Year[1], the US National Aeronautics and Space Administration (NASA) conducted the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites mission (ARCTAS 2007; Jacob et al. 2010). The experiment had two phases, a spring 2008 phase based in Fairbanks, Alaska, and a summer 2008 phase based in Cold Lake, Alberta. The primary objective of the spring-phase of ARCTAS was to measure the long-range transport of air pollution into the Arctic domain. The primary objective of the summer-phase of ARCTAS was to measure emissions from boreal forests and to track the evolution of these emissions during long-range transport. Together two aircraft, the NASA DC-8 and NASA P3-B, collected more than 14 hours of 1-minute averaged data below 1 km altitude while sampling over Western Canada (i.e., 49°N to 62.5°N, 95°W to 120°W). These data have also been analyzed as part of this assessment.

8.3.2.2 Results

8.3.2.2.1 Carbon Monoxide, CO

The MOE measurements of background concentrations of CO are not available for La Loche; however a background value of 500 parts per billion by volume (ppbv) is recommended as the 90th percentile concentration for an 8-hour averaging period (MOE 2012).

During the spring-phase of ARCTAS the NASA P-3B aircraft completed two vertical profiles over Northern Saskatchewan on March 31, 2012 (Annex I; Figure 2.2-1). The NASA P-3B aircraft observed concentrations of CO below 2 km altitude between 150 to 200 ppbv (Annex I; Section 3.4.1.1).

Forest fire activity was intense in Northern Saskatchewan in the summer of 2008 (Annex I; Section 3.4.1.1). Average and one standard deviation of the CO concentrations measured below 1 km altitude during 640 minutes (10.7 hours) of flight time aboard the P-3B were 254 ± 410 ppbv with a median of 121 ppbv. Average and one standard deviation of the CO concentrations measured below 1 km altitude during 195 minutes (3.3 hours) of flight time aboard the DC-8 were 277 ± 248 ppbv with a median of 160 ppbv. The observed concentrations are all well below the 8-hour Saskatchewan average ambient air quality standards (SAAQS), which is 5,000 ppbv for CO.

8.3.2.2.2 Oxides of Nitrogen

The NO and NO_2 concentrations (together NO_x) are measured at the MOE air quality station at La Loche. The 2008 to 2011 24-hour average and standard deviation of NO_x concentrations measured at La Loche is 3.6 ± 3.2 ppbv with a median of 2.7 ppbv. However, NO_x displays a seasonal trend due to enhanced photo-degradation in summer compared to winter (Lamsal et al. 2010). Background summertime concentrations of NO_x are 1.8 ± 0.9 and wintertime concentrations are 6.0 ± 4.0 ppbv (Annex I; Section 3.4.1.1).

There were two independent measurements of NOx aboard the NASA DC-8 during ARCTAS. Average concentrations and the standard deviation for NO_x measured below 1 km altitude during 190 minutes (3.2 hours) of flight time aboard the NASA DC-8 in July 2008 were 0.61 ± 1.41 ppbv with a median of 0.17 ppbv.

The MOE modelling guideline does not include a recommended background concentration for NO, but recommends using an annual, 24-hour average NO_2 concentration of 2.0 ppbv as a background value. The observed concentrations are well below the annual average SAAQS for NO_x, which is 50 ppbv.

[1] http://www.ipy.org/

8.3.2.2.3 Sulphur Dioxide

The 24-hour sulphur dioxide concentrations measured at La Loche by MOE averaged 0.1 ± 0.3 ppbv with a median value of 0.0 ppbv from 2008 to 2011. These values are consistent with the MOE's modelling guideline, which recommends a background annual average concentration of 0.0 ppbv (MOE 2012). The two independent instruments measuring SO_2 aboard the NASA DC-8 have instrumental accuracy and precision in the parts-per-trillion range, more than 100 times more sensitive than the ground-based MOE instruments (Annex-I; Section 3.4.1.3). During 171 minutes (2.9 hours) of flight time below 1 km altitude, the DC8 instruments recorded average SO_2 concentrations of 0.34 ± 0.36 ppbv with median values of 0.20 ppbv during the summer of 2008. All of the observed concentrations are well below the 24-hour average, annual SAAQS for SO_2, which is 10 ppbv.

8.3.2.2.4 Ozone

Due to the photochemical nature of its formation and destruction, O_3 displays a seasonal trend in background atmospheric concentrations (Annex I; Section 3.4.1.4). The 2008 to 2011 24-hour average and standard deviation of O_3 concentrations measured at La Loche in summertime are 23.1 ± 5.1 ppbv; the values in wintertime are 29.7 ± 8.6 ppbv, a significant difference ($t_{2,\alpha=0.05}$; df=548; $p<0.001$). Mean O_3 concentrations measured over 191 minutes (3.2 hours) of flight time below 1 km altitude aboard the NASA DC-8 in the summer of 2008 were 32.2 ± 5.5 ppbv with a median value of 30.3 ppbv. The observed ozone concentrations are below the 8-hour average Canada wide standard of 65 ppbv (Canadian Council of Ministers of the Environment [CCME] 2006) and the SAAQS 1-hour standard of 80 ppbv.

8.3.2.2.5 Fine Particulate Matter

Particulate matter with aerodynamic diameters smaller than 2.5 µm ($PM_{2.5}$) are a public health hazard (Seaton et al. 1995; Pope et al. 2009). Consequently, $PM_{2.5}$ has a 24-hr Canada-wide standard of 30 micrograms per cubic metre ($\mu g/m^3$). Concentrations of $PM_{2.5}$ can be elevated near the Project in springtime because of Arctic Haze (Shaw 1995), and in summertime due to boreal forest fires (Amiro et al. 2001).

Prior to May 2010 the $PM_{2.5}$ instrumentation installed at La Loche was prone to errors (see Annex I; Section 3.4.2 for more detail). Since May 2010, 24-hour average $PM_{2.5}$ concentrations at La Loche averaged 7.1 ± 1.8 $\mu g/m^3$ with a median concentration of 6.9 $\mu g/m^3$. During the spring-phase of ARCTAS the NASA P-3B aircraft measurements of $PM_{2.5}$ concentrations below 2 km were 2 to 6 $\mu g/m^3$. In summer the NASA P-3B specifically targeted intense forest fire plumes for sampling. As a result the 368 minutes (6.1 hours) of P-3B $PM_{2.5}$ concentrations measured below 1 km altitude are skewed towards large values with a mean concentration of 9.2 ± 4.4 $\mu g/m^3$. The DC-8 sampled on a regional basis during the summer-phase of ARCTAS. Over 191 minutes (3.2 hours) of flight time below 1 km altitude, the NASA DC-8 measured average $PM_{2.5}$ concentrations of 4.7 ± 6.4 $\mu g/m^3$ with a median of 6.6 $\mu g/m^3$. The annual average value recommend for modelling the background concentrations of $PM_{2.5}$ at La Loche is 3.1 $\mu g/m^3$ (MOE 2012). All of the observed concentrations of $PM_{2.5}$ are below the Canada-wide 24-hour average standard of 30 $\mu g/m^3$.

Remote sensing measurements (i.e., satellites) provide broader regional context for air pollution and haze associated with particulate matter (i.e., aerosol). NASA's Moderate Resolution Imaging Spectroradiometer sensors (MODIS[2]) have been measuring aerosol optical depth at a wavelength of 550 nanometres (nm)

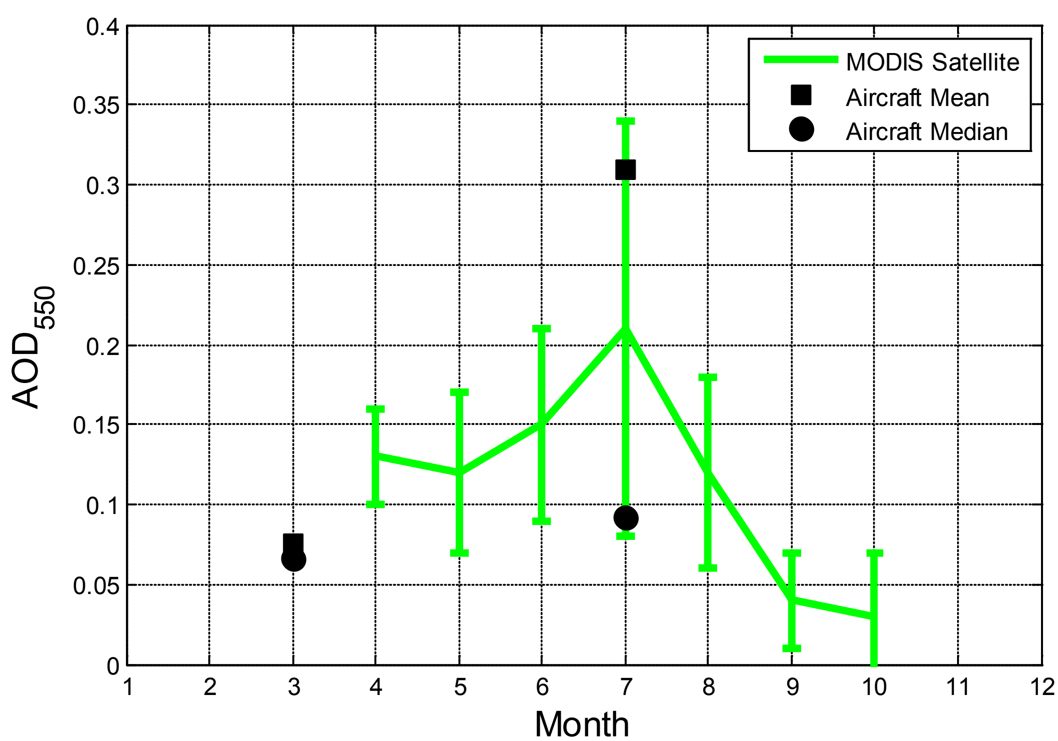
[2] http://modis.gsfc.nasa.gov/

(AOD_{550}), from onboard the TERRA and AQUA spacecraft since February, 2000 and July, 2002 respectively. Figure 8.3-4 plots the pooled monthly averaged AOD_{550} and ±1 standard deviation (1σ) measured over the region (58 to 60°N, 104.5 to 107°W) from March of 2000 until December of 2011. As expected, springtime values of AOD_{550} are elevated due to Arctic Haze. Summertime values are higher, but show large standard deviations due to episodic but intense boreal forest fires.

During ARCTAS the P-3B aircraft measured AOD_{550} directly in order to calibrate/validate satellite retrievals such as MODIS (Shinozuka et al. 2011). The NASA P-3B recorded springtime AOD values of approximately 0.08 during the profiles on March 31, 2008. Satellite measurements of AOD are not feasible during winter; however, the spring-phase ARCTAS airborne measurements are mid-way between the low October values approximately 0.03 and the elevated springtime values of approximately 0.13. AOD_{550} measured from onboard the P-3B in summertime had an average value of 0.31 (Figure 8.3-4). However the P-3B data are skewed by forest fire smoke due to the study's objectives and the sampling approach. A more representative background value of AOD is the Figure 8.3-4 median of only 0.09.

In the rare cases when forest fires are active locally, or where the Project is directly downwind from large or extensive regional fires, satellite AOD values can exceed 1.0, ground-level TSP and $PM_{2.5}$ concentrations can be expected to reach 100-200 $\mu g/m^3$ and can exceed the SAAQS 24-hour average TSP standard of 120 $\mu g/m^3$ or the Canada-wide 24-hour $PM_{2.5}$ standard of 30 $\mu g/m^3$. While such large forest fire events are usually rare, they can pose a health risk to workers or residents in the area (Seaton et al. 1995; Pope et al. 2009).

Figure 8.3-4: Monthly Average Satellite Aerosol Optical Depth Compared to Discrete Airborne Measurements



8.3.3 Noise

8.3.3.1 Methods

In Saskatchewan, there are no provincial requirements or standard methods for completing acoustic environment baseline surveys. For the purposes of this Project, the method described in Alberta's AUC Rule 012 was used to complete the acoustic environment baseline surveys.

Noise is typically considered a perception issue; therefore, the focus of acoustic environmental studies is normally on human response and public exposure. The purpose of the acoustic environmental study report is to provide acoustic baseline information for the assessment of Project-related effects on the existing environment.

At the time of the baseline survey, the Project footprint had not been finalized; therefore, representative dwellings were selected for 24-hour sound monitoring based on the anticipated Project footprint and major facility activities. To establish existing sound levels, the background sound levels were measured at four monitoring sites: R1, R2, R3, and R4. Sites R1 – Permanent Resident's Cabin and R2 – Camp Grayling are two hunting and fishing camp locations. The receptors R3 – Intake/Edge of Black Lake and R4 – Bridge/Bank of Fond du Lac River are two unoccupied locations (Table 8.3-1). Because the monitoring sites R3 and R4 are two unoccupied locations, they are not considered noise sensitive receptors defined by AUC Rule 012 and/or HC Guidance; rather R3 and R4 are included in the acoustic baseline report for information purpose only and will not be included in the analysis of effects (Section 8.5). Baseline sound monitoring sites R1, R2, R3 and R4 are shown in Figure 8.2-1.

Table 8.3-1: Coordinates for Selected Baseline Sound Monitoring Sites

Monitoring Sites	Description	Easting[a] (m)	Northing[a] (m)
R1 – Permanent Resident's Cabin	Hunting/fishing camp on Middle Lake (actual monitoring location was slightly west of Permanent Resident's Cabin property)	465945	6561488
R2 – Camp Grayling	Hunting/fishing camp on Black Lake	468548	6556465
R3 – Intake/Edge of Black Lake	Black Lake shoreline location	471198	6558515
R4 – Bridge/Bank of Fond du Lac River	West bank of the Fond du Lac River	468112	6558615

[a] Locations based on datum NAD83 and coordinate system Universal Transverse Mercator (UTM) Zone 13.
m = metres.

One 24-hour acoustic survey was completed at each of the four sound monitoring locations between July 3 and July 6, 2012. Surveys of this type and duration provide information on daily variability in sound levels as well as average daily conditions. Model 2250 Brüel and Kjaer Type I integrating sound level meters were used to collect the measurements and sound recordings. This type of meter logs sound levels and records audible sound over set intervals selected by the user. Data parameters logged every minute for the survey periods included:

- equivalent energy sound level on a one minute time scale ($L_{eq,\ 1min}$) in A-weighted decibels [dBA];1/3 octave band equivalent energy sound levels on a one minute time scale in unweighted decibels [dB]; and
- audible sound continuously in *.wav format audio files.

A Brüel and Kjaer Type 4231 calibrator was used for calibrating the meters before and after each monitoring period so that the sound meters variance was within 0.5 dB. The calibrator has an estimated uncertainty for sound pressure level of ±0.12 dB at a 99% confidence level. The calibration data were logged by the meter and calibration results were also described in field notes. Calibration results are presented in Annex I.

Rule 012 requires that monitoring be completed under conditions acceptable for sound measurement, which include wind speeds of less than 15 km/h and the absence of precipitation (AUC 2013). Weather data were collected using Kestrel 4500 pocket weather meters from Nielsen Kellerman set-up near the sound monitoring sites. The weather meters recorded wind speed and direction, temperature and relative humidity data every five minutes. Data from the weather meters were used as required for the interpretation of the recorded sound. Direct observations and field notes made by the study team included precipitation, cloud cover, wind direction, and observed audible sound sources.

Data were downloaded to a computer for analysis with the Brüel and Kjaer 7820 Evaluator® software program. The data were reviewed to identify sources of sound from the sound recordings and filter out invalid data (e.g., traffic near microphone, rain hitting the microphone, and airplane flyovers). Sounds from these sources are not considered representative of normal conditions at the monitoring locations and were removed as recommended in Rule 012. Measurements that were removed from the analysis are summarized in Annex I.

During analysis of the data, sound sources were identified mainly by sound recordings. Other indicators used to identify sources of sound were time of day and field observations. Hourly equivalent energy sound levels ($L_{eq,1hr}$) values were calculated for each hour of the survey period from the valid one-minute data, all $L_{eq,\ 1hr}$ values were based on at least 30 minutes of valid $L_{eq,\ 1min}$ data, and these $L_{eq,1hr}$ values were then used to establish daytime and nighttime baseline levels ($L_{eq,\ day}$ and $L_{eq,\ night}$, respectively) as per Rule 012. Rule 012 defines daytime as the time period between 7:00 ante meridiem (a.m.) to 10:00 post meridiem (p.m.), and nighttime as the time period between 10:00 p.m. to 7:00 a.m. Calculated $L_{eq,\ day}$, and $L_{eq,\ night}$ values in dBA for the sound monitoring locations R1, R2, R3 and R4 are provided in the following sections.

8.3.3.2 Results

The results of the acoustic environment baseline surveys at four monitoring locations are summarized in Table 8.3-2. Further information is provided in Annex I. The period averages were based on the hourly data filtered to exclude extraneous sound events and weather conditions.

Table 8.3-2: Baseline Sound Level Survey Results at Monitoring Sites

Monitoring Sites	Baseline Sound Measurements L_{eq} (dBA)	
	Day-time, $L_{eq,\ day}$ 7:00 am to 10:00 pm	Night-time, $L_{eq,\ night}$ 10:00 pm to 7:00 am
R1 – Permanent Resident's Cabin	37	34
R2 – Camp Grayling	45	41
R3 – Intake/Edge of Black Lake	33	33
R4 – Bridge/bank of Fond du Lac River	46	46

dBA = A-weighted decibels

The sound levels measured at R1 and R3 were mainly influenced by sounds from natural sources such as the rustling of leaves, birds and insects and water sound from the lake. The sound levels measured at R2 and R4 were mainly influenced by water sound from Elizabeth Falls and Fond du Lac River.

8.4 Screening of Project Interactions and Mitigation

This section identifies and evaluates the interactions between the Project components or activities with potential to cause changes to the atmospheric environment, and the corresponding effects on other VCs (e.g., surface water, soil, vegetation). The process begins with the identification of all potential interactions for the Project. To provide a robust assessment of potential effects, each interaction is initially considered to have a potential linkage to a change in air quality or noise levels.

Each potential interaction is evaluated to determine if mitigation can be developed and incorporated to remove the interaction or limit the potential effect on the atmospheric environment. Mitigation includes Project design elements, environmental best practices, and management policies and procedures, and is developed through an iterative process between the Project's engineering and environmental teams. Knowledge of the atmospheric environment and mitigation is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for a residual effect on the atmospheric environment.

Interactions are determined to be primary, secondary, or as having no linkage using scientific knowledge, professional judgment of technical specialists, logic, and experience with similar developments, and mitigation (Table 8.4-1). Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by environmental design features and mitigation so that the Project results in no detectable (measurable) change and residual effects on the atmospheric environment relative to baseline values or applicable air quality and noise criteria;
- secondary – interaction could result in a minor change, but would have a negligible residual effect on atmospheric environment relative to baseline values or applicable air quality and noise criteria and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary – interaction is likely to result in a measurable environmental change that could contribute to residual effects on the atmospheric environment relative to baseline values or applicable air quality and noise criteria.

Primary interactions are anticipated to result in a residual effect to the atmospheric environment. Changes to the atmospheric environment can cause changes to other VCs (e.g., surface water quality, terrestrial ecosystems). Because the atmospheric environment does not have assessment endpoints, residual effects are assessed for primary interactions that will be used to support the assessment of effects on other VCs. The determination of the significance of the residual effects is not completed for the atmospheric environment. Project interactions determined to have no linkage or those that are considered to be secondary are not predicted to result in significant effects on other VCs.

Project components/activities and the associated mitigation implemented during the various Project phases are summarized in Table 8.4-1. Potential effects on atmospheric environment from each Project interaction and its associated classification are also summarized in Table 8.4-1, with more detailed descriptions provided in the subsequent sections.

Table 8.4-1: Project Interactions, Environmental Design Features and Mitigation, and Potential Environmental Effects

Project Component/Activity	Expected Project Phase	Potential Interactions to Environment Components	Environmental Design Features and Mitigation	Interaction Classification
■ Air Emissions ▪ Emissions of dust from blasting activities, access road construction, and hauling waste rock to Waste Rock Disposal Areas. ▪ Emission of standard pollutants from vehicles and heavy equipment operation.	Construction Operations Closure	Emissions of criteria air contaminants can cause changes to local and regional air quality. Deposition of criteria air contaminants can change surface water, sediment, and soil chemistry, which can affect the health of vegetation, fish, wildlife, and people.	■ Equipment will be regularly maintained for compliance with provincial and federal air emission standards. ■ The equipment used for hauling and mucking operations will operate using diesel fuel with an ultra-low sulphur diesel content (less than 15 parts per million [ppm]). ■ The heavy-duty stationary and mobile diesel-fueled fleet equipment will meet or exceed EPA Tier 2/3 air quality emissions standards. ■ The gasoline-fueled fleet equipment will meet or exceed EPA Tier 2 Bin 6 air quality emissions standards. ■ A forced air method of ventilation will be used for venting of dust, gases and fumes from inside the power tunnel following blasting and will be carried out until air quality inside the working environment returns to acceptable levels. ■ Construction camp heating and cooling will be provided using propane, which is a lower GHG emissions fuel than diesel on a per kilowatt-hour basis.	Primary
		Dust emissions can cause changes to local and regional air quality. Dust deposition can change surface water, sediment, soil chemistry, and vegetation, which can affect fish habitat, wildlife habitat, and land use.	■ It is expected that most construction equipment and materials will be transported to the site between late January and late March by using the Athabasca Seasonal Road; fugitive dust emissions are naturally mitigated by 85-95% during winter. ■ An EnvPP will describe material handling protocols including dust management. ■ Soil salvage stockpiles or exposed soils will be seeded as appropriate for the area. ■ All unpaved roads will be watered on a regular basis to prevent wind driven fugitive dust. ■ A speed limit will be enforced on unpaved roads on site. ■ A forced air method of ventilation will be used for venting of dust, gases and fumes from inside the power tunnel following blasting and will be carried out until air quality inside the working environment returns to acceptable levels.	Primary
■ General Construction, Operations, and Closure Activities.	Construction Operations Closure	Changes in existing ambient sound levels and vibrations can affect land use, and human population and health.	■ Confirm that all internal combustion engines of construction equipment are well maintained with muffler systems. ■ The powerhouse will be located in a deep cut in the bedrock and insulated which will reduce noise emissions from the building. ■ A detailed Blasting Plan will be developed for the Project.	Primary

GHG = greenhouse gas; EnvPP = Environmental Protection Plan

8.4.1 Interactions with No Linkage to Effects

An interaction could have no linkage to environmental effects if the activity does not occur, or if the interaction is removed by mitigation so that the Project results in no detectable change in measurement endpoints, and subsequently, no environmental effect on the atmospheric environment. No Project interactions were determined to have no linkage to effects on the atmospheric environment (Table 8.4-1).

8.4.2 Interactions with Secondary Linkages

In some cases, both a source and an interaction exist, but since the change caused by the Project is anticipated to be minor, it has no measureable or detectable environmental effect on the atmospheric environment. No interactions were identified as having secondary linkages to the atmospheric environment (Table 8.4-1).

8.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events are not expected to affect the atmospheric environment and are not assessed in this section of the EIS.

8.4.4 Primary Interactions

The residual effects analysis considers all primary interactions that result in expected changes to air quality and noise levels, after implementing mitigation. The following interactions were determined to be primary for effects on the atmospheric environment and are carried forward to the residual effects analysis (Section 8.5):

- Emissions of criteria air contaminants can cause changes to local and regional air quality.
- Deposition of criteria air contaminants can change surface water, sediment, and soil chemistry, which can affect the health of vegetation, fish, wildlife, and people.
- Dust emissions can cause changes to local and regional air quality.
- Dust deposition can change surface water, sediment, soil chemistry, and vegetation, which can affect fish habitat, wildlife habitat, and land use.
- Changes in existing ambient sound levels and vibrations can affect land use, and human population and health.

8.5 Residual Effects Assessment

The residual effects analysis considered all primary interactions that are expected to result in measureable environmental changes and residual effects on the atmospheric environment after implementing environmental design features and mitigation. The residual effects assessment is completed by predicting changes to the following measurement endpoints:

- particulate matter ($PM_{2.5}$, PM_{10}) and TSP;
- CO, SO_2, and NO_x;
- acid deposition;
- dust deposition; and
- noise levels.

Assessment cases are defined for the effects analysis and include the baseline case and application (Project case, which includes construction, operations, and closure), and future case (if applicable). The baseline case considers the current conditions in the study areas such as natural disturbances (e.g., fire) and previous and existing human developments and activities. The regional area surrounding the Project has experienced little industrial human development and activity. Previous activity includes exploration work for the Nisto uranium deposit (mineral property #1621), which is located on the west shore of Black Lake, approximately 23 km east of the Northern Hamlet of Stony Rapids (Government of Saskatchewan 2013). In 1950, two adits were driven and lateral work was completed. Ore was mined from the shoots accessible from the northeast adit in 1959. Only exploration work has been completed in the area since 1959. Existing human-related disturbance includes trails, roads, cabins, the Black Lake sewage lagoon, and the communities of Black Lake and Stony Rapids. Populations and communities in aquatic and terrestrial ecosystems have likely adapted to the low level of human industrial activity over the preceding 50 to 60 years. Therefore, current (baseline) conditions in the study areas are expected to reflect the cumulative influence of previous and existing human industrial activities on aquatic and terrestrial ecosystems relative to reference conditions. Reference conditions represent no to little human development, except for First Nation communities, which are assumed to be part of the historical natural ecosystems.

The application case occurs during the start of construction of the Project through closure, and the associated duration of predicted effects (i.e., until effects are reversed or are deemed irreversible). The magnitude of effects from the Project are expected to be strongest during construction and the initial period of operation. For example, the magnitude of some effects, such as the changes from blasting activities to existing noise levels and dust deposition are expected to stop at the end of construction, and the duration of these effects will likely end within the initial period of operation. Most of the area disturbed will be reclaimed immediately following construction. Reclamation activities following construction will include the removal of portions of the temporary construction infrastructure not required during operation. Temporary infrastructure includes the construction camp, contractor's work areas, material laydown areas, and overburden disposal areas.

The duration of some effects from the Project have the potential to occur over the 90-year operation period. For example, the presence of the water intake structure in Black Lake could have long-term effects on the habitat suitability for fish or wildlife species that could use this area. The presence of the main access road and powerhouse for the 90 years represent Project components that will affect the atmospheric environment in the long-term, but the magnitude and geographic extent of these effects should be much smaller than similar effects during construction. Because the magnitude and geographic extent of effects are expected to be greatest during construction phase, the operations and closure phase are not assessed. Analyses were quantitative where possible and qualitative, where necessary.

There is potential for this Project to operate beyond the expected 90-year operational period; however increasing the duration of the operation phase of the Project would have little influence on effects predictions. Most of the physical changes from the operations footprint and the effects on the environment from these changes are considered permanent because of the length of operations (i.e., the duration of the change will be well beyond the temporal boundary of the assessment). The outcome of reclamation activities with respect to the operation footprint is highly uncertain, particularly in an environment where natural succession processes are slow, and trajectories can be altered by a number of factors (e.g., climate changes, fire, and unforeseeable human development).

Closure occurs when power production operations end, and decommissioning and reclamation of the final infrastructure (i.e., powerhouse, water intake, power tunnel, tailrace channel, switchyard, access roads, and distribution line) is completed.

Both Project-specific (incremental) and cumulative effects from the Project and existing human developments and activities are analyzed in this section. The future case includes baseline and the Project, plus reasonably foreseeable developments or designated projects. The geographic extent (zone of influence) of residual effects from the Project on the atmospheric environment is expected to be limited to the 5 km for noise and 10 km for air quality. No other major developments in the region are located within 10 km of the Project. Therefore, the zones of influence associated with the Project and existing developments are not expected to overlap and generate cumulative effects on the atmospheric environment. Currently, there are no reasonably foreseeable developments that could have an overlapping temporal boundary with the Project and potential to generate cumulative effects on the atmospheric environment.

8.5.1 Changes to Air Quality from the Project

Ground-level concentrations of criteria air contaminants (CACs) were modeled within the air quality study area using a screening level air dispersion model. The assessment was completed in a manner consistent with Saskatchewan regulatory guidance, which included *The Clean Air Act* (MOE 1996) and the Saskatchewan Air Quality Modeling Guidelines (MOE 2012).

Air emissions can have direct and indirect effects on other VCs (e.g., surface water quality, soil, vegetation, wildlife, and people). Air quality criteria have been established by regulators to set maximum ambient air concentrations. The most relevant air quality criteria for assessing emissions from the Project are the SAAQS established by the Government of Saskatchewan (MOE 1996). Where there was no SAAQS, the Canada-Wide Standards were used (CCME 2000). Table 8.5-1 provides a summary of the relevant criteria for the compounds assessed; bold values are those selected for use in this assessment. While the areas of enforcement for the criteria are not explicitly defined, the standards are generally applied to areas outside of the Project boundary, or areas of public access.

The National Pollutant Release Inventory (NPRI) is Canada's legislated, publicly accessible inventory of pollutant releases, disposals and transfers for recycling (Environment Canada 2013a). It requires all facilities that meet its reporting thresholds to annually report the pollutant release to air, water, and land, disposal and transfers. The NPRI reporting thresholds for CACs are listed in Table 8.5-2.

Table 8.5-1: Saskatchewan and Canada Wide Air Quality Standards

Parameter	Saskatchewan Ambient Air Quality Standards[a]	Canada-Wide Standards[b]
NO_2 (µg/m³)		
1-hour	**400**	—
Annual	100	—
SO_2 (µg/m³)		
1-hour	**450**	—
24-hour	150	—
Annual	30	—
CO (µg/m³)		
1-hour	**15,000**	—
8-hour	6,000	—
TSP (µg/m³)		
24-hour	**120**	—
$PM_{2.5}$ (µg/m³)		
24-hour	—	**30**

[a] MOE 1996.
[b] Canadian Council of Ministers of the Environment (CCME) 2000.
µg/m³ = micrograms per cubic metre; NO_2 = Nitrogen Dioxide; SO_2 = Sulphur Dioxide; CO = Carbon Monoxide; TSP = Total Suspended Particular matter; $PM_{2.5}$ = fine Particular matter with a diameter <2.5 µm; — = No criteria are available.

Table 8.5-2: NPRI Reporting Thresholds for Criteria Air Contaminants

Particulate Matter Fraction	Air Release Threshold (tonnes)
Total suspended particulate matter (TSP) – particulate matter with a diameter less than 100 micrometres (µm)	20
$PM_{2.5}$ – particulate matter with a diameter less than 2.5 µm	0.3
Carbon monoxide (CO)	20
Sulphur dioxide (SO_2)	20
Nitrogen oxides (expressed as nitrogen dioxide, NO_2)	20

Source: Environment Canada (2013b).
µm = microns; NO_2 = Nitrogen Dioxide; SO_2 = Sulphur Dioxide; CO = Carbon Monoxide; TSP = Total Suspended Particular matter; $PM_{2.5}$ = fine Particular matter with a diameter <2.5 µm.

The air quality assessment is focused on predicting the change in air quality due to Project construction, operations, and closure. The emissions from Project construction will be mainly from heavy equipment, drilling and blasting, concrete production, and waste rock handing. These activities will produce both combustion related CACs and PM emissions, and fugitive dust emissions. Changes to ambient air concentrations during Project operation will be mainly CACs and PM emissions from backup diesel generators and power house heating and air conditioning systems. Emissions from closure are expected to be negligible. Therefore, this air quality assessment focuses on emissions from the construction phase. The following was performed as part of this analysis:

- a review of existing background concentrations of CACs;
- estimation of the air emissions and dust deposition from the Project;

- prediction of the cumulative changes to air quality from the Project; and
- a comparison of the predictions to existing federal and provincial criteria.

8.5.1.1 Inventory of Air Emissions

The emission sources from the construction of the Project include diesel generators, mobile heavy-duty equipment, light-duty passenger vehicles, blasting, and materials production and handling. The inventory of emission sources is based on the information available at the time of the assessment and forms the basis for determining the emissions from the Project. Carbon monoxide, oxides of sulphur (SO_x) and NO_x, and $PM_{2.5}$ are emitted directly from stationary and mobile combustion sources and from blasting. The TSP and $PM_{2.5}$ are also emitted from drilling and blasting, waste rock and aggregate processing and handling, on site concrete production, and traffic (i.e., road dust). The sources from construction of the Project were categorized as follows:

- fuel combustion from stationary sources;
- fuel combustion from mobile sources;
- drilling and blasting;
- aggregate handling;
- on site concrete production; and
- road dust.

The sources of road dust can be further categorized into dust from access road construction, site preparation, overburden and bedrock hauling, and hauling of concrete.

Emission factors relate the production of gases and PM to energy production (e.g., kilograms per kilowatt-hour [kg/kW-hr]), fuel volume consumption (e.g., kilograms per 1000 litres [kg/1000 L]), or vehicular traffic (e.g., kilograms per vehicle kilometre travelled [kg/VKT]). Emissions factors recommended by Environment Canada are derived largely from the United States Environment Protection Agency (US EPA) standard summarized in the AP-42 document Compilation of Air Pollutant Emissions Factors, Fifth Edition (US EPA 1995 and 2006). The AP-42 emissions factors are typically listed for uncontrolled emissions; that is for direct emissions of air and particulate matter assuming no emissions reduction technologies are associated with the emissions production mechanism. Where information exists, a series of modifiers to these uncontrolled emissions can be used to reflect the following:

- most industrial and mobile combustion sources have emissions reduction technologies incorporated in Project design; and
- road dust emissions can be partially controlled using suppressants (e.g., water).

The Off-Road Compression-Ignition Engine Emission Regulations were promulgated on February 23, 2005 in Canada. These regulations introduced emission standards for model year 2006 and later diesel engines used in off-road applications such as those typically found in construction, mining, farming and forestry machines. These regulations encompassed the US EPA Tier 2 and Tier 3 standards. Thus, the US EPA Tier 2 and Tier 3 standards were used as emission factors for fuel combustion from the stationary and mobile emissions sources from Project. Detailed information on source emission assumptions, emission factors and emission rates can be found in Appendix 8.1 and values used for this assessment are summarized in the following section.

The emission estimates of CAC's and PM are summarized in Table 8.5-3. The annual emissions of SO_2 are below the NPRI reporting threshold (Table 8.5-2), whereas the $PM_{2.5}$, NO_x, and CO emissions (except for NO_x emission in 2014) have exceeded the reporting thresholds of NPRI. The annual emission of TSP exceeds the NPRI reporting threshold only in 2015 during the three construction years.

Table 8.5-3: Summary of Gas and Dust Emission during the Construction of the Project

	Criteria Air Contaminant	2014	2015	2016	2017
Emission rate, tonne/year	TSP	10.3	**22.0**	14.2	6.5
	$PM_{2.5}$	**1.42**	**4.21**	**4.09**	**2.84**
	NO_x	18.2	**65.7**	**74.2**	**53.8**
	SO_2	2.38	7.61	8.73	6.19
	CO	**31.2**	**260**	**286**	**140**

Note: **Bold values** indicate those that exceed the NPRI reporting threshold (see Table 8.5.2)
tonne/year = tonne per year; TSP = total suspended particulate matter; $PM_{2.5}$ = Particular Matter with diameter <2.5 µm; NOx = Nitrogen Oxide; CO = Carbon Monoxide

8.5.1.2 Predicting the Changes to Air Quality From the Project

A screening level air quality model was used to predict the effect of air and dust emissions from the Project on the atmospheric environment. Ambient concentrations of dust[3], nitrogen, and sulphur, as well as their deposition fluxes were also predicted using the screening model. The ambient concentrations are to evaluate the air quality measurement endpoints associated with protecting air quality and human health. Potential acid deposition and dust deposition results were completed to provide supporting information for the assessment of effects on other VCs (e.g., water quality, soil, vegetation, and human health).

8.5.1.2.1 Screening Model Selected

The MOE approved, EPA AERSCREEN model was selected as the screening modeling tool. AERSCREEN is a single source screening model based on AERMOD, which is a refined air dispersion model. The model produces estimates of 'worst-case", one-hour concentrations for a single source, without the need for hourly meteorological data. The model is intended to produce concentration estimates that are equal to or greater than the estimates produced by AERMOD with a fully developed set of meteorological and terrain data.

8.5.1.2.2 Modeling Inputs

8.5.1.2.2.1 Emissions Source Input

The Project's sources of CACs from the construction phase were simulated as a 2.5 km radius source centered approximately 750 metres (m) northeast of the proposed bridge alignment (Figure 8.2-1). The area source encompasses the proposed soil salvage stockpiles, waste rock disposal areas, other Project infrastructure, and the site access roads. The following three receptor locations were evaluated for ambient air quality parameters (Figure 8.2-1):

[3] Here dust refers to particulate matter greater than 2.5 micrometers in aerodynamic diameter, calculated as the differences between TSP and $PM_{2.5}$ (i.e. Dust = TSP – $PM_{2.5}$).

- Permanent Resident's Cabin, approximately 3.25 km from center of emissions source area;
- Camp Grayling, approximately 2.75 km from the center of the emissions source area; and
- Black Lake Community, approximately 4.75 km from the center of the emissions source area.

Three locations were also evaluated as receptors for the atmospheric deposition of dust, sulphur, and nitrogen. All are located at the 2.5 km boundary of the air emissions source area (Figure 8.2-1), and include the following general locations:

- in Middle lake, offshore of the proposed outlet of the tailrace channel;
- offshore of the proposed water intake location in Black Lake; and
- near the proposed location of the submerged weir at the Fond du Lac River.

The annual emissions of CACs were broken down into months considering the construction schedule and seasonal variations in propane consumption. The emission height of all CACs was assumed to be 1 m. The highest, lowest, and average monthly emissions rates in the highest annual emissions year are summarized in Table 8.5-4.

Table 8.5-4: Highest Monthly, Lowest Monthly, and Annual Averaged Air and Dust Emissions

	Highest Monthly			Lowest Monthly			Annual Averaged	
	tonnes/ month[(a)]	g/s	Month	tonnes/ month[(a)]	g/s	Month	tonnes/ month[(a)]	g/s
TSP	3.09	2.38	May 2015	0.56	0.43	Feb,2015	1.73	1.33
$PM_{2.5}$	0.42	0.32	May 2015	0.23	0.18	Feb, 2015	0.31	0.24
CO	30.29	23.37	July 2016	16.27	12.55	Mar, 2016	22.03	17.00
SO_2	0.71	0.55	Dec 2016	0.32	0.24	Jun, 2016	0.50	0.38
NO_x	4.67	3.60	July 2016	4.27	3.29	Mar, 2016	4.44	3.42

(a) Assumes 12-hr work day

tonne/month = tonne per month; g/s = gram per second; TSP = total suspended particulate matter; $PM_{2.5}$ = Particular Matter with diameter <2.5 µm; NOx = Nitrogen Oxide; CO = Carbon Monoxide

The highest monthly emissions were used as sources in AERSCREEN to obtain a prediction of the maximum effect the Project could have on local air quality (i.e., at the receptors). This approach is not suited to estimating the potential effects of atmospheric deposition on soil and water quality because emissions vary month-to-month and seasonally. Annual and monthly average values of atmospheric deposition for dust were calculated, and these averages are used in the assessment of effects on surface water quality, soils, vegetation, and wildlife (Sections 11.0, 13.0, 14.0, and 15.0 respectively).

8.5.1.2.2.2 Background Concentrations of Criteria Air Contaminants

The Saskatchewan Air Quality Modeling Guideline (MOE 2012) recommends the following approach:

- For one-hour and 24-hour predicted averaging times, the value selected for background depends on the purpose of the modeling assessment, as follows:
  - For screening modelling, the 99^{th} percentile value from the cumulative frequency distribution of the background monitoring data should be used.

- For refined modelling, the 90th percentile value from the cumulative frequency distribution of the background motoring data should be used.

- For the annual predicted averaging time, use the 50th percentile from the cumulative frequency distribution of the background monitoring data.

In the Saskatchewan Air Quality Modelling Guideline (MOE 2012), regional background air contaminant concentrations are listed for different averaging periods and percentiles. The air quality concentrations from the monitoring station at La Loche, Saskatchewan for the northern region of Saskatchewan were designated as the background concentrations for the air quality study area (Table 8.5-5).

Table 8.5-5: Saskatchewan Ministry of Environment, Prescribed Background Concentrations for the Northern Air Dispersion Modelling Zone

Pollutant	Averaging Period and Percentile						
	1 hour		8 hour		24 hour		Annual
	90th	99th	90th	99th	90th	99th	50th
Carbon Monoxide (CO) , µg/m^3	570.0	915.0	572.0	1030.0	—	—	—
Nitrogen Dioxides (NO_2), µg/m^3	11.3	28.2	—	—	9.4	16.9	3.8
Sulphur Dioxide (SO_2) , µg/m^3	0.0	5.2	—	—	0.0	2.6	0.0
Particulate Matter ($PM_{2.5}$), µg/m^3	—	—	—	—	6.5	13.9	3.1
Particulate Matter (PM_{10}) , µg/m^3	—	—	—	—	23.1	49.1	—

"—"= Not Applicable; µg/m^3 = micrograms per cubic metre; $PM_{2.5}$ = particulate matter with mean aerodynamic diameter of 2.5 microns; PM_{10} = particulate matter with mean aerodynamic diameter of 10 microns.

8.5.1.2.2.3 Meteorological Data Surface Characteristics

AERSCREEN model interfaces with the MAKEMET program to generate a matrix of meteorological conditions, in the form of AERMET-ready surface (AERSCREE.sfc) and profile (AERSCREEN.pfl) files. These are created based on user-specified meteorological data and surface characteristics including the following:

- minimum and maximum ambient air temperatures (Kelvin);
- minimum wind speed (m/s);
- anemometer height (m); and
- surface characteristics type.

The monthly and annual minimum and maximum ambient air temperatures from the historical meteorological data at the Stony Rapids weather station (Table 8.5-6) were used as input, along with default values of the minimum wind speed (0.5 m/s) and anemometer height (10 m).

The Project is located in the northern air dispersion modeling zone, which consists of mixed forest, deciduous forest, coniferous forest, shrubland, wetlands, rivers, and lakes. The seasonal surface characteristics of the North Forest listed in the Saskatchewan Air Quality Modeling Guideline (MOE 2012) were applied in the simulation. The values of Albedo, Bowen ratio, and surface roughness are listed in Table 8.5-7. No other input was included (e.g., building downwash) and no terrain effect was considered. There are no flagpole receptors, and the rural model mode was selected for the simulation.

Table 8.5-6: Minimum and Maximum Ambient Air Temperature

Month	Minimum Ambient Temperature		Maximum Ambient Temperature	
	°C	K	°C	K
January	-48.9	224.25	5.2	278.35
February	-45.8	227.35	7.3	280.45
March	-44.7	228.45	17.1	290.25
April	-34.6	238.55	20.9	294.05
May	-16.5	256.65	32.7	305.85
June	-3.5	269.65	36.1	309.25
July	-0.1	273.05	33.6	306.75
August	-2.4	270.75	35.4	308.55
September	-7.7	265.45	28.1	301.25
October	-24	249.15	21.5	294.65
November	-41.7	231.45	5.8	278.95
December	-47.2	225.95	3.6	276.75
Year	-48.9	224.25	36.1	309.25

°C = degree Celsius; K = kelvin

Table 8.5-7: Surface Characteristic Parameters of the Study Area

Season	Albedo	Bowen ratio	Surface roughness, m
Winter	0.505	0.5	0.492
Spring	0.141	0.646	0.644
Summer	0.141	0.454	0.71
Fall	0.141	0.881	0.71

m = metre

8.5.1.2.3 Modeling Results

The AERSCREEN model creates an output file that contains source information, meteorology associated with the maximum concentration, maximum concentrations by distances, final maximum concentration and maximum concentration at the minimum ambient distance (ambient boundary). Table 8.5-8 summarizes the maximum air and dust concentrations with distances from the ambient boundary of 2.5 km to 10 km. Table 8.5-9 lists the maximum ambient concentrations at the receptor locations.

Table 8.5-8: Maximum Hourly Air and Particulate Matter Concentrations with Distances

Distance (km)	TSP (µg/m³)	$PM_{2.5}$ (µg/m³)	CO		SO_2		NO_x	
			(µg/m³)	(ppmv)	(µg/m³)	(ppmv)	(µg/m³)	(ppmv)
2.5	85.3	11.65	774.7	0.677	22.84	0.009	119.4	0.064
3.0	57.04	7.79	512.8	0.448	15.47	0.006	79.04	0.042
3.5	47.04	6.42	422.8	0.369	12.76	0.005	65.17	0.035
4.0	41.8	5.71	375.7	0.328	11.35	0.004	57.9	0.031
4.5	37.92	5.18	340.8	0.298	10.3	0.004	52.52	0.028
5.0	34.87	4.76	313.4	0.274	9.47	0.004	48.3	0.026
5.5	32.41	4.43	291.2	0.254	8.8	0.003	44.88	0.024
6.0	30.35	4.15	272.7	0.238	8.25	0.003	42.03	0.022
7.0	27.09	3.7	243.4	0.213	7.36	0.003	37.52	0.02
8.0	24.6	3.36	221	0.193	6.69	0.003	34.06	0.018
9.0	22.62	3.09	203.2	0.177	6.15	0.002	31.32	0.017
10.0	20.99	2.87	188.6	0.165	5.71	0.002	29.06	0.015

km = kilometre; µg/m³ = micrograms per cubic metre; ppmv = parts per million by volume; NO_x = Nitrogen oxide; SO_2 = Sulphur Dioxide; O = Carbon Monoxide; TSP = Total Suspended Particular matter; $PM_{2.5}$ = fine Particular matter with a diameter <2.5 µm

Table 8.5-9: Maximum Ambient Concentrations at the Receptor Locations

Receptor	TSP (µg/m³)	$PM_{2.5}$ (µg/m³)	CO (µg/m³)	SO_2 (µg/m³)	NO_x (µg/m³)
Permanent Resident's Cabin (3.25 km)	51.7 (100.8)	7.1 (21.0)	464.6 (1,379.6)	14.0 (19.2)	71.6 (99.8)
Camp Grayling (2.75 km)	65.3 (114.4)	8.9 (22.8)	587.3 (1,502.3)	17.7 (22.9)	90.5 (118.7)
Black Lake Community (4.75 km)	36.3 (85.4)	5.0 (18.9)	326.3 (1,241.3)	9.9 (15.1)	50.3 (78.5)
SAAQS or Canadian wide standard	**120**	**30**	**15,000**	**450**	**400**
Exceedance?	No	No	No	No	No

Note: bracketed number represents the predicted maximum concentrations plus the background levels
km = kilometer; µg/m³ = micrograms per cubic metre; NO_x = Nitrogen oxide; SO_2 = Sulphur Dioxide; CO = Carbon Monoxide; TSP = total suspended particulate matter; $PM_{2.5}$ = fine particulate matter with a diameter <2.5 µm; SAAQS = Saskatchewan Average Ambient Air Quality Standards

After adding the MOE values for the background concentrations of CACs (Table 8.3-2), the maximum concentrations of the CACs at the atmospheric receptors are all below the SAAQS or the Canada Wide Standard (Table 8.5-9). Note however that the TSP values at the Camp Grayling receptor location would reach greater than 95% of the SAAQS under this is a conservative estimate of the maximum ambient concentration. The following factors affect the prediction of particulate matter at the receptors using the screening model, and can produce TSP estimates that are greater than those are that actually can be observed at the Project site:

- For the screening model, the highest monthly emissions were used (i.e., 2.38 g/s); however, if the average monthly emission rate was input into the model (i.e., 1.33 g/s), the maximum concentration at receptor Camp Grayling, including the background, is 86.6 μg/m^3; 72% of the SAAQS.

- The screening model is a conservative tool for predicting air and dust dispersion. Its input does not include complete meteorology, and no building effects or terrain data are considered in the simulation.

- The screening model does not consider the gravitational settling of dust. Spherical particles of a unit density with diameters of 10, 30, and 100 μm have settling velocities on the order of 10, 100, and 1000 metres per hour (Seinfeld and Pandis 1998). If lofted to an altitude of 1.0 m, at an average local wind speed of 16.8 km per hour, these particles could deposit within 1.68, 0.17 or 0.02 km of their source. Note however that this calculation ignores the effects of turbulence, which could both increase and decrease their settling and surface impaction rates. The calculation also ignores actual particle density and shape factor, which when combined can approximately double their gravitational settling rate.

- The MOE 24-hour 99th percentile background concentration of PM_{10} for the northern air dispersion modeling zone is 49.1 μg/m^3; a value 41% of the SAAQS for TSP. These high background concentrations are likely the result of episodic boreal forest fires common to the region. If ambient air quality was locally degraded by forest fires to the point where ambient concentrations of TSP were exceeding 50 μg/m^3, it is likely that the site construction crews would be considering a slow-down or work stoppage for occupational health and safety reasons.

- Road dust contributes 71% of the TSP emission and is the dominant source. The silt content of the road bed material was assumed to be 10%, which is conservative compared to scraper routes (8.5%), plant roads (10%), or pit haul road (8.3%) at stone quarries (US EPA 1995 and 2006). No particle size distributions of proposed road bed material were available to inform this assessment texturally; however, local materials were observed to have a high sand rather than a high silt content (Annex IV, Section 3.0).

8.5.2 Potential for Acid Deposition Due to the Project

Project emissions have the potential to affect soil and surface water quality due to acid deposition. According to the Saskatchewan Air Quality Modelling Guideline (MOE 2012), regional acid deposition modelling is only required if the following criteria are met:

1) the combined Project emissions of SO_2, NO_X, and ammonia (NH_3) are greater than 0.175 tonnes per day (t/d) of hydrogen ion equivalents (H+) equivalent, where:

$$\text{total H+ equivalent (t/d)} = 2*(SO_2\ \text{t/d})/(64)+1*(NO_x\ \text{t/d})/(46)+1*(NH_3\ \text{t/d})/(17)$$

2) or, the emissions from the facility are >5% of the baseline emissions in the region.

The air emissions inventory for the Project was used to estimate the H^+ equivalent emissions (in tonnes per day, t/d) for comparison to MOE criteria #1 above. A detailed description of these calculations can be found in Appendix 8.2. The NPRI data (Environment Canada 2013) for Saskatchewan's Northern Air Dispersion Modelling Zone (MOE 2012) were used to calculate regional baseline emissions. The Project emissions were then compared to the regional baseline emissions (expressed as a percent) to evaluate MOE criteria #2. A detailed description of these calculations can also be found in Appendix 8.2.

The maximum annual H^+ equivalents emissions rate is 0.020 t/d, and the average for the 2014-2017 construction period is 0.014 t/d. These values are well below the Saskatchewan Ministry of Environment's threshold of 0.175 t/d. The maximum H^+ emissions, which occur in 2016 are 5.6% of the regional baseline emissions; the 2014 to 2017 average emissions are 4.6% of the regional baseline emissions.

Strictly speaking, the Saskatchewan MOE requires acid deposition modelling if the proposed facility exceeds 5% of the baseline emissions for the region. However, professional opinion suggests that the proposed facility does not require acid deposition modelling for the following reasons:

1) the facilities emissions for SO_2 and NO_x are conservative;

2) the assumption that SO_2 and NO_x have reacted with sufficient NH_3 to neutralize these conjugate bases is very conservative;

3) the Northern Air Dispersion Modelling Zone is largely wilderness with few urban/industrial installation, therefore total emissions are very low compared to airsheds further south;

4) smaller urban/industrial emissions sources are not required to report their emissions to NPRI;

5) NPRI emissions do not include emissions from mobile combustion sources (e.g. gasoline and diesel powered vehicles found in the region); and

6) the emissions are for the construction phase only and are therefore "low in magnitude, local in extent and reversible."

In summary, based on an evaluation of the Project emissions using the two MOE criteria, the potential for acid deposition is low and, therefore, acid deposition modelling was not required.

8.5.3 Atmospheric Deposition of Dust

Atmospheric deposition receptors are located in Middle Lake near the tailrace channel outlet, near the power tunnel intake on Black Lake and near the submerged weir on Black Lake (Figure 8.3-1). These locations are at the 2.5 km radius ambient boundary of the AERSCREEN model. To calculate a conservative estimate of dust deposition (i.e., $PM_{2.5}$), the dust concentrations at a reference height of 1 m were used. The deposition velocity of particulate matter was assumed to be 0.01 m/s (Ruijgrok et al. 1995). The deposition flux of particulate matter can be calculated by:

$$D_{PM} = X \cdot V_d \cdot DEP \cdot F_c$$

Where: DPM = particulate matter deposition flux (kg/ha/year)

X = particulate matter concentration (µg/m^3)

V_d = deposition velocity of 0.01 m/s

DEP = total deposition to dry deposition ratio (default: 2)

F_c = unit conversion of µg/m^2/s to kg/ha/year (315.4)

The screening model predicted dust concentrations are calculated at the ambient boundary (2.5 km) using annual averaged monthly emission rate from the construction year with the highest emissions, and are summarized in Table 8.5-10. The deposition flux of dust was conservatively estimated to be 267 kg/ha/year at the receptors.

Table 8.5-10: Deposition Flux of Dust, Sulphur, and Nitrogen at Deposition Receptors

	Model Predicted Concentrations (µg/m^3)	Deposition Velocity (V_d) (m/s)	Ratio of Molecular Weights	DEP	Deposition Flux	
					µg/m^2/s	kg/ha/year
Dust[(a)]	42.34 (as PM>2.5)	0.01	-	2	0.85	267

[(a)] Here dust is defined as the particulate matter with size greater than 2.5 µm (PM >2.5).
µg/m^3 = micrograms per cubic metre; m/s = meter per second; µg/m^2/s = milligram per square meter per second; kg/ha/year = kilogram per hectare per year; PM >2.5 = particulate matter with diameter >2.5µg.

8.5.4 Greenhouse Gas Emission from the Project

Sources of greenhouse gas (GHG) emissions from the Project are fuel combustion from stationary sources (e.g., diesel generators and propane for heating) and mobile sources (e.g. diesel and gasoline power equipment and vehicles). The emission factors for GHGs are adapted from Environment Canada's GHG emissions quantification guidance (Environment Canada 2013b). The guidance provides the commonly used emission factors for fuel combustion from Canada's National Inventory Report 1990 to 2009. The emission factors used in this assessment are listed in Table 8.5-11. During the construction phase of the Project, five 100-KW diesel generators for site electricity and propane for camp and power tunnel heating and air conditioning were assumed. Mobile equipment and passenger vehicles were assumed to use either diesel or gasoline. The annual diesel, propane, and gasoline consumption and GHG emissions from the construction phase of the Project are summarized in Table 8.5-12.

Table 8.5-11: Emission Factors for Greenhouse Gases

Sources	Emission factors for GHG emission, g/L		
	CO_2	CH_4	N_2O
Diesel combustion from stationary sources	2,663	0.133	0.4
Propane combustion from stationary sources	1,510	0.027	0.108
Diesel combustion from mobile source	2,663	0.15	1.1
Gasoline combustion from mobile sources	2,289	0.49	0.084

Source: Environment Canada (2013c)
g/L = gram per liter; CO_2 = Carbon dioxide; CH_4 = Methane; N_2O = Nitrous Oxide

Table 8.5-12: Greenhouse Gas Emissions During Construction of the Project

	2014	2015	2016	2017
Diesel combustion from stationary sources				
Annual diesel usage, L	459,000	1,095,000	1,095,000	1,002,000
CO_2, tonne	1,222.32	2,915.99	2,915.99	2,668.33
CH_4, tonne	0.06	0.15	0.15	0.13
N_2O, tonne	0.18	0.44	0.44	0.40
Propane combustion from stationary sources				
Annual propane usage, L	1,325,645	3,030,720	3,030,720	2,542,656
CO_2, tonne	2,001.72	4,576.39	4,576.39	3,839.41
CH_4, tonne	0.03	0.07	0.07	0.06
N_2O, tonne	0.14	0.33	0.33	0.28
Diesel combustion from mobile sources				
Annual diesel usage, L	668829	8,294,576	7,964,443	2,831,938
CO_2, tonne	1781.09	22,088.46	21,209.31	7,541.45
CH_4, tonne	0.10	1.24	1.19	0.42
N_2O, tonne	0.74	9.12	8.76	3.12
Gasoline combustion from mobile sources				
Annual gasoline usage, L	382,347	2,529,356	1,602,311	323,159
CO_2, tonne	875.19	5,789.69	3,667.69	739.71
CH_4, tonne	0.19	1.24	0.79	0.16
N_2O, tonne	0.03	0.21	0.13	0.03

L = liter; CO_2 = Carbon dioxide; CH_4 = Methane; N_2O = Nitrous Oxide

During the operation of the Project, it is assumed that one 100- KW diesel generator will be on site to produce emergency power during the 10% of time when the Project is not operating. The assessment assumes propane will be used for power station heating and air conditioning. The annual use of diesel and propane and the greenhouse emissions from operation of the Project are summarized in Table 8.5-13.

Table 8.5-13: Annual Greenhouse Emissions During Operation of the Project

Parameter	Diesel	Propane
Annual usage, L	21,900	92,400
CO_2, tonne	583.00	140.00
CH_4, tonne	0.03	0.00
N_2O, tonne	0.09	0.01

L = liter; CO_2 = Carbon dioxide; CH_4 = Methane; N_2O = Nitrous Oxide

Greenhouse gas emissions from closure are anticipated to be less than emissions from Project construction. Therefore, 50% of the annual average emissions from construction phase are assumed for the first year of the closure phase and 25% of the construction emissions are used during the second year of closure. Total GHG emissions from all phases of the Project are summarized in Table 8.5-14. The 100-year global warming potentials of methane and nitrous oxide are 21 and 310 (Canada Gazette 2012). The total greenhouse emission in CO_2 equivalents (CO_{2e}) was also calculated and listed in Table 8.5-14.

Table 8.5-14: Total Greenhouse Gas Emissions from the Project

	Construction	Operation	Closure	Total	GWP	CO_{2e}, tonne
CO_2, tonne	88,409	17,847	16,576	122,832	1	122,833
CH_4, tonne	6.06	0.46	1.14	7.66	21	161
N_2O, tonne	24.7	1.69	4.63	31.0	310	9,606
Total						**132,600**

GWP = 100 year global warming potential; CO_2 = Carbon dioxide; CH_4 = Methane; N_2O = Nitrous Oxide; CO_{2e} = Carbon dioxide equivalent

The net energy production of the Project would be 50 MW at 90% of capacity running for 90 years. The GHG emission intensity for electricity generation of this Project was estimated. The total greenhouse gas emissions avoided by this Project compared to other electricity generation options (natural gas and diesel) were estimated. The results are summarized in Table 8.5-15.

Table 8.5-15: Comparison of Emission Intensity for Different Power Generation Options and GHG Emission Avoided by the Project

Energy producing option	Emission intensity, gCO_{2e}/kWh	Lifecycle GHG emission, kt	GHG emission avoided, kt
Tazi Twé (Hydroelectric)	3.74	133	-
Typical Natural Gas	499	17,704	17,571
Typical Diesel	787	27,921	27,789
Saskatchewan energy mixed	720	25,544	25,412

gCO_{2e}/kWh = grams of carbon dioxide equivalent per kilowatt per hour of electricity; kt = kilotonne

The overall GHG emission intensity for electricity generation in Saskatchewan is 720 grams of carbon dioxide equivalents per kilowatt per hour of electricity (gCO_2e/kWh) in 2009 (Environment Canada 2011). The GHG emission avoided by this Project is estimated to be 25,412 kilotonne (kt), which is 265 kt/year for the temporal boundary of the Project (96 years). The typical GHG emission intensities for natural gas and diesel are 499 and 787 gCO_{2e}/kWh (Gagnon 2003). The GHG emissions avoided by the Project compared to natural gas and diesel are 17,571 kt and 27,789 kt; annual emissions avoided are 183 kt and 289 kt.

8.5.5 Increase in Noise Levels and Blasting Vibrations

A noise assessment calculates the changes in noise levels from existing and proposed sound emission sources. These changes are assessed from a receptor perspective. Sound prediction models are used to simulate sound emissions from industrial facilities and to predict noise levels at selected receptors.

The guidance on assessing potential noise effects associated with Project construction is taken from Health Canada. The HC Guidance suggests five specific criteria for assessing noise effects:

- Noise-Induced Hearing Loss (NIHL);
- sleep disturbance;
- speech comprehension;

- complaints; and
- high annoyance.

The total noise levels from construction activities are used to assess the noise effects. According to the HC Guidance, total noise levels should be calculated at relevant receptor locations through the logarithmic addition of measured or estimated baseline noise levels and predicted noise contribution from the Project construction. The total noise levels calculated using the measured or estimated baseline noise levels will hereafter be referred to as the HC total noise levels. Determination of HC total noise levels and predicted change in HC Guidance criteria thresholds are discussed in detail in Appendix 8.3.

According to Rule 012, the total noise levels from operational activities are calculated through the logarithmic addition of AUC mandated ASL. The total noise levels and predicted noise contribution from the Project operation are compared to the noise criteria defined in Rule 012. Rule 012 requires that A-weighted energy equivalent total noise levels (L_{eq} in [dBA]) associated with operation of the Project not exceed a PSL at any noise sensitive receptors (i.e., dwellings) within the AUC noise assessment boundary (i.e., 1.5 km Buffer). The total noise levels calculated using the ASL specified in Rule 012 will hereafter be referred to as the AUC total noise levels.

The difference between the HC total noise levels and the AUC total noise levels is related to the method used for characterizing the existing environment. For the HC total noise level, the contribution of the existing environment is characterized using actual field measurements, while for the AUC total noise level, the contribution of the existing environment is characterized using a mandated ASL. The AUC total noise levels at relevant receptor locations will be compared to the AUC Rule 012 PSL to characterize potential noise effects associated with the Project. Determination of specific ASL and PSL values is discussed in details in Appendix 8.3.

Rule 012 also provides details on appropriate methods for assessing potential Low Frequency Noise (LFN) effects, which is presented in Appendix 8.3. LFN analysis for the Project operations is included in the noise assessment for the Project.

Guidance for completing the assessment for blasting activities during construction of the Project was obtained from the NPC 119. Additional guidance for the Project blasting limits was obtained from the OPSS 120 (OPSS 2008). The Project will follow industry standard Best Management Practices, applicable federal regulations, and DFO guidelines for use of explosives.

8.5.5.1 Noise Assessment Technical Terms

To help understand the analysis and recommendations made in this section, Appendix 8.3 gives a brief discussion of technical terms for noise. In the report, perceptible changes in noise level are analyzed and assessed. A change in noise level of 3 dB is generally accepted as a slightly perceptible change (Cowan 1994). In other words, 3 dB represents the perceptible change threshold in noise level.

8.5.5.2 Methods

Noise modeling and assessment methods are presented in details in Appendix 8.3, which include noise prediction methods, noise modeling input parameters, broadband noise assessment, low frequency noise analysis, determination of HC Guidance thresholds, and blasting assessment methods.

For the Project construction noise assessment, the HC total noise level is calculated as the sum of measured or estimated baseline noise levels, and the noise contribution from the assessed facility under representative operating conditions. HC Guidance requires the HC total noise levels at receptors to be compared with specific criterion thresholds defined in HC Guidance for the receptors. The thresholds for the HC Guidance criteria are listed in Table 8.5-16.

Table 8.5-16: HC Guidance Thresholds during Construction for Local Sound-sensitive Receptors

Receptor Location	Noise-Induced Hearing Loss (NIHL)		Sleep Disturbance	Speech Comprehension		Complaints	High Annoyance
	$L_{eq,day}$[a] (dBA)	$L_{eq,night}$[b] (dBA)	$L_{eq,night}$ (dBA)	$L_{eq,day}$ (dBA)	$L_{eq,night}$ (dBA)	$L_{eq,dn}$[c] (dBA)	%HA[d]
NR1 – Permanent Resident's Cabin	70	70	45	55	55	55	6.5%
NR2 – Camp Grayling	70	70	45	55	55	55	6.5%
NR5 – Black Lake Community	70	70	45	55	55	55	6.5%

(a) Daytime equivalent energy sound level;
(b) Nighttime equivalent energy sound level;
(c) Day-night equivalent energy sound level;
(d) Change in High Annoyance.
dBA = A-weighted decibels; PSL = Permissible Sound Level.

For the Project operation noise assessment, Rule 012 requires the AUC total noise levels at receptors to be compared with mandated PSL values for the receptors or for 1.5 km Buffer of the Project. The applicable daytime (from 7:00 a.m. to 10:00 p.m.) and nighttime (from 10:00 p.m. to 7:00 a.m.) PSLs at noise-sensitive receptor locations and at the 1.5 km Buffer are summarized in Table 8.5-17.

Table 8.5-17: Permissible Sound Level during Operations for Local Sound-sensitive Receptors

Receptor Location	Permissible Sound Levels[a] [dBA]	
	Daytime PSL	Nighttime PSL
NR1 – Permanent Resident's Cabin	50	40
NR2 – Camp Grayling	50	40
NR5 – Black Lake Community	53	43
1.5 km Buffer	50	40

(a) The PSL values were determined in accordance with Rule 012 (AUC 2013).

dBA = A-weighted decibels; PSL = Permissible Sound Level.

The AUC total noise level is calculated as the sum of an assumed ASL specified by Rule 012, noise contribution from existing and approved energy resource and power generating facilities in the noise study area, and the noise contribution from the assessed facility under representative operating conditions. There is no existing and approved energy resource and power generating facilities in the noise study area. The ASLs for the receptors and at the 1.5 km Buffer are summarized in Table 8.5-18.

Table 8.5-18: Ambient Sound Level for Local Sound-Sensitive Receptor

Receptor Location	Ambient Sound Levels[a] [dBA]	
	Daytime ASL	Nighttime ASL
NR1 – Permanent Resident's Cabin	45	35
NR2 – Camp Grayling	45	35
NR5 – Black Lake Community	48	38
1.5 km Buffer	45	35

[a] The Ambient Sound Level values were determined in accordance with Rule 012 (AUC 2013).
dBA = A-weighted decibels; ASL = Ambient Sound Level.

Rule 012 also provides details on appropriate methods for assessing potential Low Frequency Noise (LFN) effects. A LFN condition may exist when:

- the value of the predicted sound level (expressed in dBC) minus the predicted sound level (expressed in dBA) equals or exceeds 20 dB; and
- a clear tonal component exists at a frequency below 250 hertz (Hz).

The first condition can be assessed with predictions; the second condition can only be established with sound measurements.

To assess blasting effects from Project construction, limits were compiled for the Project construction blasting assessment (Table 8.5-19) through combining the limits required by NPC 119, OPSS 120, and BMP-021. Details are presented in Appendix 8.3. In summary, the blasting vibration limits for ground vibration and air vibration are 30 mm/s for Peak Particle Velocity (PPV), and 128 dBL for peak sound pressure levels (L_{peak}), respectively.

Table 8.5-19: Combined Ground and Air Vibration Limits for the Project Blasting Activity

Vibration Type	Unit	Limits for Construction with Blasting
Ground Vibration	Peak Particle Velocity (mm/s)	30
Air Vibration	Peak Pressure Level (dBL)	128

mm/s = millimetres per second; dBL = linear decibel.

8.5.5.3 Results

8.5.5.3.1 Project Construction

According to the Project construction schedule, the periods with the most construction activities are May/June 2015 and July 2016. Based on the construction activity schedule and distance between construction activities and receptors, three assessment scenarios for the Project construction were modeled and assessed. These scenarios are:

- Project Construction 1 – From May to June 2015.
    - **Scenario 1** – Project Construction 1-1: for this scenario, the location of equipment used for the Project construction activities along the west part of the access is chosen to be the closest location to NR1 and NR5 along the access roads.

- **Scenario 2** – Project Construction 1-2: for this scenario, the location of equipment used for the Project construction activities along the southeastern part of the access is chosen to be the closest location to NR2.
- **Scenario 3** - Project Construction 2 – July 2016.

Table 8.5-20 presents the noise emission as sound power levels (PWLs) of the Project construction equipment. The acoustical usage factors for the construction equipment are also listed in this table. The methods to establish construction sound emissions, the related assumptions, and the detailed PWLs at octave bands centre frequencies are presented in Appendix 8.3.

Table 8.5-20: Sound Power Levels of Project Construction Equipment

Type	Acoustical Usage Factor (%)	Overall Sound Power Levels [dBA]
Articulated Truck	80	110.8
Rigid Rock Truck	80	113.8
Wheel Tractor Scraper	80	112.6
Motor Grader	80	109.2
Compaction Equipment	40	111.6
Track Drill	40	119.3
Skidder	40	109.2
Feller Buncher	40	114.4
Hydraulic Excavator	80	116.8
Rubber Tire Loaders	80	114.8
Crawler Tractors	80	114.4
Tunnel Rubber Tired Loader	80	114.8
Shaft Drill	40	117.5
Forklift	80	100.2
Skid Steer Loader	80	114.8
Telehandler	80	115.2
Man Lift	40	100.2
Concrete Mixing Truck	80	116.0
Concrete Pump Truck	40	113.8
Fuel Truck	20	113.8
Water Truck	20	113.8
Flat Deck	80	116.3
Boom Truck	80	111.8
75 Tonne Mobile Crane	80	115.2
200 Tonne Mobile Crane	80	116.8
Pick-Up Trucks	80	87.0
Transport Bus	20	87.0
Generator	100	116.8
Crusher	100	112.0
Screen	100	121.7
Concrete Batch Plant	100	117.0

% = percent; dBA = A-weighted decibels

At the time of assessment the design and the equipment list were not finalized, consequently the associated equipment for each of the Project construction activities are assigned based on the professional assumptions and previous experience on similar projects. The details of assumptions are presented in Appendix 8.3.

Baseline noise levels measured at sound monitoring sites R1 and R2 are assigned to noise assessment receptors, NR1 and NR2, respectively. There is no baseline noise measurement for NR5. Baseline noise levels measured at sound monitoring site R1 are assigned to NR5 since NR5 is considered to have similar acoustic environment as R1.

The sound emissions presented in Table 8.5-20 were applied to the sound prediction models to determine the noise levels associated with the Project construction. In the absence of quantifiable differences in daytime and nighttime activities, the same nighttime and daytime construction usage factors were used in the noise prediction modelling as shown in Table 8.5-20.

The baseline noise levels, the predicted construction noise levels due to the Project, and the HC total noise levels for daytime, nighttime and day-night equivalent energy sound levels (i.e., $L_{eq,day}$, $L_{eq,night}$, $L_{eq,dn}$) are shown in Tables 8.5-21, 8.5-22 and 8.5-23 for the Project construction Scenarios 1, 2, and 3, respectively.

Table 8.5-21: Noise Levels of Project Construction Scenario 1

Noise Receptors	Baseline Noise Level (dBA)			Predicted Project Only Noise Level (dBA)		HC Total Noise Level[(a)] (dBA)		
	$L_{eq, day}$	$L_{eq, night}$	$L_{eq.dn}$	$L_{eq, day}$	$L_{eq, night}$	$L_{eq, day}$	$L_{eq, night}$	$L_{eq.dn}$
NR1 – Permanent Resident's Cabin	37	34	41.0	42.7	42.7	43.7	43.2	49.7
NR2 – Camp Grayling	45	41	48.3	38.5	38.5	45.9	42.9	49.9
NR5 – Black Lake Community	37	34	41.0	31.7	31.7	38.1	36.0	42.8

[(a)] Consists of the logarithmic addition of Project Predicted Noise Level and measured/estimated baseline noise level.
dBA = A-weighted decibels; PSL = Permissible Sound Level.

Table 8.5-22: Noise Levels of Project Construction Scenario 2

Noise Receptors	Baseline Noise Level (dBA)			Predicted Project Only Noise Level (dBA)		HC Total Noise Level[(a)] (dBA)		
	$L_{eq, day}$	$L_{eq, night}$	$L_{eq.dn}$	$L_{eq, day}$	$L_{eq, night}$	$L_{eq, day}$	$L_{eq, night}$	$L_{eq.dn}$
NR1 – Permanent Resident's Cabin	37	34	41.0	41.2	41.2	42.6	42.0	48.5
NR2 – Camp Grayling	45	41	48.3	40.7	40.7	46.4	43.9	50.7
NR5 – Black Lake Community	37	34	41.0	32.0	32.0	38.2	36.1	42.9

[(a)] Consists of the logarithmic addition of Project Predicted Noise Level and measured/estimated baseline noise level.
dBA = A-weighted decibels; PSL = Permissible Sound Level.

Table 8.5-23: Noise Levels of Project Construction Scenario 3

Noise Receptors	Baseline Noise Level (dBA)			Predicted Project Only Noise Level (dBA)		HC Total Noise Level[a] (dBA)		
	$L_{eq, day}$	$L_{eq, night}$	$L_{eq.dn}$	$L_{eq, day}$	$L_{eq, night}$	$L_{eq, day}$	$L_{eq, night}$	$L_{eq.dn}$
NR1 – Permanent Resident's Cabin	37	34	41.0	42.0	42.0	43.2	42.6	49.1
NR2 – Camp Grayling	45	41	48.3	40.2	40.2	46.2	43.6	50.5
NR5 – Black Lake Community	37	34	41.0	31.6	31.6	38.1	36.0	42.8

[a] Consists of the logarithmic addition of Project Predicted Noise Level and measured/estimated baseline noise level.
dBA = A-weighted decibels; PSL = Permissible Sound Level.

For each receptor, the corresponding HC total noise levels shown in Tables 8.5-21, 8.5-22 and 8.5-23 are compared to the HC criterion thresholds for NIHL, sleep disturbance, speech comprehension, and complaints, which are presented in Table 8.5-16.

- **NIHL** = comparison of HC total noise levels during daytime and nighttime to the NIHL threshold (70 dBA) indicates that the risk of NIHL to humans at the receptor locations due to the Project construction is negligible.
- **Sleep Disturbance** = comparison of HC total noise levels during nighttime to the threshold for sleep disturbance (45 dBA) indicates that risk of adverse noise effects related to sleep disturbance due to the Project construction is negligible.
- **Speech Comprehension** = comparison of HC total noise levels during daytime and nighttime to the threshold for sustaining adequate speech comprehension (55 dBA) indicates that the risk of adverse noise effects related to speech comprehension due to the Project construction is negligible.
- **Complaints** = comparison of HC total day-night noise levels to the Complaints threshold (55 dBA) indicates that risk of complaints about the noise effects due to the Project construction is negligible.

For each receptor, Health Canada recommends calculating %HA for baseline noise levels and %HA for the Project HC total noise levels, which are shown in Tables 8.5-24, 8.5-25 and 8.5-26 for each scenario. For each receptor, the %HA values are compared to the HC criterion threshold for %HA, which are presented in Table 8.5-16. The HC Guidance suggests that differences between the two %HA values greater than 6.5% are indicative of an adverse effect related to annoyance on the acoustic environment. The %HA for the Project construction are below the HC threshold at the noise assessment receptors for Scenarios 1, 2, and 3.

Table 8.5-24: Change in High Annoyance (%HA) of Project Construction Scenario 1

Noise Receptors	Baseline %HA	HC Total Noise Level %HA	Change in %HA
NR1 – Permanent Resident's Cabin	0.7	2.1	1.4
NR2 – Camp Grayling	1.7	2.2	0.4
NR5 – Black Lake Community	0.7	0.9	0.2

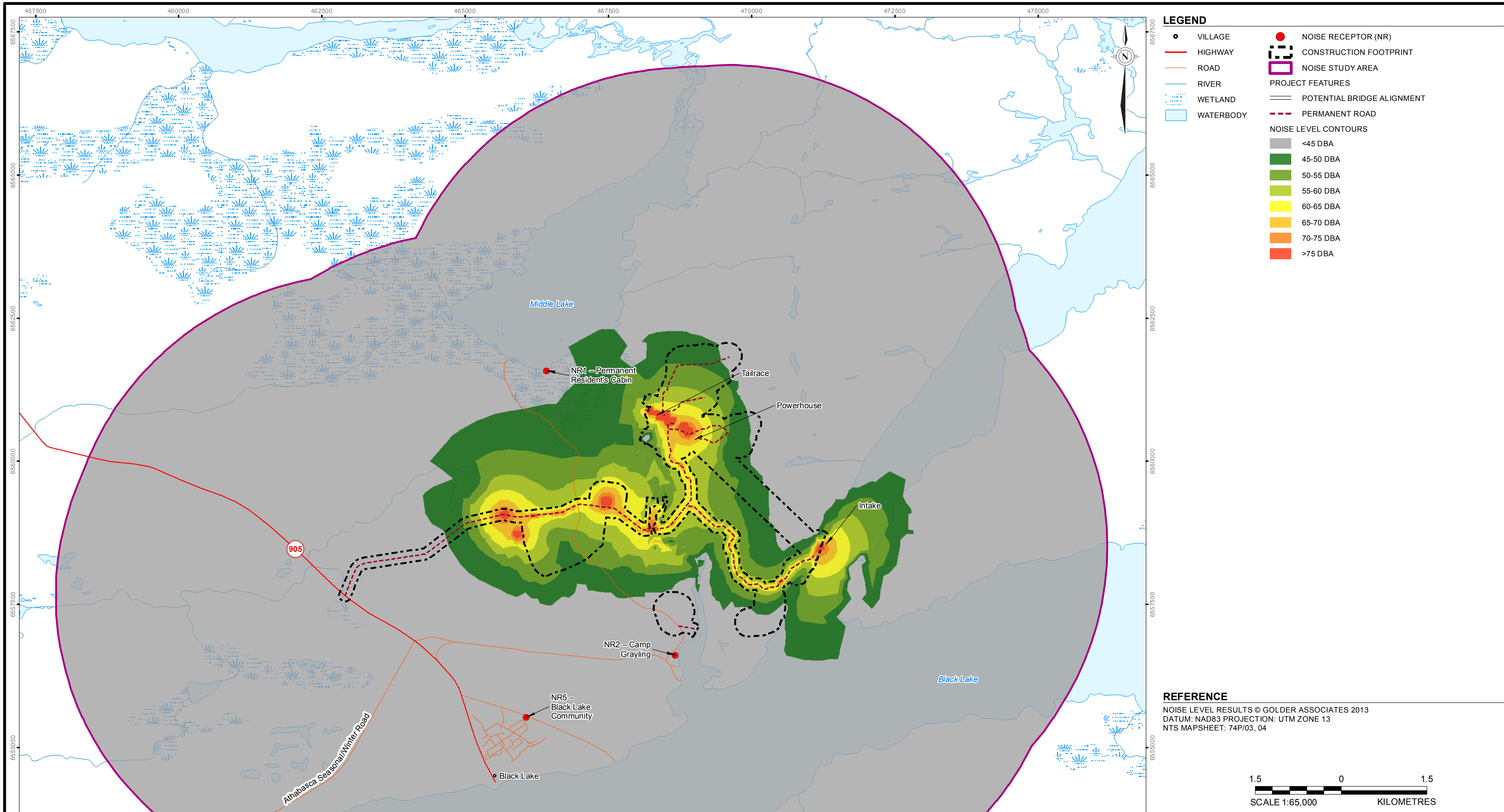
Table 8.5-25: Change in High Annoyance (%HA) of Project Construction Scenario 2

Noise Receptors	Baseline %HA	HC Total Noise Level %HA	Change in %HA
NR1 – Permanent Resident's Cabin	0.7	1.8	1.1
NR2 – Camp Grayling	1.7	2.4	0.7
NR5 – Black Lake Community	0.7	0.9	0.2

Table 8.5-26: Change in High Annoyance (%HA) of Project Construction Scenario 3

Noise Receptors	Baseline %HA	HC Total Noise Level %HA	Change in %HA
NR1 – Permanent Resident's Cabin	0.7	2.0	1.3
NR2 – Camp Grayling	1.7	2.3	0.6
NR5 – Black Lake Community	0.7	0.9	0.2

Results of the noise assessment for the Project construction indicate that the HC total noise levels and %HA are below the HC thresholds for Scenarios 1, 2, and 3, during the Project construction. It is anticipated that the construction noise will not result in nuisance for the people living in the area; although construction traffic will be audible, especially activities resulting in a noise peak, such as passing traffic, back up alarms, and dropping of hard material in empty trucks. The contours of predicted construction noise levels due to the Project during daytime for Scenarios 1, 2, and 3 are presented in Figures 8.5-1, 8.5-2, and 8.5-3, respectively.



PROJECT

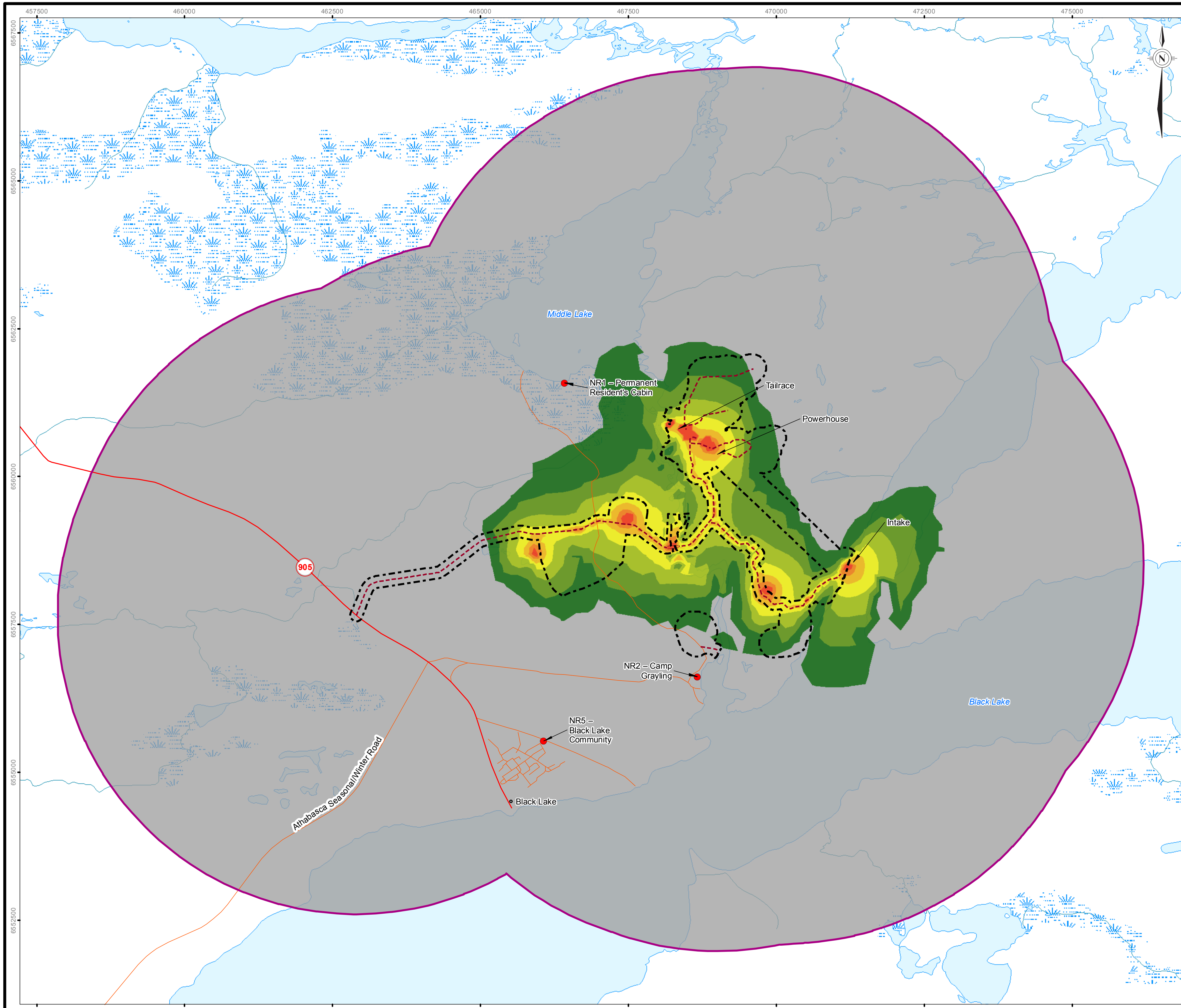
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

PROJECT CONSTRUCTION SCENARIO 1: PREDICTED DAYTIME NOISE LEVEL CONTOURS (PROJECT ONLY)

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	08/01/14	FIGURE: 8.5-1	
CHECK	ZY	09/01/14		
REVIEW	VS	09/01/14		



LEGEND

- VILLAGE
- HIGHWAY
- ROAD
- RIVER
- WETLAND
- WATERBODY
- NOISE RECEPTOR (NR)
- CONSTRUCTION FOOTPRINT
- NOISE STUDY AREA

PROJECT FEATURES

- POTENTIAL BRIDGE ALIGNMENT
- PERMANENT ROAD

NOISE LEVEL CONTOURS

- <45 DBA
- 45-50 DBA
- 50-55 DBA
- 55-60 DBA
- 60-65 DBA
- 65-70 DBA
- 70-75 DBA
- >75 DBA

REFERENCE

NOISE LEVEL RESULTS © GOLDER ASSOCIATES 2013
DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEET: 74P/03, 04

1.5 0 1.5
SCALE 1:65,000 KILOMETRES

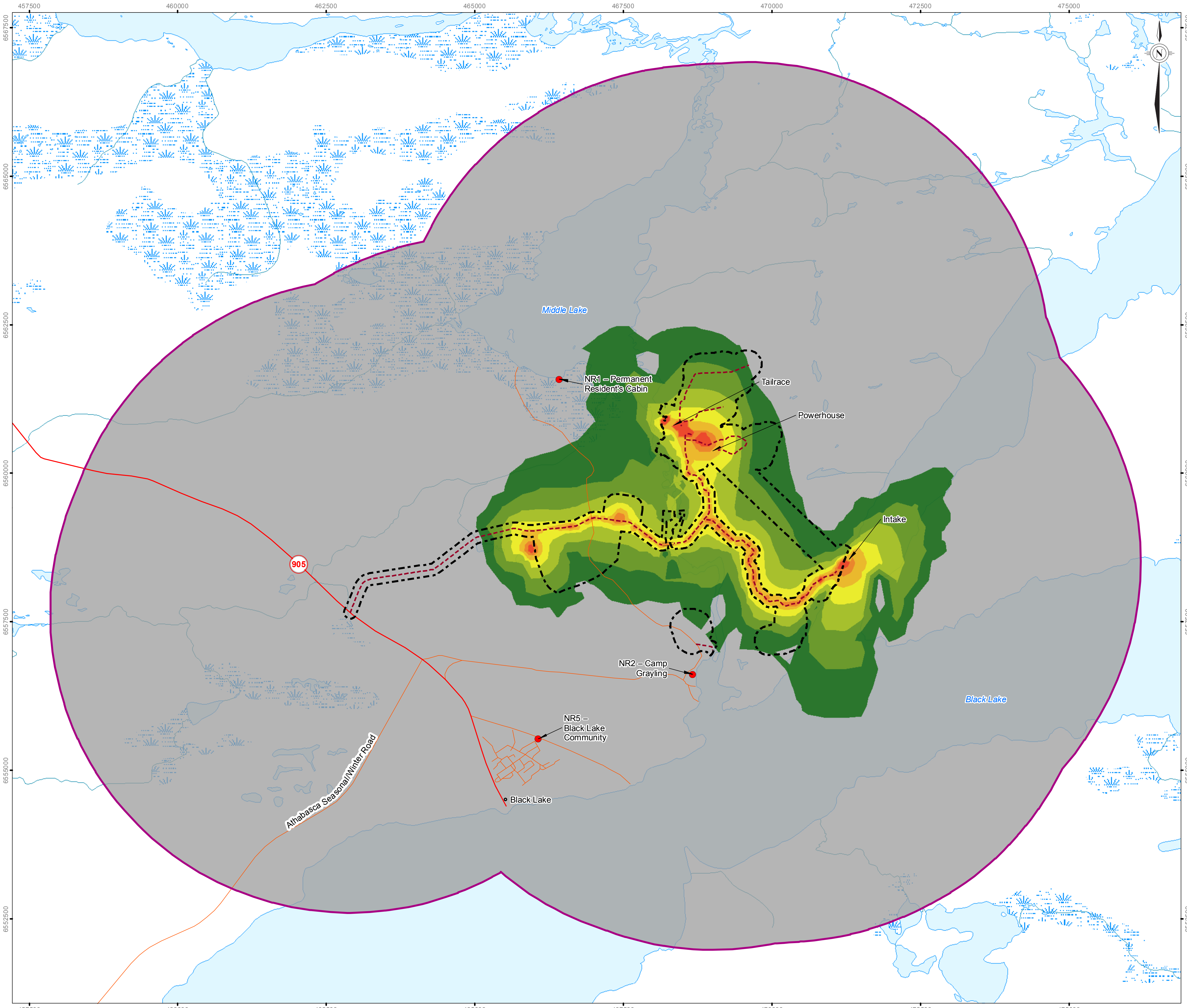
PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE **PROJECT CONSTRUCTION SCENARIO 2: PREDICTED DAYTIME NOISE LEVEL CONTOURS (PROJECT ONLY)**

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	08/01/14	**FIGURE: 8.5-2**	
CHECK	ZY	09/01/14		
REVIEW	VS	09/01/14		



LEGEND

- VILLAGE
- HIGHWAY
- ROAD
- RIVER
- WETLAND
- WATERBODY
- NOISE RECEPTOR (NR)
- CONSTRUCTION FOOTPRINT
- NOISE STUDY AREA

PROJECT FEATURES

- POTENTIAL BRIDGE ALIGNMENT
- PERMANENT ROAD

NOISE LEVEL CONTOURS

- <45 DBA
- 45-50 DBA
- 50-55 DBA
- 55-60 DBA
- 60-65 DBA
- 65-70 DBA
- 70-75 DBA
- >75 DBA

REFERENCE

NOISE LEVEL RESULTS © GOLDER ASSOCIATES 2013
DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEET: 74P/03, 04

1.5 0 1.5
SCALE 1:65,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

PROJECT CONSTRUCTION SCENARIO 3: PREDICTED DAYTIME NOISE LEVEL CONTOURS (PROJECT ONLY)

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	08/01/14	FIGURE: 8.5-3
CHECK	ZY	09/01/14	
REVIEW	VS	09/01/14	

Blasting activity of the Project construction was assessed based on the following estimates for the maximum weight of explosive (kg) detonated per delay period (i.e., W in the formula in Appendix 8.3 – Blasting Assessment Methods), which is shown in Table 8.5-27.

Table 8.5-27: Project Construction Blasting Assessment Explosive Estimates

Blast Location	Explosive Weight per Delay (kg)
Tailrace Channel	88
Power Tunnel	90

kg = kilogram

The blasting at the tailrace channel will be above ground while the blasting in the tunnel will be underground. The effects from blasting are assessed for the structures adjacent to the surface or the underground blasting operations. The details are presented in Appendix 8.3 for construction blasting emissions.

The intensity of ground vibrations, which is an elastic effect measured in units of PPV, is defined as the speed of excitation of particles within the ground resulting from vibratory motion. The magnitude of blast vibrations from the blasting activities at the Project receptors were predicted using generalized attenuation equations available in the published literature. The intensity of ground vibrations from blasting activities are primarily a function of the maximum explosive weight detonated per delay period and the distance between the blast and the receptor.

The Project construction activities that require blasting include tailrace channel excavation, water intake and powerhouse excavation, and power tunnel and surge facility. Among these activities, the tailrace channel excavation has the potential closest blasting to NR1, water intake excavation has the potential closest blasting to NR2 and powerhouse excavation has the potential closest blasting to NR5. The shortest distance between the receptor NR1 and the blast at the tailrace channel excavation location is about 2 km, the shortest distance between NR2 and the blast at the water intake excavation is about 3 km and shortest distance between NR5 and the blast at the powerhouse excavation is about 6 km. Using these distances, the maximum PPV (mm/s) for ground vibration were calculated for each of the receptors (Table 8.5-28). According to Table 8.5-19, the limits for ground vibration PPV from blasting activities is 30 mm/s. The PPVs at NR1, NR2 and NR5 due to the Project blasting activity are below the ground vibration PPV limits.

Table 8.5-28: Ground Peak Particle Velocity (mm/s) at Receptors

	PPV at NR1 (mm/s)	PPV at NR2 (mm/s)	PPV at NR5 (mm/s)
Ground Vibration	0.3	0.2	0.1

mm/s = millimetres per second; PPV = Peak Particle Velocity

The attenuation distance from the Project blasting activity to meet the minimum ground vibration PPV limit (50 mm/s) were calculated. At this distance, ground vibration PPV will be equal to the 50 mm/s limit value; beyond this distance, ground vibration PPV will be lower than 30 mm/s. This distance is referred to as ground vibration attenuation distance.

The ground vibration attenuation distances for the Project blasting activity to meet the ground vibration PPV limit are presented in Table 8.5-29. The results indicated that receptors NR1, NR2, and NR5 are at a distance much further than the ground vibration attenuation distances.

Table 8.5-29: Ground Vibration Attenuation Distances from the Project Blasting Activity

Explosive Weight per Delay (kg)	Ground Vibration Attenuation Distances (m)
88	118
90	119

kg = kilogram; m = metre

A summary of maximum explosive weight per delay period to meet the 30 mm/s PPV threshold is presented in Table 8.5-30. For each noise receptor, a distance and explosives weight are shown. The maximum weight at each of the locations is much larger than the expected weight per delay estimated for blasting at tailrace channel and power tunnel described in Table 8.5-27. As such, the expected weight per delay should not cause ground vibrations at or above 30 mm/s at any of the receptor locations.

Table 8.5-30: Maximum Charge for Ground Vibration Guidelines to be met at Receptors

Receptor location	Distance between Blast and Receptor (m)	Maximum Calculated Explosive Weight/Delay (kg) to meet 30 mm/s
NR1 – Permanent Resident's Cabin	1,915	23,161
NR2 – Camp Grayling	3,120	61,479
NR5 – Black Lake Community	6,110	235,775

kg = kilogram; m = metre; mm/s = millimetre per second

The blasting charge described in Table 8.5-27 will also result in air vibration. The air vibration levels (L_{peak}) are measured in dBL, which attenuate with distance from the blasting site, similar to airborne noise. Using the distance between the blasting site and each noise receptor, the maximum air vibration levels were calculated for each receptor and are presented in Table 8.5-31. According to the limits shown in Table 8.5-19, the limits for air vibration from blasting operations is 128 dBL. The maximum air vibration level at NR1, NR2 and NR5 due to the Project blasting activity are below this limit (Table 8.5-31).

Table 8.5-31: Air Vibration Peak Pressure Level (dBL) at Receptors

Air Vibration	L_{peak} at NR1 (dBL)	L_{peak} at NR2 (dBL)	L_{peak} at NR5 (dBL)
L_{peak} (dBL)	104.0	99.4	93.0

dBL = linear decibels

The attenuation distance from the Project blasting activity to meet the minimum air vibration limit (128 dBL) was calculated. At this distance, air vibration level will be equal to the limit value and beyond this distance, air vibration level will be lower than 128 dBL. This distance is referred to as air vibration attenuation distance. The results indicated that receptors NR1, NR2, and NR5 are at a much larger the distance than the air vibration attenuation distances shown in Table 8.5-32.

Table 8.5-32: Air Vibration Attenuation Distances from Project Blasting Activity

Explosive Weight per Delay (kg)	Air Vibration Attenuation Distances (m)
88	155
90	156

kg = kilogram; m = metre.

A summary of maximum explosive weight per delay period to meet the 128 dBL air vibration threshold is presented in Table 8.5-33. For each noise receptor, a distance and explosives weight are shown. The maximum weight at each of the locations is much larger than the expected weight per delay estimated for blasting at the tailrace channel and power tunnel described in Table 8.5-27. As such, the expected weight per delay should not cause an air vibration at or above 128 dBL at any of the selected receptors.

Table 8.5-33: Maximum Charge for Air Vibration Guidelines to be met at Receptors

Receptor location	Distance between Blast and Receptor (m)	Maximum Calculated Explosive Weight/Delay (kg) to meet 128 dBL
NR1 – Permanent Resident's Cabin	1,915	166,786
NR2 – Camp Grayling	3,120	721,302
NR5 – Black Lake Community	6,110	5,417,227

kg = kilogram; m = metre; mm/s = millimetre per second.

The ground vibration PPV and air vibration at receptors NR1, NR2, and NR5 are below the limits defined in Table 8.5-19. To satisfy the limits for both ground vibration PPV and air vibration, the explosive weight per delay cannot be over 23,161 kg. This weight is much larger than the expected weight per delay estimated for blasting at tailrace channel and power tunnel described in Table 8.5-27. As such, the expected weight per delay should not cause exceedance of ground and air vibration limits at any of the receptor locations.

8.5.5.3.2 Project Operations

The sound PWLs for the major sound sources are listed in Table 8.5-34. The methods to establish operation sound emissions and the detailed spectral data of sound power levels related to the Project used in the assessment are listed in Appendix 8.3. Because at the time of assessment, the design and the equipment list are not finalized, the PWLs for the Project operation equipment are estimated based on assumptions. Once the sound emissions were established, the sources were applied to the acoustic prediction model to determine the noise levels associated with the Project operation. Table 8.5-34 presents the summary of sound power levels of the facilities during Project operation. Noise sources typically associated with access roads during the Project operation are intermittent vehicle traffic for the Project powerhouse and related facilities operations and/or inspection. Because the access roads during the Project operation will not be heavily used, it is expected there that changes in noise levels related to the access road traffic during the Project operations will be negligible.

Table 8.5-34: Sound Power Levels of Project Operation Sound Sources

Project Operation Facilities	Quantity	Overall Sound Power Levels [dBA]
Powerhouse Roof[a]	1	79.5
Powerhouse Walls[a]	4	79.5
Generator Step-Up Transformer	2	110.1
Supply Fan	10	93.0
Exhaust Fan	9	93.0
HVAC	4	93.0
Transfer Fan	1	93.0

(a) PWL is presented in dBA/m^2 for area sources

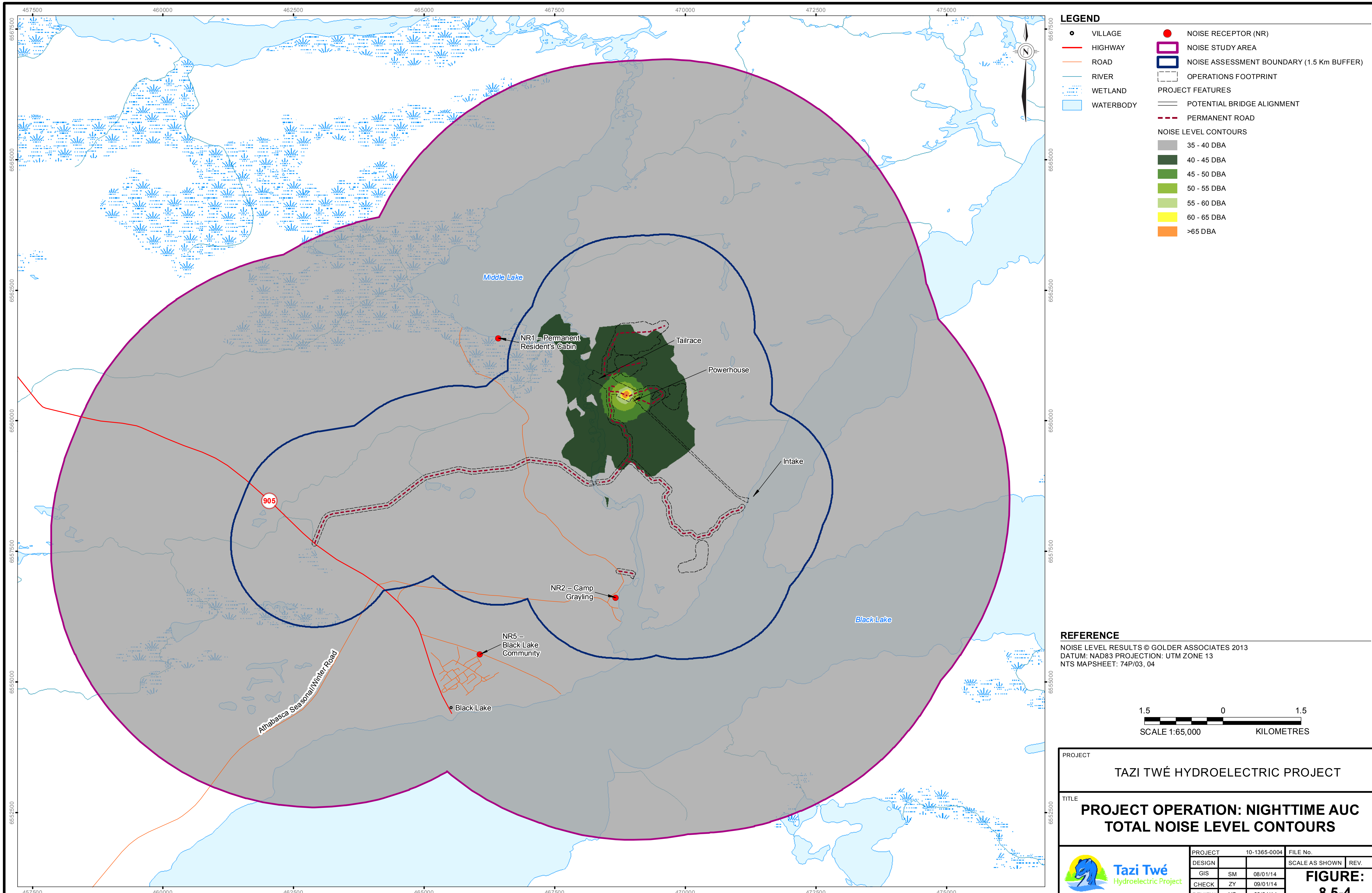
The Project noise levels at the selected receptor locations during Project operation are presented in Table 8.5-35. The contours of nighttime total noise levels for the Project operation are presented in Figure 8.5-4. At the same locations, the nighttime PSL is the more restrictive parameter than the daytime PSL when determining compliance, which means the AUC total noise levels are below PSL. The values presented include the AUC total Project noise level calculated from the mandated AUC ASL and the predicted Project sound contribution. During operations, most of the incremental daytime and nighttime noise levels from the Project are predicted to be confined to the powerhouse. According to Table 8.5-37, the nighttime sound contributions from the Project on local receptors during operations are predicted to be 31.9 dBA, 26.4 dBA and 20.1 dBA at receptors NR1, NR2, and NR5, respectively. Combined contributions from the Project and the mandated ASL are below the PSLs for the nighttime. Figure 8.5-4 shows that the predicted AUC total noise levels due to the Project operation at AUC noise assessment boundary (1.5 km Buffer) are below the nighttime PSL (40 dBA).

Table 8.5-35: Project Noise Levels of Project Operations

Receptor Location	Project Predicted Noise Levels (dBA)		Ambient Noise Level (dBA)		AUC Total Noise Level[a] (dBA)		Permissible Sound Level (PSL)		Difference	
			(dBA)		(dBA)				(PSL – AUC Total Noise Level [dBA])	
	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime
NR1 – Permanent Resident's Cabin	31.9	31.9	45	35	45.2	36.7	50	40	4.8	3.3
NR2 – Camp Grayling	26.4	26.4	45	35	45.1	35.6	50	40	4.9	4.4
NR5 – Black Lake Community	20.1	20.1	48	38	48.0	38.1	53	43	5.0	4.9

[a] Consists of the logarithmic addition of Project Predicted Noise Level and Ambient Sound Level values.
dBA = A-weighted decibels; PSL = Permissible Sound Level.

A sound that is twice the sound pressure of another indicates a 3 dB increase in sound pressure level. A change in noise level of 3 dB is generally accepted as a slightly perceptible change. According to Rule 012, the daytime and nighttime ASLs of the noise study area are defined to be representative of the existing acoustic environment with non-industrial sound sources (i.e., natural sound sources only). Therefore, at a certain distance from the sound sources, the noise levels from the Project operation activities will be dropped to same as ASLs (i.e., within this distance the noise levels from Project operation will be higher than the ASLs and beyond this distance the noise levels from Project operation will be lower than ASLs). This specific distance is referred to as noise attenuation distance.


LEGEND
VILLAGE
HIGHWAY
ROAD
RIVER
WETLAND
WATERBODY
NOISE RECEPTOR (NR)
NOISE STUDY AREA
NOISE ASSESSMENT BOUNDARY (1.5 Km BUFFER)
OPERATIONS FOOTPRINT
PROJECT FEATURES
POTENTIAL BRIDGE ALIGNMENT
PERMANENT ROAD
NOISE LEVEL CONTOURS
35 - 40 DBA
40 - 45 DBA
45 - 50 DBA
50 - 55 DBA
55 - 60 DBA
60 - 65 DBA
>65 DBA
Middle Lake
NR1 – Permanent Resident's Cabin
Tailrace
Powerhouse
Intake
905
NR2 – Camp Grayling
NR5 – Black Lake Community
Black Lake
Athabasca Seasonal/Winter Road
Black Lake
457500
460000
462500
465000
467500
470000
472500
475000
6567500
6565000
6562500
6560000
6557500
6555000
6552500
REFERENCE
NOISE LEVEL RESULTS © GOLDER ASSOCIATES 2013
DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEET: 74P/03, 04
1.5
0
1.5
SCALE 1:65,000
KILOMETRES
PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT
TITLE
PROJECT OPERATION: NIGHTTIME AUC TOTAL NOISE LEVEL CONTOURS
Tazi Twé
Hydroelectric Project
PROJECT 10-1365-0004
DESIGN
GIS SM 08/01/14
CHECK ZY 09/01/14
REVIEW VS 09/01/14
FILE No.
SCALE AS SHOWN
REV. 0
FIGURE: 8.5-4

For the Project operation, the sound sources are mainly around the powerhouse. Noise attenuation distances are different for daytime and nighttime because daytime and nighttime have different ASLs, which are 45 dBA and 35 dBA respectively. The noise attenuation distances were estimated based on the nighttime ASL of the study area of 35 dBA and the daytime ASL of 45 dBA. Since nighttime ASL is lower than the daytime ASL, the corresponding noise attenuation distance for nighttime is larger than the noise attenuation distance for daytime. The largest noise attenuation distances from the powerhouse in each direction are presented in Table 8.5-36 for nighttime and daytime, respectively.

Table 8.5-36: Largest Noise Attenuation Distances for Project Operation

Sound Source Location	Direction	Largest Noise Attenuation Distance (km)	
		Nighttime	Daytime
Powerhouse	North	1.8	0.6
	South	2.2	0.8
	West	2.2	0.7
	East	1.6	0.6

km = kilometre.

Based on the noise attenuation distances presented for the nighttime within 2.2 km from the Project operation activities, the increase in noise level will be perceptible to people. Beyond 2.2 km from Project operation activities, noise levels are expected to be below the existing nighttime ASLs. During daytime, within 0.8 km from the Project operation activities, the increase in noise level will be perceptible to people. Beyond 0.8 km from Project operation activities, noise levels are expected to be below the existing daytime ASLs. The distances between noise receptors and the Project powerhouse are about 3.0 km, 3.7 km, and 6.2 km, respectively. The NR1, NR2 and NR5 receptors are located much further than the largest noise attenuation distances.

To assess the potential for LFN effects at the identified receptor locations, the overall sound contributions from the Project were recalculated with the C-weighted filter and compared to the A-weighted results (Table 8.5-37).

Table 8.5-37: Low Frequency Noise Analysis for Project Operation

Receptor Location	Project Predicted Daytime Noise Levels			Recommended Difference Limit[b] (dB)
	(dBA)[a]	(dBC)	(dBC – dBA)	
NR1 – Permanent Resident's Cabin	31.9	52.2	20.3	20
NR2 – Camp Grayling	26.4	44.9	18.5	20
NR5 – Black Lake Community	20.1	40.0	19.9	20

(a) Project Predicted Noise Levels as shown in Table 8.5-37.

(b) As per Rule 012 (AUC 2013).

dBA = A-weighted decibels; dBC = C-weighed decibels; PSL = Permissible Sound Level; dB = decibels

The difference between the two weightings for receptor NR1 is slightly above the maximum recommended difference of 20 dB, which the guidance from Rule 012 (AUC 2013) suggests could be indicative of a LFN condition. Generally, LFN would be perceived as an indistinctive low hum; however, dBC – dBA difference in excess of 20 dB is only indicative of a potential low-frequency effect on the acoustic environment. To comment definitely on the presence or absence of a low-frequency effect, it is also necessary to have information about the tonal character of the sound, and this tonal information can only be obtained by field measurements once the Project operations start.

The potential low-frequency effect predicted for NR1 is expected to have a negligible effect on receptors as A-weighted and C-weighted ASLs were not included in the low frequency analysis, since Rule 12 does not provide recommended ambient levels in dBC. It is expected that the dBC – dBA difference would be reduced if it were possible to incorporate ASLs in the analysis. Furthermore, sound absorption in the atmosphere is highly frequency-dependent with low frequency sound propagating much better than high-frequency sound. Therefore, given the substantial distance between the Project and NR1 (3.0 km), it is expected that more low-frequency sound would overlap with NR1, verses mid and high-frequency sound..

8.5.6 Management of Uncertainty

A screening level air dispersion model was used to estimate the changes in ambient air quality from Project emissions. The accuracy of the prediction depends primarily on quality and certainty of the emissions quantification. The emission estimations have high uncertainty as limited engineering information was provided and assumptions have to be made. The assumptions were based on the scientific knowledge and experience with similar projects. However, the procedures of emission estimation are anticipated to result in a conservative assessment of changes in ambient air quality from the Project, and increase confidence that the residual adverse environmental effects are not greater than predicted. The screening model presented "worst case" predictions without a full set of meteorological data, building data, and terrain data. The conservative nature of the screening model would increase confidence that the residual adverse environmental effects are not underestimated.

According to *ISO 9613-2 Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*, the overall accuracy of the standard is ± 3 dB for distances between the source and receiver of up to 1 km (ISO 1996). The accuracy for distances up to or over 1.5 km is not stated. Overall model accuracy will also depend on the accuracy of the equipment noise emissions, which is often ± 2 dB for measured sources and even larger for emissions values estimated from generic engineering formulae. Taking this into account, the expected accuracy of the noise level predictions is ± 5 dB. To account for this level of uncertainty, the computer model incorporates conservative assumptions about noise propagation. In particular, the computer model predicts noise levels assuming downwind propagation from each source to each receiver point 100% of the time. Since downwind conditions are known to enhance noise propagation, this downwind assumption will tend to overestimate noise levels compared to what would be observed under real world propagation conditions.

8.6 Environmental Management, Monitoring, and Follow-up

The results of the air quality assessment indicate that no additional emissions management activities are required beyond those proposed to limit fugitive dust emissions during the construction phase (e.g., road watering). Should local residents deem the production of fugitive road dust a concern, increased watering of the roads will be completed to address these complaints should they arise. The results of the noise and blasting assessment indicate that no additional emissions management activities are required.

Environmental monitoring data reporting will be undertaken as part of a comprehensive Monitoring and Follow-up Plan. The plan will provide flexibility for SaskPower and MOE to effectively identify and respond to unanticipated changes to habitat quality and quantity, to adapt to new regulatory frameworks such as the Saskatchewan Environmental Code, and to provide appropriate feedback required to improve future environmental assessments. It is anticipated that data reporting will occur yearly, with data analysis being undertaken every five years and communicated in the form of Status of the Environment Reports.

Follow-up programs are typically implemented when the accuracy of the determination of significance needs to be verified or the resulting residual effects cause sufficient public concern to warrant an increased effort to determine the accuracy of the predictions or test the effectiveness of the mitigation/compensation. There is no follow-up program anticipated for the air quality or noise assessment.

8.7 References

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8.8 Glossary

Term	Description
Albedo	The ratio of reflected radiation from the surface to incident radiation upon it.
Alberta Utilities Commission (AUC)	An independent, quasi-judicial agency of the Government of Alberta. The Alberta Energy and Utilities Board (EUB) has been realigned into two separate regulatory bodies (January 1, 2008), the Alberta Utilities Commission (AUC), which regulates the utilities industry, and the Energy Resources Conservation Board (ERCB), which regulates the energy industry.
Ambient	The conditions surrounding an organism or area.
AQUA	A multi-national NASA scientific research satellite in orbit around the Earth, studying the precipitation, evaporation, and cycling of water.
A-weighted decibels	Incorporates the frequency response of the human ear. While low frequency noise could not be "heard," it can often be felt.
Bowen Ratio	The ratio of sensible to latent heat fluxes from the earth's surface up into the air.
Climate	Pattern of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods.
Criteria air contaminants	A set of air pollutants that cause smog, acid rain, and other health hazards.
C-weighted decibels	The C-weighting network weights the frequencies between 70 and 400 Hz uniformly, but below and above these limits, frequencies are slightly discriminated against.
Daytime	Hours range from 7:00 a.m. to 10:00 p.m.
dBA	A decibel value which has been A-weighted, or filtered to match the response of the human ear.
dBC	A decibel value which has been C-weighted.
Decibel	The decibel [dB] is a measure, on a logarithmic scale, of the magnitude of a particular quantity (such as sound pressure level or sound power level) with respect to a standard reference value.
Deposition	The process by which aerosol particles collect or deposit themselves on solid surfaces, decreasing the concentration of the particles in the air.
Emission intensity	The average emission rate of a given pollutant from a given source relative to the intensity of a specific activity.
Environmental Impact Statement (EIS)	A report that documents the information required to evaluate the environmental effect of a project.

Term	Description
Equivalent sound level	L_{eq}, Continuous equivalent sound level, defined as the sound pressure level that, if constant over the stated measurement period, would contain the same sound energy as the actual monitored sound that is fluctuating in level over the measurement period. This type of average takes into account the natural variability of sound. A common descriptor used in outdoor sound measurement (Cowan 1994).
Frequency	Human ear does not respond to all frequencies in the same way. Mid-range frequencies are most readily detected by the human ear, while low and high frequencies are harder to hear.
Global warming potential	A relative measure of how much heat a greenhouse gas traps in the atmosphere.
Greenhouse gas	A gas in an atmosphere that absorbs and emits radiation within the thermal infrared range.
Low Frequency Noise (LFN)	Where a clear tone is present below and inclusive of 250 Hz low frequency noise can be estimated by subtracting the overall C-weighted from the overall A-weighted sound level, or as the overall C-weighted sound level by itself.
Meteorology	Underlying science of weather and weather forecasting.
Ontario MOE	Ontario Ministry of Environment.
Nighttime	Hours range from 10:00 PM to 7:00 AM.
Noise	Unexpected sound heard or measured at a receiver.
Noise Study Area	The area where direct noise effects and small-scale indirect noise effects from the Project are expected to occur.
NPC	Noise Pollution Control
Permissible Sound Level (PSL)	The allowable overall A-weighted sound level of noise from energy industry sources, as specified by the AUC Noise Control Directive, which could contribute to the sound environment of a residential location.
Remote sensing	A method of obtaining information about properties of an object without coming into physical contact with that object.
Sound	Acoustic energy generated by natural or man-made sources, including the Project activities.
Sound level Meter	Equipment to measure sound levels.
Sound power	Rate of acoustic energy flow across a specified surface, or emitted by a specified sound source. The sound power in a frequency band is the energy flow rate associated with sound frequencies lying within the band.
Surface roughness	The geometric characteristic of a surface associated with its efficiency as a momentum sink for turbulent flow, due to the generation of drag forces and increased vertical wind shear.
TERRA	A multi-national NASA scientific research satellite in a Sun-synchronous orbit around the Earth.

8.9 List of Acronyms

Term	Definition
a.m.	ante merediem
ARCTAS	Arctic Research of the Composition of Troposphere from Aircraft and Satellites
ASL	ambient sound levels
AUC	Alberta Utility Commission
CACs	criteria air contaminants
CEAA	*Canadian Environmental Assessment Act*
CCME	Canadian Council of Ministers of the Environment
CO	carbon monoxide
EIS	Environmental Impact Statement
GHG	greenhouse gas
HRIA	Heritage Resources Impact Assessment
LFN	Low Frequency Noise
LSA	local study area
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NO	nitrogen oxide
NO_2	nitrogen dioxide
NPC	Noise Pollution Control
NPRI	National Pollutant Release Inventory
NRC	Natural Resources Canada
O_3	ozone
Ontario MOE	Ontario Ministry of Environment
OPSS	Ontario Provincial Standard Specification
p.m.	post merediem
PPV	Peak Particle Velocity
Project	Tazi Twé Hydroelectric Project
PSL	Permissible Sound Level
PWLs	power levels
RSA	regional study area
SAAQS	Saskatchewan Average Ambient Air Quality Standards
SO_2	sulphur dioxide
TSP	total suspended particulate
UTM	Universal Transverse Mercator
VC	valued component

8.10 List of Units

Term	Definition
%	percent
°C	degrees Celsius
μm	micrometres
$\mu g/m^3$	microgram per cubic metre
cm	centimetre
dBA	A-weighted decibles
gCO_2e/kWh	grams of carbon dioxide equivalents per kilowatt per hour of electricity
ha	hectares
km^2	square kilometre
km/h	kilometre per hour
kg/1000 L	kilograms per 1000 litres
kg/kW-hr	kilograms per kilowatt-hour
kg/VKT	kilograms per vehicle kilometre travelled
Kt	kilotonne
km	kilometre
$L_{eq,\ 1min}$	equivalent energy sound level on a one minute time scale
L_{peak}	peak sound pressure level
m	metre
mm	millimetre
ppbv	parts per billion by volume
ppm	parts per million

9.0 HYDROGEOLOGY

9.1 Introduction

The purpose of the hydrogeology section is to describe the subsurface environment that may be affected by the Tazi Twé Hydroelectric Project (Project) and to assess potential environmental effects on groundwater. The scope of the hydrogeology section includes an analysis of Project-related changes during construction, operation, and closure, and considers accidents, malfunctions, and unplanned events. The overall residual effects from the Project and potential for cumulative residual effects from the Project and previous, existing, and reasonably foreseeable developments on groundwater are also assessed.

Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples and the public. The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Rationale for the selection of hydrogeology as a VC is described below:

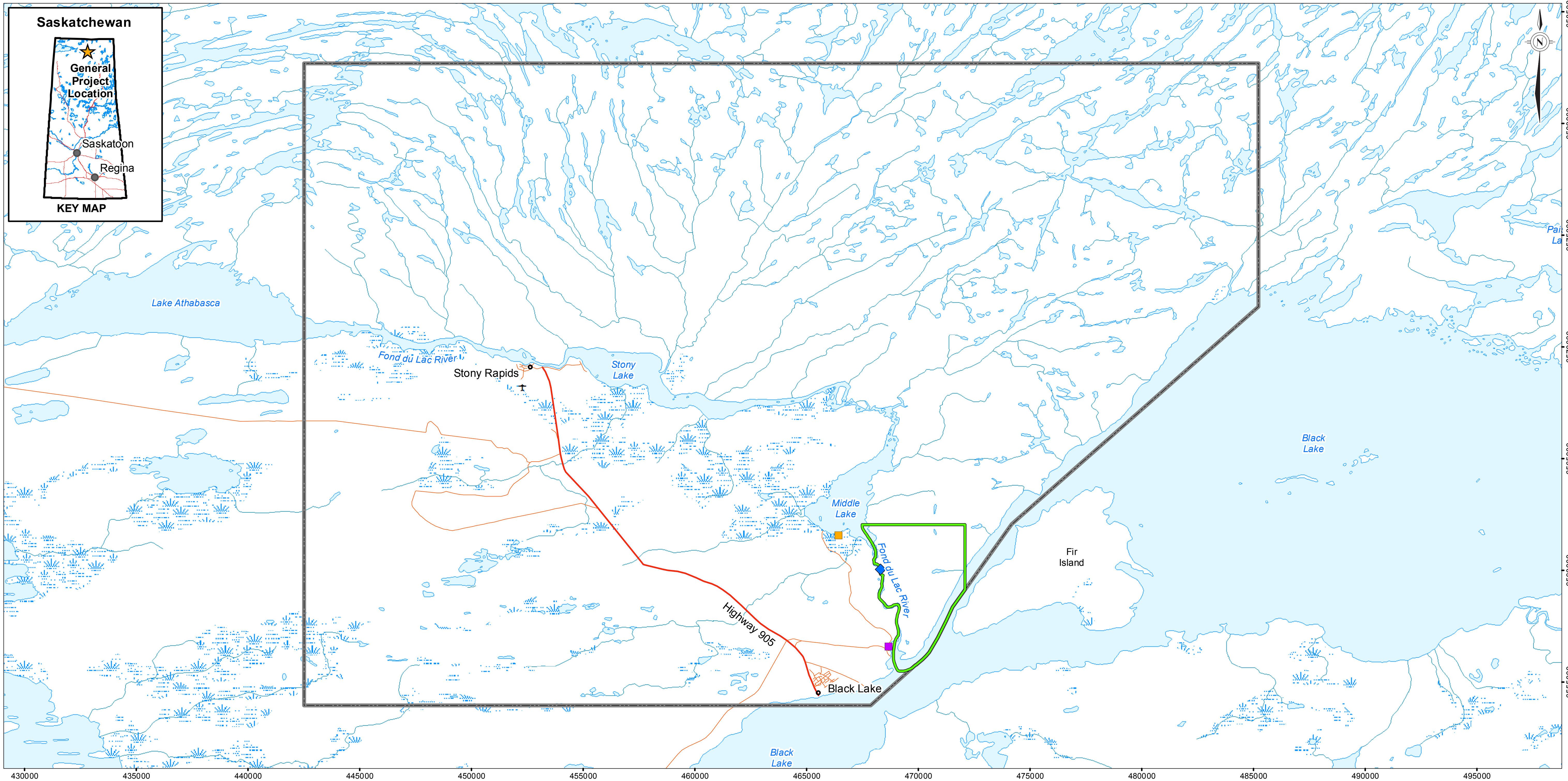
- Changes to groundwater can affect quantity and quality of surface water, which can subsequently affect the aquatic and terrestrial environments and people that use these resources.
- Changes to groundwater was identified as a concern by the public, First Nations and Métis, and regulatory agencies in the Project region.

The assessment endpoint is the key property that should be protected for use by future human generations and although hydrogeology was selected as a VC, it does not have an assessment endpoint. The results of this assessment are instead used in the effects analysis for other VCs (e.g., water quality, fish and fish habitat, soils, and vegetation). Measurement endpoints (biophysical or socio-economic indicators) represent properties of the environment, population, or system that, when changed, could result in, or contribute to, an effect on an assessment endpoint. The measurement endpoints identified for groundwater include:

- changes to groundwater levels and amount available for human use;
- physical analytes (e.g., pH, conductivity, turbidity);
- major ions and nutrients; and
- total and dissolved metals.

9.2 Spatial Boundaries

To quantify baseline conditions and evaluate potential environmental effects from the Project on hydrogeology, a local study area (LSA) and regional study area (RSA) were defined. The LSA for the hydrogeological assessment is based on the predicted direct and small-scale indirect effects from the Project on groundwater. For example, direct effects may include changes to groundwater flow and water quality resulting from the excavation of the power tunnel. The LSA for the hydrogeological assessment is constrained by Black Lake to the east, Middle Lake to the northwest, and the Fond du Lac River to the south (Figure 9.2-1).



LEGEND

●	VILLAGE	◆	ELIZABETH FALLS
	ROAD	■	CAMP GRAYLING
	RIVER	■	PERMANENT RESIDENT'S CABIN
	WETLAND		GEOTECHNICAL LOCAL STUDY AREA
	WATERBODY		GEOTECHNICAL REGIONAL STUDY AREA

5 0 5

SCALE 1:175,000 KILOMETRES

REFERENCE

DMTI HIGHWAYS AND ROADS
NTS MAPSHEET 74I, 74J, 74O, 74P
DATUM: NAD 83 PROJECTION: UTM ZONE 13

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

REGIONAL AND LOCAL STUDY AREA FOR GROUNDWATER

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 2
GIS	SM	10/07/13	
CHECK	EAM	19/07/13	**FIGURE: 9.2-1**
REVIEW	MT	19/07/13	

The boundaries for the RSAs were designed to quantify baseline conditions at a scale that is large enough to assess the maximum predicted geographic extent (i.e., maximum zone of influence) of direct and indirect effects from the Project on groundwater. While effects are not expected to occur upstream of Black Lake, there is the potential for effect to propagate into the downstream environment. Therefore, the RSA for the hydrogeological environment is defined as Black Lake, the Fond du Lac River, and Lake Athabasca to the community of Fond du Lac (Figure 9.2-1).

9.3 Existing Environment

Characterization of the geology surrounding the Project provides the framework for defining potential interactions between the Project and the hydrogeological environment. A desktop study was completed to better define the presence and spatial extent of geological units present within the RSA and LSA. Methods used in this process included review of existing reports and use of historical boreholes within the LSA.

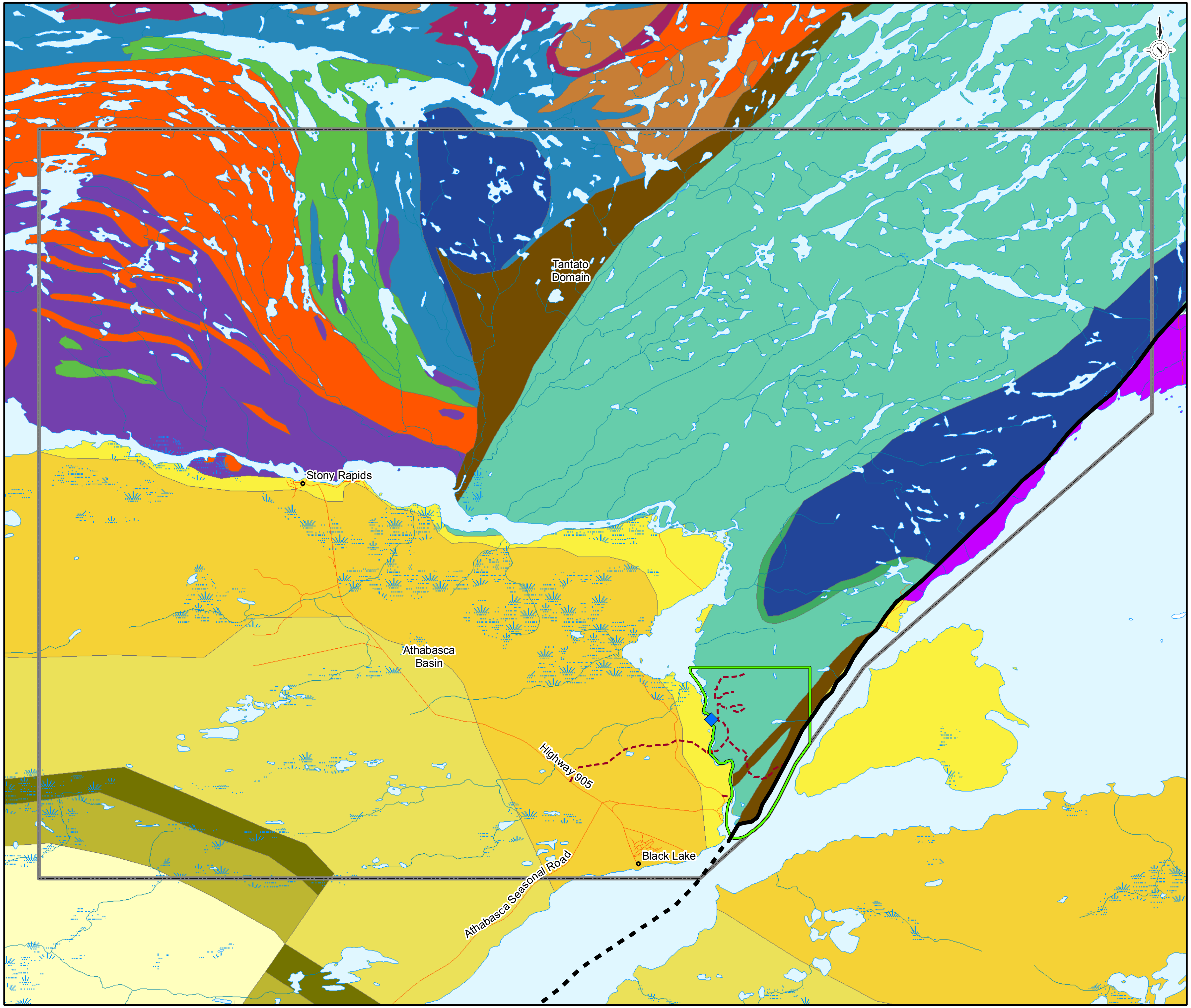
The information provided in this section includes bedrock geology, Quaternary geology, mineralization, and acid rock drainage (ARD). The information is based on a review of the regional geology (Gilboy 1978), results of terrain mapping (Mollard 1974), and geotechnical/geological investigations by Acres (2002 and 2005), Hatch Ltd. (2012) and Golder (2013), which included two geological mapping programs, two seismic refraction surveys, three geotechnical/geologic drilling programs, and a geochemical characterization study (Appendix 9.1). Detailed methods and results of the baseline geology and hydrogeology program are reported in Annex II (Geology and Hydrogeology Baseline Report).

9.3.1 Geology

9.3.1.1 Bedrock Geology

The bedrock in the RSA (Figure 9.3-1) and LSA (Figure 9.3-2) consists of Archean to Paleo-proterozoic age crystalline greenstones, mylonites, and gneiss complexes of the Rae Province of the Canadian Shield, as well as Paleo-proterozoic age sandstones and conglomerates of the Athabasca Group (SGS 1999). The northern and eastern portion of the RSA is located within the Tantato Domain, which is defined as the area between the Black Lake and Grease River Shear Zones. The southern and western portions of the RSA, including the western bank of the Fond du Lac River adjacent to the LSA, are located within the Athabasca Basin. The Athabasca Basin sediments within the RSA are comprised of fluviatile conglomerate and sandstone of the Manitou Falls Formation of the Athabasca Group (Gilboy and Raemakers 1981). The predominant rock type within the LSA is a hybrid gneiss complex comprised of felsic gneiss, amphibole schists and gneiss, and semipelitic to psammitic biotite schists and gneiss. This area is part of the Chipman Sill Swarm marking a zone most intensely intruded by metadiabase sills (Gilboy 1980).

Acres (2002), Hatch (2012) and Golder (2013) completed subsurface investigations in the water intake, power tunnel, powerhouse, and tailrace channel areas of the Project. These investigations included desktop study of regional geology, outcrop mapping, detailed core logging, rock mass classification, laboratory strength testing, and thin section analysis. In general, conditions encountered during these field investigations included gneissic rock with foliations striking southwest steeply dipping to the northwest and wide to moderate spacing of joints on outcrops.



LEGEND

- ELIZABETH FALLS
- POTENTIAL BRIDGE ALIGNMENT
- PROPOSED PERMANENT ACCESS ROAD
- ROAD
- GEOTECHNICAL LOCAL STUDY AREA
- GEOTECHNICAL REGIONAL STUDY AREA

BLACK LAKE SHEAR ZONE

TANTATO DOMAIN

- AMPHIBOLE GNEISS
- AMPHIBOLITE
- ARKOSIC BIOTITE GNEISSES
- BIOTITE GNEISS
- BIOTITE GRANODIORITE
- GARNET-FELDSPAR GNEISS
- GRANITE AND PEDMATITE
- HYBRID GNEISS COMPLEX
- MAFIC HYPERTHENE GNEISS
- MYLONITE/CATACLASTIC ROCKS
- PELITIC TO PSAMMITIC PARAGNEISS

ATHABASCA BASIC

- CLAY-INTRACLAST-RICH QUARTZARENITE
- LOWER CONGLOMERATIC QUARTZARENITE
- PEBBLY QUARTZARENITE
- QUARTZARENITE
- QUARTZARENITE, PEBBLY QUARTZARENITE
- UPPER CONGLOMERATIC QUARTZARENITE
- UPPER QUARTZ-PEBBLY QUARTZARENITE

REFERENCE

GEOLOGICAL ATLAS OF SASKATCHEWAN, SASKATCHEWAN ENERGY AND RESOURCES
GOVERNMENT OF CANADA, NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2001
PROJECTION: UNIVERSAL TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 13

3 0 3

SCALE 1:150,000 KILOMETRES

PROJECT

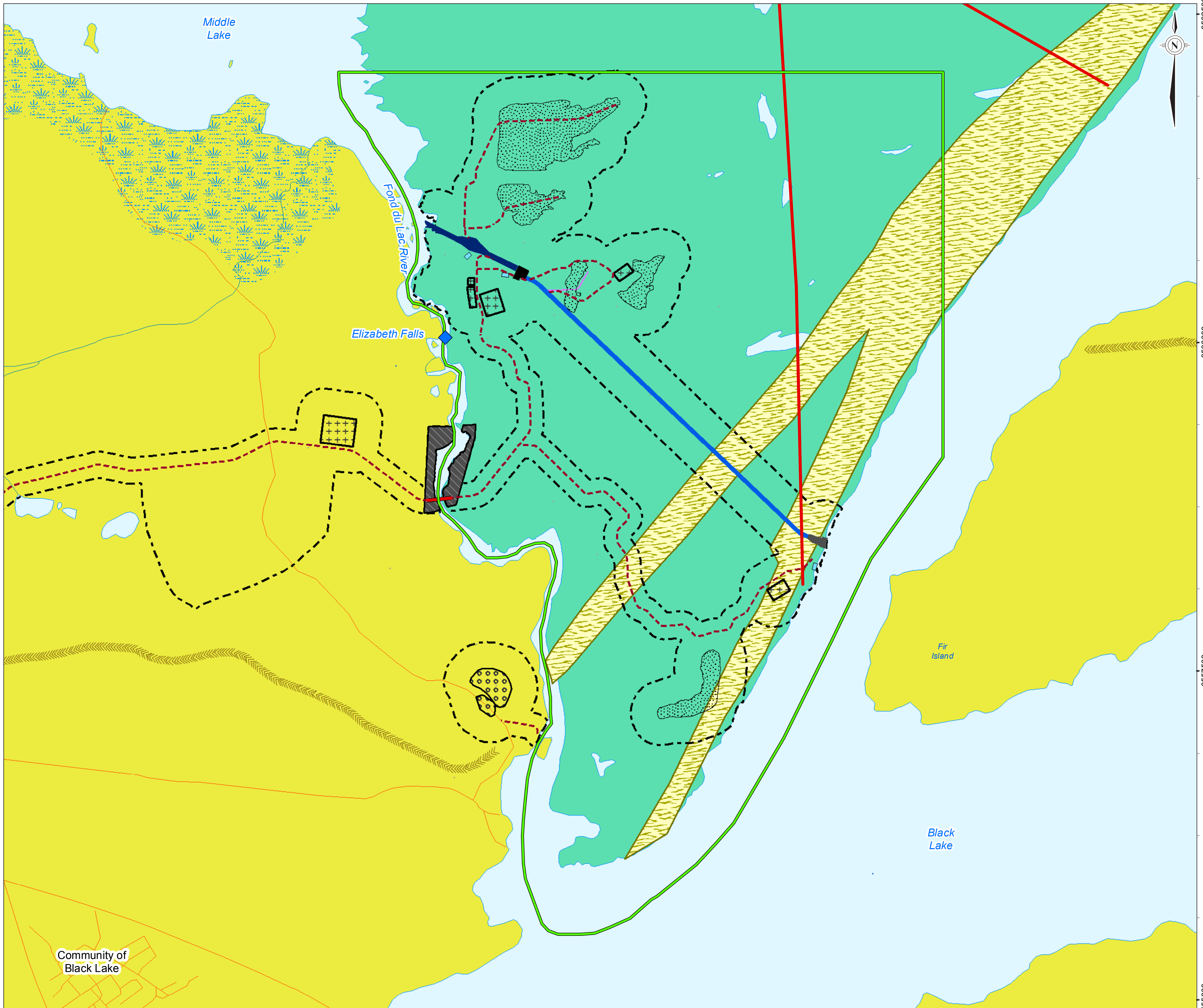
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

GEOLOGY OF THE REGIONAL STUDY AREA

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 6
GIS	SM	15/07/13		
CHECK	EAM	19/07/13	FIGURE: 9.3-1	
REVIEW	MT	19/07/13		



LEGEND

- GEOTECHNICAL LOCAL STUDY AREA
- ELIZABETH FALLS
- RIVER
- ROAD
- WETLAND
- WATERBODY

SPECIFIC CONSTRUCTION SITES

- BRIDGE ALIGNMENT
- PERMANENT ROAD
- PREDICTED PROJECT FOOTPRINT
- CONTRACTOR WORK AREA
- BORROW AREA
- SETTLING POND
- SPOIL DISPOSAL AREA
- BRIDGE ALIGNMENT AREA
- INTAKE
- POWER HOUSE
- TAILRACE
- POWER TUNNEL
- TUNNEL ADIT
- FAULT OR MAJOR AIRPHOTO LINEAMENT INTERPRETED AS A MASTER FRACTURE
- ESKER
- ATHABASCA FORMATION WELL BEDDED LAYERS OF SANDSTONE AND CONGLOMERATES
- CRYSTALINE GNEISS COMPLEX PRECAMBRIAN GRANITE INTRUDED BY A SWARM OF DIABASE DYKES
- BLACK LAKE SHEAR ZONE MYLONTIC ROCKS IN THE BLACK LAKE SHEAR ZONE GENERALLY PALE TO DARK GREY, VERY FINE GRAINED FELSIC

REFERENCE

NAD83 UTM ZONE 13
LOCAL GEOLOGY PROVIDED BY HATCH ENGINEERING, 2012
GEOLOGY: GILBOY, C.F. (1978): RECONNAISSANCE GEOLOGY, STONEY RAPIDS AREA (PARTS OF NTS AREA 74P) IN SUMMARY OF INVESTIGATIONS 1978, SASKATCHEWAN, GEOLOGICAL SURVEY, SASK-MINERAL RESOURCES, MISC. REP. 78-10, PP 35-42

0.5 0 0.5
SCALE 1:30,000 KILOMETRES

PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE
GEOLOGY OF THE LOCAL STUDY AREA

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004
DESIGN		
GIS	SM	19/07/13
CHECK	EAM	19/07/13
REVIEW	MT	19/07/13

FILE No.
SCALE AS SHOWN REV. 7

FIGURE 9.3-2

As part of the 2012 and 2013 investigation, laboratory analysis was completed on selected rock core samples. Testing completed included unconfined compressive strength (UCS), Cerchar Abrasivity Index (CAI) testing and petrographic analysis. In total, UCS testing was completed on 23 samples. Test results indicated that more than 95 percent (%) of the samples have UCS values between 25 and 250 Megapascals (MPa). The majority of samples with UCS values less than 90 MPa shows that the samples typically failed along foliation or some other discontinuity, thus indicating the intact strength of the rock is higher than the measured UCS value. The CAI testing was conducted on six samples, the results of which were not available at the time of reporting. Twenty samples were subjected to petrographic analysis. The results indicated that the rock along the tunnel alignment was mineralogically composed of variations of mafic dykes, gneiss and metagabbro.

Structural features within the RSA and LSA include foliation (most prominent), shear zones (Black Lake Shear Zone), faulting, and jointing. The Black Lake Shear Zone marks the contact between the Rae Province and Hearne Province, and delineates the eastern extent of the Tantato Domain. It was formed during the Hudsonian Orogeny (Gilboy and Raemakers 1981). The LSA includes the southern portion of the Black Lake Shear Zone that strikes parallel to the northeastern shore of Black Lake. It is approximately 100 to 500 metres (m) wide, and in the LSA represents a high angle reverse fault that down-threw Athabasca Group sediments to the southeast. Rocks in the Black Lake Shear Zone within the LSA primarily are mylonite (Gilboy and Raemakers 1981). In addition to the Black Lake Shear Zone, there are distinct areas of faulting, jointing, and topographic lineaments that could represent brittle fracturing within the RSA (Gilboy 1978).

The Project is located within the Interior Platform Seismic Zone (Earthquakes Canada 2013). This zone is a relatively stable zone seismically. Based on a search of the Earthquakes Canada database, no seismic events have been recorded within a 100 kilometre (km) radius of the Project since 1985. In addition, no earthquakes of a magnitude greater than 3.0 have occurred in the RSA or LSA as shown in Appendix 5.2, which shows greater than 3.0 magnitude earthquake locations within Canada.

9.3.1.2 Quaternary Geology

The topography within the RSA and LSA is primarily bedrock-controlled ridges generally striking north to south with low to moderate relief (Acres 2002). The area forms part of the Lake Athabasca drainage. Prominent landforms in the RSA and LSA are a result of past glaciations. Within the LSA, glaciation produced well-rounded erosion-resistant exposed bedrock, with thin and patchy overlying soil materials. To the west of the LSA, within the Athabasca Basin, glacial plain areas with gentle relief composed of glacial deposits consisting of lacustrine sand, silt, and till were formed by glacial activity. To the west of the LSA, an esker composed primarily of sand and gravel runs east to west for approximately 13 km (Figure 9.3-2; Hatch 2012). This esker is a source of aggregate and construction material in the area. On the east side of the LSA, along the west side of Black Lake, terraces up to 100 m in width have been cut into the surrounding topography. These terraces contain deposits of glacial sands that have been reworked by wave action, as well as talus (Hatch 2012).

descriptions of the soil material encountered during the subsurface investigations were provided during the site investigations undertaken in 2002 (Acres 2002), 2012 (Hatch 2012) and 2013 (Golder 2013). In general, soil materials encountered included sand, gravel, cobbles, and boulders with occasional organic material. At one location investigated in 2012 near the tailrace channel, silt and clay were encountered in the upper 4 m of strata. Gradational analysis was completed for six samples during the 2012 program, and results indicated that soil materials consisted of 0% to 36% gravel, 27% to 90% sand, and 1% to 44% fines (with the exception of the silt and clay material encountered near the tailrace channel, where fines were 73%; Hatch 2012). Based on observations made during the investigations in 2002, 2012 and 2013, the areas with the most extensive soil cover exist near the proposed water intake area and along the tailrace channel.

9.3.1.3 Mineralization

Metallic mineral resources occur almost exclusively in the Precambrian Shield area of Saskatchewan. Uranium, gold, copper, zinc, silver, and cadmium are currently mined in Saskatchewan. Within the RSA and LSA, the only known mineral deposits consist of uranium and are discussed in more detail below.

There are several known uranium deposits within the vicinity of the LSA. Based on information obtained from the Saskatchewan Mineral Deposit Index (SMDI 2012), the Nisto Mine, located approximately 5 km north of the Project has a maximum uranium grade of 0.612%. Lower grade uranium was also found in a borehole within the same fault zone, approximately 10 km to the south of the Project. The Nisto Mine, now an inactive mine site, is described as having several shear zones that contain quartz and calcite veins with mineralized fractures or shear zones in a sequence of paragneisses, meta-gabbro, and amphibolite sills in the hanging wall of the Black Lake Shear Zone. In the immediate showing area, there are three sets of fractures on the hanging wall side of the fault located along the Black Lake Shear Zone. The fracture with the strongest mineralization is steeply dipping and strikes 040°, while weaker mineralization is associated with the other two sets of fractures. These two fractures include a vertical and northwest-striking set and a steeply dipping east-striking set. Most of the fractures are 0.15 m wide, with a few shear zones up to 0.8 m wide. The length of the fractures varies from a few metres to over 150 m. The mineralization includes pitchblende and secondary yellow uranium mineralization, pyrite, galena, chalcopyrite, and stibnite in a series of quartz-calcite veins within fractures in highly hematized mylonite. A uranium showing also exists on the west side of the Fond du Lac River, near Woodcock Rapids, approximately 10 km downstream of Elizabeth Falls, located in the Athabasca Sandstone.

It should be noted that a geological mapping program found no evidence of uranium mineralization in the surface outcrops between Black Lake and the Fond du Lac River (Acres 2005 and Golder 2013). In addition, there was no evidence of uranium mineralization noted in the drill core obtained in 2002 (Acres 2002) and 2013 (Golder 2013). The bedrock cores from the boreholes drilled during the 2012 geotechnical investigation program were drilled in close proximity to the Black Lake Shear Zone. The core was scanned using a scintillometer to determine if any potential radiation occurred near the LSA. The radiation levels obtained were typically less than 150 counts per second (cps), typical of ordinary background levels and well below the 100,000 cps obtained for the known uranium showings in the area (Hatch 2012). No evidence of uranium mineralization was visually observed in the drill core or in the core sampled for petrographic analyses in 2012 or 2013.

9.3.1.4 Mechanisms for Acid Rock Drainage and Metal Leaching

Waste rock produced from excavation typically is stored in piles at surface. Gangue minerals within waste rock are predominately comprised of silicate, aluminosilicate, carbonate, oxide, and metal sulphide minerals. Exposure of waste rock to atmospheric conditions can result in the oxidation of metal sulphide minerals, the generation of acidity, and the release of constituents into the dissolved phase. Pore water within the waste rock can migrate through the subsurface and transport oxidation products into the groundwater and nearby surface water bodies. The generation of acidic and metal-rich waters, because of sulphide oxidation, is commonly referred to as ARD.

The acidity produced through oxidation reactions may be attenuated by gangue minerals that contain neutralizing capacity. Carbonate minerals, for example, are particularly important neutralizing minerals, since they are generally the most effective in counteracting acidic conditions. Other gangue minerals, such as aluminosilicates or silicates, could also contribute to the overall neutralization potential, but the dissolution of aluminosilicate and silicate minerals is kinetically limited (Jambor et al. 2003) and are only primary neutralizing minerals under low-pH conditions (<4.5) or where water-rock interaction times are very long (Blowes et al. 2004). If the amount of neutralizing minerals is insufficient, large quantities of acidity may be mobilized and released because of the oxidation of sulphide minerals.

Geochemical characterization of rock types present within the LSA was completed. The detailed results are provided in Appendix 9.1. The results of the characterization programs showed that bedrock and overburden in the LSA does not report major ARD or metal leaching (ML) issues. One sample of bedrock showed the potential to generate acid in static testing, but not during the long-term kinetic testing. Select samples had elevated concentrations of aluminum and arsenic in the leach test results. Other metals reporting sporadic concentrations greater than the applicable guidelines in waste rock leach testing included chromium, copper, iron, lead, selenium, and silver. The results of these leachates will not directly correlate to operational site conditions due to the relatively small size of the sample and the high degree of contact between the liquid and solid test charge, which may not exist under site-specific conditions.

9.3.2 Hydrogeology

9.3.2.1 Introduction

The groundwater flow system acts as a link between the surface water and terrestrial environments. Infiltration of precipitation from upland surface water bodies to the subsurface results in groundwater recharge and induces flow through water-bearing geologic units. This groundwater recharge and flow through ultimately discharges into topographically low-lying areas and often coincides with surface watercourses.

The geologic units within the RSA and LSA can be grouped as hydrostratigraphic units of aquifers and aquitards. An aquifer is composed of sediments that are sufficiently permeable to supply economic quantities of water. An aquitard refers to low permeability deposits that act as a confining layer, which is capable of storing water and transporting it from one aquifer to another, but is not capable of supplying usable quantities of water (Fetter 2001). A hydrostratigraphic unit has considerable lateral extent and is connected to the hydrological system through groundwater recharge and discharge.

9.3.2.2 Bedrock Aquifers

Precambrian Canadian Shield bedrock formations in Saskatchewan do not readily permit groundwater flow, except as fracture flow. There is little known about their hydraulic properties as very few boreholes have been completed in the Precambrian basement in this area of Saskatchewan. Prior to the 2013 investigation there have been no monitoring wells or water wells (domestic, commercial/industrial) installed within the LSA. Experience from other areas in the Canadian Shield, however, has shown that active groundwater flow is generally confined to localized shallow fracture systems. In Ontario, Singer and Cheng (2002) studied the groundwater movement in shallow bedrock of the Canadian Shield and reported that it is controlled by the secondary permeability created by fractures. Everitt et al. (1996) reported that, in Manitoba's Lac du Bonnet Batholith, groundwater movement is largely controlled by a fractured zone down to about 200 m depth. It is expected that groundwater flow within Canadian Shield rocks in Saskatchewan will be similar to those found in other locations within the Canadian Shield.

9.3.2.3 Quaternary Aquifers

In Saskatchewan, Quaternary aquifers are typically composed of well sorted glaciofluvial sand and gravel sediments, whereas the extensive till deposits typically comprise aquitards. The main Quaternary deposits within the RSA and LSA include glaciolacustrine plains, eskers, and glaciolacustrine terraces with estimated thicknesses likely to range from 0 m to approximately 20 m. Soil materials encountered during the drilling investigations were primarily sand, gravel, cobbles, and boulders. The groundwater table within the soil materials is expected to be shallow, and that shallow unconfined groundwater flow will generally parallel the surface water drainage patterns reporting to the Fond du Lac River, Black Lake, and Middle Lake. During the field investigations, monitoring wells were installed within the soil materials in the vicinity of the tunnel alignment during the 2013 investigation. Hydraulic conductivity testing and groundwater sampling were conducted within the Quaternary deposits with the results discussed in Sections 9.3.2.4 to 9.3.2.6.

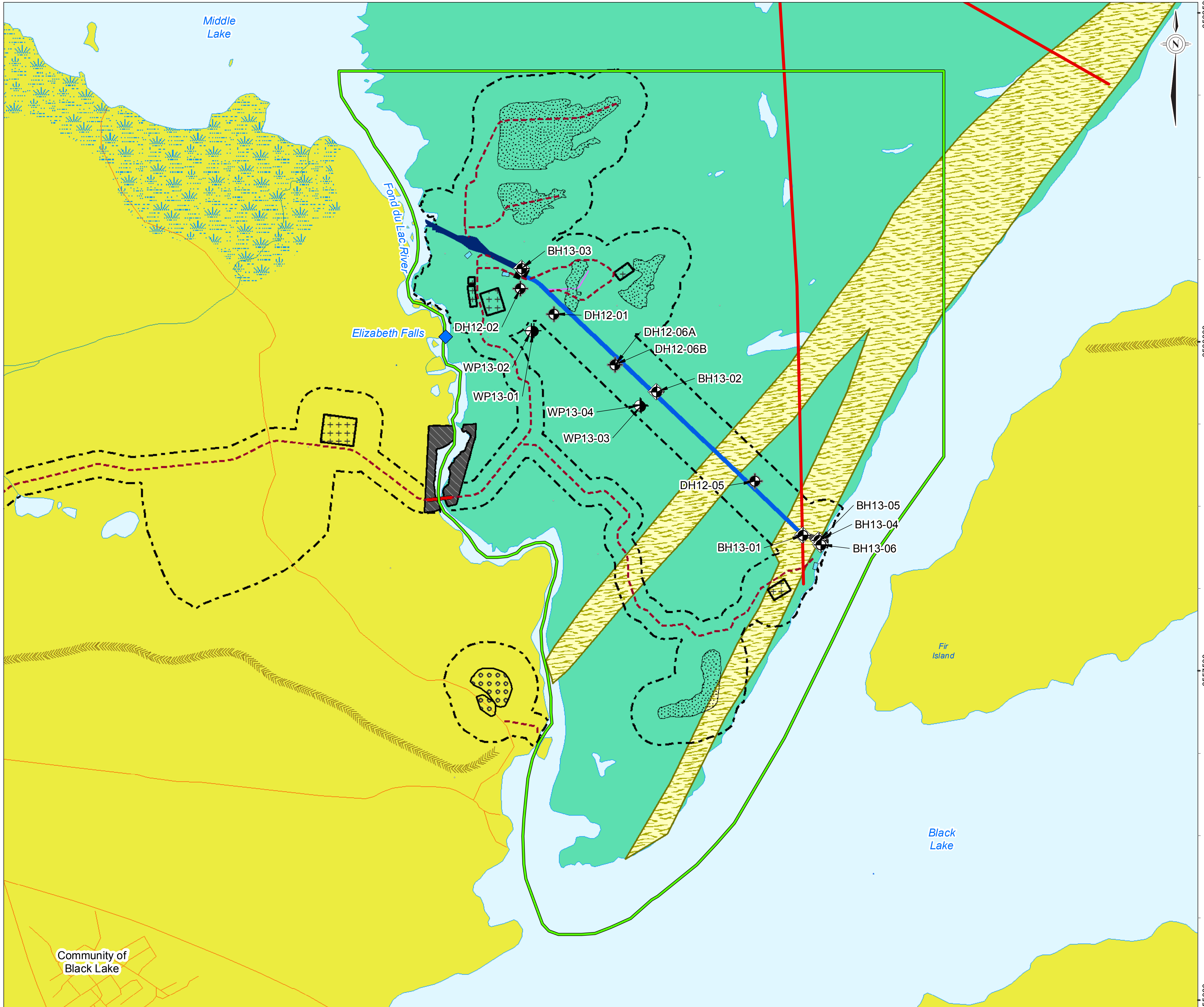
9.3.2.4 Groundwater Chemistry

A drilling program was completed at the Project site in October 2013 where four monitoring wells and four drive point piezometers were installed for the purpose of collecting groundwater samples from overburden and bedrock aquifers (Figure 9.3-3). Groundwater samples were collected from six of the eight wells; two of the drive point piezometers (WP13-02 and WP13-03) were dry at the time of sampling. The water quality results for the monitoring wells and drive points are provided in Table 9.3-1.

Aluminum and iron concentrations are elevated in the drive point piezometer WP13-01 compared to the monitoring wells. This is likely due to the oxidizing conditions in the shallow groundwater compared to the deeper bedrock groundwater resulting in the dissolution of aluminum and iron oxides in the strata.

Uranium concentrations range between 1 and 7.8 micrograms per litre (µg/L) at all the monitoring wells installed except BH13-01 (302 µg/L). BH13-01 was installed within the Black Lake Shear Zone (mylonitic gneiss) and intersected two major faults (approximately 0.5 m). Because known uranium deposits have been identified in the shear zone, the elevated uranium concentrations at this location are likely not indicative of uranium concentrations in groundwater across the site and are considered localized in nature. This is further supported by the low uranium concentrations at BH13-02 and BH13-03, installed along the tunnel alignment to the northwest.

The groundwater water quality results for BH13-05 may not be representative of actual site conditions at this location. The water quality results show a pH of 10.7 at this monitoring well, which is typically the result of grout impacts in the monitoring well. The elevated pH in the monitoring well will result in dissolution/precipitation reactions that would not typically occur under more neutral pH values (e.g., 6.5 to 9). Based on the pH values from the other monitoring wells and drive points, a neutral pH would be expected in the groundwater at this location.



LEGEND

- GEOTECHNICAL LOCAL STUDY AREA
- ELIZABETH FALLS
- RIVER
- ROAD
- WETLAND
- WATERBODY

SPECIFIC CONSTRUCTION SITES

- BRIDGE ALIGNMENT
- PERMANENT ROAD
- PREDICTED PROJECT FOOTPRINT
- CONTRACTOR WORK AREA
- BORROW AREA
- SETTLING POND
- SPOIL DISPOSAL AREA
- BRIDGE ALIGNMENT AREA
- INTAKE
- POWER HOUSE
- TAILRACE
- POWER TUNNEL
- TUNNEL ADIT
- 2012 BOREHOLE LOCATION
- 2013 BOREHOLE LOCATION
- 2013 DRIVE POINT PIEZOMETER
- FAULT OR MAJOR AIRPHOTO LINEAMENT INTERPRETED AS A MASTER FRACTURE
- ESKER
- ATHABASCA FORMATION WELL BEDDED LAYERS OF SANDSTONE AND CONGLOMERATES
- CRYSTALINE GNEISS COMPLEX PRECAMBRIAN GRANITE INTRUDED BY A SWARM OF DIABASE DYKES
- BLACK LAKE SHEAR ZONE MYLONTIC ROCKS IN THE BLACK LAKE SHEAR ZONE GENERALLY PALE TO DARK GREY, VERY FINE GRAINED FELSIC

REFERENCE

NAD83 UTM ZONE 13
LOCAL GEOLOGY PROVIDED BY HATCH ENGINEERING, 2012
GEOLOGY: GILBOY, C.F. (1978): RECONNAISSANCE GEOLOGY, STONEY RAPIDS AREA (PARTS OF NTS AREA 74P) IN SUMMARY OF INVESTIGATIONS 1978, SASKATCHEWAN, GEOLOGICAL SURVEY, SASK-MINERAL RESOURCES, MISC. REP. 78-10, PP 35-42

0.5 0 0.5
SCALE 1:30,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATION OF GROUNDWATER MONITORING WELLS

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 7
GIS	SM	19/07/13		
CHECK	DL	22/01/14	FIGURE 9.3-3	
REVIEW	MT	22/01/14		

Table 9.3-1: Site-specific Groundwater Chemistry Values for the Project, October 2013

Parameter	Units	BH13-01	BH13-02	BH13-03	BH13-05	WP13-01	WP13-04
Conventional							
pH	pH units	8.93	8.95	8.30	10.71	6.43	6.95
Specific Conductivity	µS/cm	212	320	153	393	80	119
Total Alkalinity	mg/L as $CaCO_3$	102	140	69	114	40	59
Total Hardness	mg/L	75	41	50	28	41	79
Total Dissolved Solids	mg/L	134	207	130	219	171	229
Nutrients							
Ammonia as N	mg/L as N	0.08	--	--	0.31	--	--
Nitrate (calculated)	mg/L as N	<0.09	<0.04	<0.04	<0.04	<0.04	<0.04
Phosphorus	mg/L	0.01	--	--		--	--
Major Ions							
Bicarbonate	mg/L	105	146	84	<1	49	72
Calcium	mg/L	16	8.4	10	11	8.6	12
Chloride	mg/L	1.5	24	2.4	6	0.2	1.4
Fluoride	mg/L	0.40	0.34	0.17	0.46	0.06	0.14
Magnesium	mg/L	7.2	3.2	3.8	2	4.6	12
Potassium	mg/L	3.3	2.0	1.5	31	3.0	12
Sodium	mg/L	16	57	16	37	1.3	6.1
Sulphate	mg/L	10	2.4	12	23	1.3	5.4
Dissolved Metals							
Aluminum	mg/L	0.016	0.025	0.023	<0.005	0.95	--
Antimony	mg/L	0.0055	0.0076	0.0086	<0.002	<0.002	--
Arsenic	mg/L	0.020	0.022	0.092	0.001	0.001	--
Barium	mg/L	0.0077	0.0031	0.0011	0.096	0.033	--
Beryllium	mg/L	<0.0001	<0.0001	<0.0001	<0.001	<0.001	--
Bismuth	mg/L	<0.0002	<0.0002	<0.0002	<0.002	<0.002	--
Boron	mg/L	0.12	0.48	0.10	0.1	0.1	--
Cadmium	mg/L	0.00001	<0.00001	<0.00001	<0.0001	0.0001	--
Chromium	mg/L	0.0006	<0.0005	<0.0005	<0.005	0.010	--
Cobalt	mg/L	0.0015	0.0001	<0.0001	<0.001	<0.001	--
Copper	mg/L	0.0008	<0.0002	0.0002	0.002	0.004	--
Iron	mg/L	0.29	0.021	0.010	<0.005	5.8	--
Lead	mg/L	0.0005	0.0001	<0.0001	<0.001	0.001	--
Lithium	mg/L	0.023	0.012	0.0085	0.0034	0.002	--
Manganese	mg/L	0.0033	0.0049	0.0052	<0.005	0.12	--
Mercury	mg/L	0.00007	<0.00002	<0.00002	<0.00002	<0.00002	--
Molybdenum	mg/L	0.0051	0.0053	0.013	0.018	0.002	--
Nickel	mg/L	0.0009	0.0038	0.0013	<0.001	0.016	--
Selenium	mg/L	0.0060	0.0001	0.0024	<0.001	<0.001	--

Table 9.3-1: Site-specific Groundwater Chemistry Values for the Project, October 2013 (continued)

Parameter	Units	BH13-01	BH13-02	BH13-03	BH13-05	WP13-01	WP13-04
Dissolved Metals (continued)							
Silicon, soluble	mg/L	3.3	3.3	3.2	4.6	9.5	--
Silver	mg/L	<0.00005	<0.00005	0.00005	<0.0005	<0.0005	--
Strontium	mg/L	0.27	0.10	0.11	0.69	0.56	--
Thallium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.002	--
Tin	mg/L	<0.0001	<0.0001	<0.0001	<0.001	<0.001	--
Titanium	mg/L	<0.0002	0.0004	0.0003	<0.002	0.046	--
Uranium	mg/L	0.302	0.0054	0.0078	0.002	<0.001	--
Vanadium	mg/L	0.015	0.0020	0.0017	0.001	0.012	--
Zinc	mg/L	0.0046	0.0025	0.0022	<0.005	0.051	--
Radionuclides							
Lead-210	Bq/L	0.18	0.05	<0.02	<0.02	<0.02	--
Polonium-210	Bq/L	0.02	0.01	0.005	<0.005	0.006	--
Radium-226	Bq/L	0.02	<0.005	<0.005	0.03	0.02	--
Thorium-230	Bq/L	<0.01	<0.01	<0.01	<0.01	0.02	--

mg/L = milligrams per litre, mg/L as $CaCO_3$ = milligrams per litre as calcium carbonate; µg/L = micrograms per litre; µS/cm = microSiemens per centimetre; N = nitrogen; Bq/L = Becquerels per litre; -- = no data available

9.3.2.5 Groundwater Flow

Monitoring wells were installed in the overburden and bedrock during the 2013 drilling program to assess hydraulic head across the tunnel alignment. Groundwater elevations along the tunnel alignment ranged from 263.9 to 323.7 metres above sea level (m ASL) in the bedrock and 271.95 to 314.94 m ASL in the overburden with higher groundwater levels corresponding to higher topographic areas and lower groundwater levels near Black Lake and Fond du Lac River. Groundwater flow in both the overburden and bedrock, therefore, appears to be similar to the topographic grade with groundwater flowing from high elevation areas in a radial pattern towards Black Lake, Fond du Lac River, and Middle Lake.

9.3.2.6 Hydraulic Conductivity

The hydraulic conductivities of the hydrostratigraphic units in the LSA were determined from packer testing performed at select boreholes in 2012 and at all six boreholes drilled in 2013. The results of the hydraulic conductivity testing are presented in Annex II.

The results of packer tests were used to develop probability distributions of hydraulic conductivity in bedrock, which inferred that:

- there were no meaningful differences in the hydraulic conductivity of the various bedrock units; and
- the bedrock at a depth of less than 45 m appears to be slightly more permeable than below this depth.

The geometric mean values of the hydraulic conductivity for the upper 45 m of bedrock are estimated to be about 1.3×10^{-7} metres per second (m/s) and for the deeper bedrock, it was about 5.5×10^{-8} m/s. The geometric mean of all the tests in bedrock was about 9.7×10^{-8} m/s.

During the 2002 investigation one falling head test was completed in an open borehole in the vicinity of the water intake, where a hydraulic conductivity of $2x10^{-5}$ m/s was measured in the soil material (Acres 2002). Drive point piezometers were installed in the overburden as part of the 2013 investigation. Falling head tests were conducted on the monitoring wells to determine the hydraulic conductivity of the overburden. The results ranged from $5x10^{-4}$ to $4x10^{-3}$ m/s, with a geometric mean of $4x10^{-4}$ m/s, consist with the results from 2002 and published values of similar lithologies.

9.3.2.7 Groundwater Inflow Model

Numerical simulations were conducted to estimate groundwater inflows to the power tunnel during excavation. A detailed assessment is presented in Appendix 9.2. The current conceptual and numerical hydrogeologic models indicate that the potential groundwater inflows to the proposed power tunnel and tailrace channel could be a maximum of approximately 1,100 cubic metres per day (m^3/day) in the base case scenario. In this scenario the groundwater loss from the unnamed lake north of the tunnel alignment (Lake A) could increase from approximately 35 m^3/day (pre-tunneling) to approximately 100 m^3/day (end of tunnelling). This increase is likely a most conservative estimate as the connection between the lake and the tunnel is considered as a discrete hydraulic conductivity zone which enhances the connection between the lake and the tunnel. This assumption is considered to be conservative as suggested from the 2013 drilling program where one potential shear zone was intersected and found to not be a significantly permeable zone. Furthermore, the model does not take into account any potential low permeability sediments at the bottom of the lake which would also affect flow between the lake and tunnel.

Sensitivity analyses were conducted by varying the fault, overburden and bedrock hydraulic conductivities, and the recharge through the overburden. The maximum inflow to the power tunnel and tailrace channel (4,700 m^3/day) predicted in these simulations were those for the case when a constant head was applied to the overburden, the overburden hydraulic conductivity was decreased, and the bedrock and fault hydraulic conductivity were increased.

Initial interpretations of the extent of overburden have been undertaken using air photographs and borehole logs. The results suggest that only about one-third of the Project location is overlain by greater than 1 m of overburden. There are limited data on the degree of saturation of these sediments. Considering the above observations, and assuming that the overburden where present at greater than 1 m thickness is saturated, then the upper bound is estimated to be 3,600 m^3/day (or approximately 2.3 times greater than the predicted inflow for the case when a saturated overburden is not considered). It is recommended that 3,600 m^3/day be used as an upper bound for the assessment.

9.4 Screening of Project Interactions and Mitigation

This section identifies and evaluates the interactions between Project components or activities and the correspondent potential environmental effects on groundwater. To provide a robust assessment of potential environmental effects, each interaction is initially considered to have a potential linkage to change in the environment and associated potential environmental effects on groundwater.

Each potential interaction is evaluated to determine if mitigation can be developed and incorporated to remove the interaction or limit the potential environmental effect on groundwater. Mitigation includes Project design elements, environmental best practices, and management policies and procedures, and it is developed through an iterative process between the Project's engineering and environmental teams. Knowledge of the hydrogeologic environment and mitigation is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for a residual environmental effect (i.e., effect remaining after incorporation of mitigation) on groundwater.

Interactions between the Project and the hydrogeologic environment are determined to be primary, secondary, or as having no linkage using scientific knowledge, professional judgment of technical specialists, logic and experience with similar developments and proposed mitigation (Table 9.4-1). Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by environmental design features and mitigation so that the Project results in no detectable (measurable) change and no residual effects on groundwater relative to baseline or guideline values;
- secondary – interaction could result in a minor change, but would have a negligible residual effect on groundwater relative to baseline or guideline values and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary – interaction is likely to result in a measurable change that could contribute to residual effects on groundwater relative to baseline or guideline values.

Using a conservative approach, any interactions that require a comprehensive assessment to determine if there is a residual environmental effect also are considered primary. Primary interactions are anticipated to result in a residual environmental effect on groundwater. Project interactions determined to have no linkage or those that are considered secondary are not predicted to result in environmental effects on groundwater. As such, interactions with no linkage or that are considered secondary are not analyzed further in this Environmental Impact Statement (EIS).

Project components and activities, and the associated mitigation implemented during the various Project phases, including accidents, malfunctions, and unplanned events are summarized in Table 9.4-1. Potential environmental effects on groundwater from each Project interaction and its associated classification are summarized in Table 9.4-1, with descriptions that are more detailed are provided in the subsequent sections.

Table 9.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to the Hydrogeological Environment

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ Blasting Activities	Construction	Use of explosives can affect groundwater quality.	■ A detailed Blasting Plan will be developed for the Project. ■ Best practices, as outlined in the Blasting Plan for the Project, will be applied to blasting activities to limit potential for enhanced nitrogen loading of groundwater inflows due to the placement and use of ammonium nitrate fuel oil (ANFO) during construction. ■ A Site Water Management Plan will be developed for the Project. ■ Construction and monitoring of settling ponds or water treatment areas will be part of the Site Water Management Plan.	No Linkage
■ Construction of the Power Tunnel	Construction	Dewatering of the power tunnel during construction may change groundwater quantity.	■ n/a	Secondary
■ Air Emissions ▪ emission of dust from blasting activities and hauling waste rock to disposal areas. ▪ emission of standard pollutants from vehicles and heavy equipment operation	Construction Operations Closure	Deposition of criteria air contaminants can change soil quality, which can affect groundwater quality.	■ Equipment will be regularly maintained for compliance with provincial and federal air emission standards. ■ The equipment used for hauling and mucking operations will operate using diesel fuel with an ultra-low sulphur content (less than 15 ppm). ■ The heavy-duty stationary and mobile diesel-fueled equipment fleet will meet or exceed EPA Tier 2/3 air quality emissions standards. ■ The gasoline-fueled equipment fleet will meet or exceed EPA Tier 2 Bin 6 air quality emissions standards. ■ An EnvPP will describe material handling protocols including dust management. ■ Soil salvage stockpiles or exposed soils will be seeded as appropriate for the area. ■ All unpaved roads will be watered on a regular basis to prevent wind driven fugitive dust. ■ A speed limit will be enforced on unpaved roads on site. ■ A forced air method of ventilation will be used for venting of dust, gases and fumes from inside the power tunnel following blasting and will be carried out until air quality inside the working environment returns to acceptable levels.	No Linkage
		Dust deposition can change the chemical properties of soil, which can affect groundwater quality.		No Linkage
■ Power Generation Activities ▪ water withdrawal for power generation ▪ diversion of water through the power tunnel to the powerhouse ▪ discharge of tailrace channel flows	Operations	Diversion of water through the power tunnel may change groundwater quantity.	■ A submerged weir will be constructed on the Fond du Lac River at the outlet of Black Lake and will be designed to maintain the range of water levels in Black Lake and in the uppermost section of the Fond du Lac River within the historical range, for all powerhouse operating flow conditions. ■ The tailrace channel outlet will be located upstream of important fish spawning habitat near the Fond du Lac River outflow to Middle Lake to maintain minimum required flows at this location. ■ For planned or unplanned shutdowns longer than 15 minutes duration during the spring spawning and rearing period (May 15 to July 15) and low winter flow period, downstream flows will be maintained by bypassing water around the powerhouse turbine generator unit using a bypass conduit. ■ A spring spawning trigger flow (by May 1) of 70 m^3/s will be implemented to support successful spawning of Arctic grayling and other spring spawners in the Fond du Lac River. ■ Rock material used to construct the submerged weir will be tested and will consist of rock with low potential for acid generation or radioactive materials.	No Linkage
		Maintenance shutdowns of power generation activities can change groundwater flow.	■ Scheduled maintenance shutdowns will occur annually on a unit-by-unit basis and are estimated to last from a few days up to two weeks. ■ Only one unit at a time will be removed from service for maintenance. ■ Maintenance shutdowns will be timed to limit effects, for example during winter months, during other periods when there is low flow available to pass through the powerhouse turbine generator units, or during summer when sufficient in-river flow is available. ■ Each unit may be taken out of service, once per month, to perform minor adjustments, inspections, and maintenance. ■ The power tunnel will be drained for inspection for one to two weeks approximately every five years. ■ Major overhaul work on the turbine and generator units will be completed approximately every 30 years.	No Linkage

Table 9.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to the Hydrogeological Environment (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ Potable and Industrial Water Supply	Construction	Water withdrawal for domestic (e.g., potable water) and industrial (e.g., dust suppression) purposes can change groundwater flow.	■ Potable water for the construction camp is anticipated to be sourced from one or more new wells located near the camp, although this water could potentially be drawn from either Black Lake or the Fond du Lac River.	Secondary
■ Site Water Management ▪ collection and treatment of surface runoff within the project footprint ▪ discharge of wastewater ▪ collection and treatment of groundwater in the power tunnel	Construction and Operations	Collection and disposal of wastewater from the site can affect groundwater quality.	■ A Site Water Management Plan will be developed for the Project. ■ Construction and monitoring of settling ponds or water treatment areas will be part of the Site Water Management Plan. ■ Groundwater originating from construction of the power tunnel will be collected, monitored, and treated (if necessary) to confirm discharge criteria are met prior to release into the receiving environment. ■ Runoff from the waste rock disposal areas will be directed to settling ponds prior to discharge to the Fond du Lac River. ■ Wastewater released from the settling ponds will meet applicable water quality guidelines (CCME) at the end of the mixing zone. ■ Contingency plans for off-site disposal of dewatered settling pond sludge will be included in a Construction Environmental Management Plan. ■ Implementation of Water Quality Monitoring Program.	No Linkage
■ Waste Rock Disposal Areas	Construction Operations Closure	Seepage from waste rock disposal areas can change groundwater quality.	■ A Waste Rock Management Plan will be developed for the Project. ■ Excavated material will be stored away from watercourses or lakes. ■ Excavated rock and aggregate materials will be tested to confirm that this material will not have negative effects on the surrounding environment. Specific mitigation measures (engineered containment) will be applied if the material is identified to be acid generating, or contain elevated levels of metals or radionuclides. ■ Construction and monitoring of settling ponds or water treatment to receive runoff from the waste rock disposal areas will be included in the Site Water Management Plan. ■ Additional site investigation and laboratory testing will be completed upon completion of the final Project design and during construction of the Project.	No Linkage
■ Closure Activities	Closure	Cessation of power generation activities, including the withdrawal, diversion, and discharge of water, can change groundwater flows.	■ A Decommissioning and Reclamation Plan will be developed for the Project. ■ A series of concrete bulkheads will be placed in the power tunnel, if necessary, to isolate mineralized bedrock zones and reduce potential for mineralized groundwater to discharge through the power tunnel. ■ Quality of groundwater discharging through the power tunnel at the decommissioning phase may be monitored and sampled, if required.	Secondary

Table 9.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to the Hydrogeological Environment (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ Accidents, Malfunctions and Unplanned Events ▪ hazardous materials spills ▪ failure of embankment dyke	Construction Operations Closure	Release or spills of hazardous substances (e.g., fuel, oil) can change groundwater quality.	■ Individuals working on-site and handling hazardous materials will be trained in WHMIS and TDG. ■ Controlled products will not be allowed on-site unless accompanied by approved labels and MSDS. ■ All fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard; a lined and dyked containment area around these tanks will be provided to contain any potential fuel spills. The design of the containment area will be based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. ■ The storage containers will be regularly inspected for leaks or damage, and replaced when necessary. ■ Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled, and located in lined and bermed containment areas. ■ Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers. ■ Regular maintenance of construction equipment. ■ Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. ■ Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills of fuel would flow to the sump, which would be pumped out to a container for shipment off-site. ■ An Emergency Response Plan will be developed. ■ Spill response material (e.g., sorbent pads) will be stored on-site in designated areas and in vehicles. ■ Contaminated (impacted) soils will be removed and disposed of in an approved landfill or waste management facility.	No linkage
	Construction Operations Closure	Failure of the embankment dykes around the settling ponds can change groundwater quality.	■ Fill material used for constructing the embankment dykes around the settling pond will be clean mineral soil with sufficient moisture to allow for proper compaction. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap as soon as practical following construction. ■ Water produced during construction or runoff through the site will be contained, tested and treated if required before release in accordance with the regulations. ■ The settling ponds will be engineered to provide adequate storage of wastewater streams under normal and extreme operating conditions (e.g., settling ponds will be designed to contain the 1:100 year storm event). In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling ponds would be provided by the inclusion of an overflow spillway in the embankment. ■ The settling ponds will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. ■ During the detailed design stage, additional mitigation could be identified and included as part of the Environmental Protection Plan and the Emergency Response Plan.	No Linkage

EnvPP = Environmental Protection Plan; CCME = Canadian Council of Ministers of the Environment; WHMIS = Workplace Hazardous Materials Information System; TDG = Transportation of Dangerous Goods; MSDS = Material Safety Data Sheets; ppm = parts per million; m^3/s = cubic metres per second

9.4.1 Interactions with No Linkage to Effects

An interaction may have no linkage to environmental effects if the activity does not occur, or if the interaction is removed by mitigation so that the Project results in no detectable change in measurement endpoints, and subsequently, no effect on groundwater. The following interactions are anticipated to have no linkage to effects on groundwater and will not be carried through the environmental effects analysis.

- **Use of explosives can affect groundwater quality.**

During the construction phase of the Project, blasting activities will occur as the power tunnel progresses. The use of explosives could potentially introduce ammonia and nitrates to the groundwater. A Blasting Plan is expected to be developed for the Project, which will describe the type of explosives used (e.g., ammonium nitrate/fuel oil [ANFO] and water-resistant explosives like Unimax® or similar) and the method of detonation (e.g., singular versus sequential blasting). At the present time, ANFO is expected to be used for the tunnel excavation. As part of this Blasting Plan, best practices will be applied to blasting activities to reduce the potential for enhanced nitrogen loading of groundwater.

Pumping of groundwater will occur during the construction phase of the Project, which will cause drawdown in groundwater levels around the power tunnel. This drawdown should prevent the release of ammonia or nitrate from blasting into groundwater. Waste rock produced from blasting activities is expected to contain trace amounts of residual substances from use of the explosives; therefore, surface water runoff from the waste rock disposal areas might contain residual substances. Potentially contaminated wastewater from waste rock disposal areas run-off will be collected in on-site settling ponds. Once wastewater is collected, it will be tested and treated, if required, prior to discharge. Wastewater will meet applicable water quality guidelines (e.g., CCME) prior to being released into a the Fond du Lac River. Consequently, changes to groundwater quality from the use of explosives are predicted to be non-detectable, and are determined to have no linkage to effects on groundwater.

- **Diversion of water through the power tunnel may change groundwater quantity.**

Construction and operation of the Project may also affect groundwater quantity. Some entrainment of groundwater flows within the power tunnel flows may occur during Project operation. Therefore, withdrawal of water from Black Lake during operations has the potential to change groundwater infiltration. The water table is anticipated to be near the ground surface in the Project area, based on the relatively low hydraulic conductivity of the bedrock at this location. Little infiltration from precipitation is expected. The general regional groundwater flow directions are expected to be similar to the topographic grade. Groundwater is expected to flow from high elevation areas in a radial pattern towards Black Lake, Fond du Lac River, and Middle Lake. Overall, the diversion of water through the power tunnel is not predicted to change groundwater quantity. Therefore, this interaction is determined to have no linkage to effects on groundwater.

- **Deposition of criteria air contaminants can change soil quality, which can affect groundwater quality.**
- **Dust deposition can change the chemical properties of soil, which can affect groundwater quality.**

Construction and operation of the Project will generate air emissions such as carbon monoxide (CO), oxides of sulphur (SO_x, includes sulphur dioxide [SO_2]), oxides of nitrogen (NO_x), particulate matter ($PM_{2.5}$, PM_{10}), and total suspended particulates (TSP). Air quality modelling was completed to predict the spatial extent of air and dust emissions and deposition from the Project (Section 8.5). Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates.

Air emissions (i.e., SO_2 and NO_2) can result from the use of fossil fuels in generators, vehicles, and machinery during construction and operation of the Project. The deposition of SO_2 and NO_2 can alter soil pH, nutrient content, and cause acidification of the soils, which could lead to changes in groundwater quality. Brunisolic soils in the RSA were rated as having a high sensitivity to acidification (Section 13.3.3.2). Gleysolic soils were rated as having a Low to High sensitivity; however, this is dependent on proximity to wetlands. Organic soils that occur in moderate and rich fens are least susceptible to acidification and therefore have a Low sensitivity rating. Organic soils that occur in bogs and in poor fens have a Medium sensitivity rating.

Results of the air quality modelling indicate that the maximum ground-level concentrations of CO, SO_2 and NO_x are all below the Saskatchewan Ambient Air Quality Standards (SAAQS 1996) and the Canada Wide Standard (CCME 2000) (Section 8.5.1), and are limited to the immediate vicinity of the Project. Therefore, the results indicate that deposition of SO_2 and NO_x will not likely result in changes to soil pH. Overall, it is expected there will be no changes to soil quality from SO_2 and NO_x. Consequently, changes to groundwater quality are not expected.

Dust deposition can cause chemical loading in soils as dust emissions can include metal particles. Modelling results indicate that the Project's maximum annual emissions rate is 0.020 tonnes of H+ per day (t/d) and the average for the 2014 to 2017 construction period is 0.014 t/d. These values are well below the Saskatchewan Ministry of Environment's threshold of 0.175 t/d. The Project's potential for acid deposition is low and therefore, it is expected there will be no change to soils from acidification.

Most of the traffic to the Project will occur during construction. All unpaved roads will be watered regularly to prevent wind driven fugitive dust. Speed limits will be enforced to reduce dust generation from roads. Once construction is complete, the number of vehicles travelling to and from the Project is expected to decrease (Section 5.5.1). Modelling results indicate that the maximum predicted TSP and $PM_{2.5}$ concentrations are 114.4 $\mu g/m^3$ and 22.8 $\mu g/m^3$, respectively, which do not exceed the SAAQS and Canada-Wide Standard (Section 8.5.1.2.3). Because PM and TSP predictions are below applicable criteria, it is expected there will be no changes to soil quality, and subsequently, to groundwater quality. Overall, air and dust emissions and subsequent deposition are not expected to result in measureable changes to groundwater quality; therefore, these interactions were determined to have no linkage to effects on groundwater.

- **Collection and discharge of wastewater can affect groundwater quantity and quality.**

Discharge of wastewater during Project construction and operation can change groundwater quality and quantity. Site wastewater will be of several types, including waste rock runoff, groundwater collected during the construction of the power tunnel, general site runoff, and water in settling ponds. To mitigate effects on groundwater, a Site Water Management Plan will be developed for the Project.

Three settling ponds have been included in the construction plan for the Project and will act as environmental design features for the treatment and management of the Project's wastewater (other than site runoff and sewage and grey water). One settling pond will be located near the water intake to collect the intake construction water along with a portion of the power tunnel dewatering flows and waste rock runoff from the waste rock disposal area south of the intake (Figure 5.1-1). A second settling pond will be located near the powerhouse excavation to collect the remainder of the power tunnel and powerhouse dewatering. A third settling pond, beside the downstream end of the tailrace channel, will collect the tailrace channel dewatering and any runoff directed from the main waste rock disposal areas to the northeast of the tailrace channel (Figure 5.1-1). Water collected in disturbed areas located away from the settling ponds will be pumped to these locations. Surface water diversions could also be constructed to maintain natural drainage characteristics, whereas other structures could be designed to actively divert water away from its natural flow path to prevent the interaction with site infrastructure, potentially contaminated water, or areas sensitive to erosion.

Retention of runoff in the settling ponds will allow suspended sediments and associated parameters (e.g., some metals) to settle out. This water will eventually be discharged downstream to its natural receiving waterbody (the Fond du Lac River through the tailrace channel). The Water Quality Monitoring Program will be developed during the permitting process to determine the nature of potential changes to the water quality of the Fond du Lac River receiving discharge from the settling ponds. Water in the settling ponds will be pumped to the Fond du Lac River after the water has been tested and treated (if necessary) to meet appropriate discharge criteria. Contingency plans for off-site disposal of dewatered settling pond sludge will be included in the EnvPP. Contingency plans for off-site disposal of dewatered settling pond sludge will be included in the EnvPP.

During power tunnel construction, it is estimated that a maximum of 3,600 m^3 of groundwater will seep into the power tunnel each day (m^3/day). The volume of groundwater inflow is expected to be 680 m^3/day during operations. Power tunnel seepage water will be pumped into above ground settling ponds where it will be treated, if required, and monitored to confirm discharge criteria are met prior to release into the environment.

Overall, surface water runoff and wastewater from the Project are expected to result in non-detectable changes to groundwater quantity and quality, relative to baseline conditions. Therefore, these interactions were determined to have no linkage to effects on groundwater.

- **Maintenance shutdowns of power generation activities can change groundwater flow.**

Regular maintenance will be conducted on the power tunnel during operations. Groundwater flow could be affected by shutdowns due to diversion of water. To limit the potential effect of the scheduled maintenance, shutdowns of the turbines will occur annually on a unit-by-unit basis and are estimated to go on from a few days up to two weeks. Only one unit at a time will be removed from service for maintenance. Maintenance shutdowns will be completed during winter months or during other periods when there is less flow available to pass through the plant. The power tunnel will be drained for inspection for one to two weeks approximately every five years. Major overhaul work on the turbine and generator units will be completed approximately every 30 years. No detectable changes to groundwater quality relative to baseline conditions are anticipated, therefore, no linkage to effects on groundwater are expected.

- **Seepage from waste rock disposal areas can change groundwater quality**

Construction of the powerhouse, water intake, power tunnel, and tailrace channel will produce approximately 1,074,000 m^3 of waste rock and 118,000 m^3 of overburden that will need to be stored on-site. The exposure of the waste rock disposal areas to oxygen, precipitation, and subsequent infiltration and run-off could affect the groundwater quality. The waste rock disposal areas will be placed in locations that are easily modified to control seepage and a Waste Rock Management Plan will be prepared for the Project. Site grading, ditches, and berms will be used to capture runoff from the waste rock disposal areas, which will be sent to settling ponds.

Some portion of the waste rock excavated from the power tunnel could be acid-generating, have elevated concentrations of various metals, or contain uranium mineralization, particularly waste rock from the section of the power tunnel within, or near, the Black Lake Shear Zone. Previous geological testing has confirmed that radioactive waste rock is not likely to be encountered in the LSA (Hatch 2005, 2012). However, a Waste Rock Management Plan will be prepared for the Project that will outline methods to visually identify and classify waste rock including the rock type, waste unit designation, and ARD/ML potential. The rock will be segregated for special management if the bedrock materials are determined to be potentially acid-generating or contain metals. On-site geochemical characterization will be performed using simple visual techniques that can be learned and implemented by site personnel who have little or no geological background. It is anticipated that the waste rock will be classified into one of three materials types with respect to ARD potential or radioactivity: negligible, low, or uncertain potential.

The results of the on-site visual classification will be recorded along with the blast designation, the waste unit designation, and the disposal location. Representative samples of waste rock from within or near the Black Lake Shear Zone, or displaying evidence of uranium mineralization, will be screened using a scintillometer. Offsite confirmatory analyses will be carried out to confirm the visual classification. Confirmatory sampling of waste units with negligible or low potential for ARD or uranium will occur at a lower frequency than waste units with uncertain potential. In the event that drainage from specific portions of the waste rock disposal area cannot be monitored separately, or does not occur as a defined flow, field-monitoring bins could be constructed with leachate from the waste rock being sampled in the same manner as would occur with direct sampling of waste rock runoff. Regular visual inspections of the waste rock disposal areas will take place during active periods of power tunnel excavation. It is expected that a designated waste rock disposal area would be set aside to isolate materials deemed to be potentially ARD generating or that could contain uranium.

Any rock waste that is found to be radioactive will be disposed of according to provincial and federal guidelines. Environmental design features will be required to limit seepage from the waste rock disposal areas. A containment system will be designed to control seepage from the waste rock disposal areas to groundwater or underlying aquifers. The design will control shallow horizontal migration. Potentially contaminated wastewater from waste rock disposal areas run-off will be collected in on-site settling ponds. Once wastewater is collected, it will be tested and treated, if required, prior to discharge. Wastewater will meet applicable water quality guidelines (e.g., CCME) prior to being released into a the Fond du Lac River.

If no adverse characteristics are identified in the waste rock, this material can be used as aggregate for road construction and concrete production. It can be used as riprap to armour the walls of the tailrace channel or to construct the weir across the Fond du Lac River at Grayling Island. Re-use of clean waste rock at the Project site will reduce the overall volume stored in the waste rock disposal areas.

With the proposed life of the Project being approximately 90 years, there is potential for long-term contaminant transport from the waste rock disposal areas that could affect groundwater quality. To mitigate the potential for long-term contaminant transport, the potentially ARD/ML or radioactive waste rock disposal areas will be placed on engineered pads that will limit infiltration. Furthermore, recharge of groundwater to bedrock aquifer systems typically is limited to fracture networks. Therefore, a release of contaminants from the waste rock disposal areas is more likely to occur in the downstream surface water environment and not in the groundwater system.

Ongoing monitoring requirements outside of those specified within the Project license would default to terms outlined within the relevant federal and provincial acts, regulations, and standards applicable at the time. Effects to groundwater quality from seepage and long-term contaminant transport from the waster rock pile are expected to be limited using mitigation and environmental design features. Therefore, these interactions are not expected to result in detectable changes in groundwater quality and were determined to have no linkage to effects on groundwater.

9.4.2 Interactions with Secondary Linkages

In some cases, both a source and an interaction exist, however, the resultant change caused by the Project is anticipated to be so minor there is no measureable or detectable environmental effect on groundwater relative to baseline or guideline values. The following interactions are expected to be minor and therefore will not be carried through the residual environmental analysis.

- **Dewatering of the power tunnel during construction may change groundwater quantity.**

During the construction of the power tunnel, water intake, and tailrace channel, work will be completed “in the dry” and potential seepage into these areas will require dewatering. The period of dewatering could continue throughout construction (i.e., three years), but is not expected to reach maximum drawdown rates until the latter stages. Dewatering activities may drawdown the local groundwater table and affect water volumes in surface waterbodies located within the zone of influence. To determine the potential effect on groundwater, a groundwater inflow model was constructed; the detailed results are presented in Appendix 9.2.

The results of the model show that the potential groundwater inflows to the power tunnel and tailrace channel could be a maximum of approximately 1,100 m^3/day in the base case scenario. The base case scenario represents the conservative case with respect to potential changes to the water balance of the unnamed lake north of the tunnel alignment (Lake A) owing to groundwater flow to/from the lake. In this scenario, groundwater loss from Lake A will increase from approximately 35 m^3/day (pre-tunneling) to approximately 100 m^3/day (end of tunnelling).

Sensitivity analyses were conducted by varying the fault, overburden and bedrock hydraulic conductivities, and the recharge through the overburden. The maximum inflows to the power tunnel and tailrace channel (4,700 m^3/day) predicted in these simulations were those for the case when a constant head was applied to the overburden, the overburden hydraulic conductivity was decreased, and the bedrock and fault hydraulic conductivities were increased.

Minor changes to the groundwater flow directions in the southern portion of the LSA are predicted. Groundwater flow in this area is typically in a south-southeast direction towards the Fond du Lac River; however, with the excavation of the power tunnel and tailrace channel, groundwater flow is expected to occur in an east-northeast direction towards the power tunnel and tailrace channel. Discharge of groundwater will still report to the Fond du Lac River and Middle Lake. Therefore, this interaction was determined to have a negligible residual effect on groundwater.

- **Water withdrawal for domestic (e.g., potable water) and industrial (e.g., dust suppression) purposes can change groundwater levels and flow.**

Potable water for the construction camp is anticipated to be sourced from one or more new wells located near the camp, although this water could potentially be drawn from either Black Lake or the Fond du Lac River. Water usage will vary depending on the number of workers on-site and is expected to be greatest during the construction phase of the Project when up to 250 people are expected to be on-site. Water requirements for the construction phase can reach up to 4,700,000 litres (L) per year (i.e., approximately 13 m^3/d) for industrial water and potable water use is expected to be between and 30,000 and 45,000 litres/day). During operations, approximately 365,000 L/year (i.e., 1 m^3/d) of water will be required for the Project. Potable water will be drawn from the penstock and treated for use. Industrial water (i.e., used for fire suppression, preparing concrete, and controlling road dust) will be taken from Black Lake (i.e., intake location) and the Fond du Lac River (i.e., bridge location). Overall, minor changes to groundwater quantity are expected if potable and industrial water were to be sourced from wells on-site. Therefore, residual effects on groundwater are anticipated to be negligible.

- **Cessation of power generation activities, including the withdrawal, diversion, and discharge of water, can change groundwater levels or groundwater quality.**

The temporal boundary for Project operation is 90 years; however, the operational lifespan of the Project is expected to extend beyond this. Upon cessation of power generation activities, the power tunnel will be decommissioned, which could affect groundwater level, flow, and quality. The power tunnel void may create a directly interconnected flow path for groundwater from the Black Lake area to the Fond du Lac River to the west. To limit the potential effects on groundwater, concrete bulkheads will be placed in the power tunnel at the water intake, powerhouse, and at other possible locations within the tunnel to limit flow of mineralized groundwater. A valve equipped discharge pipe will be constructed within the downstream bulkhead to allow for long-term monitoring of groundwater quality. It is anticipated that groundwater levels and flow will return to pre-Project conditions after closure.

The effect of cessation of power generation activities on groundwater quality are expected to be minor based on the results presented in the geochemical characterization (Appendix 9.1). The exposure of a larger amount of bedrock surface in the power tunnel to groundwater interaction is not expected to result in increased loading of potential contaminants to the groundwater environment. Overall, cessation of power generation activities could cause a minor change in groundwater levels, flow, and quality. As such, this interaction is anticipated to have a negligible effect on groundwater.

9.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events occurring on-site have the potential to adversely affect groundwater. The following events were identified as having potential interaction with groundwater.

- **Release or spills of hazardous substances (e.g., fuel, oil) can change groundwater quality.**

Spills during construction, operations, or closure activities have the potential to adversely affect groundwater. Spills that occur in high enough concentrations could contaminate surface waters or soil, and subsequently affect groundwater quality. Spills are generally preventable and local in nature. Spills will be promptly reported and managed according to the procedures identified in the Emergency Response Plan. Mitigation identified in the EnvPP will be implemented to reduce the likelihood and extent of spills associated with the Project.

The powerhouse will be equipped with an oil containment and separation system to prevent the release of petroleum-based wastes into waterways. The turbine governor pumping systems will be surrounded by trenches or curbs to allow drainage through a trench or sumps to catch and to transfer wastes to the powerhouse oil separation system. Any room with the potential to produce an oil spill will also be equipped with containment curbs and door ramps. Additionally, the governor hydraulic power units will be high-pressure systems to reduce the potential for spills by limiting the total volume of hydraulic oil in the system. The main transformers will be removed from the main tailrace channel deck and surrounded by oil spill containment walls to reduce the potential for spills to interact with the waterways. Double-walled heat exchangers will be used for the turbine and generator cooling systems to reduce the risk of cooling coil failure will discharge oil into the water. Self-lubricated bushings will be employed throughout the design to eliminate sources of water pollution typical of greased bushings.

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks and to limit the effects of spills and leaks on groundwater. Spill containment supplies will be available in designated areas and within Project vehicles. An Emergency Response Plan will be developed and will include instruction for the rapid response, control, and management of spills or release of hazardous substances occurring on site. All spills will be isolated and immediately cleaned up. Spills will be reported to the appropriate agency if the spill exceeds reportable volumes for the material spilled as outlined in the provincial Environmental Spill Control Regulations (Government of Saskatchewan 1981, with amendments). In the unlikely event of a large spill, disposal of all contaminated soil will be handled by a licensed contractor and will be hauled off-site to an approved disposal facility. Alternative approaches for in-situ treatment of contaminated soils may also be considered (e.g., phyto- or bio- remediation), depending on the substance spilled and capacity to treat the volume of material affected.

Storage facilities for hazardous wastes will meet regulatory requirements. All fuel storage tanks will be designed and constructed based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. The storage containers will be regularly inspected for leakage or damage, and replaced when necessary. Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double-walled and located in lined and bermed containment areas. Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers.

Vehicles will be regularly maintained and will carry fire extinguishers and standard emergency clean-up kits. Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired near waterbodies. Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills on the fueling stations would flow to the sump, which would be pumped out to a container for shipment off-site.

Implementation of the above mentioned environmental design features are expected to reduce the likelihood and extent of the release or spills of hazardous materials occurring on-site. No detectable changes to groundwater quality relative to baseline conditions are anticipated. Therefore, these interactions are determined to have no linkage to effects on groundwater.

- **Failure of the embankment dykes around the settling ponds can change groundwater quality.**

Failure of embankment dykes around the settling ponds could result in the release of sediment laden water and potential contaminants to the environment. Environmental controls will be in place to limit the potential for embankment dyke failure. For example, water from the waste rock disposal areas will be diverted to the settling ponds by gravity. The settling ponds will be engineered to provide adequate storage of process streams under normal and extreme operating conditions. Maximum operating levels will be developed to provide adequate storage volumes for the design storm event. In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling pond would be provided by the inclusion of an overflow spillway in the embankment.

The embankment dyke will be constructed around the settling pond to contain wastewater from site and from the waste rock disposal areas. Embankment dykes will be stripped of vegetation, topsoil, and roots to expose the mineral soil subgrade as necessary to accommodate the size of the settling pond. Fill material used for constructing the dyke will be clean mineral soil with sufficient moisture to allow for proper compaction and will be placed in lifts not exceeding 150 millimetres (mm) in compacted thickness and compacted to a minimum of 95% standard proctor maximum dry density. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap immediately following construction.

The settling pond will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. During the detailed design stage, additional mitigation will be identified and included as part of the EnvPP and the Emergency Response Plan. Consequently, embankment dyke failure was determined to have no linkage to effects on groundwater.

9.4.4 Primary Interactions

The environmental effects analysis considers all primary interactions that result in expected changes to groundwater after implementing mitigation. However, the mitigations implemented as part of the Project are expected to negate any potential interactions, therefore, no primary interactions were identified to result in residual effects on groundwater.

9.5 Environmental Management, Monitoring, and Follow-up

Monitoring programs implemented during the Project may include a combination of environmental monitoring to track conditions and implement further mitigation as required (e.g., monitoring of groundwater inflow quantity during construction), and follow-up monitoring to verify the accuracy of the effect predications and inform adaptive management and implementation of further mitigation as required.

The rate of groundwater inflow will be monitored as power tunnel construction progresses so there is advanced warning if flow volumes increased faster than expected. Groundwater quality will be monitoring during construction and operation of the Project, and following closure. Results from this monitoring program will be used to support development and adjustments to the Decommissioning and Reclamation Plan. Project closure requires input from regulatory agencies and communities to identify closure objectives and strategies; therefore, the specifics of the monitoring program is unknown at this time.

9.6 References

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9.7 List of Acronyms

Acronym	Definition
ANFO	ammonium nitrate/fuel oil
ARD	acid rock drainage
CAI	Cerchar Abrasivity Index
CCME	Canadian Council of Ministers of the Environment
CO	carbon monoxide
EHS	Environmental, Health, and Safety
EIS	Environmental Impact Statement
EnvPP	Environmental Protection Plan
LSA	local study area
ML	metal leaching
MSDS	Material Safety Data Sheets
NO_x	oxides of nitrogen
PM	particulate matter
Project	Tazi Twé Hydroelectric Project
RSA	regional study area
SAAQS	Saskatchewan Ambient Air Quality Standards
SO_2	sulphur dioxide
SO_x	sulphur
TDG	Transportation of Dangerous Goods
TDS	total dissolved solids
TSP	total suspended particulates
UCS	unconfined compressive strength
VC	valued component
WHMIS	Workplace Hazardous Material Information System

9.8 List of Units

Term	Definition
%	percent
<	less than
µg/L	micrograms per litre
µS/cm	microSiemens per centimetre
Bq/L	Becquerels per litre
cps	counts per second
kg	kilograms
km	kilometres
km^2	square kilometres
L	litres
m	metres
mm	millimetres
m ASL	Metres above sea level
m^3/day	cubic metres per day
m^3/s	cubic metres per second
m/s	metres per second
mg/L	milligrams per litre
MPa	Megapascals
ppm	parts per million
t/d	tonnes per day

10.0 HYDROLOGY

10.1 Introduction

The purpose of the hydrology section is to describe the surface water environment that could be affected by the Tazi Twé Hydroelectric Project (Project) and to assess the potential environmental effects from the Project on hydrology. The scope of the hydrology section includes an analysis of Project-related changes to hydrology during construction, operations, and closure, and considers accidents, malfunctions, and unplanned events. Potential effects from the Project on hydrology are evaluated together with potential cumulative environmental effects from the Project and other applicable developments.

Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples and the public. The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development, and are therefore, used to predict the effects of the Project on all environmental components. Rationale for selection of hydrology as a VC is as follows:

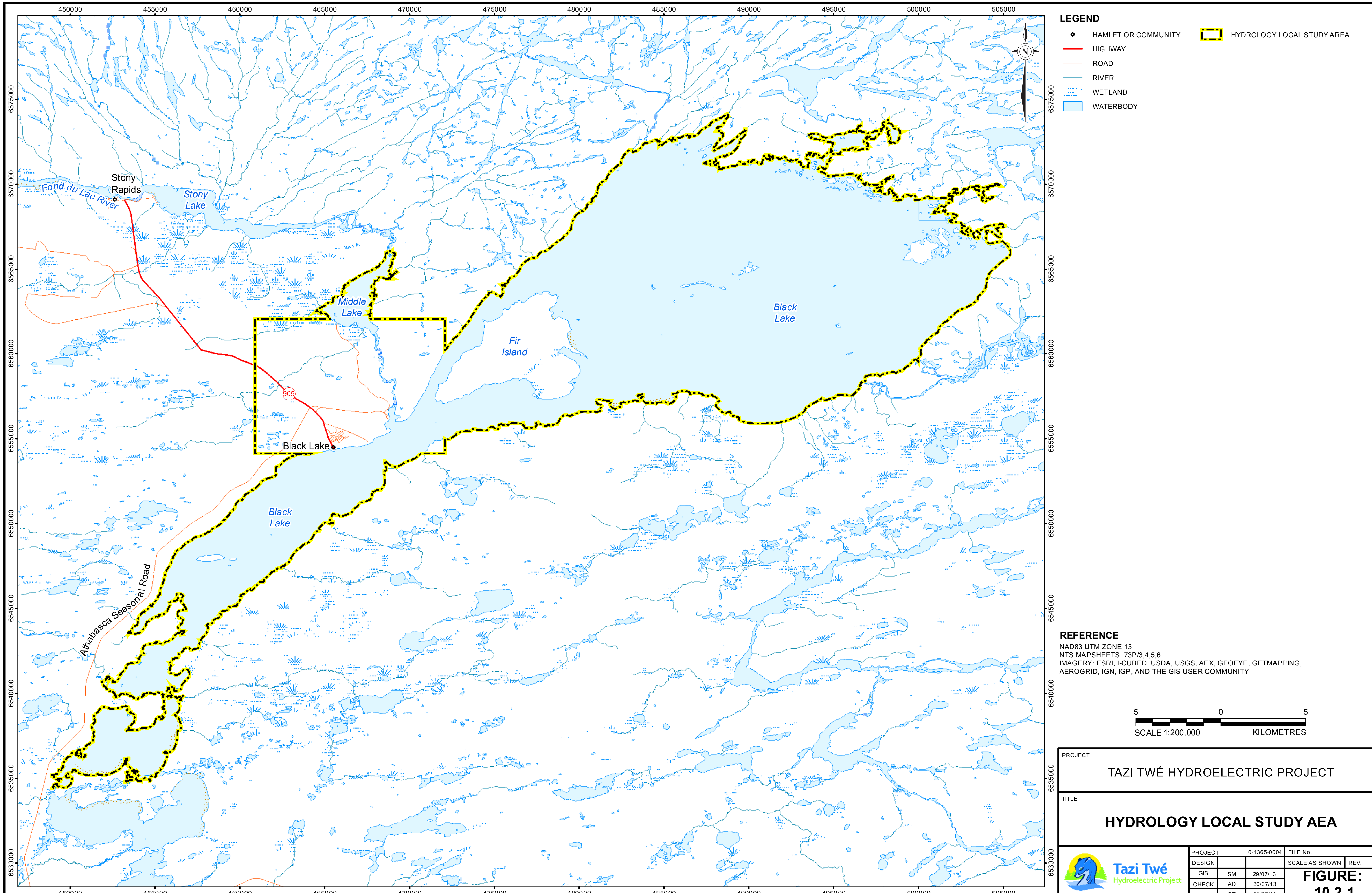
- availability of surface water to sustain aquatic life was identified as a concern by the public, First Nations and Métis, and regulatory agencies in the Project region;
- natural and human-related disturbances can alter the timing and nature of the interaction between physical and biological components of the surface water environment; and
- changes to surface water quantity can influence components of the terrestrial environment and the availability of natural resources for traditional and non-traditional human use.

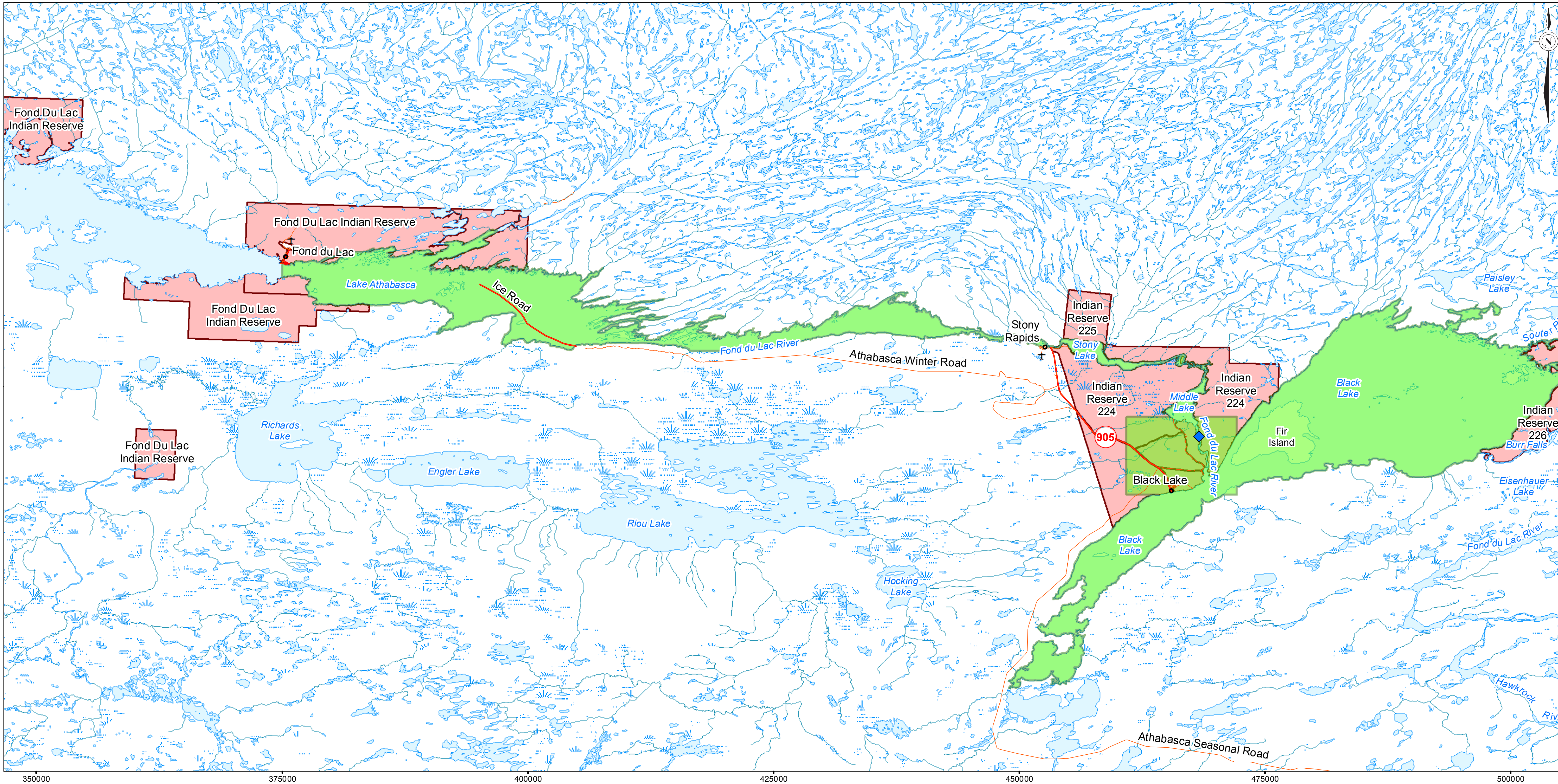
The assessment endpoint is the key property that should be protected for use by future human generations and although hydrology was selected as a VC, it does not have an assessment endpoint (Section 7.2). The results of this assessment are instead used in the effects analysis for other VCs (e.g., surface water quality, fish and fish habitat, soils, vegetation, and wildlife). The measurement endpoints are quantifiable and qualitative expressions of change to hydrologic parameters, and include water level, waterbody volume, flow rates, and watershed area.

10.2 Spatial Boundaries

To quantify baseline conditions and evaluate potential environmental effects on hydrology, a local study area (LSA) and regional study area (RSA) were defined. Potential direct effects and indirect effects on the surface water environment from the Project are predicted to occur in three major waterbodies: Black Lake, the section of the Fond du Lac River between Black Lake and Middle Lake, and Middle Lake. Effects could occur in smaller waterbodies and watercourses in upland areas under the Project footprint and immediately downstream. The LSA for the hydrology assessment includes Black Lake, the Fond du Lac River (between Black Lake and Middle Lake), Middle Lake and upland areas associated with site infrastructure, and the corresponding downstream areas (Figure 10.2-1).

While no direct or indirect effects are predicted to occur upstream of Black Lake, larger-scale direct effects and indirect effects could propagate into the downstream environment. Lake Athabasca is the receiving waterbody of the Fond du Lac River and is considered the downstream extent of the RSA. Thus, the RSA for the hydrology assessment is defined as Black Lake, the Fond du Lac River, and Lake Athabasca to the community of Fond du Lac, including all areas in the LSA (Figure 10.2-2).


LEGEND
HAMLET OR COMMUNITY
HIGHWAY
ROAD
RIVER
WETLAND
WATERBODY
HYDROLOGY LOCAL STUDY AREA
Stony Rapids
Fond du Lac River
Stony Lake
Middle Lake
Fir Island
Black Lake
Black Lake
Black Lake
905
Athabasca Seasonal Road
REFERENCE
NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
IMAGERY: ESRI, I-CUBED, USDA, USGS, AEX, GEOEYE, GETMAPPING, AEROGRID, IGN, IGP, AND THE GIS USER COMMUNITY
5 0 5
SCALE 1:200,000
KILOMETRES
PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT
TITLE
HYDROLOGY LOCAL STUDY AEA
Tazi Twé
Hydroelectric Project
PROJECT 10-1365-0004
FILE No.
DESIGN
SCALE AS SHOWN
REV. 0
GIS SM 29/07/13
CHECK AD 30/07/13
REVIEW BT 30/07/13
FIGURE: 10.2-1



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WETLAND
- WATERBODY
- INDIAN RESERVE
- ELIZABETH FALLS
- REGIONAL STUDY AREA

REFERENCE

DMTI HIGHWAYS AND ROADS
NTS MAPSHEET 74I, 74J, 74O, 74P
NAD 83 UTM ZONE 13

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

HYDROLOGY REGIONAL STUDY AREA

Tazi Twé
Hydroelectric Project

PROJECT	10-1365-0004	FILE No.	
DESIGN		SCALE AS SHOWN	REV. 2
GIS	SM	29/07/13	**FIGURE: 10.2-2**
CHECK	AD	30/07/13	
REVIEW	BT	30/07/13	

10.3 Existing Environment

10.3.1 Introduction

The purpose of this section is to describe the existing hydrological conditions in the LSA and RSA as a basis to assess the potential Project-specific effects on hydrology. The detailed methods and results for the baseline surveys are located in Section 3.0 of Annex III; however, some statistics presented here may differ from those in Annex III, as datasets have been updated and adjusted as new information has become available and hydrological models have been developed.

Hydrological field data were collected in 2010, 2011, and 2012, and were compiled with other regional and local data sources to describe hydrologic conditions in detail. These datasets present information on watershed characteristics, flow rates, water levels, and morphologies of the waterbodies in the LSA including Black Lake, the Fond du Lac River, Middle Lake, and the upland area containing the site facilities.

10.3.2 Methods

Bathymetric data were collected using a Garmin GPSMAP or a Sontek M9 RiverSurveyor, or from digitizing depth data points available from existing literature (i.e., Johnson 1971). Waterbody morphology was described by examining satellite imagery, bathymetry, and field observations. Sections of the Fond du Lac River were classified according to a system adapted from R.L. & L. (1986) and Hawkins et al. (1993) based on channel gradient, velocity, depth, and substrate. Wetlands were determined using spectral signals and remote sensing software and were ground-truthed during vegetation surveys, while ponds were delineated from satellite imagery and streams were extracted from National Topographic System (NTS) maps.

A dataset of flow rates for the Fond du Lac River was created using archived historical hydrometric data from the Water Survey of Canada (WSC; Environment Canada 2012) for the period of 1963 to 2011. High flow and low flow statistics were derived using an equation developed by Pilon and Harvey (1994).

Water surface elevations were measured on a continuous basis during the 2010 monitoring period using a Levelogger pressure transducer/data logger system, manufactured by Solinst Canada Ltd. The Levelogger sensors were programmed to record water levels at 30-minute intervals. An engineer’s rod and level were used to measure water level and monitor for potential movement; a Sokkia GRX1 Real Time Kinematic (RTK) receiver and base station were used to adjust arbitrary level measurements to geodetic. Water levels were calculated using the continuous discharge record available for the Fond du Lac River and the stage-discharge relationships established for Black Lake and Middle Lake.

10.3.3 Results

10.3.3.1 Fond du Lac River

At the outlet of Black Lake, the Fond du Lac River has an upstream drainage area of 50,800 square kilometres (km^2) and receives minimal additional runoff from 10.6 km^2 to the inflow of Middle Lake. The Fond du Lac River between Black Lake and Middle Lake has a total length of 6.1 kilometres (km) and a total change in elevation of approximately 36 metres (m). For the period 1963 to 2011, the Fond du Lac River has an average flow rate of 304 cubic metres per second (m^3/s), a maximum daily flow rate of 860 m^3/s, and a minimum daily flow rate of 122 m^3/s (Figure 10.3-1). Flood flow and low flow magnitude and frequency estimates for the Fond du Lac River are provided in Table 10.3-1.

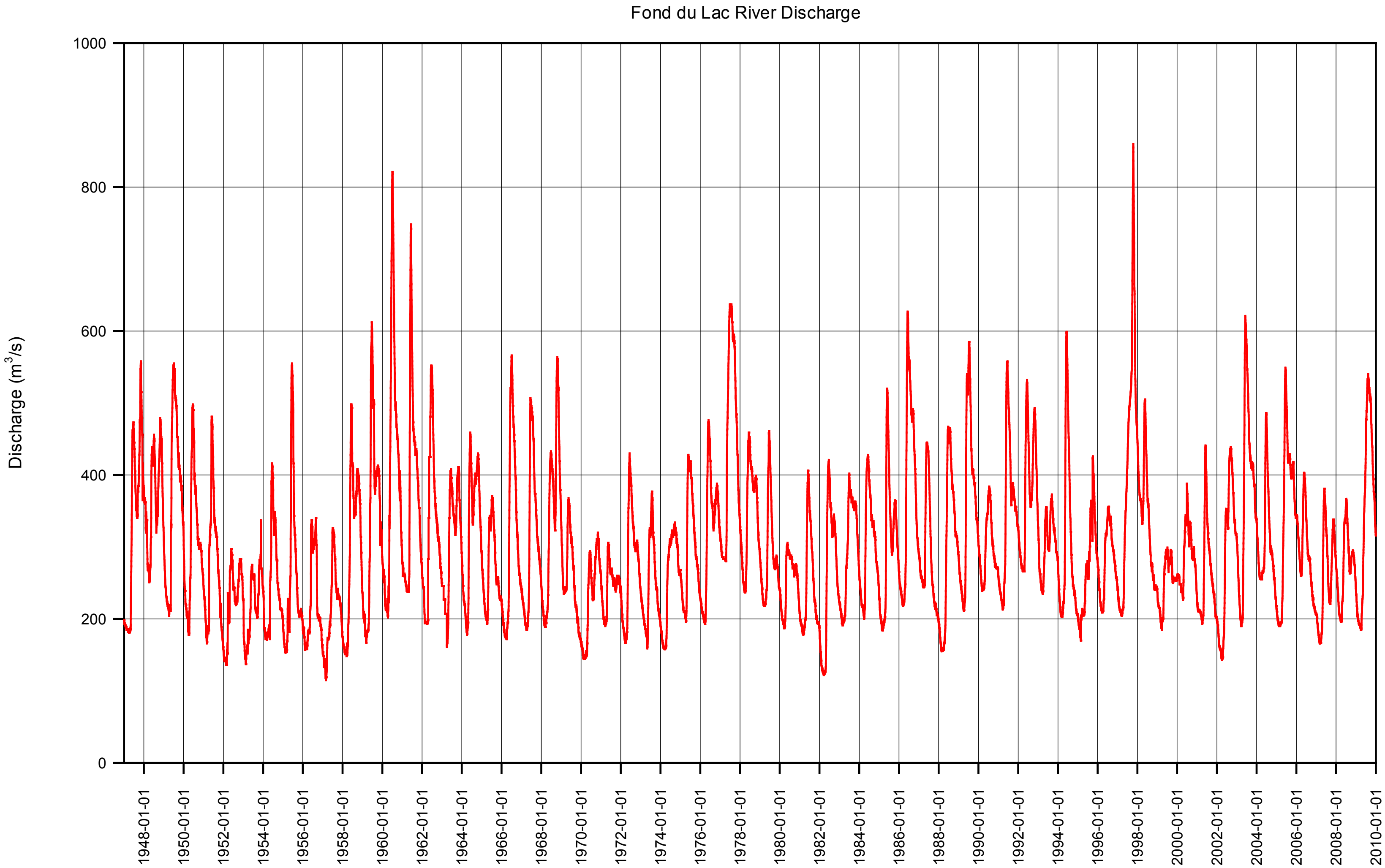


Figure 10.3-1: Fond du Lac River Baseline Discharge

Table 10.3-1: Fond du Lac River Flood Flow and Low Flow Magnitude and Frequency

Frequency (years)	Flood Flow Magnitude (m^3/s)	Low Flow Magnitude (m^3/s)
2	453	187
5	564	160
10	636	147
20	705	137
50	792	125
100	856	118

Note: statistics are based on 1963 to 2011
m^3/s = cubic metres per second

While the hydrograph typically displays low flows during the winter, peak flows in the spring, and a slow receding limb throughout the summer and fall, there is considerable variability in the magnitude and timing of flow events. Most peak flow events occur during the first two weeks of June, with a distribution between approximately mid-May and mid-July. While no annual peak flow events have been recorded during most of August, 20% of the recorded peak flows occurred during the late summer to fall period (from August to December), while the remaining peak flows occurred during the spring to early summer (from May to July). The range in magnitude during the fall peak flow events is similar to the range in magnitude for the spring peak events. All annual low flow events on record occurred during winter (from December to May), in contrast to the annual peak flow events, which occurred from June to November. The most extreme low flow events occurred in February and March.

10.3.3.2 Black Lake

Black Lake is at the upstream end of the Project and drains via the Fond du Lac River; Black Lake flows eventually discharge into Lake Athabasca. Black Lake has two lobes: one to the southwest of the outflow and a larger one to the northeast. The southwest lobe is approximately 25 km long and has a maximum width of approximately 5 km while the northeast lobe is approximately 40 km long and has a maximum width of approximately 15 km. Black Lake has a total surface area of 418,000,000 square metres (m^2) and has mean and maximum depths of 13.7 and 57.6 m. Morphometric statistics are presented in Table 10.3-2.

Table 10.3-2: Black Lake Morphometric Characteristics

Area (m^2)	418,000,000
Volume (m^3)	6,610,000,000
Maximum depth (m)	57.6
Mean depth (m)	13.7
Maximum Length (km)	62.7
Perimeter shore length (km)	276.7
Island shore length (km)	106.5

m^2 = square metres; m^3 = cubic metres; m = metres; km = kilometres

Water levels in Black Lake follow a seasonal pattern, similar to that for the Fond du Lac River (Figure 10.3-1). Peak levels typically occur during the spring, while low levels occur during the late winter. Black Lake has a historical mean elevation of 277.159 metres above sea level (m ASL). The lake fluctuates at an average of 0.814 m within a year; however, in 1997 the lake had the maximum-recorded variation within a year with a difference of 1.431 m. Over the period of record, lake levels have reached a historical minimum of 276.485 (in

March 1982) and a historical maximum of 278.250 (in October 1997). An exceedence curve for the Fond du Lac River is presented in Figure 10.3-2.

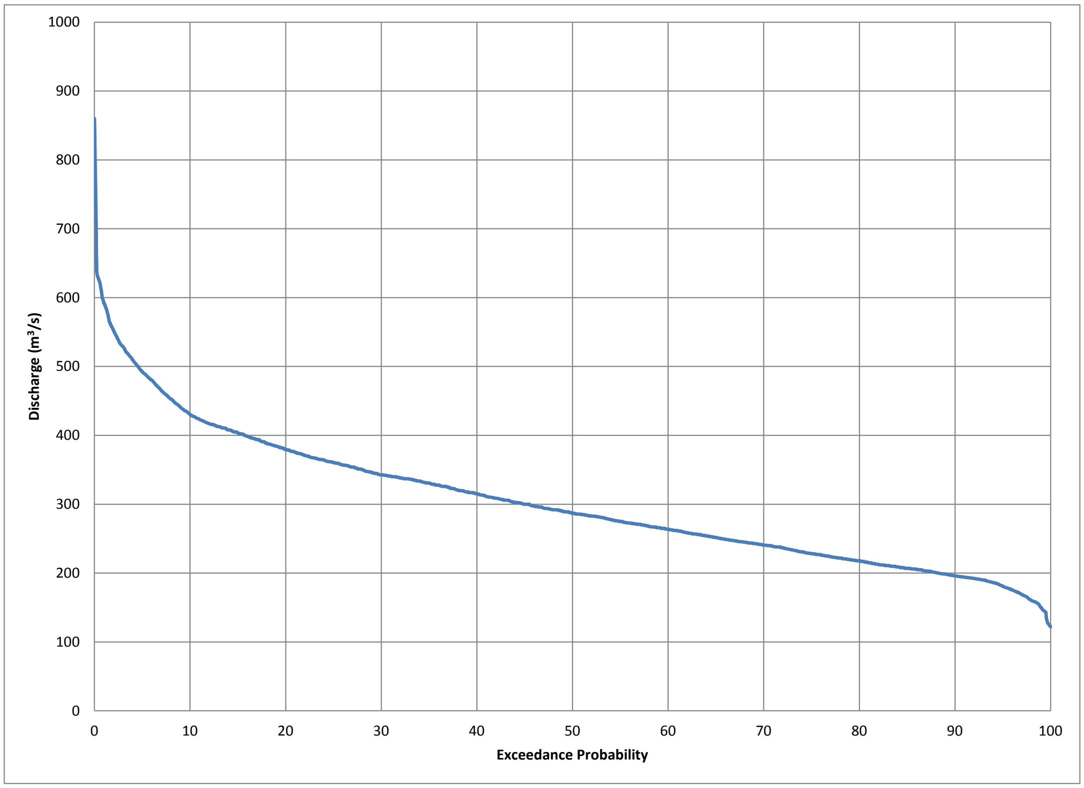


Figure 10.3-2: Fond du Lac River Exceedence Curve

10.3.3.3 Middle Lake

Middle Lake is at the downstream end of the LSA and is effectively a widening of the Fond du Lac River before it continues through another section of the Fond du Lac River to Stony Lake and eventually into Lake Athabasca. Middle Lake has a total surface area of 7,510,000 m^2 and has mean and maximum depths of 2.65 and 14.4 m. Morphometric characteristics are presented in Table 10.3-3. The Fond du Lac River constitutes 99.8% of the inflow to Middle Lake. Because Middle Lake is a small waterbody relative to its flow though, outflow rates are considered equivalent to those at the outflow of Black Lake (Figure 10.3-1).

Table 10.3-3: Middle Lake Morphometric Characteristics

Area (m^2)	7,510,000
Volume (m^3)	19,400,000
Maximum depth (m)	14.4
Mean depth (m)	2.65
Maximum Length (km)	4.3
Perimeter shore length (km)	19.7
Island shore length (km)	0.832

m^2 = square metres; m^3 = cubic metres; m = metres; km = kilometres

10.3.3.4 Upland Area

The upland area associated with the hydrology LSA covers approximately 75 km^2 (i.e., not including Black Lake, Fond du Lac River, or Middle Lake). The upland area is largely devoid of surface water, with the exception of 0.2 km^2 of small ponds, 9.5 km^2 of wetland areas, and 15 km of streams. There are three streams in the upland area, the largest of which drains an area of 80.5 km^2 and flows into the south end of Middle Lake. The largest lake in the upland area (Lake A) is 71,000 m^2, has a drainage area of 637,000 m^2 and flows into Black Lake. Most of the LSA upland area (44 km^2) drains north into Middle Lake, while 13 km^2 drain directly into Black Lake and 16 km^2 drain directly into the Fond du Lac River through overland flow and small streams.

10.3.3.5 Lake Athabasca

Lake Athabasca is in the RSA and is the receiving waterbody of the Fond du Lac River. Lake Athabasca is Saskatchewan's largest lake with a surface area of 7,900 km^2, a volume of approximately 205 x 10^9 m^3, and a shoreline length of 1,900 km; the morphometric statistics for Lake Athabasca are presented in Table 10.3-4.

Table 10.3-4: Lake Athabasca Morphometric Characteristics

Surface area (km^2)	7,900
Maximum depth (m)	120
Mean depth (m)	26.0
Volume (10^9 m^3)	205
Length of shoreline (km)	1,900
Island Number	633
Island Area (km^2)	114
Length of island shoreline (km)	248

Source: Koshinsky 1970
m^3 = cubic metres; m = metres; km = kilometres; km^2 = square kilometres

Lake Athabasca has many notable river inflows, including the Fond du Lac River at the east and the Athabasca River at the west. Lake Athabasca has a total drainage area of 271,000 km^2 and flows north into the Slave River.

Water level in Lake Athabasca fluctuates seasonally with a minimum, mean, and maximum annual variability of 0.64, 1.50, and 3.74 m. Over the 53 years of continuous water level data available, water level has fluctuated within 4.55 m. The particularly high variability in Lake Athabasca is due primarily to the high inflow and outflow rates and their temporal variability, and the lake's interaction with large rivers to the west.

10.4 Screening of Project Interactions and Mitigation

This section identifies and evaluates the interactions between Project components or activities with the potential to cause changes to hydrology and the corresponding potential effects on other VCs (e.g., water quality, fish and fish habitat, vegetation, and wildlife). The process begins with the identification of all potential interactions for the Project. To provide a robust assessment of potential effects, each interaction is initially considered to have a linkage to a change in the surface water environment and associated potential effects on hydrology.

Each potential interaction is evaluated to determine if mitigation can be developed and incorporated to remove the interaction or limit the potential effect on hydrology. Mitigation includes Project design elements, environmental best practices, and management policies and procedures, and is developed through an iterative process between the Project's engineering and environmental teams. Knowledge of the surface water environment and mitigation is applied to each interaction to determine the expected Project-related changes to the environment (i.e., change in a measurement endpoint) and if there is potential for a residual effect on hydrology.

Interactions are determined to be primary, secondary, or as having no linkage using scientific knowledge, professional judgment of technical specialists, and experience with similar developments, and mitigation (Table 10.4-1). Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by environmental design features and mitigation so that the Project results in no detectable (measurable) change or residual effects on hydrology relative to baseline values;
- secondary – interaction could result in a minor change to measurement endpoints, but would have a negligible residual effect on hydrology relative to baseline values is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary – interaction is likely to result in a measurable change that could contribute to residual effects on hydrology relative to baseline values.

Primary interactions are anticipated to result in a residual effect on hydrology. Because hydrology has no assessment endpoint, residual effects are assessed for primary interactions that will be used to support the assessment of effects on other VCs. The determination of the significance of the residual effects is not completed for hydrology. Project interactions determined to have no linkage or those that are considered secondary are not predicted to result in significant effects on hydrology.

Project components, activities, and the associated mitigation implemented during the various Project phases, including accidents, malfunctions, and unplanned events are summarized in Table 10.4-1. Potential effects on hydrology from each Project interaction and its associated classification are summarized in Table 10.4-1, with more detailed descriptions provided in the subsequent sections.

10.4.1 Interactions with No Linkage to Effects

A Project interaction can have no linkage to effects if the activity does not occur or if the interaction is removed by mitigation and environmental design features so that the Project results in no detectable change to hydrology. Subsequently, no residual effect on hydrology is expected. The following interactions are anticipated to have no linkage to effects on hydrology and will not be carried through the residual effects assessment:

- **Diversion of water through the power tunnel may change groundwater quantity, which can change hydrology.**

Construction and operation of the Project may also change groundwater quantity, which can subsequently alter hydrology. Some entrainment of groundwater flows within the power tunnel flows may occur during Project operation. Therefore, withdrawal of water from Black Lake during operations has the potential to change groundwater infiltration. The water table is anticipated to be near the ground surface in the Project area, based on the relatively low hydraulic conductivity of the bedrock at this location. Little infiltration from precipitation is expected. The general regional groundwater flow directions are expected to be similar to the topographic grade. Groundwater is expected to flow from high elevation areas in a radial pattern towards Black Lake, Fond du Lac River, and Middle Lake. Overall, the diversion of water through the power tunnel is not predicted to change groundwater quantity. Therefore, this interaction is determined to have no linkage to effects on hydrology.

- **Water withdrawal for domestic (e.g., potable water) and industrial (e.g., dust suppression) purposes can change hydrology.**

The withdrawal of water for domestic and industrial purposes during Project construction and operation has the potential to change hydrology. Water usage will vary depending on the number of workers on-site and is expected to be greatest during the construction phase of the Project when up to 250 people are expected to be on-site. Water requirements for the construction phase can reach up to 4,700,000 litres (L) per year (i.e., approximately 13 m^3/d) for industrial water and potable water use is expected to be between 30,000 and 45,000 litres/day). Potable water for the construction camp is anticipated to be sourced from one or more new wells located near the camp, although this water could be drawn from either Black Lake or the Fond du Lac River. During operations, approximately 365,000 L/year (i.e., 1 m^3/d) of water will be required for the Project. Potable water will be drawn from the penstock and treated for use. No effects on hydrology are anticipated if the water requirements are extracted from groundwater.

A supply of industrial water will be required for dust suppression and fire-protection during Project operation. Industrial water will be diverted from power generation flows passing through the power station. Storage tanks will provide the appropriate storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (2 hours of available water at 750 US gallons per minute). Industrial water (i.e., used for fire suppression, preparing concrete, and controlling road dust) will be taken from Black Lake (i.e., water intake location) and the Fond du Lac River (i.e., bridge location).

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Table 10.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Hydrology

<table>
<tr><th>Project Component/Activity</th><th>Project Phase when the Component/Activity Occurs</th><th>Potential Interaction to Hydrology</th><th>Environmental Design Features and Mitigation</th><th>Interaction Classification</th></tr>
<tr><td>■ Infrastructure Footprints
▪ Temporary infrastructure
– construction camp
– overburden disposal areas
– construction area and materials laydown area
▪ Operational infrastructure
– power generation station
– water intake structure
– power tunnel
– tailrace channel
– submerged weir
– bridge
– transmission line
– waste rock disposal areas
– water diversion structures around the Project footprint
– potable water and wastewater intake and discharge structures
– site access roads (including source material)</td><td>Construction</td><td>Dewatering of the power tunnel during construction may change groundwater quantity, which can change hydrology.</td><td>■ Not applicable</td><td>Secondary</td></tr>
<tr><td rowspan="3">■ Power Generation Activities
▪ water withdrawal for power generation
▪ diversion of water through the power tunnel to the powerhouse
▪ discharge of tailrace channel flows</td><td rowspan="3">Operations</td><td>Withdrawal, diversion, and discharge of water for power generation may change hydrology.</td><td rowspan="2">■ A submerged weir will be constructed on the Fond du Lac River at the outlet of Black Lake and will be designed to maintain the range of water levels in Black Lake and in the uppermost section of the Fond du Lac River within the historical range for all powerhouse operating flow conditions.
■ Project site runoff resulting from rainfall, snowmelt, and groundwater releases will be managed by directing runoff around work site infrastructure by using appropriately sized ditches, channels, and culverts.</td><td>Primary</td></tr>
<tr><td>Diversion of water through the power tunnel may change groundwater quantity, which can change hydrology.</td><td>No Linkage</td></tr>
<tr><td>Maintenance shutdowns of power generation activities can change hydrology.</td><td>■ Scheduled maintenance shutdowns will occur annually on a unit-by-unit basis and are estimated to last from a few days up to two weeks.
■ Only one unit at a time will be removed from service for maintenance.
■ Maintenance shutdowns will be timed to minimize effects, for example during winter months, during other periods when there is less flow available to pass through the powerhouse turbine generator units, or during summer when sufficient water is available.
■ Each unit may be taken out of service, once per month to perform minor adjustments, inspections, and maintenance.
■ The power tunnel will be drained for inspection for one to two weeks approximately every five years.
■ Major overhaul work on the turbine and generator units will be completed approximately every 30 years.
■ During planned maintenance shutdowns, downstream flows will be maintained by bypassing water around the powerhouse turbine generator unit using a bypass conduit, if required.</td><td>Primary</td></tr>
</table>

Table 10.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Hydrology (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interaction to Hydrology	Environmental Design Features and Mitigation	Interaction Classification
■ Potable and Industrial Water Supply	Construction and Operations	Water withdrawal for domestic (e.g., potable water) and industrial (e.g., dust suppression) purposes can change hydrology.	■ Potable water for the construction camp is anticipated to be sourced from one or more new wells located near the camp, although this water could potentially be drawn from either Black Lake or the Fond du Lac River.	No Linkage
■ Site Water Management ▪ collection and treatment of surface runoff within the Project footprint ▪ discharge of wastewater ▪ collection and treatment of groundwater in the power tunnel	Construction and Operations	The interception and collection of direct precipitation and surface runoff within the Project footprint may change hydrology.	■ Surface runoff will be diverted around and away from waste rock disposal areas as much as possible. ■ The site will be properly graded and will be surrounded by ditches and berms to capture runoff from the waste rock disposal areas. ■ The waste rock disposal areas will be placed in locations that are easily modified to control run-on and run-off. ■ Runoff from the waste rock disposal areas will be directed to settling ponds prior to discharge to the Fond du Lac River. ■ Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns. ■ Ditch capacities will be sized to accommodate an extreme daily rainfall event. ■ Runoff from areas unaffected by the Project will be directed away from construction areas and allowed to discharge through natural channels. ■ A Site Water Management Plan will be developed for the Project.	No Linkage
		Surface water diversions (e.g., berms, ditches, and waste rock disposal areas) around the Project footprint can change drainage areas, runoff characteristics, and local and downstream hydrology.		No Linkage
		Collection and disposal of wastewater from the site can cause changes to hydrology.	■ A Site Water Management Plan will be developed for the Project. ■ Runoff from the waste rock disposal areas will be directed to settling ponds prior to discharge to the Fond du Lac River.	No Linkage
■ Closure Activities ▪ site grading, contouring, reclamation, and re-establishment of natural drainage characteristics ▪ waste rock management ▪ cessation of potable water withdrawal and wastewater discharge	Closure	Cessation of power generation activities, including the withdrawal, diversion, and discharge of water, can change hydrology.	■ A Decommissioning and Reclamation Plan will be developed for the Project.	No Linkage
■ Accidents and Malfunctions ▪ emergency shutdowns of power turbines	Operations	Emergency shutdowns of power generation activities can change hydrology.	■ During unplanned emergency shutdowns, downstream flows will be maintained by bypassing water around the powerhouse generator units using a bypass conduit.	Primary

Water withdrawal from Black Lake or the Fond du Lac River for domestic and industrial use during construction and operations is not expected to have a measureable effect on water volumes or flow rates. Black Lake has a waterbody volume of 6,610,000,000 m^3 and the Fond du Lac River has an average baseline flow rate of 304 m^3/s. Withdrawal of 21,125 m^3/year from these waterbodies will account for less than 0.0001% of the corresponding waterbody volume and flow rate. Because water requirements during operations are lower than those for construction, potential effects during operations are expected to be much lower, despite the reductions in riparian flows that will occur as a result of power generation.

Based on the predicted volumes of water that could potentially be withdrawn from Black Lake or the Fond du Lac River, no detectable changes to flows in Black Lake or the Fond du Lac are expected. As such, there is no linkage to residual effects on hydrology.

- **The interception and collection of direct precipitation and surface runoff within the Project footprint may change hydrology.**
- **Surface water diversions (e.g., berms or ditches) around the Project footprint can change drainage areas, runoff characteristics, and local and downstream hydrology.**

The Project footprint and proposed surface water diversions have the potential to change the local hydrology, such as surface runoff characteristics. The footprint of the Project will be as compact as possible to limit the area affected by Project activities and subsequent changes to hydrology. The total area to be cleared is approximately 869 hectares (ha). Of this 869 ha, 589 ha will be reclaimed immediately following construction and about 280 ha will be required for operation. Following closure of the Project, the entire area will be reclaimed.

Protecting and managing surface drainage water (and sediment) will be addressed through implementation of a Site Water Management Plan. Surface runoff from areas unaffected by the Project will be directed away from construction areas and into natural drainage courses. Runoff that is redirected from roadways, construction laydown areas, and other areas affected by construction, including groundwater collected during construction of the power tunnel, will be collected in settling ponds. Surface runoff also will be diverted away from waste rock disposal areas as much as possible; locations of waste rock disposal areas will be such that run-on and run-off can be easily controlled. Ditches will be sized to accommodate extreme rainfall events and riprap energy dissipaters and ditch liners will be installed in areas where runoff velocities are deemed excessive. Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns.

The interception and collection of direct precipitation within the Project footprint will be limited to a total area of less than 1 km^2, corresponding to waste rock disposal areas, settling ponds, contractor's work areas, and borrow areas. The potential 1 km^2 of intercepted and collected precipitation and runoff will be dispersed across several sub-watersheds. While the runoff characteristics and hydrology within these areas will be affected, these changes will be contained within the disturbed areas, which account for a fraction of 1% of the greater Fond du Lac River watershed. Thus, the interception and collection of direct precipitation and runoff within the Project footprint is not expected to result in measurable changes to hydrology in downstream waterbodies.

The preferred design and location of the traffic bridge across the Fond du Lac River is a single-pier bridge located approximately 600 m upstream of Elizabeth Falls. The abutments for the bridge will be installed so that they extend below the current high water mark, but above the high-water mark anticipated for the Project. Therefore, no changes to flows in the Fond du Lac River are expected.

Given the footprint size and design of surface water management structures, it is expected that there will be no measureable changes on flows in the Fond du Lac River. Therefore, the Project infrastructure-related changes on downstream flows were determined to have no linkage to residual effect on hydrology.

- **Collection and disposal of wastewater from the site can cause changes to hydrology.**

Discharge of wastewater during Project construction and operation can change hydrology. Site wastewater will be of several types, including waste rock runoff and groundwater collected and treated during the construction of the power tunnel, powerhouse, water intake structure, and the tailrace channel. To mitigate effects on hydrology, a Site Water Management Plan will be developed for the Project. The Site Water Management Plan involves the collection and discharge of treated wastewater. While swales, culverts, and ditches will be designed to reduce the amount of water requiring collection and manual discharge, some areas within the Project footprint will require active water management strategies.

The amount of water managed within the Project footprint is limited to waste rock disposal areas and their corresponding upstream watersheds. Runoff from these areas may include up to 2.1 km^2. Three settling ponds have been included in the construction plan for the Project for the treatment and management of the Project's wastewater (other than site runoff and sewage and grey water). Water produced during construction or runoff through the site will be contained, tested, and treated, if necessary, before release in accordance with regulations. Water collected in disturbed areas located away from the settling ponds may need to be pumped to these locations. Surface water diversions could also be constructed to maintain natural drainage characteristics, whereas other structures could be designed to actively divert water away from its natural flow path to prevent the interaction with site infrastructure, potentially contaminated water, or areas sensitive to erosion. Water in the settling ponds will be pumped to the Fond du Lac River at one or both of two potential discharge locations after the water has been tested and confirmed to meet appropriate discharge criteria. The potential change in flow is not expected to be measureable, as the collection area accounts for a fraction of 1% of the Fond du Lac River watershed areas (50,800 km^2).

During construction of the water intake, power tunnel, and tailrace channel, work will be completed "in the dry" and will therefore require the collection of water through sumps or dewatering wells. This water will be placed into settling ponds prior to release into the Fond du Lac River. Groundwater seepage rates are predicted to gradually increase during power tunnel advancement to an estimated maximum inflow rate of 4,700 m^3/d by completion. The discharge of this groundwater to the Fond du Lac River or Black Lake amounts to less than 0.001% of the lowest recorded discharge and water volume of Black Lake.

Overall, surface water runoff and wastewater within the Project footprint are expected to result in no detectable changes to flows in the Fond du Lac River. Therefore, these interactions were determined to have no linkage to effects on hydrology.

- **Cessation of power generation activities, including the withdrawal, diversion, and discharge of water, can change hydrology.**

The assessment boundary for Project operation is 90 years. It is anticipated that cessation of power generation and removal of the weir at the outlet of Black Lake will allow for the re-establishment of natural (i.e., pre-development) flow regimes in the Fond du Lac River. Returning flows in the Fond du Lac River to pre-Project levels is expected to increase the maximum depths of bypassed river reaches and increase flow velocities to pre-Project (i.e., historical) values).

A Decommissioning and Reclamation (D&R) Plan will be developed for the Project. Closure when it occurs, is expected to be completed in compliance with all federal and provincial acts, regulations, and standards applicable at the time, and in discussion with BLFN. Plans for development of habitat restoration plans and additional monitoring plans will be discussed prior to cessation of power generation and commencement of site decommissioning.

Overall, the cessation of power activities is not expected to result in measurable changes to hydrology relative to baseline conditions. Therefore, this interaction was determined to have no linkage to residual effects on hydrology

10.4.2 Interactions with Secondary Linkages

In some cases, both a source and an interaction exist, but since the change caused by the Project is anticipated to be minor, it is expected to have a negligible residual effect on hydrology relative to baseline values. The following interaction is expected to be minor and will not be carried through the residual effects assessment.

- **Dewatering of the power tunnel during construction may change groundwater quantity, which can change hydrology.**

During the construction of the power tunnel, water intake, and tailrace channel, work will be completed “in the dry” and potential seepage into these areas will require dewatering. The period of dewatering could continue throughout construction (i.e., three years), but is not expected to reach maximum drawdown rates until the latter stages. Dewatering activities may drawdown the local groundwater table and affect water volumes in surface waterbodies located within the zone of influence.

The only surface waterbody within the zone of influence and potentially affected by dewatering activities is Lake A, which is located approximately 1.5 km north of the water intake structure. This lake is assumed to be fish-bearing on the basis that its outflow to Black Lake has no known barriers to fish passage. Lake A has a drainage area of 637,000 square metres (m^2) and flows into Black Lake at an estimated average annual rate of 0.036 m^3/s; however flow rates are likely higher during the spring and summer and lower during the late winter.

Groundwater modeling results predict an incremental flux out of Lake A at up to 0.001 m^3/s during construction. This flux rate is approximately 3% of the average annual flow though rate, indicating that the outflow channel should remain active for the majority of its flow season and that any drawdown that occurs during low inflow periods will be replenished annually. Additionally, this rate of drawdown is predicted only during a short period in the latter stages of construction and could be of lower magnitude if less conservative fault, overburden, and bedrock hydraulic conductivities and recharge through the overburden exist.

The amount of drawdown that is expected to occur within Lake A because of power tunnel dewatering is considered to be within the range of natural variation associated with estimated annual outflow rates. Therefore, this Project interaction is expected to have negligible residual effect on hydrology.

10.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events occurring on-site have the potential to affect fish and fish habitat. The following event was identified as a primary pathway for hydrology and has been carried through the residual effects analysis (Section 10.5).

- **Emergency shutdowns of power generation activities can change surface hydrology.**

10.4.4 Primary Interactions

The residual environmental effects analysis considers all primary interactions that result in expected changes to hydrology, after implementing mitigation. The following interactions were determined to be primary for effects on hydrology and are carried forward to the residual effects analysis (Section 10.5).

- **Withdrawal, diversion, and discharge of water for power generation can change hydrology.**
- **Maintenance shutdowns of power generation activities can change surface hydrology.**

10.5 Residual Effects Analysis

The residual effects analysis considered all interactions that are expected to result in changes to hydrology after implementing environmental design features and mitigation. The residual effects assessment is completed by predicting changes to the following measurement endpoints:

- water level;
- waterbody volume;
- flow rates; and
- watershed area.

To determine the magnitude of Project effects and their corresponding temporal and spatial characteristics, two models were developed. A water level and flow rate model was developed to determine the magnitude of effects and the associated timing, duration, and frequency (Appendix 10.1). This model is physically based and simulates natural water levels and flow rates for a 49-year period at a daily resolution. The Project is integrated into this model to include the submerged weir at the outflow of Black Lake, the withdrawal of water at the water intake, the discharge of water at the tailrace channel outlet, and the temporal characteristics of these activities. Appendix 10.1 provides information about model description, setup, and input parameters. Outputs from this model include water levels in Black Lake, flow rates in the Fond du Lac River, and flow rates from Middle Lake.

While the flow rate and water level model effectively describes the magnitude of effects and the timing, duration, and frequency associated with flow events, it does not describe the spatial distribution of effects within the three waterbodies. To determine the spatial distribution of effects within the Fond du Lac River, a River2D model was developed (Appendix 10.2). This model uses hydrological principles and digital elevation data to describe the distribution of water and its velocities along the Fond du Lac River under specific flow scenarios. The flow scenarios modeled in River2D include 30, 40, 50, 112, 210, 302, 320, 400, and 510 m^3/s. From these simulations, spatial characteristics such as water depth, cross sectional area, and flow velocity for specific locations were determined.

10.5.1 Changes to Hydrology during Routine Operations

10.5.1.1 Changes to Black Lake

Summary statistics for natural water levels and predicted water levels during operations are presented in Table 10.5-1 and Figure 10.5-1. While the submerged weir will be designed to maintain the mean water level near that of natural conditions, the variability in water levels will be reduced during operations. The most notable changes are predicted to occur during low water periods, for example during droughts or in the late winter when the weir restricts water levels from dropping. During these periods, low water levels may be elevated by up to 0.5 m; however, changes in water level of more than 0.1 m are predicted to occur approximately 15% of the time.

Table 10.5-1: Predicted Water Levels in Black Lake

Water Level	Natural (m)	Operations (m)	Change (m)
Minimum	276.485	276.922	0.437
10th percentile	276.788	276.922	0.134
25th percentile	276.908	276.940	0.032
50th percentile	277.122	277.118	-0.004
Mean	277.159	277.171	0.012
75th percentile	277.380	277.326	-0.054
90th percentile	277.578	277.509	-0.069
Maximum	278.250	278.262	0.012

Note: Statistics are derived from 1963 to 2011 and are processed at a daily resolution.
m = metre

10.5.1.2 Changes to the Fond du Lac River

Summary statistics for natural flow rate and flow rate during operations along the bypassed section of the Fond du Lac River are presented in Table 10.5-2 and Figure 10.5-2. While the hydrograph characteristics during operations follow patterns similar to those observed during natural conditions, the daily range of potential flow rates is reduced and the magnitude of flow rates are reduced throughout the hydrograph.

The distribution of flow rates in the bypassed section of the Fond du Lac River are below those recorded during baseline conditions; minimum flow rates are reduced from 122 m^3/s to 40 m^3/s, mean flow rates are less than half of those naturally observed, and maximum flow rates are reduced from 860 m^3/s to 665 m^3/s.

During the lowest flow period of the year, approximately from February to mid-April, discharge is predicted to be the most consistent and the mean flow rate during this time is estimated to be 49 m^3/s. Similar to natural conditions, results indicate that the discharge increases in the spring and displays considerable variability between years, but is generally reduced by about 195 m^3/s. During the fall and early winter, as natural discharge decreases, the distribution of flows under operations becomes increasingly skewed towards lower flows. The spatial distribution of flows in the bypassed section of the Fond du Lac River under various flow scenarios are presented in Appendix 10.2.

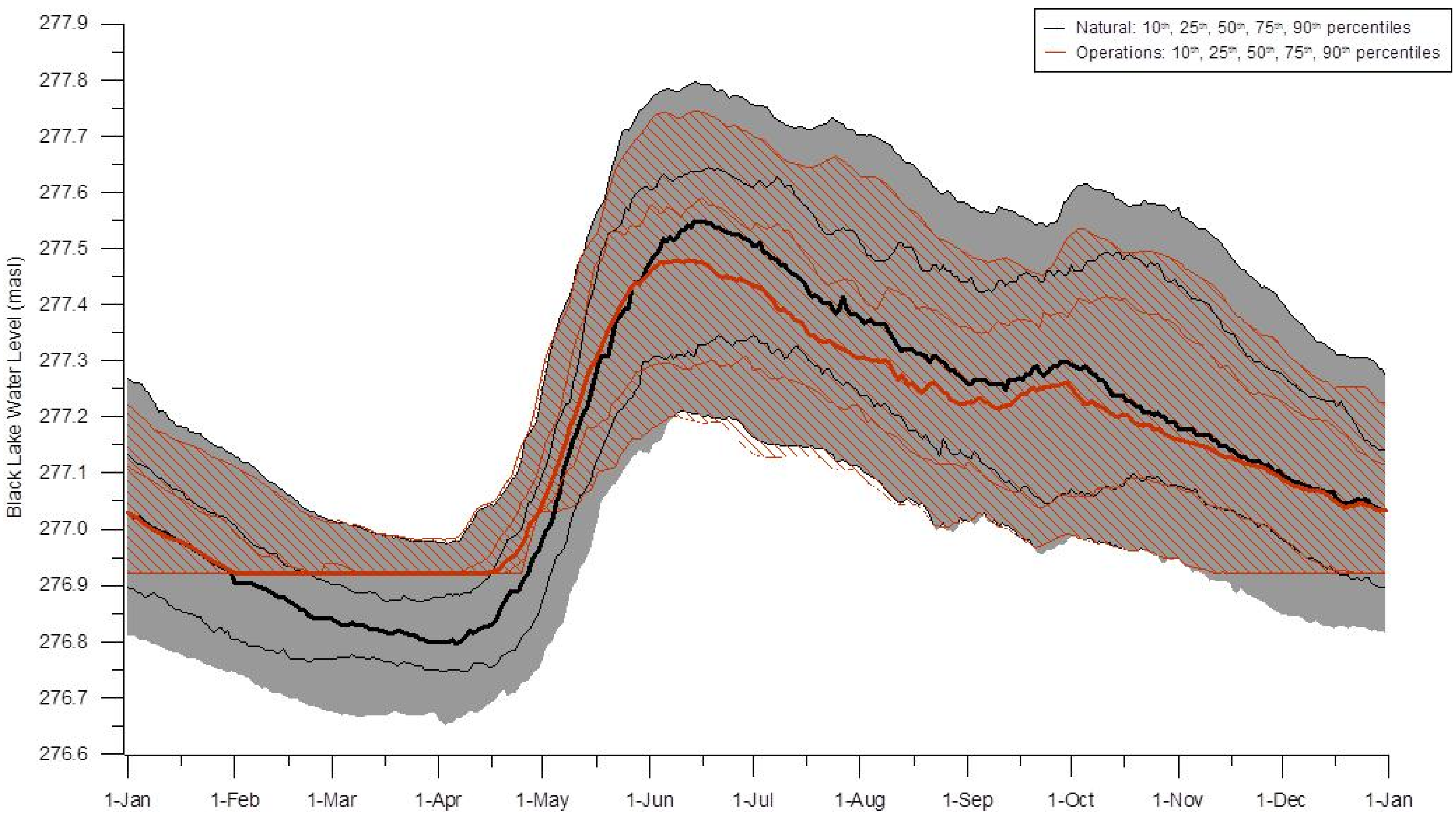

Figure 10.5-1: Predicted Changes in Daily Water Level in Black Lake

Note: Statistics are derived from 1963 to 2011 and are processed at a daily resolution.

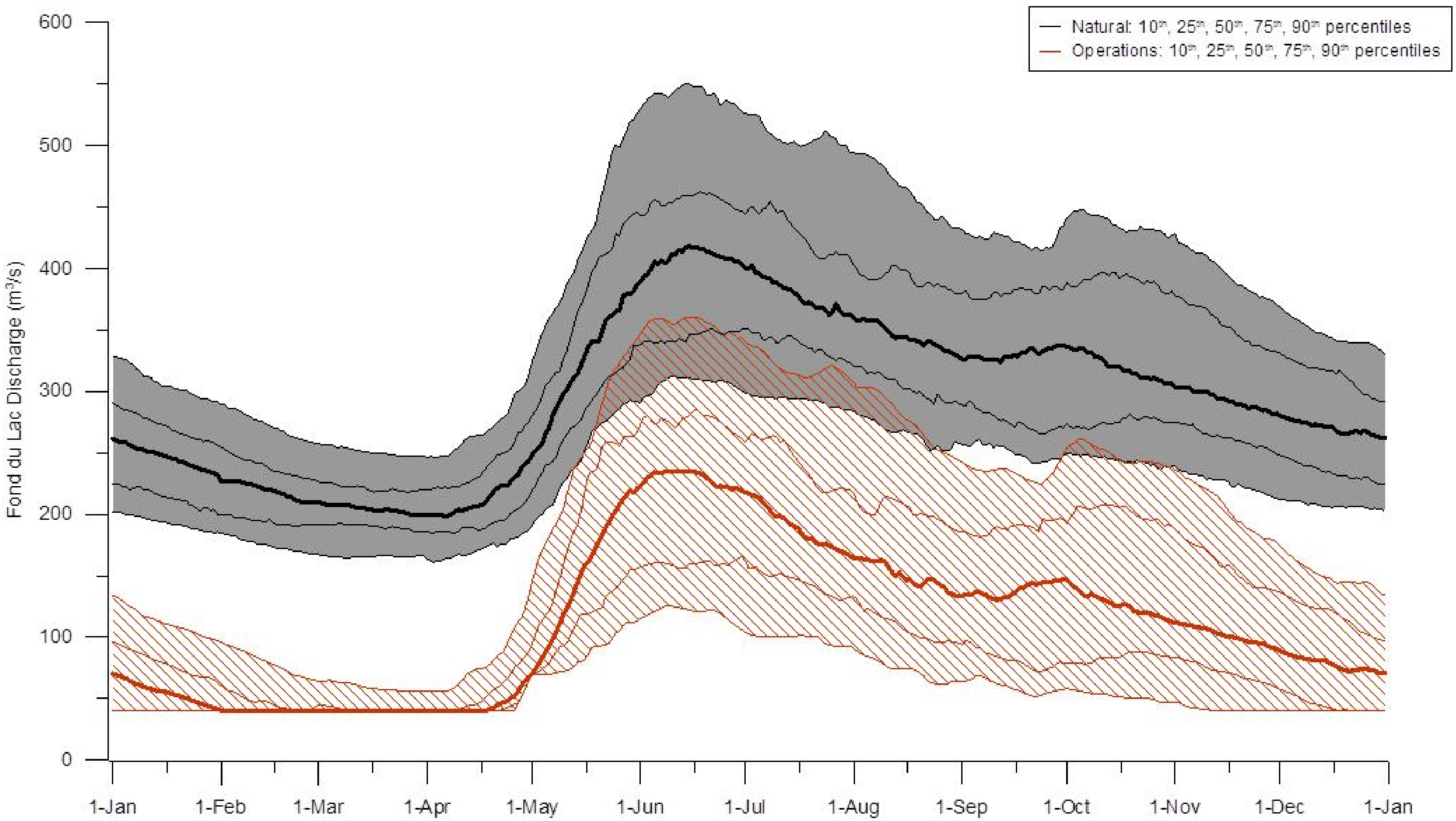

Figure 10.5-2: Predicted Changes in Daily Discharge in the Bypassed Section of the Fond du Lac River

Note: Statistics are derived from 1963 to 2011 and are processed a daily resolution.

Table 10.5-2: Predicted Flow Rates in the Bypassed Section of the Fond du Lac River

Discharge (m^3/s)	Natural (m^3/s)	Operations (m^3/s)	Change (m^3/s)
Minimum	122	40	-82
10th percentile	196	40	-156
25th percentile	228	45	-183
50th percentile	287	97	-190
Mean	304	124	-179
75th percentile	361	173	-188
90th percentile	430	249	-182
Maximum	860	665	-195

Note: Statistics are derived from 1963 to 2011 and are processed at a daily resolution.
m^3/s = cubic metres per second

10.5.1.3 Changes to Middle Lake

During natural conditions, Middle Lake receives inflow from the Fond du Lac River, while during operations it receives inflow from the Fond du Lac River and the tailrace channel outlet. A statistical representation of the annual hydrograph for Middle Lake discharge under natural conditions and Project operations is presented in Table 10.5-3 and Figure 10.5-3. Discharge is predicted to remain within 10 m^3/s of its natural rate, except during periods of extreme low flow when flow in the bypass section of the Fond du Lac River is at the minimum IFR (40 m^3/s) and inflow rates to Black Lake are as low. During these periods, water through the power tunnel is also reduced to less than 50 m^3/s to maintain water level in Black Lake and the IFR in the Fond du Lac River. Flow from Middle Lake can be reduced by up to 50%, during periods of extreme low; however, a reduction in Middle Lake Outflow of more than 10% is predicted to occur less than 3% of the time.

Table 10.5-3: Predicted Inflow Rates to Middle Lake

Discharge (m^3/s)	Natural (m^3/s)	Operations (m^3/s)	Change (m^3/s)
Minimum	122	82	-40
10th percentile	196	191	-5
25th percentile	228	232	4
50th percentile	287	287	1
Mean	304	304	0
75th percentile	361	363	2
90th percentile	430	439	8
Maximum	860	854	-6

m^3/s = cubic metres per second

10.5.1.4 Changes to the Downstream Environment

Hydrological effects are predicted to propagate downstream of the LSA, but diminish as watershed areas and flow rates increase. Additionally, effects will attenuate as they pass through large waterbodies such as Stony Lake and Lake Athabasca. Effects are predicted to diminish completely at Lake Athabasca. Due to the large volume of Lake Athabasca, changes in inflow at the magnitude predicted for Middle Lake will not be measureable in Lake Athabasca or any further downstream location.

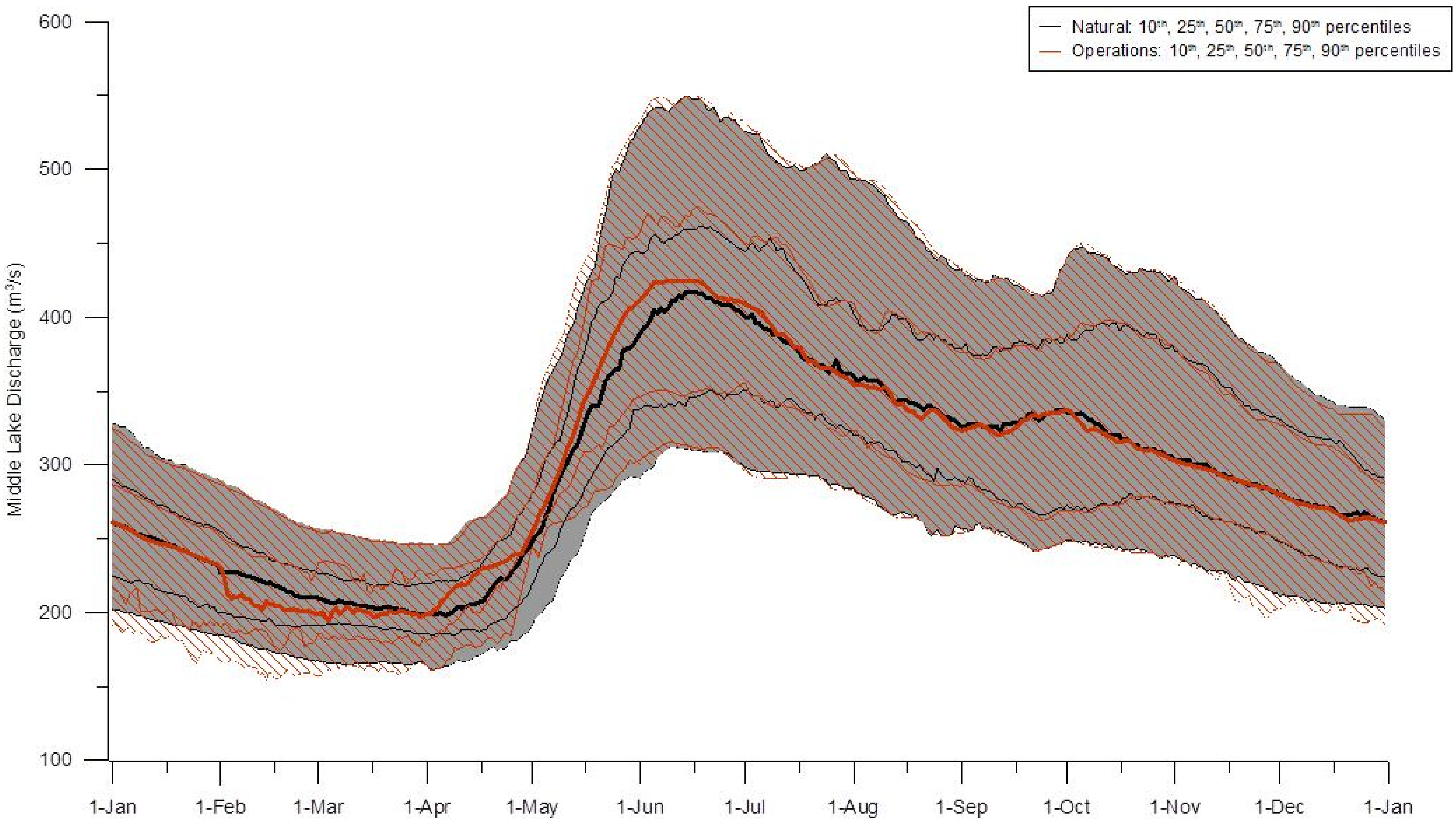

Figure 10.5-3: Predicted Changes in Discharge in Middle Lake

Note: Statistics are derived from 1963 to 2011 and are processed a daily resolution.

10.5.2 Changes to Hydrology during Maintenance Shutdowns

Changes to hydrology during maintenance shutdown events could occur according to the four maintenance schedules. The assessments completed here are based on the presence of two turbines. This approach is conservative for the purposes of predicting effects on hydrology since the shutdown of one of two turbines (95 m^3/s) will cause greater disruption relative to operations than the shutdown of one of four turbines (47.5 m^3/s).

- Monthly - One turbine at a time will be shut down for a routine inspection, adjustments, and maintenance.

  Because flow rates and water levels are typically low in January, February, March, and early April, the existing water management strategy typically results in the operation of only one turbine during these months. Thus, routine operation during this time will not additionally affect flow rates or water levels. While both turbines typically are active from April through December, shutting down one turbine for an 8-hour period during this time will only increase the water level in Black Lake by approximately 0.005, m and reduce the water level in Middle Lake by 0.05 m, relative to those predicted under routine operations.

- Annually - One turbine at a time will be shut down for up to two weeks for annual maintenance. To limit environmental effects and increase efficiency, this annual maintenance will occur when water levels are low and only one turbine is required for power generation.

  Under Project operations, as described in Section 10.5.1 and Appendix 10.1, one turbine will be shutdown, due to natural low water levels and flow rates, for up to 104 days per year. This typically occurs from January to April. Since the annual maintenance schedule can be timed to coincide with this window, no additional effects on hydrology are anticipated above those predicted during low flow years and routine operations.

- 5 years - Approximately every five years, both turbines will be shut down and the power tunnel will be drained for an inspection and maintenance lasting as long as one week.

  The week of complete shutdown every five years will be timed to occur during high flow periods that do not interfere with fish spawning; for example, during the first week of August, when riparian flow is at an average of 177 m^3/s. A shutdown during this period will result in up to a 0.150 m increase in Black Lake water levels relative to routine operations. Outflow from Middle Lake will reduce, from an average of 367 m^3/s for the first week of August to 178 m^3/s.

- 30 years - It is estimated that the turbine and generator units will require major overhaul maintenance approximately every 30 years. It is expected that only one unit at a time will be shut down for up to three months.

  Under Project operations, as described in Section 10.5.1 and Appendix 10.1, one turbine will be shutdown, due to natural low water levels and flow rates, for up to 104 days per year. Thus, this maintenance could occur during this period to prevent effects on hydrology beyond those predicted under routine operations.

10.5.3 Changes to Hydrology during Emergency Shutdowns

It is estimated that the plant will undergo between 10 and 50 emergency shutdowns per year, with most of these occurring during the summer months (i.e., weather-related). Most of the shutdowns would be for about 10 to 60 minutes. Emergency shutdowns often are caused by the effect of adverse weather conditions on the electrical grid and the frequency, distribution, and duration can vary from year to year. When the generating station is shut down, flow through the powerhouse generator units will be diverted through a flow bypass conduit. The flow bypass system will be designed so that it will maintain flows from the tailrace channel outlet into Middle Lake and the downstream environment during the emergency shutdowns.

The power plant will be shut down without advance notice if there is a load rejection in the transmission system due to transmission line failure. These unplanned shutdowns are expected to be infrequent and relatively brief, typically lasting from a few minutes to four or five hours. On occasions when the unplanned shutdown exceeds 15 minutes, the bypass conduit at the powerhouse would begin releasing flow to reduce drawdown effects on the Fond du Lac River below the tailrace channel outlet and Middle Lake. During these periods, flows through the natural outlet would slowly increase as water levels in Black Lake respond to reduced outflows.

The turbine generator units for the proposed station will be equipped with turbine inlet valves (TIV) to start and stop flows. The TIVs will be designed to close at a rate that will avoid undesirable increases in water pressure in the power tunnel.

A surge facility/adit will be incorporated into the Project conveyance system to control hydraulic transient pressures. The surge facility will limit the rise and fall of pressure when the turbine and generator units experience a load rejection by quickly reducing the water flow. The surge facility will limit the reduction in pressure when the units are started or when the load quickly increases. Due to the length of the power tunnel, the units would not maintain a constant speed while reacting to load changes if there was no surge facility.

The surge facility will be an inclined tunnel branching off the power tunnel and emerging at the surface at an elevation sufficient to contain the highest water pressures during operation, which will be above the surface level of Black Lake. The surge facility will provide access to the power tunnel during construction. An alternate design option being considered uses a raised bore vertical shaft excavated in the rock to the surface above the level of Black Lake. The surge facility will connect to the power tunnel a short distance upstream of the powerhouse. An alternate design option being considered uses a raised bore vertical shaft excavated in the rock to the surface above the level of Black Lake. The surge facility will connect to the power tunnel a short distance upstream of the powerhouse.

During average flow conditions, a 60 minute emergency shutdown would result in an increase in Black Lake water level of less than 1 millimetre (mm). Modelling has been completed to simulate a worst-case scenario when all units suddenly shut down for an extended period. During a prolonged emergency shutdown and average natural flow conditions, inflow to Middle Lake would be reduced by 190 m^3/s, which would result in a decrease in Middle Lake water level of approximately 8.6 centimetres per hour (cm/hour) and a maximum drawdown of 0.9 m. With the activation of the bypass conduit the drawdown rate in Middle Lake would be reduced to 4.35 cm/hour with a maximum total drawdown of 0.41 m (Appendix 10.3).

10.5.4 Management of Uncertainty

Predicting the response of natural systems to man-made disturbances is often uncertain due to a lack of comprehensive data required to constrain the magnitude and duration of these Project-related environmental effects. The following presents the main uncertainties associated with the hydrology assessment and the corresponding management of these uncertainties:

- Uncertainty associated with extrapolation - This uncertainty largely manifests in models as they extrapolate outside the measured bounds. Occurrences of extrapolation in hydrological assessment include:
  - Black Lake water level outside those measured;
  - Middle Lake water level below outside those measured;
  - low flows (<122 m^3/s) in the Fond du Lac River; and
  - areas along the Fond du Lac River without measured bathymetric data.

  These areas of uncertainty are presented and detailed methods are provided to allow interpretation of results in the context of extrapolation and uncertainty. In addition, extrapolations were verified with secondary information including high water marks, extent of shoreline vegetation, and professional judgment.

- Uncertainty associated with future conditions - The hydrological assessment explored future conditions by simulating the Project effects during observed historical conditions. While the 49 years represented in this dataset mean that a large variety of conditions were captured, there is inherent uncertainty about whether or not future hydrological conditions deviate from those observed historically. To address this concern, a climate change assessment was completed (Appendix 5.1) that predicts an increase in precipitation over the next century in the region, and thus, a likely increase in water level and flow rate. Because Project effects are more sensitive to low water levels and flow conditions, historical conditions were simulated to integrate conservatism.

- Uncertainty associated with baseline data - A high degree of confidence is associated with the baseline data for this Project. A large portion of these data were derived from credible and reliable data sources including Environment Canada (2012) and Project-specific field studies. Due to the interconnected nature of the hydrological and spatial datasets, multiple opportunities existed to compare, validate, and verify datasets; results indicated that all datasets were in sufficient agreement. For example, overlap was exploited to the extent possible within and between the following:
  - water level measurements from multiple sources (e.g., Environment Canada, baseline surveys, LiDAR, and in-situ sensor data);
  - flow measurements from independent sources (e.g., Environment Canada and baseline surveys), and
  - topographic data from multiple sources (e.g., airborne LiDAR topographic surveys, NTS datasets, baseline surveys, and in situ water level sensor data).

- Uncertainty associated with Project operations - While the Project operations are described with a high degree of confidence, there is considerably more uncertainty associated with predicting accidents, malfunctions, and unplanned events. To manage this uncertainty, conservatism was incorporated into the assessment where possible. For example, the "worst case scenario" was assessed for the emergency shutdown of the turbines, which simulates the most conservative estimate for timing (during drought conditions) and duration (longest predicted emergency).

10.6 Environmental Management, Monitoring, and Follow-up

Monitoring will be used to test and verify predictions and determine the effectiveness of mitigation and environmental design features. Monitoring also will be used to identify unanticipated changes and implement adaptive management. The following monitoring and follow-up programs are proposed for the Project as it related to changes in hydrology.

- Continuous water level sensors can be installed on Black Lake to monitor predicted effects on these waterbodies. These sensors can be regularly surveyed using an engineer's rod and level to correct for potential movement.
- Continuous flow records can be maintained in the bypassed section of the Fond du Lac River to verify environmental effects predictions.
- Some of the streamflow and water level data collected during the monitoring and follow-up programs can be used in the hydrological models applied to this assessment allowing for verification and validation of model results. These data also can be used to verify the hydrologic function of the weir at the outflow of Black Lake.

10.7 References

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10.8 Glossary

Term	Definition
Bathymetry	Measurement of the depth of a waterbody.
Channel	The main component of a given watercourse, it typically has flowing water, on at least a seasonal basis, and is usually defined by the area of the stream substrate.
Creek	Branch or small tributary of a river.
Discharge	The volume rate of water flow passing through a given cross-sectional area of a stream channel. The units typically used to express discharge are cubic meters per second (m^3/s).
Ephemeral	A phenomenon or feature that lasts only a short time (e.g., an ephemeral stream is only present for short periods during a year).
Evaporation	The process by which water is changed from a liquid to a vapour.
Flow Pathway	Flow preferred path in a drainage area.
Hydrology	The branch of science referring to the properties of surface water, including the spatial and temporal distribution.
Hydrometric Data	Data related with the components of the hydrological cycle, for example, precipitation, snow, rainfall, groundwater characteristics, or flow characteristics of surface water.
Hydrometric Station	A station where measurement of hydrological parameters is performed.
LiDAR	Light Detection and Ranging.
Mean	Centroid value of data population when viewing its probability distribution function (or historgram) as a mass distribution.
Morphology	Describes the physical form and structure of a waterbody or watercourse.
NTS	National Topographic System.
Runoff	The portion of water from rain and snow that flows over land to streams, ponds or other surface waterbodies. It is the portion of water from precipitation that does not infiltrate into the ground, or evaporate.
Stage-discharge relationship	Typically refers to a curve or lookup table showing the relation between the discharge of a stream and the water level in the stream.
Topography	Description or representation of physical geographic features such as land surfaces and shapes.
Transect	A line of travel (usually straight) across or within a lake that is either boated or waded allowing for a particular set of parameters to be measured at various points along the distance travelled.
Waterbody	A general term that refers to ponds, bays, lakes, estuaries and marine areas.
Watercourse	A general term that refers to riverine systems such as creeks, brooks, streams and rivers.
Watershed Area	A region of land that eventually contributes water to a river or lake.
Watershed	The area of land bounded by topographic features that drains water to a larger waterbody such as a river, wetlands or lake. Watersheds can range in size from a few hectares to thousands of kilometres.

10.9 List of Acronyms

Term	Definition
D&R	Decommissioning and Reclamation
LSA	local study area
NTS	National Topographic System
RTK	Real Time Kinematic
Project	Tazi Twé Hydroelectric Project
RSA	regional study area
TIV	turbine inlet valves
VC	valued component
WSC	Water Survey of Canada

10.10 List of Units

Term	Definition
<	less than
%	percent
cm	centimetres
cm/hour	centimetres per hour
ha	hectares
km	kilometre
km^2	square kilometre
L	litres
m	metre
m^2	square metre
m^3	cubic metre
m^3/d	cubic metres per day
m^3/s	cubic metres per second
m ASL	metres above sea level
mm	millimetre

11.0 SURFACE WATER QUALITY

11.1 Introduction

The purpose of the surface water quality section is to describe the physical and chemical characteristics of surface waterbodies that could be affected by the Tazi Twé Hydroelectric Project (the Project) and to assess the potential environmental effects from the Project on surface water quality. The scope of the surface water quality section includes an analysis of potential Project-related changes during construction, operation, and closure, and considers accidents, malfunctions, and unplanned events. Potential effects from the Project on surface water quality are evaluated together with potential cumulative environmental effects on surface water quality from the Project and other applicable developments.

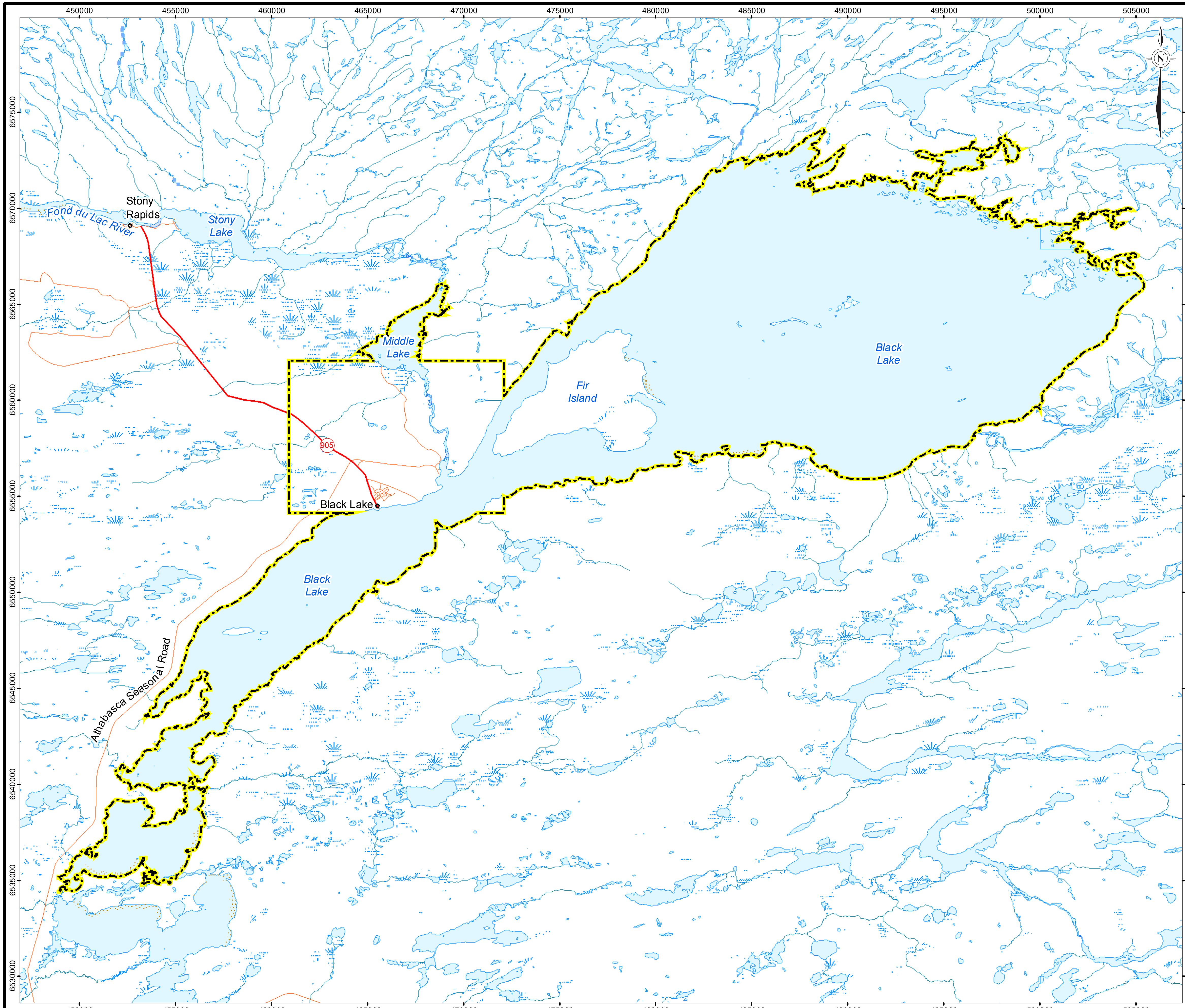
Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples and the public. The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development, and are therefore, used to predict the effects of the Project on all environmental components. Rationale for selection of surface water quality as a VC is as follows:

- surface water quality is important to community members, First Nations and Métis, and provincial and federal government regulators; and
- changes to surface water quality can affect other biophysical and socio-economic VCs that depend on suitable surface water quality.

The assessment endpoint is the key property that should be protected for use by future human generations and for surface water quality considers the protection of surface water quality for aquatic and terrestrial ecosystems, and human use. Measurement endpoints are quantifiable and qualitative expressions of change to the assessment point. For surface water quality, measurement endpoints include the concentrations of physical parameters (e.g., pH, conductivity, and turbidity), major ions, nutrients, metals, and radionuclides in water. Where appropriate, potential changes to sediment quality resulting from the Project have been considered. For example, particulate matter (e.g., total suspended solids [TSS]) in water can serve as a medium for the transport of chemical parameters from the water column to bottom sediments (Mackay 1991). Therefore, TSS changes in water could result in changes to sediment quality.

11.2 Spatial Boundaries

To quantify baseline conditions and evaluate potential environmental effects from the Project on surface water quality, a local study area (LSA) and regional study area (RSA) were defined. The LSA for the surface water quality assessment is based on the predicted direct and small-scale indirect effects from the Project on surface water and sediment quality. Potential direct effects and small-scale indirect effects on the surface water environment from the Project potentially could occur in three major waterbodies: Black Lake, the section of the Fond du Lac River between Black Lake and Middle Lake, and Middle Lake. Effects could occur in smaller waterbodies and watercourses in upland areas within the Project footprint and immediately downstream. Thus, the LSA for the surface water quality section of the EIS includes Black Lake, the Fond du Lac River (between Black Lake and Middle Lake), Middle Lake, and upland areas associated with site infrastructure and their corresponding downstream areas (Figure 11.2-1).



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WETLAND
- WATERBODY
- SURFACE WATER QUALITY LOCAL STUDY AREA

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6

5 0 5
SCALE 1:200,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

SURFACE WATER QUALITY LOCAL STUDY AEA

Tazi Twé
Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	29/07/13	**FIGURE: 11.2-1**	
CHECK	CF	30/07/13		
REVIEW	JF	30/07/13		

The RSA for the surface water quality assessment is based on the potential larger-scale direct and indirect effects from the Project. Lake Athabasca is the receiving waterbody of the Fond du Lac River and is considered to be the downstream extent of the RSA. Thus, the RSA for the surface water quality component is defined as Black Lake, the Fond du Lac River, and Lake Athabasca to the community of Fond du Lac, including all areas in the LSA (Figure11.2-2). The assessment of Project-specific and cumulative effects on surface water quality is completed at the scale of the RSA.

11.3 Existing Environment

The purpose of this section is to briefly describe the existing surface water and sediment quality conditions in the LSA and RSA as a basis for evaluating potential Project-specific and cumulative environmental effects. Detailed methods and results of the baseline surface water quality program are reported in Annex III.

11.3.1 Methods

The objectives of the water and sediment quality baseline programs were to collect site-specific information to document baseline conditions within the study areas, and to evaluate potential spatial, seasonal, and temporal trends. Water and sediment quality samples and in situ water column physico-chemical water quality (limnology) profile measurements or spot surface water measurements were collected from specific locations in Black Lake, the Fond du Lac River, and Middle Lake in different seasons throughout 2010 and 2011 (Figure 11.3-1; Annex III, Figure 4.2-1). Sediment chemistry samples were collected during spring and summer at two locations in Middle Lake and three locations in Black Lake.

Limnology water column profiles were recorded at two locations on the Fond du Lac River during the fall season, at four locations in Middle Lake during all four seasons, and at three locations in Black Lake during all four seasons. Limnology measurements were also recorded at stations where fish and other aquatic organisms were collected (Annex III, Appendix Table III.5-1). Water, sediment, and limnology sampling locations are provided in Figure 11.3-1.

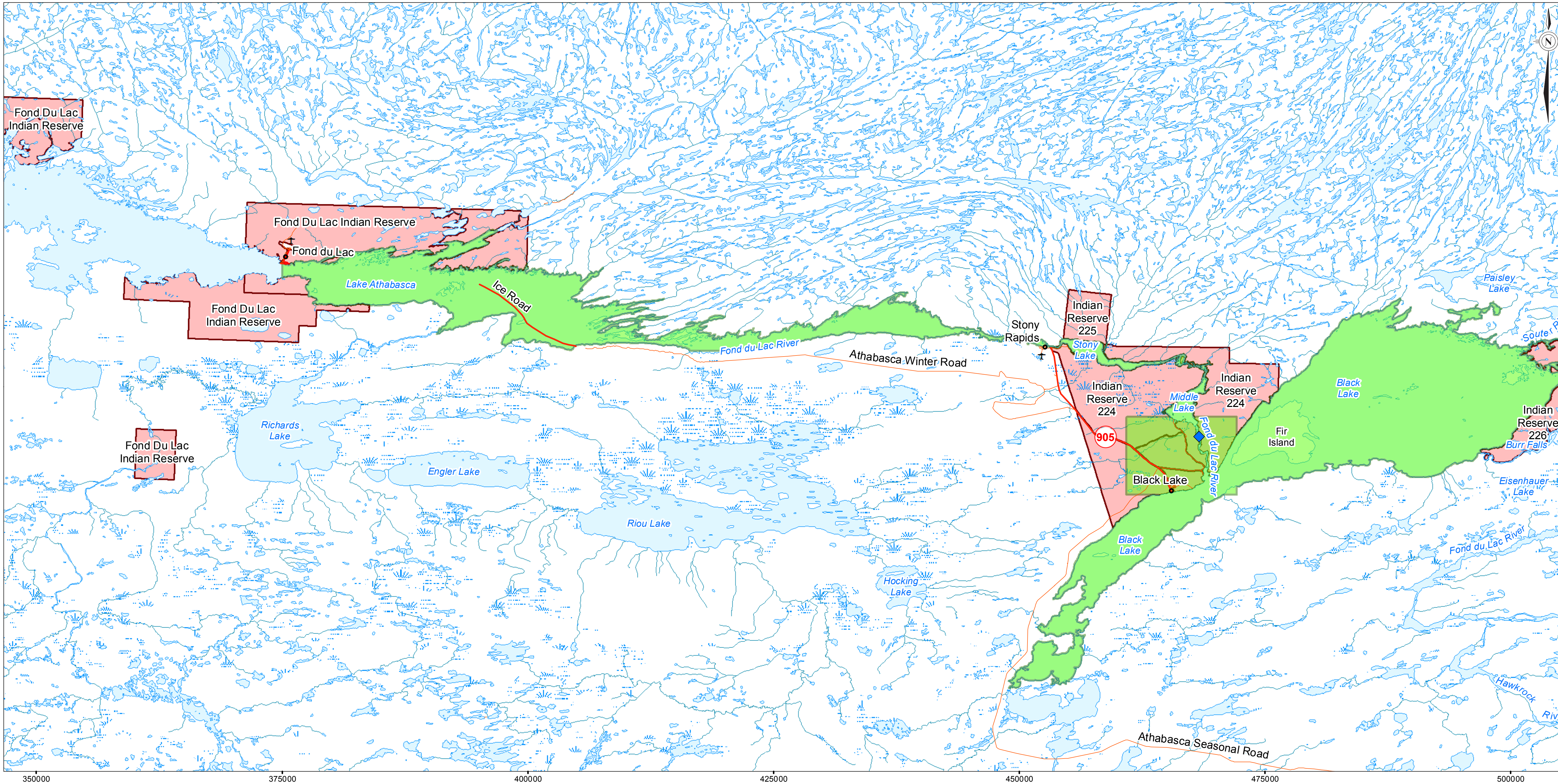
In addition to the in situ limnology measurements, water chemistry samples were analyzed for select conventional water quality parameters, major ions, nutrients, total metals, and radionuclides (Annex III, Tables 4.3-2 and 4.3-4). Sediment quality samples were analyzed for select physical characteristics, nutrients, total metals, and radionuclides (Annex III, Table 4.3-3 and 4.3-5).

Baseline surface water chemistry data were evaluated by comparing concentrations of individual parameters with federal and provincial water quality guidelines and objectives, including the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines (CWQG) for the protection of aquatic life and the Saskatchewan Surface Water Quality Objectives (SSWQO) for the protection of aquatic life (CCME 1999; Saskatchewan Environment 2006).

Baseline sediment chemistry data were evaluated by comparing the concentrations of individual parameters with CCME Sediment Quality Guidelines for the protection of aquatic life, which are composed of Interim Sediment Quality Guidelines (ISQG) and Probable Effects Level (PEL) values (CCME 2002).

11.3.2 Results

Baseline surface water chemistry and sediment chemistry data collected from Black Lake and Middle Lake are presented in Tables 11.3-1 and 11.3-2, respectively.



LEGEND

- VILLAGE
- HIGHWAY
- ROAD
- RIVER
- WETLAND
- WATERBODY
- INDIAN RESERVE
- ELIZABETH FALLS
- REGIONAL STUDY AREA

10 0 10

SCALE 1:400,000 KILOMETRES

REFERENCE

DMTI HIGHWAYS AND ROADS
NTS MAPSHEET 74I, 74J, 74O, 74P
DATUM: NAD 83 PROJECTION: UTM ZONE 13

PROJECT

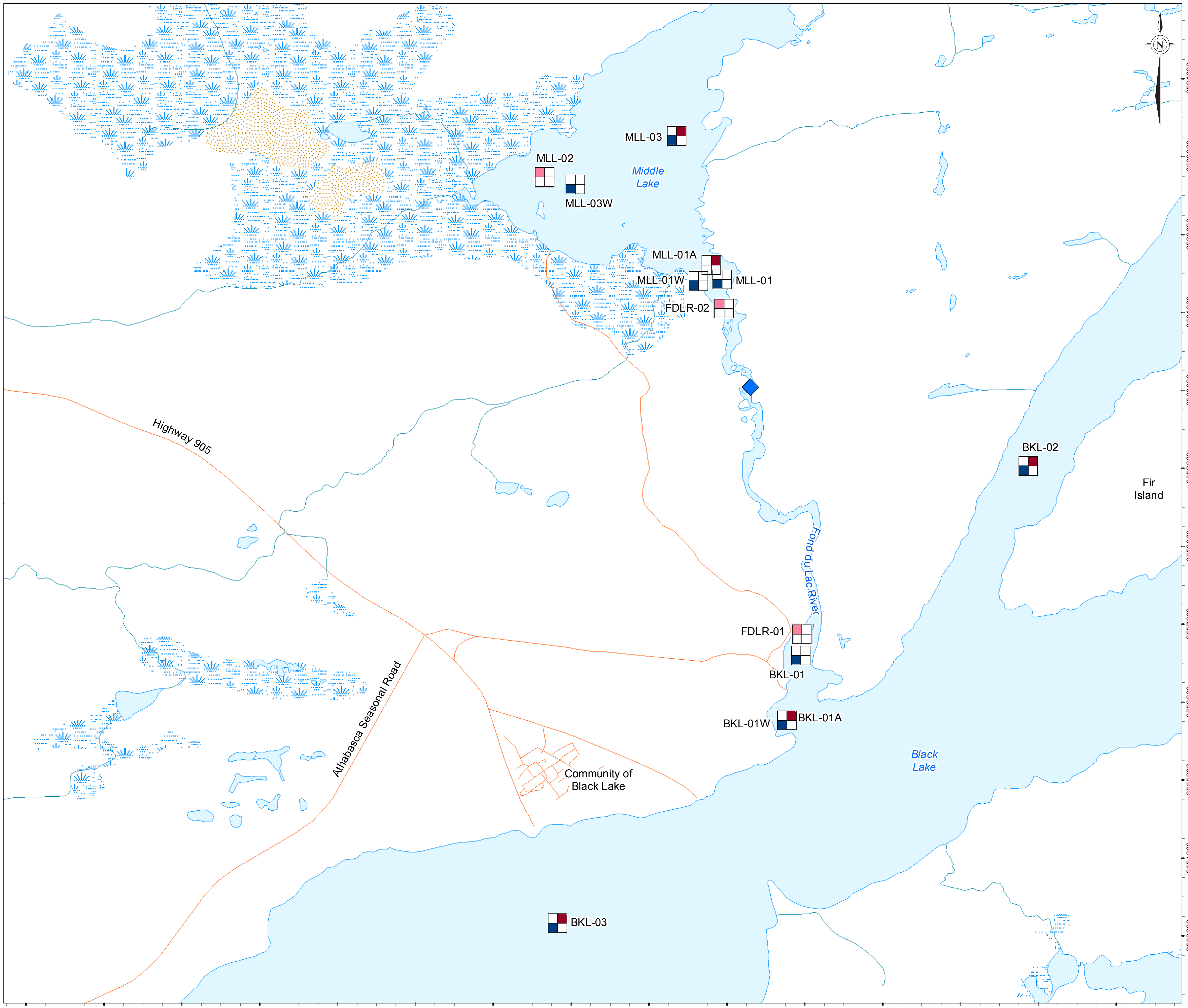
TAZI TWÉ HYDROLELECTRIC PROJECT

TITLE

SURFACE WATER QUALITY REGIONAL STUDY AREA

Tazi Twé
Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 2
GIS	SM	23/07/13	FIGURE:	
CHECK	CF	30/07/13	11.2-2	
REVIEW	JF	30/07/13		



LEGEND

- ROAD
- RIVER
- WETLAND
- WATERBODY
- ELIZABETH FALLS

AQUATIC SAMPLE LOCATION KEY

LIMNOLOGY
SEDIMENT CHEMISTRY
WATER CHEMISTRY

REFERENCE

DATUM: NAD83 PROJECTION: UTM ZONE 13
DMTI HIGHWAYS AND ROADS

1 0 1
SCALE 1:50,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

WATER AND SEDIMENT QUALITY SAMPLING LOCATIONS, 2010 AND 2011

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 2
GIS	SM	23/07/13	
CHECK	CF	30/07/13	**FIGURE: 11.3-1**
REVIEW	JF	30/07/13	

Table 11.3-1: Summary of Water Chemistry Results for Samples Collected from Black Lake and Middle Lake, Spring 2010 to Winter 2011

Parameters	Unit	Guidelines		Detection Limit	Black Lake				Middle Lake			
		SSWQO[a]	CWQG[b]		BKL - 01	BKL-01W	BKL - 02	BKL - 03	MLL - 01	MLL-01W	MLL - 03	MLL-03W
					n = 5	n = 1	n = 4	n = 5	n = 4	n = 1	n = 3	n = 1
Conventional Parameters (Field-Measured)												
Dissolved Oxygen	mg/L	6.5/9.5[c]	6.5/9.5[c]	-	9.6 - 13.5	13.3	9.6 - 13.8	9.5 - 13.1	10.2 - 13.9	14.5	10.6 - 13.9	14.8
pH	pH Unit	-	6.5-9.0	-	6.5 - 7.6	6.8	6.4 - 7.8	6.0 - 7.8	6.6 - 7.3	7.4	6.6 - 7.5	7.4
Specific Conductivity	µS/cm	-	-	-	30 - 37	58	31 - 41	39 - 56	35	44	35 - 36	43
Water Temperature	°C	-	-	-	5.38 - 15.58	1.67	2.89 - 10.7	3.24 - 10.8	3.45 - 15.1	0.09	3.79 - 15.73	0.14
Conventional Parameters (Laboratory-Measured)												
Total Alkalinity	mg/L	-	-	1	15 - 22	22	12 - 21	11 - 24	12 - 20	25	12 - 15	26
Total Hardness	mg/L	-	-	1	11 - 14	17	11 - 14	13 - 16	13	15	13	16
Total Dissolved Solids	mg/L	-	-	1	28 - 29	43	24 - 29	28 - 36	26 - 31	41	25 - 31	42
Total Suspended Solids	mg/L	-	-	1	<1 - 3	<1	<1 - 2	<1 - 2	<1 - 2	<1	<1 - 1	<1
Nutrients												
Ammonia as Nitrogen	mg/L	0.855[d]	0.855[d]	0.01	<0.01	<0.01	<0.01 - 0.05	<0.01	<0.01 - 0.02	<0.01	<0.01	<0.01
Nitrate	mg/L as NO_3	-	13	0.04	<0.04 - 0.13	0.04	<0.04 - 0.13	<0.04 - 0.11	<0.04 - 0.165 [m]	0.09	<0.04 - 0.09	0.09
Nitrite+Nitrate as Nitrogen	mg/L	-	-	0.01	<0.01 - 0.08	0.01	<0.01 - 0.03	<0.01 - 0.03	<0.01 - 0.04	0.02	<0.01 - 0.02	0.02
Total Kjeldahl Nitrogen	mg/L	-	-	0.05	0.13 - 0.25	0.24	0.15 - 1.4	0.16 - 0.82	0.15 - 0.22	0.19	0.14 - 0.16	0.26
Total Nitrogen	mg/L	-	-	0.05	0.13 - 0.28	0.25	0.17 - 1.4	0.18 - 0.84	0.15 - 0.25	0.21	0.14 - 0.18	0.28
Total Phosphorus	mg/L	-	-	0.01	<0.01 - 0.01	<0.01	<0.01 - 0.02	<0.01	<0.01 - 0.02	<0.01	<0.01 - 0.02	<0.01
Dissolved Phosphorus	mg/L	-	-	0.01	<0.01 - 0.01	<0.01	<0.01	<0.01 - 0.03	<0.01 - 0.01	<0.01	<0.01	0.01
Major Ions												
Bicarbonate	mg/L	-	-	1	18 - 27	27	15 - 26	13 - 29	15 - 24	30	15 - 18	32
Calcium	mg/L	-	-	0.1	2.9 - 3.3	4	2.9 - 3.3	3.1 - 3.8	3.1 - 3.2	3.6	3.1	3.9
Chloride	mg/L	-	120	0.1	1.2 - 5.1[m]	6.8	0.8 - 2.4	3.3 - 7.0	2.4 - 3.6	3.7	2.4 - 4.0	4.0
Magnesium	mg/L	-	-	0.1	1.0 - 1.3	1.7	1.0 - 1.3	1.2 - 1.6	1.2	1.5	1.2	1.5
Potassium	mg/L	-	-	0.1	0.5 - 0.7	0.9	0.5 - 0.8	0.7 - 0.9	0.6 - 0.7	0.8	0.6 - 0.7	0.8
Sodium	mg/L	-	-	0.1	1.3 - 1.7	2.4	1.2 - 1.6	1.8 - 2.3	1.5 - 1.7	1.9	1.5 - 1.8	1.9
Sulfate	mg/L	-	-	0.2	1.3 - 1.4	1.4	1.3 - 1.5	1.1 - 1.4	1.2 - 1.3	1.4	1.2 - 1.3	1.5

Table 11.3-1: Summary of Water Chemistry Results for Samples Collected from Black Lake and Middle Lake, Spring 2010 to Winter 2011 (continued)

Parameters	Unit	Guidelines		Detection Limit	Black Lake				Middle Lake			
		SSWQO[a]	CWQG[b]		BKL - 01	BKL-01W	BKL - 02	BKL - 03	MLL - 01	MLL-01W	MLL - 03	MLL-03W
					n = 5	n = 1	n = 4	n = 5	n = 4	n = 1	n = 3	n = 1
Organics												
Chlorophyll *a*	mg/m^3	-	-	0.1	1.0 - 3.0[m]	0.1	<0.1 - 2.8	<0.1 - 4.6	2.4 - 2.6	<0.1	2.2 - 3.6	<0.1
Total Metals												
Aluminum	mg/L	0.005-0.1[e]	0.005-0.1[e]	0.0005	0.0026 - 0.0036	0.0035	0.0024 - 0.0040	0.0017 - 0.0054[m]	0.0030 - 0.0033	0.0044	0.0016 - 0.0028	0.0042
Antimony	mg/L	-	-	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Arsenic	µg/L	5	5	0.1	0.1 - 0.2	0.1	<0.1 - 0.1	0.1 - 0.2	0.1	0.1	0.1	0.1
Barium	mg/L	-	-	0.0005	0.0042 - 0.0044	0.0042	0.0040 - 0.0048	0.0041 - 0.0048	0.0041 - 0.0044	0.0049	0.0037 - 0.0045	0.005
Beryllium	mg/L	-	-	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Boron	mg/L	-	1.5	0.01	<0.01 - 0.01	0.02	<0.01	0.01 - 0.02	<0.01 - 0.01	0.01	<0.01 - 0.01	0.01
Cadmium	mg/L	0.000017[f]	0.000006[f]	0.00001	<0.00001	0.00001	<0.00001 - 0.00001	<0.00001 - 0.00001	<0.00001	0.00001	<0.00001	<0.00001
Chromium	mg/L	-	0.0010/0.0089[g]	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Cobalt	mg/L	-	-	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper	mg/L	0.002[h]	0.002[h]	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Iron	mg/L	0.3	0.3	0.0005	0.017 to 0.055	0.04	0.010 - 0.046	0.020 - 0.086	0.011 - 0.075	0.035	0.0096 - 0.078	0.034
Lead	mg/L	0.001[i]	0.001[i]	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Manganese	mg/L	-	-	0.0005	0.0097 to 0.019	0.0044	0.0040 - 0.0061	0.0062 - 0.034	0.0092 - 0.025	0.0042	0.0085 - 0.027	0.0039
Mercury	µg/L	0.026[j]	0.026[j]	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	mg/L	-	0.073	0.0001	0.0001 to 0.0002	<0.0001	0.0001 - 0.0002	<0.0001 - 0.0001	<0.0001 - 0.0001	0.0001	<0.0001 - 0.0001	<0.0001
Nickel	mg/L	0.025[k]	0.025[k]	0.0001	0.0001	<0.0001	0.0001	<0.0001 - 0.0001	<0.0001 - 0.0001	0.0001	<0.0001 - 0.0001	0.0001
Selenium	mg/L	0.001[l]	0.001[l]	0.0001	<0.0001 to 0.0002	<0.0001	<0.0001 - 0.0001	<0.0001	<0.0001	<0.0001	<0.0001 - 0.0002	<0.0001
Silver	mg/L	0.0001	0.0001	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Strontium	mg/L	-	-	0.0005	0.021 - 0.042	0.061	0.018 - 0.032	0.048 - 0.064	0.036 - 0.040	0.045	0.033 - 0.044	0.047
Thallium	mg/L	-	0.0008	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Tin	mg/L	-	-	0.0001	0.0005 to 0.0010	<0.0001	<0.0001 - 0.0009	<0.0001 - 0.0013	0.0006 - 0.0011	<0.0001	0.0004 - 0.0008	<0.0001
Titanium	mg/L	-	-	0.0002	<0.0002 to 0.0003	<0.0002	<0.0002 - 0.0004	<0.0002 - 0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Uranium	µg/L	15	15	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	mg/L	-	-	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Zinc	mg/L	0.03	0.03	0.0005	<0.0005	<0.0005	<0.0005	<0.0005 - 0.0006	<0.0005 - 0.0014	<0.0005	<0.0005	<0.0005

Table 11.3-1: Summary of Water Chemistry Results for Samples Collected from Black Lake and Middle Lake, Spring 2010 to Winter 2011 (continued)

Parameters	Unit	Guidelines		Detection Limit	Black Lake				Middle Lake			
		SSWQO[(a)]	CWQG[(b)]		BKL - 01	BKL-01W	BKL - 02	BKL - 03	MLL - 01	MLL-01W	MLL - 03	MLL-03W
					n = 5	n = 1	n = 4	n = 5	n = 4	n = 1	n = 3	n = 1
Radionuclides												
Lead-210	Bq/L	-	-	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Radium-226	Bq/L	-	-	0.005	<0.005 - 0.008	<0.005	<0.005 - 0.005	<0.005 - 0.006	<0.005 - 0.010	<0.005	<0.005 - 0.01	<0.005
Thorium-230	Bq/L	-	-	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Notes: Values that are equal to or exceed the SSWQO are bolded. Values that are equal to or exceed the CWQG are underlined. Non-detected values that are higher than one or more guideline are italicized. If all values for a sampling station were the same, a single value is presented.

(a) Saskatchewan Environment's (2006) Saskatchewan Surface Water Quality Objectives (SSWQO).
(b) Canadian Council of Ministers of the Environment's (CCME) Canadian water quality guidelines (CWQG) for the protection of aquatic life - freshwater (CCME 1999 plus updates).
(c) The guidelines for dissolved oxygen for cold-water biota are 9.5 mg/L for early life stages and 6.5 mg/L for other life stages.
(d) The guidelines for ammonia are dependent on temperature and pH; therefore, the guideline for each station was calculated and the lowest overall value determined for Black Lake and Middle Lake was used for screening of the baseline data.
(e) The guidelines for aluminum are pH-dependent; the guideline is 0.005 mg/L at pH<6.5; 0.1 mg/L at pH>6.5. Field pH values were used in the screening.
(f) The SSWQO for cadmium is hardness-dependent; for hardness ranging from 0 to 48.5 mg/L as $CaCO_3$, the guideline is 0.017 µg/L. The CWQG is also hardness dependent; this guideline was calculated using the equation ($10^{0.86 \times [\log10(\text{hardness})] - 3.2}$); based on a mean hardness of 13.3 mg/L as $CaCO_3$ for Black Lake, the guideline is 0.006 µg/L.
(g) The guideline for chromium is speciation-dependent; the guideline is 0.0089 mg/L for trivalent chromium and 0.0010 mg/L for hexavalent chromium.
(h) The guidelines for copper are hardness-dependent. The mean baseline hardness for Black Lake was 13.3 mg/L $CaCO_3$. For hardness ranging from 0 to 120 mg/L as CaCO3, the SSWQO is 0.002 mg/L. The CWQG is determined based on a specific equation; however, the minimum guideline of 0.002 mg/L applies in this case.
(i) The guidelines for lead are hardness-dependent. The mean baseline hardness for Black Lake was 13.3 mg/L $CaCO_3$. For hardness ranging from 0 to 60 mg/L as CaCO3, the SSWQO is 0.001 mg/L. The CWQG is determined based on a specific equation; however, the minimum guideline of 0.001 mg/L applies in this case.
(j) Mercury objective is for inorganic mercury only.
(k) The guidelines for nickel are hardness-dependent; the mean baseline hardness for Black Lake was 13.3 mg/L $CaCO_3$. For hardness ranging from 0 to 60 mg/L as $CaCO_3$, the SSWQO is 0.025 mg/L. The CWQG is determined based on a specific equation; however, the minimum guideline of 0.025 mg/L applies in this case.
(l) Selenium guideline is based on waterborne exposure.
(m) While the majority of data complied with program Quality Control (QC) limits, one datum from the range was reported as variable and outside program QC limits.

mg/L = milligrams per litre; mg/L as NO_3 = milligrams per litre as nitrate; µS/cm = microSiemens per centimetre; ºC = degrees Celsius; mg/m^3 = milligrams per cubic metre; µg/L = micrograms per litre; Bq/L = Becquerels per litre; n = number of samples; mg $CaCO_3$/L = milligrams of calcium carbonate per litre; < = less than; - = not applicable or not collected.

Table 11.3-2: Sediment Chemistry Results for Samples Collected from Black Lake and Middle Lake, Fall 2010

Parameter Group	Parameter	Unit	CCME ISQG[(a)]	PEL[(b)]	Detection Limit	Stations				
						BLK-01A	BLK-02	BLK-03	MLL-01A	MLL-03
Physical Properties	Gravel	%	-	-	0.10	<0.10	<0.10	<0.10	1.96	<0.10
	Coarse Sand	%	-	-	0.10	18.5	0.48	0.11	82.8	15.6
	Fine Sand	%	-	-	0.10	50.3	7.83	1.00	11.9	61.6
	Silt	%	-	-	0.10	28.9	78.5	77.0	3.2	21.7
	Clay	%	-	-	0.10	2.30	13.2	21.9	0.14	1.06
	Loss on Ignition	%	-	-	-	14.81	6.49	41.08	0.78	4.00
	Moisture Content	%	-	-	0.01	67.88	75.3	76.60	44.14	50.55
Nutrients	Nitrite+Nitrate Nitrogen	µg/g	-	-	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Total Kjeldahl Nitrogen	µg/g	-	-	5	115	2,450	3,950	204	1,450
	Total Nitrogen	µg/g	-	-	5	115	2,450	3,950	204	1,450
	Total Organic Carbon	%	-	-	-	2.29	2.76	5.39	0.23	1.74
	Total Phosphorus	µg/g	-	-	1 to 50	1,540	1,100	750	140	970
Metals	Aluminum	µg/g	-	-	20	5,300	10,400	9,200	4,830	6,600
	Antimony	µg/g	-	-	0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	Arsenic	µg/g	5.9	17	0.1	**17**	**7.9**	4.2	0.9	5.1
	Barium	µg/g	-	-	0.5 - 20	520	140	97	24	61
	Beryllium	µg/g	-	-	0.1	0.6	0.6	0.6	<5	0.6
	Boron	µg/g	-	-	1	<1	<1	<1	9	4
	Cadmium	µg/g	0.6	3.5	0.1	0.2	0.3	0.2	<0.1	<0.1
	Chromium	µg/g	37.3	90	0.5	14	32	24	10	27
	Cobalt	µg/g	-	-	0.2	9.9	9.3	4.4	1.7	5.0
	Copper	µg/g	35.7	197	0.5	6.2	13	9.3	1.5	3.7

Table 11.3-2: Sediment Chemistry Results for Samples Collected from Black Lake and Middle Lake, Fall 2010 (continued)

Parameter Group	Parameter	Unit	CCME ISQG[(a)]	PEL[(b)]	Detection Limit	Stations				
						BLK-01A	BLK-02	BLK-03	MLL-01A	MLL-03
Metals (continued)	Iron	µg/g	-	-	20	46,000	33,100	21,700	3,400	17,900
	Lead	µg/g	35	91.3	0.1	7.5	9.5	8.8	2.0	3.9
	Manganese	µg/g	-	-	20	7,500	3,100	540	93	370
	Molybdenum	µg/g	-	-	0.1	5.6	2.7	1.4	<0.1	0.9
	Nickel	µg/g	-	-	0.1	12	22	13	6.1	14
	Selenium	µg/g	-	-	0.1	0.4	0.6	0.6	<0.1	0.2
	Silver	µg/g	-	-	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Strontium	µg/g	-	-	0.5	42	56	58	27	30
	Thallium	µg/g	-	-	0.2	0.2	0.2	<0.2	<0.2	<0.2
	Tin	µg/g	-	-	0.1	0.5	0.3	0.6	0.4	0.3
	Titanium	µg/g	-	-	20	370	910	510	160	420
	Uranium	µg/g	-	-	0.1	3.3	5.9	4.3	0.7	2.0
	Vanadium	µg/g	-	-	0.1	37	48	36	9.4	29
	Zinc	µg/g	123	315	0.5	42	60	42	11	51
Radionuclides	Lead-210	Bq/g	-	-	0.04	0.40	0.27	0.46	<0.04	0.13
	Polonium-210	Bq/g	-	-	0.01	0.50	0.31	0.44	0.02	0.08
	Radium-226	Bq/g	-	-	0.01	0.23	0.11	0.07	0.03	0.04
	Thorium-230	Bq/g	-	-	0.02	0.04	0.03	0.03	<0.02	<0.02

Note: Values greater than or equal to ISQGs are bolded. Values greater than or equal to PELs are bolded and underlined.
Non-detect values that have detection limits that are greater than guidelines are italicized.
(a) ISQG = Interim Freshwater Sediment Quality Guidelines (CCME 2002).
(b) PEL = Probable Effect levels (CCME 2002).
CCME = Canadian Council of Ministers of the Environment; % = percentage; µg/g = micrograms per gram; Bq/g = Becquerels per gram; < = less than; - = not applicable.

11.3.2.1 Black Lake

Black Lake has surface water quality that is characteristic of other lakes in northern Saskatchewan, being low in dissolved and suspended solids, nutrients, and metals (Table 11.3-1). Dissolved oxygen concentrations were usually uniform throughout the water column in the spring and fall, with decreases in dissolved oxygen concentrations below weak thermoclines observed in the summer at the two deepest sampling locations (Figure 11.3-1; BKL-02 and BKL03). Thermoclines often develop in deep lakes located in areas with temperate climates, such as Black Lake (Fee et al. 1996). In general, dissolved oxygen concentrations were lowest during the summer and close in value to the CCME CWQG for the protection of cold-water aquatic life (i.e., 9.5 milligrams per litre [mg/L]). During spring, fall, and winter, dissolved oxygen concentrations were generally above the upper limit of the CCME CWQG. Specific conductivity was generally low (maximum of 58 microSiemens per centimetre [µS/cm]), and was generally higher in the winter and spring. The pH of Black Lake was generally lower during the spring, being slightly acidic and below the lower limit for the protection of aquatic life (pH 6.5). During the summer, fall, and winter, the pH was generally higher than spring and within the pH range for the protection of aquatic life (pH 6.5 to 9.0; CCME [1999]).

Black Lake was characterized by low hardness, alkalinity, and TSS, which indicates Black Lake water is soft with low buffering capacity, and possessing high transparency (Table 11.3-1; Annex III; Figure 4.3-2 to Figure 4.3-4). Generally, nutrient levels were measured at concentrations near or below analytical detection limits, indicating Black Lake has low biological productivity. More specifically, in a majority of the water samples, total phosphorus was measured at or below the detection limit of 0.01 mg/L, which is the upper range of total phosphorus for an oligotrophic lake (and lower range for a mesotrophic lake) as defined by the CCME (2004). Ammonia and nitrate concentrations were also at or slightly above their detection limits. Low concentrations of chlorophyll *a* (<0.1 to 4.6 milligrams per cubic metre [mg/m^3]), and relatively large Sechhi depths that ranged from 3.0 to 6.0 metres (m) (Annex III, Appendix III.5), further supported Black Lake's oligotrophic to mesotrophic status. Baseline metal concentrations generally did not exceed CCME CWQG or SSWQO, with metal concentrations often being below analytical detection limits; exceptions included aluminum, barium, iron, manganese, and strontium, which were measured in concentrations above their detection limits, but still below applicable guidelines. Baseline concentrations of cadmium exceeded the current CWQG for protection of aquatic life (0.006 micrograms per litre [µg/L]) because the method detection limit (0.01 µg/L) also exceeds the guideline (CCME 1999); however, this highly conservative guideline is currently under federal review and revision. Radionuclides were often measured at or below the analytical detection limits and did not exceed guidelines.

Sediment chemistry results for samples collected from Black Lake in the fall of 2010 are presented in Table 11.3-2. In general, the substrates at locations sampled in Black Lake were predominately a silty clay composition, while occasional samples had a higher proportion of sand. Nutrient and metal concentrations in sediment were variable among the three sampling locations in Black Lake. Arsenic was the only metal to exceed the CCME ISQG or PEL thresholds, with concentrations at BKL-01A (i.e., 17 micrograms per gram [µg/g]) exceeding PEL, and concentrations at BKL-02 (7.9 µg/g) exceeding ISQG.

11.3.2.2 Middle Lake

Limnology profiles were collected in spring, summer, and fall. During the open water season, temperature and dissolved oxygen profiles were well mixed, likely due to the shallow depth and inflow of water from the Fond du Lac River (Table 11.3-1; Annex III, Section 4.3.3). Conductivity levels were low and similar to those in Black Lake, with conductivity slightly higher in the winter. The pH of Middle Lake followed a similar pattern to the pH of

Black Lake, with slightly lower spring values, although values in Middle Lake were above the lower limit for the protection of aquatic life (pH 6.5). Limnology information for Middle Lake could not be collected during the winter due to unsafe conditions (i.e., thin ice or open water conditions).

The water chemistry in Middle Lake was similar to that of Black Lake. Middle Lake was characterized by low hardness, alkalinity, and TSS, which indicates Middle Lake water is soft with low buffering capacity, and high transparency. Generally, nutrient levels (i.e., phosphorus, ammonia, and nitrate) were measured at concentrations near or below the analytical detection limits, indicating Middle Lake is in the oligotrophic to mesotrophic range. Most metals and radionuclides were measured at or below their analytical detection limits, with no exceedances of CCME CWQG or SSWQO observed (with the exception of cadmium where the CWQG is below the detection limit). As with Black Lake, metals in Middle Lake with concentrations above their detection limits included aluminum, barium, iron, manganese, and strontium.

Sediment chemistry results for samples collected from Middle Lake in the fall of 2010 are presented in Table 11.3-2. Middle Lake sediments were characterized as being dominated by sand with some silt, and low organic carbon content. Metal concentrations in Middle Lake sediment were variable between the sampling locations; however, no exceedances of the CCME ISQG or PEL were observed.

11.3.2.3 Fond du Lac River

As water quality parameters in the Fond du Lac River between Black Lake and Middle Lake are expected to be similar to those measured at the Black Lake outlet and the Middle Lake inflows, only limnology parameters and chlorophyll *a*, a measure of aquatic ecosystem productivity, were measured for the baseline investigation (Annex III, Section 4.3.1). Dissolved oxygen concentrations were generally high in spring and fall, with all measurements above the lower CCME CWQG limits, while dissolved oxygen concentrations were generally lower in the summer, with concentrations falling below the CCME lower limit (9.5 mg/L) at approximately half of the sampling locations. During the spring, pH values were often slightly acidic and lower than the lower bound CCME CWQG (6.5), while pH values were neutral to slightly alkaline and within the CCME CWQG range and SSWQO during the summer. Because the water quality directly upstream in Black Lake was characterized by low nutrient and chlorophyll *a* concentrations, and chlorophyll *a* measurements in the Fond du Lac River were low (2.9 and 5.2 mg/m^3), it is assumed that the Fond du Lac River also has low biological productivity.

11.4 Screening of Project Interactions and Mitigation

This section identifies and evaluates the interactions between Project components or activities, and the corresponding potential environmental effects on the continued sustainability of surface water quality for aquatic life (i.e., the assessment endpoint), consistent with the approach for the EIS, as presented in Section 7.0. The process begins with the identification of potential environment/Project interactions. To provide a robust assessment of potential environmental effects, each interaction is initially considered to have a potential linkage to change in the surface water environment and associated potential environmental effects on surface water quality. Potential interactions between the Project and surface water quality are identified in a matrix format in Table 11.4-1. When appropriate, potential changes to sediment quality have been considered.

Table 11.4-1: Project Interactions, Environmental Design Features and Mitigation, and Potential Interactions to the Surface Water Environment

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Environmental Components	Environmental Design Features and Mitigation Measures	Interaction Classification
■ Infrastructure Footprints ▪ Temporary infrastructure – contractor camp area – overburden and Waste Rock Disposal Areas – construction area and materials laydown area ▪ Operational infrastructure – power generation station – water intake structure – power tunnel – tailrace channel – submerged weir – bridge – transmission line – water diversion structures around the Project footprint – potable water and wastewater intake and discharge structures – site access roads (including source material)	Construction Operations Closure	Site clearing, contouring, and excavation can cause soil erosion, which can change surface water and sediment quality.	■ A site-specific assessment will be completed prior to soil salvage to identify surficial stripping depths and develop a site-specific soil salvage plan. ■ An Erosion and Sediment Control Plan will be developed based on industry standard Best Management Practices (BMPs) and federal and provincial regulatory requirements. ■ Site drainage and surface runoff will be managed through the incorporation of erosion control methods (e.g., ditch blocks, silt fences) so that overland flow does not direct sediment-laden water into any natural watercourses. ■ Culverts will be incorporated into the design where necessary to maintain local drainage patterns. ■ Soil will be salvaged separately from overburden materials and saved for reclamation. ■ Salvaged topsoil will be stored on-site and away from surface waterbodies and sensitive areas, as well as areas that may be subject to travel, storage of equipment or material, or future disturbances (i.e., reduce soil handling). ■ Waste rock disposal areas will be contoured with the surrounding landscape. ■ Erosion control practices will be applied to salvaged topsoil to reduce potential erosion and sediment transport off-site. ■ Disturbed areas (e.g., access roads and banks) will be graded to a stable angle after work is completed, reclaimed, and revegetated.	No Linkage
	Construction	Dewatering of the tunnel during construction may change groundwater quantity, which can change hydrology, and affect surface water quality.	■ not applicable	Secondary
■ Construction of In-water Works ▪ water intake structure ▪ tailrace channel outlet ▪ submerged weir structure ▪ bridge	Construction	Construction of the water intake structure, submerged weir, tailrace channel outlet, and bridge abutments may disturb sediment, which can change surface water quality.	■ In-water works will be completed in accordance with conditions outlined in the DFO authorization. ■ DFO In-Water Construction Timing Windows will be followed during the Project. ■ An environmental monitor will be on site during in-water work to monitor compliance with the construction specifications and to confirm project approvals are achieved. ■ Cofferdams or turbidity curtains will be used to contain sediment released during in-water construction. ■ In-water work will be isolated from flowing water and adjacent lake or river habitats to reduce downstream or offsite effects. ■ An Erosion and Sediment Control Plan will be developed. ■ Any materials used for shoreline stabilization will be clean and free of fine sediments and contaminants. ■ A turbidity/total suspended solids regression will be developed and a Turbidity Monitoring Program will be implemented. ■ Dewatering operations will be directed to settling ponds prior to discharge to watercourses. ■ Water will be discharged to watercourses in a manner that does not cause erosion or other damage to adjacent areas. ■ No in-water construction activities will begin until fish salvage activities for the associated in-water work area are complete.	Secondary

Table 11.4-1: Project Interactions, Environmental Design Features and Mitigation, and Potential Interactions to the Surface Water Environment (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Environmental Components	Environmental Design Features and Mitigation Measures	Interaction Classification
■ Blasting Activities	Construction	Use of explosives near surface waterbodies can change surface water and sediment quality.	■ A detailed blasting plan will be developed for the Project and set-back distances during blasting of the water intake foundation, and tailrace channel outlet will be included as part of this plan. ■ A Blasting Plan is expected to be developed for the Project, which will describe the type of explosives used (e.g., ammonium nitrate/fuel oil [ANFO] and water-resistant explosives like Unimax® or similar) and the method of detonation (e.g., singular versus sequential blasting). ■ DFO's Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters (Wright and Hopky 1998) will be used for this Project. ■ A Site Water Management Plan will be developed for the Project. ■ Construction and monitoring of settling ponds or water treatment areas to receive runoff from the waste rock disposal areas will be part of the Site Water Management Plan.	Primary
■ Air Emissions ▪ emissions of dust from blasting activities and hauling Waste Rock Disposal Areas ▪ emission of standard pollutants from vehicles and heavy equipment operation	Construction Operations Closure	Deposition of criteria air contaminants (e.g., NOx and SOx) can change surface water quality.	■ Equipment will be regularly maintained for compliance with provincial and federal air emission standards. ■ The equipment used for hauling and mucking operations will operate using diesel fuel with an ultra-low sulphur diesel content less than 15 parts per million (ppm). ■ The heavy-duty stationary and mobile diesel-fueled equipment fleet will meet or exceed EPA Tier 2/3 air quality emissions standards. ■ The gasoline-fueled equipment fleet will meet or exceed EPA Tier 2 Bin 6 air quality emissions standards. ■ An Environmental Protection Plan (EnvPP) will describe material handling protocols including dust management. ■ Soil salvage stockpiles or exposed soils will be seeded. ■ All unpaved roads will be watered on a regular basis to prevent wind driven fugitive dust. ■ A speed limit will be enforced on unpaved roads on site. ■ A forced air method of ventilation will be used for venting of dust, gases and fumes from inside the power tunnel following blasting. ■ A Water Quality Monitoring Program will be implemented.	Primary
	Construction Operations Closure	Dust deposition can change surface water and sediment quality.		Primary
■ Power Generation Activities ▪ water withdrawal for power generation ▪ diversion of water through the power tunnel to the powerhouse ▪ discharge of tailrace channel flows	Operations	Withdrawal, diversion, and discharge of water for power generation may change groundwater, surface water, and sediment quality.	■ The proposed Project has been designed to incorporate a subsurface water intake as part of the tunnel diversion, which is anticipated to reduce the amount of air entrained in the system by the water intake and reduce the plunging of air and water to depth at the tailrace channel outlet ■ Rock material used to construct the submerged weir will consist of rock with low potential for acid generation or radioactive materials.	No Linkage
	Operations	Withdrawal and discharge for power generation may change the temperature of the water.	■ A wide, shallow water intake approach is expected to withdraw water from the surface of the lake to reduce temperature differences between the water entering the river at the tailrace channel outlet and what naturally enters the Fond du Lac River through the Black Lake outlet.	Secondary
■ Potable and Industrial Water Supply	Construction Operations	Water withdrawal for domestic (e.g., potable water) and industrial (e.g., dust suppression) purposes can change hydrology, which can affect surface water quality.	■ Potable water for the construction camp is anticipated to be sourced from one or more new wells located near the camp, although this water could potentially be drawn from either Black Lake or the Fond du Lac River.	No Linkage

Table 11.4-1: Project Interactions, Environmental Design Features and Mitigation, and Potential Interactions to the Surface Water Environment (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Environmental Components	Environmental Design Features and Mitigation Measures	Interaction Classification
■ Site Water Management ▪ collection and treatment of surface runoff within the project footprint ▪ withdrawal of potable and industrial water ▪ discharge of wastewater ▪ collection and treatment of groundwater in the tunnel	Construction Operations	The interception and collection of direct precipitation and surface runoff within the Project footprint may change hydrology, which can affect surface water quality.	■ Surface runoff will be diverted around and away from waste rock disposal areas as much as possible. ■ The site will be properly graded and will be surrounded by ditches and berms to capture runoff from the waste rock disposal areas. ■ The waste rock disposal areas will be placed in locations that are easily modified to control run-on and run-off. Runoff from the waste rock disposal areas will be directed to settling ponds prior to discharge to the Fond du Lac River; water quality will be confirmed before release to the environment (e.g., Fond du Lac River). ■ Runoff and drainage from within and around Project roadways and structures will be managed through the incorporation of erosion control methods (e.g., ditch blocks, silt fences) so that overland flow does not direct sediment-laden water into natural watercourses. ■ Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns. ■ Ditch capacities will be sized to accommodate an extreme daily rainfall event. ■ Riprap energy dissipaters and ditch lining will be installed in areas where runoff velocities are deemed excessive to reduce soil erosion. ■ Runoff from areas unaffected by the Project will be directed away from construction areas and allowed to discharge through natural channels. ■ A Site Water Management Plan will be developed for the Project. ■ Power tunnel seepage water will be monitored for quality and quantity and treated or managed to acceptable standards before discharge to the environment.	No Linkage
	Construction Operations	Surface water diversions (e.g., berms, ditches, waste rock disposal areas) around the Project footprint can change drainage areas, runoff characteristics, and local and downstream hydrology, which can affect surface water quality.		No Linkage
	Construction Operations	Collection and disposal of wastewater from the site can cause changes to surface water and sediment quality.	■ A Site Water Management Plan will be developed for the Project. ■ Implementation of Water Quality Monitoring Program. ■ Construction and monitoring of settling ponds or water treatment areas will be part of Site Water Management Plan. ■ Groundwater originating from construction of the power tunnel will be collected, treated if necessary, and monitored to confirm discharge criteria are met prior to release into the receiving environment. ■ Runoff from the waste rock disposal areas will be directed to settling ponds prior to discharge to the Fond du Lac River. ■ Wastewaters released from the settling ponds will meet applicable water quality guidelines (e.g., CCME) at the end of the mixing zone in the Fond du Lac River. ■ Contingency plans for off-site disposal of dewatered settling pond sludge will be included in an EnvPP. ■ Portable toilet facilities and holding tanks will be used at the construction camp. ■ Sewage and grey water will be hauled off-site and disposed of at the Black Lake lagoon.	Primary
	Construction Operations	Discharge of sewage and grey water can affect surface water and sediment quality.		No Linkage

Table 11.4-1: Project Interactions, Environmental Design Features and Mitigation, and Potential Interactions to the Surface Water Environment (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Environmental Components	Environmental Design Features and Mitigation Measures	Interaction Classification
■ Waste Rock Disposal Areas	Construction Operations Closure	Seepage from waste rock disposal areas can change surface water and sediment quality.	■ A Waste Rock Management Plan will be developed for the Project. ■ Excavated material will be stored away from watercourses or lakes. ■ Excavated rock and aggregate materials will be tested to confirm that this material will not have negative effects on the surrounding environment. Specific mitigation measures will be applied if the material is identified to be acid generating, or containing elevated levels of metals or radionuclides. ■ Construction and monitoring of settling ponds or water treatment areas will be included in the Site Water Management Plan. ■ Additional site investigation and laboratory testing will be completed upon completion of the final Project design and during construction of the Project.	Primary
■ Closure Activities	Closure	Cessation of power generation activities, including the withdrawal, diversion, and discharge of water, can change hydrology, and surface water quality.	■ A Decommissioning and Reclamation Plan will be developed for the Project. ■ A series of concrete bulkheads will be placed in the tunnel, if necessary, to isolate mineralized bedrock zones and reduce potential for mineralized groundwater to discharge through the power tunnel. ■ Quality of groundwater discharging through the tunnel may be monitored and sampled during the decommissioning phase, if required.	Secondary
■ Accidents, Malfunctions, and Unplanned Events ▪ emergency shutdowns of power turbines ▪ hazardous materials spills ▪ embankment failure	Construction Operations Closure	Release or spills of hazardous substances (e.g., fuel, oil) can change surface water and sediment quality.	■ All fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard; a lined and dyked containment area around these tanks will be provided to contain any potential fuel spills. The design of the containment area will be based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. ■ The storage containers will be regularly inspected for leaks or damage, and replaced when necessary. ■ Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled, and located in lined and bermed containment areas. ■ Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers. ■ Regular maintenance of construction equipment. ■ Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. ■ Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills of fuel would flow to the sump, which would be pumped out to a container for shipment off-site. ■ An Emergency Response Plan will be developed. ■ Spill response material (e.g., sorbent pads) will be stored on-site in designated areas and in vehicles. ■ Contaminated (impacted) soils will be removed and disposed of in an approved landfill or waste management facility.	No Linkage
	Construction Operations Closure	Failure of the embankment dykes around the settling ponds can change surface water and sediment quality.	■ Embankment dykes will be stripped of vegetation, topsoil, and roots to expose the mineral soil subgrade as necessary to accommodate the size of the footprint. ■ Fill material will be clean mineral soil with sufficient moisture to allow for proper compaction ■ The embankment will be covered with topsoil, seeded, or protected with gravel or riprap as soon as practical following construction. ■ The settling pond will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway.	No Linkage

DFO = Fisheries and Oceans Canada; EnvPP = Environmental Protection Plan; CCME = Canadian Council of Ministers of the Environment; % percent

Each potential interaction is evaluated to determine if mitigation can be developed and incorporated to remove the interaction or limit the potential environmental effect on surface water quality. Mitigation, including Project design elements, environmental best practices, and management policies and procedures, is developed through an iterative process between the Project's engineering and environmental teams. Knowledge of the surface water environment and mitigation is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for a residual environmental effect (i.e., effect remaining after incorporation of mitigation) on surface water quality.

Interactions between the Project and the biophysical environment are determined to be primary, secondary, or having no linkage using scientific knowledge, professional judgment of technical specialists, experience with similar developments, and mitigation (Table 11.4-1). Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by environmental design features and mitigation so that the Project results in no detectable (measurable) change and residual effects on surface water quality relative to baseline or guideline values;
- secondary - interaction could result in a minor change, but would have a negligible residual effect on surface water quality relative to baseline or guideline values and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary – interaction is likely to result in a measurable change that could contribute to residual effects on surface water quality relative to baseline or guideline values.

Primary interactions are anticipated to result in a residual environmental effect on the continued sustainability of surface water quality to support aquatic life and human use, and require further analysis to determine the significance of the residual environmental effect. Project interactions determined to have no linkage or those that are considered to be secondary are not predicted to result in environmental effects on the continued sustainability of surface water quality to support aquatic life and human use. As such, interactions with no linkage or those considered secondary are not analyzed further in this EIS.

11.4.1 Interactions with No Linkage to Effects

An interaction could have no linkage if the activity does not occur, or if the interaction is removed by environmental design features or other types of mitigation. These Project interactions result in no detectable (i.e., measurable) environmental change and therefore no residual effects on surface water quality in the Project area. The following interactions are expected to have no linkage to surface water quality and, therefore, will not be carried through the effects assessment.

- **Site clearing, contouring, and excavation can cause soil erosion, which can affect surface water and sediment quality.**

Site clearing, contouring, and excavation during construction have the potential to cause soil erosion, which could cause soil to enter waterbodies within the LSA and result in changes to surface water quality. Increased sediment runoff as a result of site clearing, contouring, and excavation may result in increased TSS and trace metal (e.g., aluminum, cadmium, chromium, copper, iron, mercury, and silver) concentrations in receiving and downstream waterbodies. An Erosion and Sediment Control Plan will be developed based on industry standard Best Management Practices (BMPs) and federal and provincial regulatory requirements.

The adverse effects of soil erosion can be reduced by implementing recommended mitigation practices, which include the following:

- conducting site clearing, soil salvage, and construction and decommissioning of Project infrastructure (e.g., roads or laydown areas), during dry or frozen conditions, where and when practical;
- applying erosion control practices (e.g., seeding soil salvage stockpiles or silt fences) to salvaged topsoil to reduce potential erosion and sediment transport to surface waterbodies;
- storing salvaged topsoils on-site and away from surface waterbodies;
- applying coarse riprap or other erosion control measures to the banks of watercourses to prevent soil erosion after the removal of culverts;
- conducting site-specific assessments to identify appropriate surficial stripping depths and develop a site-specific soil salvage plan; and
- adhering to the conceptual Erosion and Sediment Control Plan.

With the implementation of the mitigation techniques described above, it is anticipated that the changes to surface water quality from soil erosion will not be detectable. Therefore, this interaction is expected to have no linkage to effects on surface water quality.

- **Withdrawal, diversion, and discharge of water for power generation may change groundwater and surface water quality.**

Withdrawal of water from Black Lake, diversion of water into the power tunnel, and subsequent discharge of water to the Fond du Lac River for power generation during operation of the Project has the potential to affect surface water quality. As water passes through a hydroelectric facility, it could become super-saturated with dissolved gases (Becker et al. 2003). The proposed Project has been designed to incorporate a subsurface water intake as part of the tunnel diversion, which is anticipated to reduce the amount of air entrained in the system by the water intake and reduce the plunging of air and water to depth at the tailrace channel outlet (CEA 2001).

Characteristics (e.g., depth, turbulence) of the receiving waters immediately downstream of the power plant discharge determine the rate of degassing for water released from the power generating facility. Gases in super-saturated waters dissipate rapidly in shallow, well-mixed areas of rivers; degassing potential is much lower in river reaches or lakes that are deep or calm (Parametrix Inc. [Parametrix] 2005). The tailrace channel is expected to be approximately 800 m long, 25 m wide, and contain flows 5.5 m deep, with a design velocity predicted to be around 1.4 metre per second (m/s). Tailrace design is subject to optimization. Because air entrainment within the tailrace channel flows is expected to be minimal, it is anticipated that mixing of Project and riparian flows below the tailrace channel outlet will limit the potential for super-saturated conditions downstream in Middle Lake.

The proportion of groundwater inflows within the power tunnel flows is expected to be minimal during operation of the Project (i.e., 680 cubic metres per day [m^3/d]; Appendix 9.2). These groundwater inflows represent a very small fraction of the total operational flows through the tunnel, i.e., 0.004 percent (%) of the flow through the tunnel (approximately up to 190 cubic metres per second [m^3/s] for a 50 megawatt (MW) facility). Therefore, release of mineralized groundwater to the surface water environment from the power tunnel during operations is anticipated to have only a negligible effect on surface water quality in Middle Lake.

Successful diversion of water into the power tunnel, while maintaining historical water levels within Black Lake, will require the construction of a submerged weir. Rock used to construct the weir will consist of un-weathered rock with low potential for acid generation or radioactive materials. Therefore, the quality of water flowing through the Fond du Lac River during operations is not expected to be affected by the presence of the weir.

Withdrawal of water from Black Lake, diversion of water into the power tunnel, and subsequent discharge of water to the Fond du Lac River during Project operation is not expected to change groundwater quality, and consequently, surface water quality. Therefore, there is no linkage between the withdrawal, diversion, and discharge of water for power generation during operations and effects on surface water quality.

- **Water withdrawal for domestic (e.g., potable water) and industrial (e.g., dust suppression) purposes can change hydrology, which can affect surface water quality.**

The withdrawal of water for domestic and industrial purposes during Project construction and operation has the potential to change hydrology. Water usage will vary depending on the number of workers on-site and is expected to be greatest during the construction phase of the Project when up to 250 people are expected to be on-site. Water requirements for the construction phase can reach up to 4,700,000 L/y (i.e., approximately 13 m^3/d) for industrial water and potable water use is expected to be between 30,000 and 45,000 litres per day (L/d) (i.e., 30 to 45 m^3/d). Potable water for the construction camp is anticipated to be sourced from one or more new wells located near the camp, although this water could be drawn from either Black Lake or the Fond du Lac River. During operations, approximately 365,000 L/y (i.e., 1 m^3/d) of water will be required for the Project. Potable water will be drawn from the penstock (i.e., located at the area of transition from the power tunnel to the powerhouse and turbines) and treated for use.

A supply of industrial water will be required for dust suppression and fire-protection during Project operation. Industrial water will be diverted from power generation flows passing through the power station. Storage tanks will provide the appropriate storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (2 hours of available water at 750 US gallons per minute [2,839 litres per minute]). Industrial water (i.e., used for fire suppression, preparing concrete, and controlling road dust) will be taken from Black Lake (i.e., water intake location) and the Fond du Lac River (i.e., bridge location).

Water withdrawal from Black Lake or the Fond du Lac River for domestic and industrial use during construction and operations is not expected to have a measureable effect on water volumes or flow rates. Black Lake has a waterbody volume of 6,610,000,000 cubic metres (m^3), and the Fond du Lac River has an average baseline flow rate of 304 m^3/s. Withdrawal of 21,125 m^3/y from these waterbodies will account for less than 0.0001% of the corresponding waterbody volume and flow rate. Because water requirements during operations are lower than those for construction, potential effects during operations are expected to be much lower, despite the reductions in riparian flows that will occur as a result of power generation.

Based on the predicted volumes of water that could potentially be withdrawn from Black Lake or the Fond du Lac River, no detectable changes to flows in Black Lake or the Fond du Lac are expected. As such, there is no linkage to residual effects on surface water quality.

- **The interception and collection of direct precipitation and surface runoff within the Project footprint may change hydrology, which can affect surface water and sediment quality.**
- **Surface water diversions (e.g., berms, ditches, waste rock disposal areas) around the Project footprint can change drainage areas, runoff characteristics, and local and downstream hydrology, which can affect surface water and sediment quality.**

The Project footprint and proposed surface water diversions have the potential to change the local hydrology, such as surface runoff characteristics, which can affect available fish habitat. The footprint of the Project will be as compact as possible to limit the area affected by Project activities and subsequent changes to hydrology. The total area to be cleared is approximately 869 hectares (ha), and the Project will use existing roads and corridors where possible to reduce the extent of new disturbance and related alteration of drainage patterns and surface water runoff. Of this 869 ha, approximately 600 ha will be reclaimed immediately following construction and about 250 ha will be required for operation. Following closure of the Project, the entire area will be reclaimed.

Protecting and managing surface drainage water (and sediment) will be addressed through implementation of a Site Water Management Plan. Surface runoff from areas unaffected by the Project will be directed away from construction areas and into natural drainage courses. Runoff that is redirected from roadways, construction laydown areas, and other areas affected by construction, including groundwater collected during construction of the power tunnel, will be collected in settling ponds. Surface runoff will also be diverted away from waste rock disposal areas as much as possible; locations of waste rock disposal areas will be such that run-on and run-off can be easily controlled. Runoff from waste rock disposal areas and power tunnel seepage water will be monitored to confirm water quality objectives are met before discharge to the environment. Ditches will be sized to accommodate extreme rainfall events and riprap energy dissipaters and ditch liners will be installed in areas where runoff velocities are deemed excessive. Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns.

The interception and collection of direct precipitation within the Project footprint will be limited to a total area of less than 1 square kilometre (km^2), corresponding to waste rock disposal areas, contractor's work areas, and borrow areas. The potential 1 km^2 of intercepted and collected precipitation and runoff will be dispersed across several sub-watersheds, and while the runoff characteristics and hydrology within these areas will be affected, these changes will be contained within the disturbed areas, which account for a fraction of 1% of the greater Fond du Lac River watershed. Thus, while some changes could be observed in small upland streams, ponds, and drainage paths, the interception and collection of direct precipitation and runoff within the Project footprint are not expected to result in measurable changes to hydrology in downstream waterbodies.

The preferred design and location of the traffic bridge across the Fond du Lac River is a single-pier bridge located approximately 600 m upstream of Elizabeth Falls. The abutments for the bridge will be installed so that they extend below the current high water mark, but above the high-water mark anticipated for the Project. Therefore, no changes to flows in the Fond du Lac River are expected.

Given the footprint size and design of surface water management structures, it is expected that there will be no measureable changes on surface water quality. Therefore, the Project infrastructure-related changes on downstream flows were determined to have no linkage to residual effect on surface water quality.

- **Discharge of sewage and grey water can affect surface water and sediment quality.**

Sewage and grey water from the Project will be transported to the Black Lake Lagoon for treatment. The amount of sewage and grey water produced at the site during Project construction and operation will be dependent upon the number of workers on site. It is currently anticipated that a maximum of 250 people will be on-site during construction, although the exact number of people employed will be determined when the design of the generating station is finalized. During the peak construction period, it is expected that the workers will produce about 30,000 L/d of sewage and grey water (e.g., the equivalent of two truckloads a day). Based on similar facilities located in remote northern regions, it is anticipated that between six and eight people could be required to operate the plant. Therefore, it is estimated that the Project will produce approximately 1,400 litres (L) of wastewater per day. Sewage and grey water from plumbing fixtures will be directed to the sanitary system and pumped to an outdoor buried fiberglass sewage-holding tank. The sewage-holding tank will be pumped out as required (about once a week) and disposed of at the Black Lake lagoon.

The Black Lake lagoon was completed in 2009, and at the time of design had a design horizon to 2018 (Lukey 2013, pers. comm.). The lagoon will have the capacity to accommodate the peak Project camp requirements (Lukey 2013, pers. comm.). The storage cell at the lagoon has a volume of 165,500 m^3, while the primary cell has a volume of approximately 100,000 m^3 (Keleman 2013, pers. comm.). Treated water is released to the west of the Black Lake lagoon into a wetland/swamp area once every six months (in spring and in fall). Prior to release, the treated water must meet applicable water quality criteria as per Wastewater Systems Effluent Regulations (Government of Canada 2013).

As sewage and grey water will be managed on-site during construction and operations and disposed off-site at the Black Lake lagoon, no linkage to residual effects on surface water quality are expected.

11.4.2 Interactions with Secondary Linkages

In some cases, both a source of change from the Project and an interaction with the environment exist, but since the change caused by the Project is anticipated to be small, relative to baseline or guideline values, only a negligible residual effect is anticipated to surface water quality. Interactions with these characteristics are classified as secondary linkages. The following interactions are considered to be secondary linkages, and will not be carried through the environmental effects analysis.

- **Dewatering of the power tunnel during construction may change groundwater quantity, which can change hydrology, and affect surface water quality.**

During the construction of the power tunnel, water intake, and tailrace channel, work will be completed “in the dry” and potential seepage into these areas will require dewatering. The period of dewatering could continue throughout construction (i.e., three years), but is not expected to reach maximum drawdown rates until the latter stages. Dewatering activities may drawdown the local groundwater table and affect water volumes in surface waterbodies located within the zone of influence.

The only surface waterbody within the zone of influence and potentially affected by dewatering activities is Lake A, which is located approximately 1.5 kilometres (km) north of the proposed water intake structure. This lake is assumed to be fish-bearing on the basis that its outflow to Black Lake has no known barriers to fish passage. Lake A has a drainage area of 637,000 square metres (m^2) and flows into Black Lake at an estimated average annual rate of 0.036 m^3/s; however, flow rates are likely higher during the spring and summer, and lower during the late winter.

Groundwater modeling results predict an incremental flux out of Lake A at up to 0.001 m^3/s during construction. This flux rate is approximately 3% of the average annual flow though rate, indicating that the outflow channel should remain active for the majority of its flow season and that any drawdown that occurs during low inflow periods will be replenished annually. Additionally, this rate of drawdown is predicted only during a short period in the latter stages of construction and could be of lower magnitude if less conservative fault, overburden, and bedrock hydraulic conductivities and recharge through the overburden exist.

The amount of drawdown that is expected to occur within Lake A because of power tunnel dewatering is considered to be within the range of natural variation associated with estimated annual outflow rates. Therefore, this Project interaction is expected to have negligible residual effect on surface water quality.

- **Construction of the water intake structure, submerged weir, and tailrace channel outlet may disturb sediment, which can change surface water and sediment quality.**

Construction of the water intake structure in Black Lake, the weir, and the tailrace channel outlet in the Fond du Lac River will include in-water work, and will therefore require an Authorization from DFO. Disturbance of sediments during in-water work could change surface water and sediment quality by increasing concentrations of TSS in adjacent and downstream waterbodies. Additionally, settling of sediments disturbed during construction or decommissioning of in-water works could fill the interstitial spaces within the substrate or change the substrate composition.

Appropriate precautions through mitigation and management activities will be taken during in-water construction works to reduce potential impacts to surface water and sediment quality. These include the following:

- completing in-water construction works in accordance with the DFO Authorization;
- completing fish salvages for in-water work areas prior to the commencement of in-water works;
- using cofferdams or turbidity barriers to contain sediment released during in-water construction work to isolate in-water works from flowing water and adjacent lake habitats, thereby reducing the potential for downstream or off-site impacts;
- developing a turbidity/TSS regression and implementing a Turbidity Monitoring Program during in-water construction work to identify if further mitigation is required at the excavation site or at any sensitive receptor near the excavation site;
- having an environmental monitor on site during in-water work to monitor compliance with the construction specifications and Project approvals;
- directing dewatering operations toward sediment control devices (e.g., settling ponds) or natural attenuation areas prior to discharge to watercourse;
- discharging water to watercourses in a manner that does not cause erosion or other damage to discharge areas; and
- developing and implementing a conceptual Sediment and Erosion Control Plan for the Project.

Changes to surface water quality from the release of sediment during construction of the water intake, submerged weir, tailrace channel outlet, and bridge abutments are expected to be minor due to mitigation, use of appropriate construction methods, and adherence to regulatory guidance. Consequently, this Project interaction is anticipated to have negligible residual effects on surface water quality.

- **Withdrawal and discharge for power generation may change the temperature of the water.**

Diversion of water for hydroelectric power generation can affect surface water quality and, subsequently fish and fish habitat. Changes to water temperatures at the water intake site and in waterbodies downstream of the discharge location are often among the most prevalent surface water quality issues encountered at hydropower facilities (Oak Ridge National Laboratory [ORNL] et al. 2010). Water diverted for power generation is often withdrawn from near the reservoir bottom; in temperate regions where lakes and reservoirs tend to be thermally stratified, this can lead to withdrawal of cooler water in the summer and relatively warm water in the winter (ORNL et al. 2010). Withdrawal and discharge of cooler bottom water in the summer, for example, may cause water temperatures at the water intake site to increase and water temperatures downstream of the power generation facility to decrease (Department of Electricity Development [DOED] 2002). The opposing phenomenon would be expected during winter, when inverse stratification is likely to occur in lakes and reservoirs. These untimely changes to water temperatures at the water intake and locations downstream of the discharge site can affect overwintering, spawning, and foraging habitats, as well as the processes and behaviors that are important to survival of fish (Scotland and Northern Ireland Forum for Environmental Research [SNIFFER] 2011).

The water intake for the Project has been designed to reduce the thermal effects of water withdrawal and discharge, and subsequently, mitigate potential environmental effects on fish and fish habitat. The water intake approach channel will be designed and constructed so that diverted water is withdrawn from near the surface of the lake, thereby reducing temperature differences between Project water and water entering the river through the natural Black Lake outlet (Appendix 12.3). Because Black Lake will not be impounded, the volumes and temperatures of water flowing out of the lake during operation (i.e., through the natural outflow and the water intake) will be similar to current values (i.e., volumes and temperatures of water flowing out the natural outflow) throughout much of the year. However, it is possible that during winter, water withdrawn from greater depths (i.e., closer to 5 m deep) in Black Lake could be slightly warmer than water draining naturally at the outlet to the Fond du Lac River. Overall, very minor changes to water temperature in Black Lake are anticipated.

Water withdrawn from Black Lake will pass through a 2.95 km long power tunnel to the powerhouse and then discharge into an open tailrace channel, which flows into the Fond du Lac River approximately 5 km downstream of the natural Black Lake outlet and about 1 km upstream of Middle Lake. The tailrace channel will be approximately 800 m long. It is anticipated that water passing through the Project facility will not have the same opportunity to cool (winter) or warm (summer) as water passing down the Fond du Lac River under open channel flow conditions. During winter, water entering the Fond du Lac River from the tailrace channel may cool slightly when exposed to cold air, but is expected to be slightly warmer than the natural flow in the Fond du Lac River where the two flows converge, upstream of Middle Lake (Golder 2013).

Because flows in the bypassed river reaches will be reduced, it is anticipated the rate of heat exchange between the water remaining in the river channel and ambient air will increase, thereby potentially altering water temperatures. The most extreme temperature effects of the Project would be expected to occur during the periods of lowest riparian flow and extreme cold (i.e., winter), as well as periods of extreme heat (summer). The modelled data presented in Hydrology indicates that riparian flow temperatures could fall as low as 0 degrees

Celsius (°C) when the Project is operating during winter and riparian flows in the Fond du Lac River are reduced below approximately 50 m^3/s (Golder 2013).

Water temperatures downstream of the tailrace channel outlet in the Fond du Lac River will be governed by mixing of water that has passed through Project infrastructure (i.e., water intake, power tunnel, and tailrace channel) and water that has flowed through the bypassed river reaches. The maximum difference between the river temperature upstream of the tailrace channel outlet in the Fond du Lac River and the mixed river temperature downstream of the tailrace channel discharge is expected to be approximately 0.5°C, assuming a low winter riparian flow of 40 m^3/s. Based on this riparian flow rate, the temperature of water entering Middle Lake in the winter months is expected to be approximately 0.3°C warmer than under current conditions.

In winter, cooler ambient air temperatures and reduced riparian flow volumes resulting from Project operation can affect overwintering habitat of fish by reducing water temperatures and increasing the potential for ice formation (Stantec 2010) in the bypassed section of the Fond du Lac River. Formation and buildup of frazil ice has the potential to damage fish habitat and may be a direct cause of fish injury and mortality. Formation of anchor ice (i.e., submerged ice that is anchored to the bottom) is not reported to occur in Black Lake, Middle Lake, or the connecting section of the Fond du Lac River under current temperature and flow conditions. Formation of frazil ice and anchor ice is not expected to be an issue downstream of the tailrace channel outlet when the Project is operating because the mixed water is expected to be slightly warmer during winter. Because the water entering Middle Lake during winter may be slightly warmer than under current conditions, it is anticipated that the period and spatial extent of ice cover on Middle Lake may be somewhat reduced. In spring and summer, the reduced flow of water in the bypassed reaches of the Fond du Lac River could become heated by relatively warm ambient air.

Minor changes to water temperature from withdrawal and discharge of water for power generation are expected to result in negligible residual effects on surface water quality due to implementation of environmental design features and maintenance of minimum instream flow requirements.

- **Cessation of power generation activities, including the withdrawal, diversion, and discharge of water, can change hydrology, which can affect surface water quality.**

The assessment boundary for Project operation is 90 years; however, the operational lifespan of the Project could extend 100 years or more. It is anticipated that cessation of power generation and removal of the submerged weir at the outlet of Black Lake will allow for the re-establishment of natural (i.e., pre-Project) flow regimes in the Fond du Lac River. Returning flows in the Fond du Lac River to pre-Project levels is expected to increase the maximum depths of bypassed river reaches and increase flow velocities to pre-Project (i.e., historical) values.

A Decommissioning and Reclamation (D&R) Plan will be developed and submitted for the Project. Closure, when it occurs, will comply with all federal and provincial acts, regulations, and standards applicable at the time, and in discussion with the BLFN. Plans for development of habitat restoration plans and additional monitoring plans will be discussed prior to cessation of power generation and commencement of site decommissioning.

When the Project ceases operations, the power tunnel void could create a directly interconnected flow path for groundwater from the Black Lake area to the Fond du Lac River to the west. It is anticipated that a series of concrete bulkheads will be placed in the power tunnel, if necessary, to isolate mineralized bedrock zones and reduce potential for mineralized groundwater to discharge through the power tunnel. Quality of groundwater discharging through the power tunnel could be monitored, if required.

Because Project closure is expected to comply with applicable and timely regulations, standards, and guidelines and provisions for design and implementation of reclamation and restoration plans will be in place, it is anticipated that changes to flow volumes and quality associated with this Project interaction will be minor and have negligible residual effects on surface water quality.

11.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events occurring on-site have the potential to affect surface water quality. The following events were identified as having a potential interaction with surface water quality.

- **Release or spills of hazardous substances (e.g., fuel, oil) can change surface water and sediment quality.**

Spills during construction, operations, or decommissioning and reclamation activities following closure have the potential to change surface water and sediment quality. Spills that occur in high enough concentrations could contaminate runoff and surface water. Spills are generally preventable and local in nature. Spills will be promptly reported and managed according to the procedures identified in the Emergency Response Plan. Mitigation identified in the Environmental Protection Plan (EnvPP) will be implemented to reduce the likelihood and extent of spills associated with the Project.

The powerhouse will be equipped with an oil containment and separation system to prevent the release of petroleum-based wastes into waterways. The turbine governor pumping systems will be surrounded by trenches or curbs to allow drainage through a trench or sumps to catch and to transfer wastes to the powerhouse oil separation system. Any room with the potential to produce an oil spill will also be equipped with containment curbs and door ramps. Additionally, the governor hydraulic power units will be high-pressure systems to reduce the potential for spills by limiting the total volume of hydraulic oil in the system. The main transformers will be removed from the main tailrace channel deck and surrounded by oil spill containment walls to reduce the potential for spills to interact with the waterways. Double-walled heat exchangers will be used for the turbine and generator cooling systems to reduce the risk of cooling coil failure will discharge oil into the water. Self-lubricated bushings will be employed throughout the design to eliminate sources of water pollution typical of greased bushings.

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks and to limit the effects of spills and leaks on surface water and sediment quality. Spill containment supplies will be available in designated areas and within Project vehicles. An Emergency Response Plan will be developed and will include instruction for the rapid response, control, and management of spills or release of hazardous substances occurring on site. All spills will be isolated and immediately cleaned up. Spills will be reported to the appropriate agency if the spill exceeds reportable volumes for the material spilled as outlined in the provincial Environmental Spill Control Regulations (Government of Saskatchewan 1981, with amendments). In the unlikely event of a large spill, disposal of all contaminated soil will be handled by a licensed contractor and will be hauled off-site to an approved disposal facility. Alternative approaches for in-situ treatment of contaminated soils may also be considered (e.g., phyto- or bio- remediation), depending on the substance spilled and capacity to treat the volume of material affected.

Storage facilities for hazardous wastes will meet regulatory requirements. All fuel storage tanks will be designed and constructed based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. The storage containers will be regularly inspected for leakage or damage, and replaced when necessary. Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double-walled and located in lined and bermed containment areas. Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers.

Vehicles will be regularly maintained and will carry fire extinguishers and standard emergency clean-up kits. Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired near waterbodies. Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills on the fueling stations would flow to the sump, which would be pumped out to a container for shipment off-site.

Implementation of the above mentioned environmental design features are expected to reduce the likelihood and extent of the release or spills of hazardous materials occurring on-site. No detectable changes to surface water and sediment quality relative to baseline conditions are anticipated. Therefore, these interactions are determined to have no linkage to effects on surface water quality.

- **Failure of the embankment dykes around the settling ponds can change surface water and sediment quality.**

Failure of embankment dykes around the settling ponds could result in the release of sediment laden water and potential contaminants to the surface water environment. Environmental controls will be in place to limit the potential for embankment dyke failure. For example, water from the waste rock disposal areas will be diverted to the settling ponds by gravity. The settling ponds will be engineered to provide adequate storage of process streams under normal and extreme operating conditions. Maximum operating levels will be developed to provide adequate storage volumes for the design storm event. In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling pond would be provided by the inclusion of an overflow spillway in the embankment.

The embankment dyke will be constructed around the settling pond to contain wastewater from site and from the waste rock disposal areas. Embankment dykes will be stripped of vegetation, topsoil, and roots to expose the mineral soil subgrade as necessary to accommodate the size of the settling pond. Fill material used for constructing the dyke will be clean mineral soil with sufficient moisture to allow for proper compaction and will be placed in lifts not exceeding 150 mm in compacted thickness and compacted to a minimum of 95% standard proctor maximum dry density. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap as soon as practical following construction.

The settling pond will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. During the detailed design stage, additional mitigation will be identified and included as part of the EnvPP and the Emergency Response Plan. Consequently, embankment dyke failure was determined to have no linkage to effects on surface water quality.

11.4.4 Primary Interactions

Primarily based on the need for further detailed assessment to establish potential magnitude of effect, the following interactions were determined to involve primary linkages for effects on surface water and sediment quality and are carried forward to the residual effects analysis (Section 11.5):

- Use of explosives near surface waterbodies can change surface water quality.
- Deposition of criteria air contaminants can change surface water quality.
- Dust deposition can change surface water and sediment quality.
- Discharge of wastewater can change hydrology and surface water and sediment quality.
- Seepage from waste rock disposal areas can change surface water and sediment quality.

These interactions have been integrated into two broader interactions for the residual effects analysis, based on the deposition of air emissions and site water discharges:

- Deposition of site emissions can change surface water and sediment quality in the receiving environment.
- Discharge of water from the site area can change surface water and sediment quality in the receiving environment.

11.5 Residual Effects Analysis

The residual effects analysis considered all primary interactions that could result in effects on surface water and sediment quality after implementing environmental design features and mitigation. The residual effects assessment is completed by predicting changes to the measurement endpoints, which are concentrations of various parameters in water. Both Project-specific (incremental) and cumulative effects from the Project and existing human developments and activities are considered. Information relating to management of uncertainty also is provided.

Assessment cases are defined for the effects analysis and include the baseline case, the application case (Project case, which includes construction, operations, and closure phases), and the future case (if applicable). The baseline case considers the current conditions in the RSA such as natural disturbances (e.g., fire) and previous and existing human developments and activities. Existing human-related disturbance includes trails, roads, cabins, the Black Lake sewage lagoon, and the communities of Black Lake and Stony Rapids.

Investigations into the operating details of the Black Lake lagoon determined that the lagoon is considered part of the baseline case for the assessment. The lagoon was constructed and commenced operation in 2009 (Lukey 2013 pers. comm.), prior to the time baseline studies were conducted for the Project (i.e., 2010 and 2011). Therefore, baseline water quality data would have included potential influences, if any, of the Black Lake lagoon to surface water in the LSA. As well, treated water is released to the west of the Black Lake Lagoon into a wetland/swamp area, not directly into any water bodies in the area (e.g., Black Lake, Fond du Lac River, and Middle Lake) (Keleman 2013 pers. comm.). Discharge occurs once every six months (in spring and in fall). Prior to release, the treated water must meet applicable water quality criteria as per Wastewater Systems Effluent Regulations (Government of Canada 2013).

Populations and communities in aquatic and terrestrial ecosystems have likely adapted to the low level of human industrial activity over the previous 50 to 60 years. Therefore, current (baseline) conditions in the RSA are expected to reflect the cumulative influence of previous and existing human industrial activities on aquatic and ecosystems. Reference conditions represent no to little human development, except for First Nation communities, which are assumed part of the historical natural ecosystems.

The application case occurs during the start of construction of the Project through closure, and the associated duration of predicted effects (i.e., until effects are reversed or are deemed irreversible). The magnitudes of effects from the Project are expected to be strongest during construction and the initial period of operation. There is potential for this Project to operate beyond the expected 90-year operational period; however increasing the duration of the operation phase of the Project would have little influence on effects predictions, since most of the changes to surface water and sediment quality are anticipated to take place during construction or early operations. Closure occurs when power production ends and decommissioning and reclamation of the final infrastructure (i.e., powerhouse, water intake, power tunnel, tailrace channel, switchyard, access roads, waste rock disposal areas, and distribution line) is completed.

Both the Project-specific (incremental) and cumulative effects from the Project and previous and existing human developments and activities are analyzed in this section. The future case includes baseline and the Project, plus reasonably foreseeable developments or designated projects. The geographic extent (zone of influence) of residual effects from the Project on vegetation is expected to be limited to the RSA. No other major developments in the region are located within the RSA. Therefore, the zones of influence associated with the Project and existing developments are not expected to overlap and generate cumulative effects on surface water quality. Currently, there are no reasonably foreseeable developments that could have an overlapping temporal boundary with the Project and potential to generate cumulative effects on surface water quality.

11.5.1 Deposition of Air and Dust Emissions Can Change Surface Water and Sediment Quality in the Receiving Environment

The air quality assessment (Section 8.0) focused on emissions associated with the construction phase of the Project, because the magnitudes of effects from the Project are expected to be strongest during construction and the initial period of operation. For example, the magnitude of some effects, such as the changes from blasting activities to dust deposition, are expected to stop at the end of construction, and the duration of these effects will likely end within the initial period of operation. The sources of air emissions from construction of the Project were categorized as follows:

- fuel combustion from stationary sources;
- fuel combustion from mobile sources;
- drilling and blasting;
- aggregate handling;
- on site concrete production; and
- road dust (e.g., dust from access road construction, site preparation, overburden, and waste rock hauling, and hauling of concrete).

Carbon monoxide (CO), oxides of sulphur (SO_x) and nitrogen (NO_x), and particulate matter ($PM_{2.5}$) are emitted directly from stationary and mobile combustion sources and from blasting. Total suspended particulate (TSP) and $PM_{2.5}$ are also emitted from drilling and blasting, waste rock and aggregate processing and handling, on-site concrete production, and traffic (i.e., road dust).

This section includes the residual effects analysis for the following primary interactions:

- Deposition of criteria air contaminants can change surface water quality.
- Dust deposition can change surface water and sediment quality.

11.5.1.1 Methods

11.5.1.1.1 Deposition of Criteria Air Contaminants Can Change Surface Water Quality

Air emissions of criteria contaminants can result from the use of fossil fuels in generators, vehicles, and machinery during construction and operation of the Project. Deposition of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) can lead to acidification of waterbodies (Bobbink et al. 1998). Determination of the potential effects of Project-related SO_2 and NO_2 emissions on the acidification of water bodies within the LSA involves consideration of the following:

- sensitivity of surface waters in the LSA to acid deposition;
- potential for acid deposition due to the Project; and
- environmental design features incorporated into the Project to limit the effects of air emissions on surface water quality.

Sensitivity of Surface Waters to Acid Deposition

The sensitivity of surface waters to acid deposition can be evaluated based on various characteristics of the water body of concern and surrounding area (e.g., alkalinity). Alkalinity refers to the capacity of water to neutralize strong inorganic acids (Wetzel 2001). The term "alkalinity" is typically used when acid neutralizing capacity is estimated using titration. Alkalinity is frequently expressed in units of mg/L as calcium carbonate ($CaCO_3$).

Acid sensitive lakes are situated in areas where soils have little or no capacity to reduce the acidity of the atmospheric deposition. Soil chemistry (i.e., particle size, texture, soil pH, or cation exchange capacity), soil depth, drainage, vegetation cover and type, bedrock geology, and topographic relief are all factors that determine the sensitivity of the drainage basin to acid deposition (Lucas and Cowell 1984; Holowaychuk and Fessenden 1987; Sullivan 2000). Surface waters that are sensitive to acidification usually have the following characteristics:

- acid sensitive lakes are dilute, with low concentrations of major ions (i.e., specific conductance is less than 25 µS/cm);
- base cation concentrations are low (i.e., in relatively pristine areas, the combined concentration of calcium, magnesium, potassium, and sodium in sensitive waters is generally less than 50 to 100 microequivalents per litre (µeq/L);

- organic acid concentrations are low (i.e., dissolved organic carbon [DOC] concentration is generally less than 3 to 5 mg/L)
- the pH is low (i.e., less than 6);
- physical characteristics are as follows:
  - elevation of acid sensitive lakes tends to be moderate to high;
  - acid sensitive lakes are located in areas of high relief;
  - acid sensitive lakes are subject to severe, short-term changes in hydrology;
  - minimal contact occurs between drainage waters and soils or geologic material that could contribute weathering products to solution; and
  - acid sensitive lakes may have small drainage basins that derive much of their hydrologic input as direct precipitation to the lake surface.

The acid sensitivity of Black Lake and Middle Lake was established by comparing these aforementioned criteria to available baseline surface water chemistry for these two lakes (Annex III). The acid sensitivity of the various smaller lakes near the Project could not be established due to the lack of water chemistry data (D. Turner pers. comm. 2013).

Potential for Acid Deposition Due to the Project

In the air quality assessment, an emissions inventory for the Project was created (Appendix 8.1), and an air quality screening model (AERSCREEN) was used to predict the ambient concentrations of SO_2 and NO_x (Section 8.5). These air emissions could contribute to the potential for acidification in receiving waters through atmospheric deposition. As AERSCREEN is a screening model, it cannot be used to quantify potential for acid deposition as it cannot speciate the various forms of nitrogen and sulphur as they move through the atmosphere. The use of a more specialised model, such as CALPUFF, is better for quantifying potential for acid deposition (e.g., CALPUFF accounts for regional modelling and long-range transport).

According to the Saskatchewan Air Quality Modelling Guideline (MOE 2012), regional acid deposition modelling is only required if the following criteria are not met:

3) the combined Project emissions of SO_2, NO_X, and NH_3 are greater than 0.175 tonnes per day (t/d) of H+ equivalent, where:

$$\text{total H+ equivalent (t/d)} = 2*(SO_2\text{ t/d})/(64)+1*(NO_x\text{ t/d})/(46)+1*(NH_3\text{ t/d})/(17)$$

4) or, the emissions from the facility are >5% of the baseline emissions in the region.

The air emissions inventory for the Project was used to estimate the H^+ equivalent emissions for comparison to MOE criterion #1 above. National Pollutant Release Inventory (NPRI) data (Environment Canada 2013) for Saskatchewan's Northern Air Dispersion Modelling Zone (MOE 2012) were used to calculate regional baseline emissions. The Project emissions were compared to the regional baseline emissions (expressed as a percent) to evaluate MOE criterion #2.

11.5.1.1.2 Dust Deposition Can Change Surface Water and Sediment Quality

Blasting activities, removal of waste rock, and dust emissions from Project facilities and operating vehicles could potentially increase dust deposition to nearby waterbodies during Project construction and operations. This component of the assessment evaluates the potential for increased deposition of dust to effect surface water and sediment quality in the area surrounding the Project. Modelled ambient concentrations of dust and estimated deposition rates were applied to define the context of potential changes to surface water and sediment quality due to dust deposition from the Project.

Ambient concentrations of dust and deposition rates were predicted using AERSCREEN, as described in the air quality assessment (Section 8.5). The AERSCREEN model produces estimates of “worst-case” one-hour concentrations for a single source. It is noted that one-hour concentrations are not considered suitable for predicting potential effects on surface water and sediment quality because emissions can vary month-to-month and seasonally. For the purposes of evaluating effects of dust deposition on surface water and sediment quality, the annual rate of atmospheric deposition for dust was estimated. Three locations, approximately 2.5 km from the air emissions source, were evaluated as receptors for the atmospheric deposition of dust:

- Middle Lake near the tailrace channel outlet;
- near the water intake on Black Lake; and
- near the submerged weir at the Black Lake outlet.

Methods used to estimate potential dust deposition rates were highly conservative. For example, when using the screening model, several factors affect the prediction of particulate matter at the receptors and can produce TSP estimates that are greater than those that could actually be observed at the Project site (as described in Section 8.5.1.2.3). Furthermore, the annual average rate of dust deposition was calculated using the construction year with the highest emission rates.

11.5.1.2 Results

11.5.1.2.1 Deposition of Criteria Air Contaminants Can Change Surface Water Quality

Sensitivity of Surface Waters to Acid Deposition

Two methods were applied to evaluate the lake sensitivity to acidification for Black Lake and Middle Lake: Saffran and Trew (1996 (Table 11.5-1) and Sullivan (2000) (Table 11.5-2). Both methods suggested these lakes possess a low to moderate acid sensitivity. As a basis for comparison, baseline alkalinity levels ranged from 11 to 22 mg/L for Black Lake and from 12 to 26 mg/L for Middle Lake.

Table 11.5-1: Acid Sensitivity Scale for Lakes Based on Alkalinity

Acid Sensitivity	Alkalinity (mg/L as $CaCO_3$)
high	0 to 10
moderate	>10 to 20
low	>20 to 40
least	>40

Source: Saffran and Trew (1996).
mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than.

Table 11.5-2: Characteristics Of Acid Sensitive Lakes Compared To Black Lake And Middle Lake

Characteristics of Acid Sensitive Lakes[(a)]	Black Lake[(b)]	Middle Lake[(b)]
Low concentrations of major ions (i.e., specific conductance is less than 25 µS/cm).	Baseline specific conductivity = 30 to 58 µS/cm.	Baseline specific conductivity = 35 to 44 µS/cm.
Low base cation concentrations (i.e., in relatively pristine areas, the combined concentration of calcium, magnesium, potassium, and sodium in sensitive waters is generally less than 50 to 100 µeq/L).	Combined concentration of four major cations is 356 µeq/L[(c)].	The combined concentration of four major cations = 359 µeq/L[(c)].
Low organic acid concentrations (i.e., dissolved organic carbon [DOC] concentration is generally less than 3 to 5 mg/L).	N/A	N/A
Low pH (i.e., less than 6).	Field-measured baseline pH = 6.0 to 7.8.	Field-measured baseline pH = 6.6 to 7.5.
Elevation of acid sensitive lakes tends to be moderate to high.	Elevation of Black is relatively low, with the average water level of 277 m.	Elevation of Middle Lake is relatively low, with the average water level of 241 m.
Acid sensitive lakes are located in areas of high relief.	Black Lake is located in low to moderate relief, with the elevation of most of the immediate upland area peaking at approximately 400 m.	Middle Lake is located in low to moderate relief, with the elevation of the immediate upland area peaking at around 300 m.
Acid sensitive lakes are subject to severe, short-term changes in hydrology.	Black Lake is attenuated (i.e., relatively slow to respond to changes caused by precipitation, for example) due to the large drainage areas.	Middle Lake is attenuated due to the large drainage areas and the volume of water in the Fond du Lac River.
Minimal contact occurs between drainage waters and soils or geologic material that could contribute weathering products to solution.	N/A	N/A
Acid sensitive lakes could have small drainage basins that derive much of their hydrologic input as direct precipitation to the lake surface.	Black Lake is associated with quite large watersheds that receive mostly river input.	Middle Lake is associated with quite large watersheds that receive mostly river input.

(a) Source: Sullivan (2000)
(b) Source: baseline data (see Annex III - Surface Water Environment Baseline Report)
(c) Based on average baseline cation concentrations
µS/cm = microSiemens per centimetre; µeq/L = microequivalents per litre; mg/L = milligrams per litre; m = metre; N/A = data not available

Potential for Acid Deposition Due to the Project

The MOE states two criteria have to be met for a proposed facility to forego acid deposition modelling (Section 11.5.1.1.1). The maximum emissions rate of H^+ equivalents for the Project is estimated at 0.020 tonnes per day (t/d) and the average for the 2014 to 2017 construction period is 0.014 t/d (Section 8.0, Appendix 8.2). These values are well below the MOE acid deposition modelling threshold of 0.175 t/d.

The maximum H^+ equivalents emissions for the Project, which occur in 2016, have been estimated at 5.6% of the regional baseline emissions; the 2014 to 2017 average Project emissions are predicted to be 4.6% of the regional baseline emissions (Section 8.0, Appendix 8.2). Strictly speaking, the MOE requires acid deposition modelling if the proposed facility exceeds 5% of the baseline emissions for the region. However, professional opinion suggests that the proposed facility does not require acid deposition modelling for the following reasons:

- the facilities emissions for SO_2 and NO_x are conservative;

- the assumption that SO_2 and NO_x have reacted with sufficient NH_3 to neutralize these conjugate bases is very conservative;
- the Northern Air Dispersion Modelling Zone is largely wilderness with few urban/industrial installation, therefore total emissions are very low compared to airsheds further south;
- smaller urban/industrial emissions sources are not required to report their emissions to NPRI;
- NPRI emissions do not include emissions from mobile combustion sources (e.g., gasoline and diesel powered vehicles found in the region); and
- the emissions are for the construction phase only and are low in magnitude, local in extent and reversible.

In summary, based on an evaluation of the Project emissions using the two MOE criteria, the potential for acid deposition is low and, therefore, acid deposition modelling was not required.

Environmental design features will be incorporated into the Project to limit the effects of air emissions on surface water chemistry. For example, motorized diesel equipment used in the power tunnel during construction will be fueled with ultra-low sulphur diesel having the minimum practicable octane number and a sulphur content of approximately 15 parts per million (ppm). The heavy-duty stationary and mobile diesel-fueled equipment fleet will meet or exceed EPA Tier 2/3 air quality emissions standards. The gasoline-fueled equipment fleet will meet or exceed EPA Tier 2 Bin 6 air quality emissions standards. Equipment will be kept in optimal working order; scheduled maintenance will be completed to meet federal and provincial air emissions standards. A forced air ventilation system will be used in the power tunnel to clear dust, gases, and fumes from inside the tunnel. An EnvPP will describe material handling protocols including dust management.

Given the low potential for acid deposition in the Project area, and the low to moderate acid sensitivity of Black Lake and Middle Lake, acidification of these water bodies from Project air emissions is not anticipated.

11.5.1.2.2 Dust Deposition Can Change Surface Water and Sediment Quality

The maximum predicted ground-level $PM_{2.5}$ concentration of 22.8 micrograms per cubic metre (µg/m^3) (accounting for background levels), estimated to occur near Camp Grayling and the submerged weir during the construction phase, does not exceed the 24-hour Canada-Wide Standard of 30 µg/m^3 (Section 8.5.1.2.3). Modelling results also indicated that the maximum predicted TSP concentration of 114.4 µg/m^3 (including background), near Camp Grayling during construction, does not exceed the Saskatchewan Average Ambient Air Quality Standard (SAAQS) of 120 µg/m^3 (Section 8.5.1.2.3).

The dust deposition rate was conservatively estimated to be 0.85 micrograms per square metre per second (µg/m^2/s) or 267 kilograms per hectare per year (kg/ha/y) at the 2.5 km ambient boundary (Table 8.5-10). This deposition would occur over a relatively short period (i.e., periodically during the three year construction phase) and over a limited geographic extent. Minor Project-related increases in TSS could occur in association with the spring freshet, when accumulated dust deposited over winter migrates with melted snow; however, this increase would be very short in duration (i.e., over the duration of the freshet) and would likely only occur during the three year construction phase when dust deposition is expected to be greatest.

Various environmental design features have been incorporated into the Project to reduce the amounts of dust generated. For example, unpaved roads will be watered regularly to prevent wind-driven fugitive dust. Water pipes will be installed along the active faces of the power tunnel; this water will be used to spray muck piles in the tunnel to reduce dust production. The approved Blasting Plan will follow DFO's Guidelines for the Use of Explosives in or Near Canadian Waters (Wright and Hopky 1998) to limit the potential for residual blasting interactions with downstream water quality. The Blasting Plan will provide mitigation to limit the potential for effects on surface water and sediment chemistry from fugitive dust generation through excavation and material transport.

11.5.2 Discharge of Water from the Site Area Can Change Surface Water and Sediment Quality in the Receiving Environment

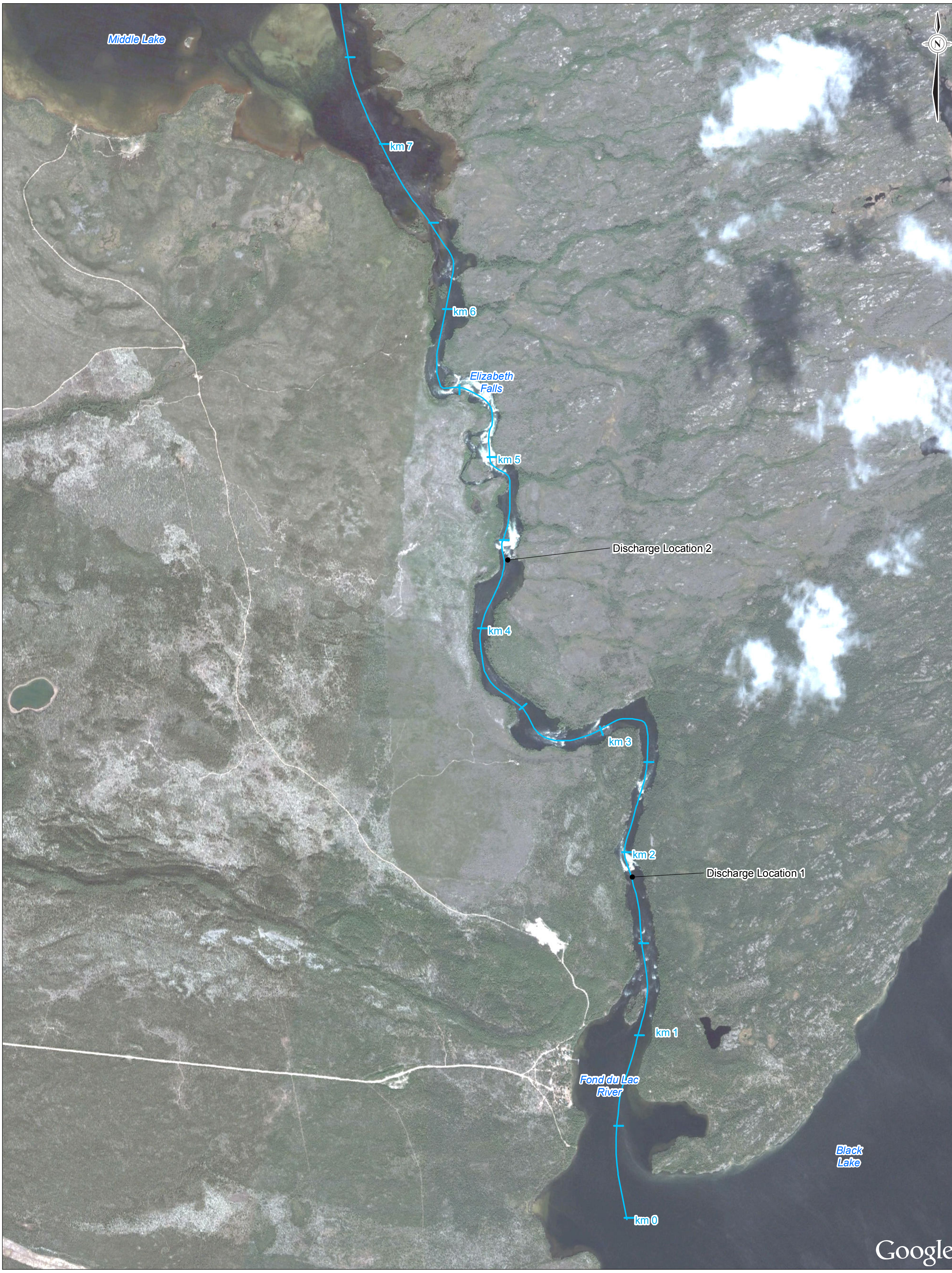
This section includes the residual effects analysis of the following primary interactions:

- Use of explosives near surface waterbodies can change surface water quality.
- Collection and disposal of wastewater from the site can cause changes to surface water and sediment quality.
- Seepage from waste rock disposal areas can change surface water and sediment quality.

Site wastewater will be of several types, waste rock runoff, groundwater inflows during the construction of the power tunnel, and water collected in settling ponds. Water collected within the three settling ponds for the Project will be composed of waste rock runoff and groundwater inflows during the construction of the power tunnel (Figure 11.5-1). More specifically, one pond will be located near the water intake to collect the construction water along with a portion of the tunnel dewatering flows and waste rock runoff from the waste rock disposal area south of the intake. A second settling pond will be located near the powerhouse excavation to collect the remainder of the tunnel and powerhouse dewatering. A third settling pond, beside the downstream end of the tailrace channel will collect the tailrace channel dewatering and any runoff directed from the main waste rock disposal areas to the northeast of the tailrace channel. At this preliminary design stage, each settling pond is anticipated to be approximately 43 m long by 11 m wide and have a flow capacity of about 3,300 m^3/d. Water collected in disturbed areas located away from the settling ponds will be pumped to these locations.

Water within the settling ponds will be tested and treated, if necessary, before release to the Fond du Lac River, in accordance with applicable regulations and licence requirements. Retention of Project-affected water in the settling ponds will allow suspended sediments and associated parameters (e.g., some metals) to settle out. Water in the settling ponds will be pumped to the Fond du Lac River at one or both of two potential discharge locations after the water has been tested and confirmed to meet appropriate discharge criteria (if required, to be developed during the permitting process; refer to Appendix 11.1 for further discussion on effluent quality criteria) (Figure 11.5-1).

Waste rock runoff and groundwater inflows to the settling ponds will be influenced by geochemical interactions and the nitrogen residual from the use of explosives. Modelling was conducted to predict the potential effects of the settling pond discharge on the water quality of the Fond du Lac River. The methods and results of this modelling exercise are summarized below, together with associated environmental design features and mitigation.



LEGEND

DISTANCE CHAIN (0.5 KM INTERVAL)

400 0 400

SCALE 1:20,000 METRES

REFERENCE

GOOGLE EARTH IMAGE © 2010 DIGITAL GLOBE
NAD 83 UTM ZONE 13

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

TWO POTENTIAL LOCATIONS OF SETTLING POND DISCHARGE TO THE FOND DU LAC RIVER

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	LMR	21/10/13	**FIGURE: 11.5-1**	
CHECK	LT	25/10/13		
REVIEW	BC	25/10/13		

11.5.2.1 Methods

Surface water quality modelling was completed to evaluate the potential effects of discharge to the Fond du Lac River from the settling ponds and to identify Parameters of Potential Concern (POPC; Appendix 11.1). The modelling focused on the construction phase because that is the period of peak discharge from the settling ponds, due to the anticipated volume of groundwater inflow into the power tunnel at that time (maximum upper-bound estimate of 4,700 m^3/d; Appendix 9.2). In comparison, the volume of groundwater inflow is expected to be 680 m^3/d during operations, which is approximately 15% of the maximum construction inflow. As well, operational groundwater inflows represent a very small fraction of the total operational flows through the tunnel (i.e., 0.004% of the flow through the tunnel, which is estimated to be approximately up to 190 m^3/s for a 50 MW facility).

Currently, two potential locations are being considered for the discharge of water from the settling ponds into the Fond du Lac River (Figure 11.5-1). Water will be pumped through pipelines from the settling ponds to one or both of these locations. Assessment of the hydraulic characteristics of the river sections at these locations shows that the current speed at the northern location (Discharge Location 2) will be higher than at Discharge Location 1. Additionally the discharge will be subject to enhanced mixing due to bathymetric configuration of this location. Therefore, to be conservative, the southern location (Discharge Location 1) with less favorable mixing conditions was considered in the modelling exercise. The model involves continuous discharge from a single settling pond, with the assumption that incoming water is held within the pond long enough to allow suspended sediments to settle out to acceptable levels.

Furthermore, the model assumes one settling pond would receive both the waste rock runoff and the groundwater inflows instead of three settling ponds; this simplifies the model and provides a conservative approach to the predicted water quality. More specifically, assuming release of wastewater from a single settling pond is more conservative because the total predicted load of each parameter enters the system at a single location, with a greater potential to exceed applicable guidelines, rather than having the smaller loads spread out over three locations.

A mass-balance modelling platform, GoldSim™, was used for the water quality modelling of the discharges into the Fond du Lac River. Primary inputs into the model included baseline water chemistry, historical low river flows, and loadings of various parameters from the groundwater inflows and the waste rock runoff, which included consideration of the quality and quantity of wastewater associated with these two sources. The model applied a conservative approach, incorporating maximum concentrations of various parameters in the groundwater and waste rock runoff, upper-bound rates of groundwater inflow, and low river flow rates (i.e., 7Q10 flow, which is the lowest average discharge over a period of one week with a recurrence interval of 10 years). Background water chemistry in the Fond du Lac River was based on water chemistry results from Black Lake measured periodically in 2010 and 2011. Values for these various input data are provided in Appendix 11.1.

Explosives will be used during the construction phase on the Project and have the potential to change surface water and sediment quality in nearby waterbodies and watercourses. Some types of explosives used in blasting have the potential to release nitrogen residual substances (e.g., ammonia and nitrate) that could affect surface water in nearby waterbodies. Loads of ammonia and nitrate associated with the use of ammonium nitrate/fuel oil (ANFO) and water resistant emulsion explosives for Project blasting were estimated and integrated into the model.

These various input data were used within the site model to predict Fond du Lac River concentrations resulting from the settling pond discharge. Two scenarios were calculated: concentrations considering fully mixed conditions of associated constituent loads and concentrations at the end of a mixing zone. Typically, an effluent plume will travel a certain distance before it mixes fully across the river flow. For this modelling, the mixing zone was defined as extending 1.2 km from the point of discharge, which is 10 times the river width (AEP 1995).

Predicted concentrations of parameters in the Fond du Lac River under each scenario were then compared to applicable federal and provincial guidelines for drinking water and the protection of aquatic life. More specifically, the water quality objectives (WQO) used in the evaluation were:

- Canadian Water Quality Guidelines (CWQG) for the protection of aquatic life (long-term values) from the Canadian Council of Ministers of the Environment (CCME 1999);
- Saskatchewan Surface Water Quality Objectives for the protection of aquatic life (SSWQO; Saskatchewan Environment 2006);
- Canadian Drinking Water Guidelines (Health Canada 2012); and
- Saskatchewan Drinking Water Standards and Objectives (Saskatchewan Environment 2002).

Applicable guidelines from other provinces (e.g., British Columbia and Ontario) were included if CWQG or SSWQO for the protection of aquatic life were not available from these other sources.

Effluent discharges rarely mix instantaneously with a receiving stream (AEP 1995). Mixing zones for initial dilution of the effluent plume are a practical necessity. These limited exceedance areas are established to ensure protection of the waterbody as a whole (chronic) and to limit acute lethality to organisms passing through the effluent plume (acute) (AEP 1995). Within this analysis, the quality of water within the receiving environment was believed to be protective of aquatic life if WQO were met under fully mixed conditions and at the edge of the mixing zone. If the WQO were not met for fully mixed conditions or at the edge of the mixing zone for a given parameter, then the reason for the exceedence was investigated and, if appropriate, the parameter was listed as a POPC. For several parameters, dispersion characteristics were modelled within the mixing zone to investigate the potential distribution of the settling pond discharge. Detailed results of the modelling and comparison to WQO analysis are found in Appendix 11.1.

Given an appropriate residence time, the settling pond will effectively remove suspended sediments from wastewater through sedimentation. More specifically, it is expected that TSS associated with waste rock runoff and groundwater inflows will settle out in the pond; therefore, potential negative effects of TSS from settling pond discharges to water and sediment quality in the receiving environment will be negligible. As a result, release of suspended sediment was not considered in this modelling exercise. It is anticipated that effluent quality criteria for TSS and pH in the settling pond will be established within the permitting processes, as these parameters often have regulatory limits. It is also anticipated that acute toxicity testing of the settling pond discharge will be a regulatory requirement.

11.5.2.2 Results

11.5.2.2.1 Model Results

The results of the modelling exercise indicated that minor, short-term changes would occur to the water chemistry of the Fond du Lac River during the construction phase because of discharge from the settling pond

(Appendix 11.1). For example, predicted concentrations of various parameters under fully mixed conditions at the edge of the mixing zone are within the range of baseline concentrations measured in 2010 and 2011 (Table 11.5-3). The one exception was uranium, where predicted concentrations (i.e., 0.0001 to 0.0002 mg/L) were estimated to be slightly above the baseline value (<0.0001 mg/L). These results take into consideration a very conservative maximum uranium concentration in the groundwater inflows. More specifically, the maximum uranium concentration used in the model (0.302 mg/L) was based on a concentration from a bore hole installed within the Black Lake Shear Zone (mylonitic gneiss) and intersected two major faults (approximately 0.5 m). As known uranium deposits have been identified in the shear zone, but are localized, the elevated uranium concentration at this location is likely not indicative of uranium concentrations in groundwater across the site. This is further supported by the low uranium concentrations measured at other bore hole locations installed along the tunnel alignment to the northwest. However, the highest uranium concentration recorded at the shear zone was conservatively used in the water quality model (see Section 3.2.1 of Appendix 11.1).

Predicted changes in river water quality do not result in exceedences of applicable WQO under fully mixed conditions or at the edge of the applicable mixing zone in the Fond du Lac River, with the exception of cadmium. Both baseline and predicted concentrations (under fully mixed conditions) of cadmium exceeded the current CWQG for protection of aquatic life (0.006 µg/L), primarily because the method detection limit (0.01 µg/L) also exceeded the guideline (CCME 1999). This highly conservative guideline is currently under federal review and revision, with the future guideline value likely to be higher than the current guideline value.

The modelling also indicated that loads of ammonia and nitrate from the use of explosives would result in very minor changes to background concentrations of these parameters in the Fond du Lac River immediately downstream of the discharge point and would not result in exceedances of applicable water quality guidelines for the protection of aquatic life under fully mixed conditions or at the edge of the mixing zone (Figure 11.5-2). Additionally, blasting residues are a finite quantity within the waste rock, which will diminish over time.

As a result of predicted parameter concentrations primarily being within baseline ranges and not exceeding WQO, no POPC were identified within this assessment. The primary reason for parameters remaining in baseline ranges and not exceeding WQO in the river is the relatively small rate of discharge from the settling pond compared to the flow rate of the Fond du Lac River. For example, the rate of discharge from the settling pond used in the model ranged from 0.058 to 0.080 m^3/s, while the river flows used in the model were much larger at 156 to 250 m^3/s (i.e., 0.04% and 0.03%, respectively).

Table 11.5-3: Baseline and Modelled Fond du Lac River Water Chemistry Given Settling Pond Discharge

Parameters	Units	Water Quality Objectives					Baseline Concentrations[n]	Predicted River Concentrations (Fully Mixed Conditions for Three Scenarios)		
		SSWQO[a]	CWQG[b]	CDWG[c]	SDWO[d]	Other		Annual	Winter	Spring
Conventional Parameters										
Total Alkalinity	mg/L as $CaCO_3$	-	-	-	500 (AO)	-	11 to 24	22	20	17
Total Hardness	mg/L as $CaCO_3$	-	-	-	800 (AO)	-	11 to 17	16	14	12
Total Dissolved Solids	mg/L	-	-	≤ 500 (AO)	1500 (AO)	-	24 to 43	35	33	28
Nutrients										
Total Ammonia	mg/L as N	0.88[e]	0.88[e]	-	-	-	<0.01 to 0.05	0.02	0.02	0.01
Nitrate	mg/L as NO_3	-	13	-	45	-	< 0.04 to 0.13	0.10	0.11	0.14
Major Ions										
Calcium	mg/L	-	-	-	-	-	2.9 to 4	3.7	3.5	3.0
Chloride	mg/L	-	120	≤ 250 (AO)	250 (AO)	-	0.8 to 7	5.1	4.2	2.3
Magnesium	mg/L	-	-	-	200 (AO)	-	1 to 1.7	1.5	1.4	1.1
Potassium	mg/L	-	-	-	-	-	0.5 to 0.9	0.9	0.8	0.6
Sodium	mg/L	-	-	≤ 200 (AO)	300 (AO)	-	1.2 to 2.4	2.1	1.9	1.5
Sulphate	mg/L	-	-	≤ 500 (AO)	500 (AO)	128[o]	1.1 to 1.5	1.4	1.4	1.3
Total Metals										
Aluminum	mg/L	0.1[f]	0.1[f]	-	-	-	0.0017 to 0.0054	0.0042	0.0038	0.0031
Antimony	mg/L	-	-	-	-	0.02[p]	<0.0002	0.0001	0.0001	0.0001
Arsenic	mg/L	0.005	0.005	0.01	0.025	-	<0.0001 to 0.0002	0.0002	0.0002	0.0002
Barium	mg/L	-	-	1	1	1[q]	0.0040 to 0.0048	0.0045	0.0044	0.0042
Beryllium	mg/L	-	-	-	-	0.0053[q]	<0.0001	0.0001	0.0001	0.0001
Boron	mg/L	-	1.5	5	5	-	<0.01 - 0.02	0.02	0.01	0.01
Cadmium[l,m]	mg/L	0.000017[g]	0.000006[g]	0.005	0.005	-	<0.00001 to 0.00001	0.00001	0.00001	0.00001
Chromium	mg/L	0.001	0.001	0.05	0.05	-	<0.0005	0.0003	0.0003	0.0003
Copper	mg/L	0.002[h]	0.002[h]	≤ 1 (AO)	1	-	<0.0002	0.0001	0.0001	0.0001
Iron	mg/L	0.3	0.3	≤ 0.3 (AO)	0.3 (AO)	-	0.01 to 0.086	0.032	0.043	0.064
Lead	mg/L	0.001[i]	0.001[i]	0.01	0.01	-	<0.0001	0.0001	0.0001	0.0001
Manganese	mg/L	-	-	≤ 0.05 (AO)	0.05 (AO)	0.8[o]	0.004 to 0.034	0.005	0.009	0.017
Mercury	mg/L	0.000026	0.000026	0.001	0.001	-	<0.00001	0.00001	0.00001	0.00001
Molybdenum	mg/L	-	0.073	-	-	-	<0.0001 to 0.0002	0.0001	0.0001	0.0002
Nickel	mg/L	0.025[j]	0.025[j]	-	-	-	<0.0001 to 0.0001	0.0001	0.0001	0.0001

Table 11.5-3: Baseline and Modelled Fond du Lac River Water Chemistry Given Settling Pond Discharge (continued)

Total Metals (continued)										
Selenium	mg/L	0.001[k]	0.001[k]	0.01	0.01	-	<0.0001 to 0.0002	0.0001	0.0001	0.0001
Silver	mg/L	0.0001	0.0001	-	-	-	<0.00001	0.00001	0.00001	0.00001
Thallium	mg/L	-	0.0008	-	-	-	<0.0002	0.0001	0.0001	0.0001
Uranium	mg/L	0.015	0.015	0.02	0.02	-	<0.0001	0.0002	0.0002	0.0001
Vanadium	mg/L	-	-	-	-	0.006[p]	<0.0001	0.0001	0.0001	0.0001
Zinc	mg/L	0.03	0.03	≤ 5 (AO)	5 (AO)	-	<0.0005 to 0.0006	0.0003	0.0003	0.0003

(a) Saskatchewan Surface Water Quality Objectives (SSWQO) (Saskatchewan Environment 2006).
(b) Canadian water quality guidelines (CWQG) for the protection of aquatic life - freshwater (CCME 1999).
(c) Canadian drinking water guidelines (Health Canada 2012); unless stated, the guideline concentrations are Maximum Acceptable Concentrations (MAC).
(d) Saskatchewan Drinking Water Standards and Objectives (SDWO) (Saskatchewan Environment 2002).
(e) The guidelines for total ammonia are dependent on temperature and pH . Total ammonia is the sum of ammonia (NH_3) and ammonium (NH_4^+) concentrations and is expressed as 'total ammonia-nitrogen' due to the slightly different relative molecular masses. The conservative guideline value chosen was based on a maximum pH of 7.8 and temperature of 15.58°C for Black Lake.
(f) The guidelines for aluminum are pH-dependent. Based on the mean baseline pH value (7.1) for Black Lake, the guideline is 0.1 mg/L.
(g) The SSWQO for cadmium is hardness-dependent; for hardness ranging from 0 to 48.5 mg/L as $CaCO_3$, the guideline is 0.017 µg/L. The CWQG is also hardness dependent; this guideline was calculated using the equation ($10^{0.86 \times [\log10(hardness)] - 3.2}$); based on a mean hardness of 13.3 mg/L for Black Lake, the guideline is 0.006 µg/L.
(h) The guidelines for copper are hardness-dependent. The mean baseline hardness for Black Lake was 13.3 mg/L $CaCO_3$. For hardness ranging from 0 to 120 mg/L as $CaCO_3$, the SSWQO is 0.002 mg/L. The CWQG is determined based on a specific equation; however, the minimum guideline of 0.002 mg/L applies in this case.
(i) The guidelines for lead are hardness-dependent. The mean baseline hardness for Black Lake was 13.3 mg/L $CaCO_3$. For hardness ranging from 0 to 60 mg/L as $CaCO_3$, the SSWQO is 0.001 mg/L. The CWQG is determined based on a specific equation; however, the minimum guideline of 0.001 mg/L applies in this case.
(j) The guidelines for nickel are hardness-dependent; The mean baseline hardness for Black Lake was 13.3 mg/L $CaCO_3$. For hardness ranging from 0 to 60 mg/L as $CaCO_3$, the SSWQO is 0.025 mg/L. The CWQG is determined based on a specific equation; however, the minimum guideline of 0.025 mg/L applies in this case.
(k) The selenium guideline is based on waterborne exposure. However, selenium has a bioaccumulation pathway similar to mercury.
(l) Since the detection limit of cadmium is 0.00001 mg/L, it is indeterminate if the predicted values are above the SSWQO guideline.
(m) Since the detection limit of cadmium is 0.00001 mg/L, baseline detection limit and predicted concentrations equal to that value are above the CWQG (0.000006 mg/L).
(n) Baseline Report Annex III Surface Water Environment – Tazi Twé Hydroelectric Project. Report 10-1365-004/DCN-072
(o) Guideline was obtained from British Columbia Ministry of Environment (BCMOE 2013) for the protection of aquatic life. Guideline is hardness-dependent. Black Lake mean baseline hardness of 13.3 mg/L $CaCO_3$ used in determining guideline value.
(p) Guideline was obtained from Ontario Ministry of Energy and Environment (OMEE 1994) for the protection of aquatic life.
(q) Draft guideline under review by BCMOE (2013) for the protection of aquatic life.

Notes: mg/L = milligrams per litre; mg $CaCO_3$/L = milligrams of calcium carbonate per litre; ≤ = less than or equal to; - = not applicable; N = nitrogen; NO_3 = nitrate; AO = Aesthetic objectives.

Predicted Plume Dispersion

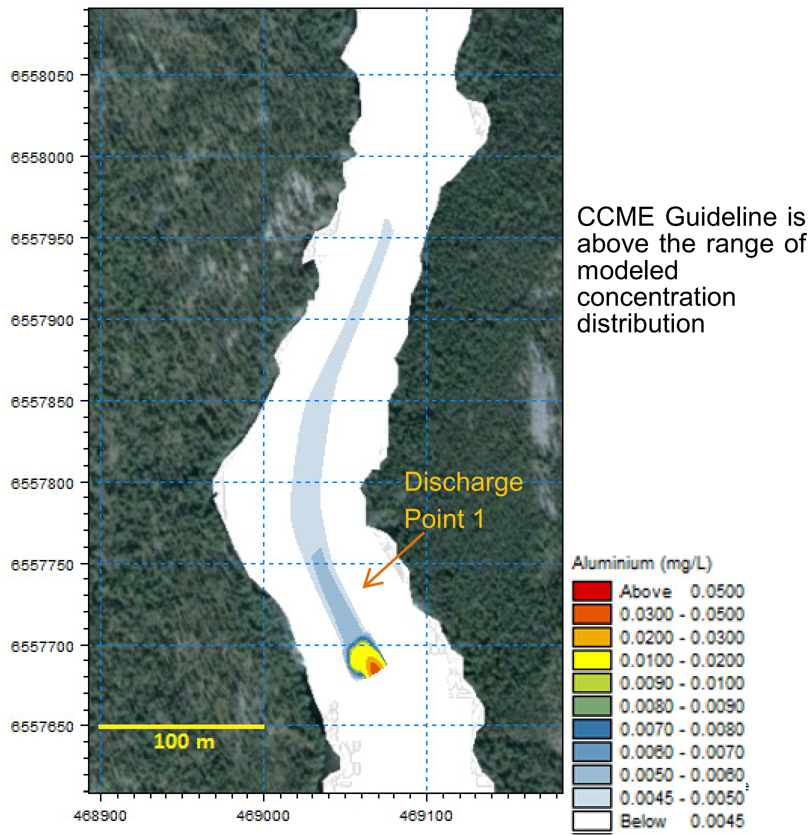
Aluminum was selected for assessment of plume dispersion within the mixing zone (see Appendix 11.1). The predicted parameter concentrations downstream of the discharge point are presented in Figure 11.5-2. Concentrations of aluminum were predicted to be below guideline values well before the edge of the mixing zone, for the considered 7Q10 flow and upper bound of the groundwater flows and chemistry. Under these conservative conditions, dispersion was very rapid.

As illustrated in Figure 11.5-2, given the assumed condition of discharge occurring in the middle of the Fond du Lac River and because of the large volume of the natural river flow relative to the small volume of settling pond discharge, the effluent from the settling pond should be entrained by the river flow almost immediately and carried over the falls where turbulent mixing will occur. The dispersed plume would likely then move downstream near the centre of the river. The extending (i.e. lengthening) and further-dispersing plume would not be expected to reach the shoreline areas for some distance (likely several hundred metres) downstream of the diffuser location, if at all.

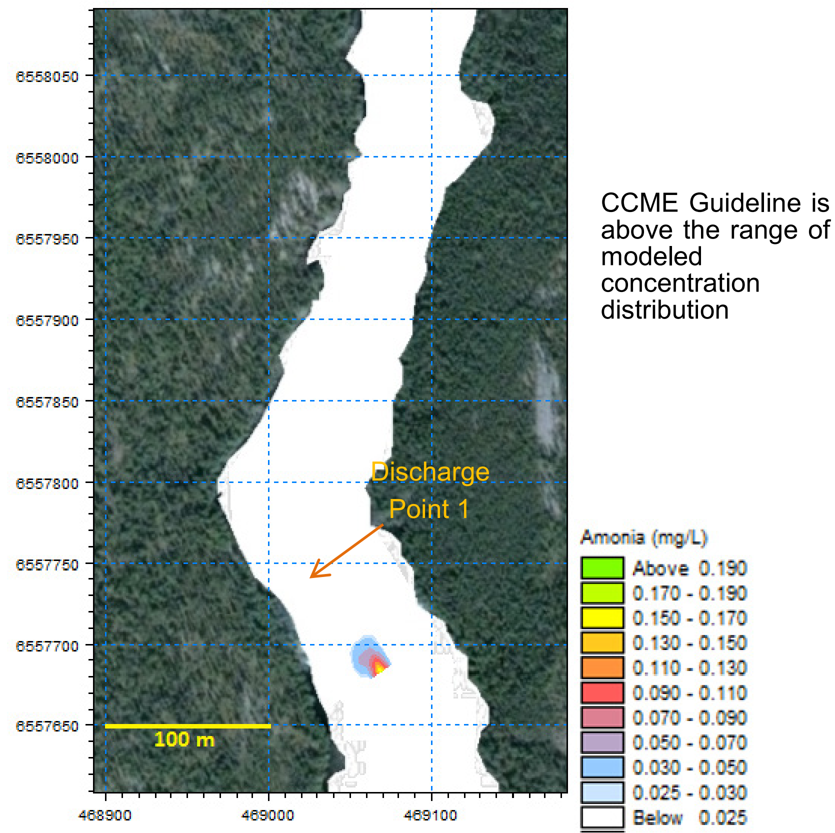
Consideration of potential effects to discharge on fish habitat was evaluated based on fish habitat information within the mixing zone of 1.2 km for both potential discharge locations (see Section 12 of the Environmental Impact Statement for details). In general, no sensitive fish habitat (e.g., overwintering, spawning) is located within the mixing zone of Discharge Location 2 (see Figure 11.5-1 for discharge locations). For Discharge Location 1, which is the location considered in this modeling exercise, the following conditions were determined regarding overwintering and spawning habitat in the 1.2 km mixing zone.

- Several small zones of suitable and moderately suitable adult Arctic grayling overwintering habitat exist at the discharge location and along the west shoreline in the 1.2 km downstream of the discharge point. However, these zones are not likely to be critical as much larger areas of suitable habitat occur upstream of the diffuser and downstream of the plume (i.e., greater than 1.2 km downstream of the diffuser).
- Some overwintering habitat for juvenile Arctic grayling occurs on the west shore at the discharge location (immediately upstream of the falls). Larger areas of suitable overwintering habitat are accessible upstream and much further downstream of the discharge location.
- Several small zones of potentially moderately suitable or suitable Arctic grayling spawning habitat occur along the shore at the diffuser location and nearby falls. Fish above the falls have access to much larger areas of suitable habitat upstream.

Figure 11.5-2: Modelled concentration distribution of A) Aluminum, (B) Total Ammonia and (C) Nitrate Within the Mixing Zone for Annual 7Q10 Flow



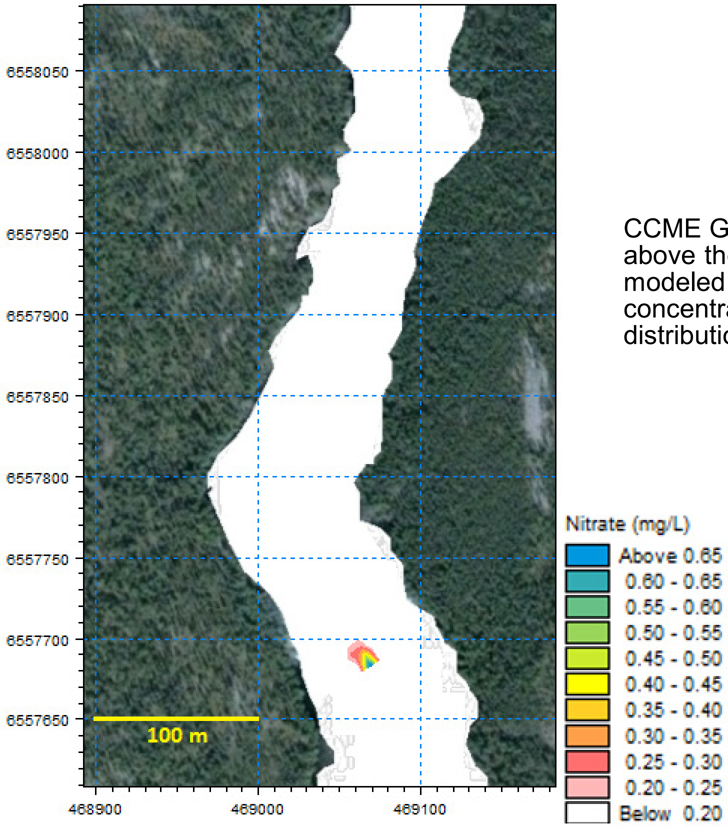
(A) Aluminum



(B) Total Ammonia

Notes: mg/L = milligrams per litre, µg/L = micrograms per litre.
The upper bound CCME guideline for aluminum was applied (0.1 mg/L) as the mean baseline pH for Black Lake (= 7.1) is above 6.5.

Figure 11.5-2: (cont'd) Modelled concentration distribution of (A) Aluminum, (B) Total Ammonia, and (C) Nitrate within the Mixing Zone for Annual 7Q10 Flow



(C) Nitrate

Notes: mg/L = milligrams per litre, µg/L = micrograms per litre.

11.5.3 Management of Uncertainty

Key areas of uncertainty for the assessment of effects on surface water and sediment quality include the following:

- surface water quality modelling, including appropriateness of input data (especially the quality and quantity of groundwater inflow and waste rock runoff); and
- elements of the final Project design as they pertain to surface water drainage and discharge to the receiving environment (e.g., locations of waste rock disposal areas, location of settling ponds, and discharges to the Fond du Lac River).

The main approach for managing areas of uncertainty was to make conservative assumptions. For example, for the surface water quality modelling, it was assumed that one settling pond would receive both waste rock runoff and groundwater collected from the power tunnel and discharge to one location in the Fond du Lac River (see Section 11.5.2 and Appendix 11.1 for further details). Natural surface runoff into the settling pond, which would act to dilute these two other sources, was not considered. Other key assumptions that support a conservative approach include the following:

- an upper bound value of 4,700 m^3/d for groundwater inflow into the power tunnel;
- the use of low river flows such as the 7Q10, which is the lowest average discharge over a period of one week with a recurrence interval of 10 years; and
- the use of maximum estimated parameter concentrations for site-specific groundwater chemistry and estimated waste rock runoff quality.

Groundwater will start to flow into the power tunnel as soon as the tunnel construction begins, but the flow rate will not reach its peak until after the full construction of the tunnel. However, the estimated upper bound groundwater flow rate into the tunnel was conservatively adopted for the modelling. The groundwater inflow is anticipated to continue until the commencement of the operation, when the lake water passing through the tunnel will reduce inflow of groundwater into the tunnel. Additional assumptions for the surface water quality modelling are listed in Appendix 11.1. Assumptions related to the groundwater assessment are described in Section 9.0.

11.6 Determination of Significance

11.6.1 Residual Effects Criteria

The classification of residual effects from primary interactions provides the foundation for determining environmental significance from the Project and other developments on the continued suitability of surface water quality to support aquatic life and human use. The main sources of residual effects are related to construction and initial operation of the Project.

The following criteria have been used to assess the residual effects from the Project in the EIS:

- direction;
- magnitude;
- geographic extent;

- duration;
- reversibility;
- frequency; and
- likelihood.

Definitions for each of the criteria for the determination of the significance of residual effects on surface water quality used in this assessment are provided below and summarized in Table 11.6-1.

Direction - indicates whether the residual effect on surface water quality is negative (i.e., less favourable), positive (i.e., improvement), or neutral (i.e., no change). While the focus of the residual effects assessment is to predict whether the development is likely to cause significant negative residual effects on surface water quality or cause public concern, the positive changes associated with the Project also are reported. Neutral changes are not assessed.

Magnitude - a measure of the intensity of a residual adverse environmental effect, or the degree of change caused by the Project relative to baseline conditions or a guideline value. It is classified into three scales: negligible to low, moderate, and high. The magnitude of residual adverse environmental effects on surface water quality is evaluated by assessing the ability of surface water to support aquatic life, as indicated by applicable surface water quality guidelines. Because effects threshold levels on aquatic life are not known for the LSA or RSA, the magnitude of residual adverse environmental effects is assessed qualitatively for the population and the ecological properties of aquatic populations. For a change in state from baseline conditions to occur, the magnitude of alterations in surface water quality must be large enough so that there is a potential significant residual adverse environmental effect on aquatic population process and properties, and on human use.

Geographic Extent - refers to the spatial extent of the effect, and is different from the spatial boundary (i.e., study area) for the effects analysis. The study area for the effects analysis represents the maximum area used for the assessment. However, the geographic extent of effects can occur on a number of scales within the spatial boundaries of the assessment. Geographic extent refers to the area affected, and is categorized into three scales of local, regional, and beyond regional. Effects at the local scale are largely associated with the predicted maximum extent of incremental changes from the Project. Effects at the regional scale are associated with incremental and cumulative changes from the Project and other developments. The beyond regional scale includes cumulative residual effects from the Project and other developments that extend beyond the RSA.

Duration - defined as the amount of time (usually in years) from the beginning of a residual effect on when the effect on surface water quality is reversed, and is expressed relative to Project phases. Duration has two components. Essentially, duration is a function of the length of time that valued components are exposed to Project activities and reversibility. Some residual effects could be reversible soon after the effect has ceased, while other residual effects could take longer to be reversed. By definition, residual effects that are short-term, medium-term, or long-term in duration are reversible.

In some cases, available scientific information and professional judgment could predict that the residual effect is irreversible. Alternately, the duration of the residual effect could not be known, except that it is expected to be extremely long and well beyond the temporal boundary of the assessment (95 years). In other words, science and logic predict that the likelihood of reversibility is so low that the residual effect is irreversible.

Table 11.6-1: Definitions of Terms Used in the Determination of Significance for Residual Effects on Surface Water and Sediment Quality

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood
Negative: There is a less favourable change relative to baseline values or conditions **Positive:** There is an improvement over baseline values or conditions	**Negligible to Low:** There is no measurable residual adverse environmental effect on aquatic life. **Moderate:** The residual adverse environmental effect on aquatic life is measurable, but within the anticipated resilience limits of the aquatic life. **High:** The residual adverse environmental effect is near or exceeding the anticipated resilience limits of aquatic life.	**Local:** The residual effect is limited to the LSA **Regional:** The residual effect is limited to the RSA and can include cumulative effects from the Project and other developments **Beyond Regional:** The residual effect will extend beyond the RSA and includes cumulative effects from the Project and other developments	**Short-term:** The residual effect is reversible at the end of construction **Medium-term:** The residual effect is reversible at a defined length of time beyond construction following initial decommissioning and reclamation activities **Long-term:** The residual effect is reversible within a defined length of time beyond closure and final decommissioning and reclamation activities **Permanent:** The residual effect is irreversible within the temporal boundary of the assessment (95 years)	**Reversible:** The residual effect is reversible within a time period that can be identified when the Project no longer influences surface water quality **Irreversible:** The residual effect is predicted to affect surface water quality indefinitely	**Isolated:** The residual effect is confined to a specific discrete period (i.e., construction) or Project activity **Periodic:** The residual effect occurs intermittently, but repeatedly over the temporal boundary of the assessment (95 years) **Continuous:** The residual effect will occur continually over the temporal boundary of the assessment (95 years)	**Unlikely:** The residual effect is possible but unlikely within the temporal boundary of the assessment (95 years; <10% chance of occurring) **Possible:** the residual effect is possible within a year, or a chance of occurring within the temporal boundary of the assessment (95 years) **Likely:** The residual effect is probable within a year, or at least a chance of occurring in the next 10 years (>80% chance of occurring) **Highly Likely:** The residual effect is certain

LSA = local study area; RSA = regional study area

Reversibility - the likelihood that the Project will no longer influence surface water quality at a future predicted period in time after removal of the Project activity or stressor. This term usually has only one alternative: reversible or irreversible. The period is provided for reversibility (i.e., duration) if a residual effect is reversible. Permanent residual effects are considered irreversible.

Frequency - refers to how often a residual effect will occur and is expressed as isolated (confined to a discrete period), periodic (occurs intermittently, but repeatedly over the temporal boundary of the assessment), or continuous (occurs continuously over the temporal boundary of the assessment). Frequency is explained more fully by identifying when the residual effect occurs (e.g., once at the beginning of the Project). If the frequency is periodic, then the length of time between occurrences, and the seasonality of occurrences (if present) is discussed.

Likelihood - probability of an effect occurring and is described in parallel with uncertainty. Four categories are used: unlikely (residual effect is possible, but unlikely to occur within the temporal boundary of the assessment [95 years; less than 10% chance of occurring]), possible (residual effect is possible within a year, or a chance of occurring within the temporal boundary of the assessment [95 years], but is not certain), likely (residual effect is likely to occur or probable within a year, or at least a change of occurring in the next 10 years, and greater than 80% chance of occurring), and highly likely (the residual effect is certain).

11.6.2 Classification of Residual Effects

Residual effects anticipated for surface water quality include changes resulting from the deposition of criteria air contaminants and dust, and the discharge of wastewater. The classification of residual effects of the Project on surface water and sediment quality is reported in Table 11.6-2.

The residual effects on surface water and sediment quality from the deposition of air emissions, both dust and criteria air emissions (SO_2 and NO_2) with the potential to acidify local waterbodies are expected to be negligible to low in magnitude, local in spatial extent, and medium-term. Peak air emissions are expected to occur continuously during the three years of construction and decline quickly during early operations, particularly due to the cessation of blasting and reduction in activity levels from construction to operations. Small Project-related increases in TSS could occur in association with the spring freshet, when accumulated dust deposited over winter migrates with melted snow; however, this increase would be very short in duration (i.e., over the time of the freshet) and would likely be limited to the construction phase when dust generation and deposition is expected to be greatest. Given the low to moderate acid sensitivity of Black Lake and Middle Lake and the low amount of acid deposition potential associated with the Project, the deposition of criteria air contaminants is not expected to result in a measurable change to the chemistry of waterbodies in the LSA. The small potential changes to water quality from Project air emissions are also expected to be reversible, with water quality in the LSA returning to background conditions during early operations. Implementation of various environmental design features and mitigation will also help to limit potential effects.

Table 11.6-2: Summary of the Classification of Residual Effects on Surface Water and Sediment Quality

Residual Effect	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood
Deposition of air emissions: ■ Criteria air contaminants ■ Dust	Negative	Negligible to low	Local	Medium-term	Reversible	Continuous	Highly Likely
Discharge of Wastewater: ■ Use of Explosives ■ Groundwater Inflow ■ Waste Rock Seepage	Negative	Negligible to low	Local	Short-term	Reversible	Continuous	Highly Likely

In general, given the incorporation of various environmental design features, it is anticipated that the residual effects on surface water and sediment quality from the discharge of wastewater (i.e., from the settling ponds) will be negligible to low in magnitude, local in spatial extent, and short-term in duration, occurring primarily during the construction phase of the Project. To be conservative, the southern location (Discharge Location 1) with less favorable mixing conditions was considered in the modelling exercise. Surface water quality modeling results for settling pond discharges predicted minor changes in the water quality of the Fond du Lac River. For example, predicted concentrations of various parameters are within the range of baseline concentrations measured in 2010 and 2011, with the predicted uranium concentration being slightly above baseline given very conservative input groundwater chemistry for this parameter (Table 11.5-3). As well, applicable water quality guidelines for drinking water and protection of aquatic life are expected to be met under fully mixed conditions, and at the edge of the mixing zone (see Table 11.5-3 and Appendix 11-1). Loads of ammonia and nitrate from blasting residues were also incorporated into the surface water quality model; again, minor changes to water quality were predicted, with guidelines being met at the edge of the mixing zone. These changes are also expected to be reversible, with water quality in the LSA returning to background conditions during early operations.

11.6.3 Significance of Residual Effects

The classification of residual effects from the primary interactions provides the foundation for determining environmental significance from the Project and other developments on the ability of surface water to support aquatic life and human use. Magnitude, geographic extent, and duration (which include reversibility) are the principal criteria used to predict significance (FEARO 1994). Other criteria, such as frequency and likelihood are used as modifiers (where applicable) in the determination of significance. Significance is determined for the residual effect of the Project overall, as well as for the cumulative effects from the Project and previous and existing developments (there a currently no known reasonably foreseeable developments that overlap the spatial and temporal boundaries of the assessment [Section 11.5]).

Environmental significance is used to identify predicted effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to the ability of surface water to support aquatic life and human use. A number of high magnitude and long-term or irreversible effects at the population and community levels (beyond local scale) would likely be significant. Non-significant effects are strong enough to be detectable at the population and community levels, but are not likely to decrease resilience or alter the state and increase the risk to the ability of surface water to support aquatic life and human use.

In summary, the following information is used in the evaluation of the significance of residual effects from the Project on surface water quality:

- results from the residual effects classification;
- magnitude, geographic extent, and duration of the effect as principal criteria, with frequency and likelihood as modifiers; and
- application of professional judgment and ecological principles, such as resilience, to predict the duration and associated reversibility of residual effects.

The residual effects on surface water quality from the Project are not predicted to be large enough to alter the ability of surface water to support aquatic life and human use. The scale of residual effects from the Project interactions, independently or combined, should not be large enough to cause irreversible changes to surface water quality and its ability to support aquatic life or human use. Overall, the residual effects on surface water from the Project are not significant.

11.7 Environmental Management, Monitoring, and Follow-up

Management plans and monitoring programs relating to the surface water quality component will be designed to incorporate baseline data, compliance data (e.g., regulatory documents, standards, or guidelines), and real time data. These plans and programs will also include any contingency procedures/plans or other adaptive management provisions as a means of addressing unforeseen effects or correcting exceedances, as required, complying or conforming to benchmarks, regulatory standards, or guidelines. Management plans that will apply to surface water quality include:

- Site Water Management Plan;
- Environmental Protection Plan (EnvPP);
- Environmental Response Plan (ERP);
- Erosion and Sediment Control Plan;
- Blasting Plan;
- Waste Rock Management Plan; and
- Decommissioning and Reclamation Plan.

Environmental monitoring is completed to track conditions or issues during the Project lifespan, and is a key component of adaptive management (e.g., monitoring water quality and discharge volumes) and for continuous improvement of the Project-specific EnvPP. Information obtained during environmental monitoring programs can be used to implement further mitigation as required. Specific examples of environmental monitoring of surface water quality for the Project will include the following:

- Groundwater inflow into the power tunnel during construction will be monitored for quality and quantity. It will be collected in a settling pond, which will be monitored for quality prior to discharge to the Fond du Lac River.
- The rate of groundwater inflow will be monitored as power tunnel construction progresses so there is advanced warning if flow volumes increased faster than expected. The contingency plan involves having settling ponds sized to store larger volumes of water, if required.
- A program will be established to verify predicted changes in water quality in the Fond du Lac River given the discharges from the settling ponds.

Follow-up monitoring is designed to verify the accuracy of effects predictions, reduce uncertainty, determine the effectiveness of environmental design features and mitigation, and provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices. A program will be established to monitor potential changes in water quality in Black Lake, Middle Lake, and several small lakes near the Project to verify the prediction of no effects on water quality due to acid deposition from the Project. If monitoring detects effects that are different from predicted effects, or the need for improved or modified design features, then adaptive management will be implemented.

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11.9 Glossary

Term	Definition
Acidification	The decrease of acid neutralizing capacity in water, or base saturation in soil, caused by natural or anthropogenic processes. Acidification is exhibited as the lowering of pH.
Alkalinity	A measure of water's capacity to neutralize an acid. It indicates the presence of carbonates, bicarbonates and hydroxides, and less significantly, borates, silicates, phosphates and organic substances. Alkalinity is expressed as an equivalent of calcium carbonate. Its composition is affected by pH, mineral composition, temperature and ionic strength. However, alkalinity is normally interpreted as a function of carbonates, bicarbonates and hydroxides. The sum of these three components is called total alkalinity.
Background	An area not influenced by chemicals released from the site under evaluation.
Base Case	The assessment case that includes existing environmental conditions as well as existing and approved projects or activities.
Buffering	The capability of a system to accept acids without the pH changing appreciably. The greater amounts of the conjugate acid-base pair, the more resistant they are to a change in pH.
Cation	A positively charged ion.
Conductivity	A measure of the capacity of water to conduct an electrical current. It is the reciprocal of resistance. This measurement provides an estimate of the total concentration of dissolved ions in the water. Specific conductivity is conductivity that has been standardized to a certain temperature.
Groundwater	That part of the subsurface water that occurs beneath the water table, in soils and geologic formations that are fully saturated.
Hydrogeology	The study of the factors that deal with subsurface water (groundwater) and the related geologic aspects of surface water. Groundwater as used here includes all water in the zone of saturation beneath the earth's surface, except water chemically combined in minerals.
Hydrology	The science of waters of the earth, their occurrence, distribution, and circulation; their physical and chemical properties; and their reaction with the environment, including living beings.
Oligotrophic	Trophic state classification for lakes characterized by low productivity and low nutrient inputs (particularly total phosphorus).
Runoff	The portion of water from rain and snow that flows over land to streams, ponds or other surface waterbodies. It is the portion of water from precipitation that does not infiltrate into the ground, or evaporate.
Sediment	Solid material that is transported by, suspended in, or deposited from water. It originates mostly from disintegrated rocks; it also includes chemical and biochemical precipitates and decomposed organic material, such as humus.
Total Suspended Solids (TSS)	The amount of suspended substances in a water sample. Solids, found in wastewater or in a stream, that can be removed by filtration or settling. The origin of suspended matter could be artificial or anthropogenic wastes or natural sources such as silt.

11.10 List of Acronyms

Acronym	Definition
ARD	acid rock drainage
BMP	Best Management Practices
$CaCO_3$	calcium carbonate
CCME	Canadian Council of Ministers of the Environment
CO	carbon monoxide
CWQG	Canadian Water Quality Guidelines
DFO	Fisheries and Oceans Canada
DOC	dissolved organic carbon
EIS	Environmental Impact Assessment
EnvPP	Environmental Protection Plan
ERP	Emergency Response Plan
ISQG	Interim Sediment Quality Guidelines
LSA	local study area
MOE	Ministry of Environment
MSDS	Material Safety Data Sheet
NO_2	nitrogen dioxide
NO_x	nitrogen
PAG	potentially acid generating
PEL	Probably Effects Level
PM	particulate matter
Project	Tazi Twé Hydroelectric Project
RSA	regional study area
SAAQS	Saskatchewan Average Ambient Air Quality Standard
SO_2	sulphur dioxide
SO_x	oxides of sulphur
SSWQO	Saskatchewan Surface Water Quality Objectives
TSP	total suspended particulate
TSS	total suspended solids
WHMIS	Workplace Hazardous Materials Information System

11.11 List of Units

Term	Definition
°C	degrees Celsius
%	percent
<	less than
>	greater than
µeq/L	microequivalents per litre
µg/g	micrograms per gram
µg/L	micrograms per litre
µg/m^2/s	micrograms per square metre per second
µg/m^3	micrograms cubic metre
µS/cm	microSiemens per centimetre
Bq/g	Becquerels per gram
ha	hectares
kg/ha/y	kilograms per hectare per year
km	kilometres
km^2	square kilometres
L	litres
L/d	litres per day
L/y	litres per year
m	metres
m/s	metres per second
m^2	square metres
m^3	cubic metres
m^3/d	cubic metres per day
m^3/s	cubic metres per second
m^3/y	cubic metres per year
mg/L	milligrams per litre
mg/m^3	milligrams per cubic metre
MW	Megawatt
ppm	parts per million

12.0 FISH AND FISH HABITAT

12.1 Introduction

This section of the Environmental Impact Statement (EIS) for the Tazi Twé Hydroelectric Project (the Project) discusses potential effects of the Project on fish and fish habitat. The scope of the fish and fish habitat section includes the analysis of Project-related changes during construction, operations, closure, and considers accidents, malfunctions, and unplanned events. The overall residual environmental effects from the Project on fish and fish habitat and the potential for cumulative residual effects from the Project and previous, existing, and reasonably foreseeable developments are assessed. Baseline data (Annex III) and detailed effects assessments provided in Appendices 12.1 through 12.4 were used along with the Project's Atmospheric Environment (Section 8.0), Hydrogeology (Section 9.0), Hydrology (Section 10.0), Surface Water Quality (Section 11.0), and Soils (Section 13.0) assessments to form the basis for the Fish and Fish Habitat assessment for the Project. The Fish and Fish Habitat assessment was completed to identify and evaluate potential effects from the Project on fish and fish habitat and to provide recommendations on best practices and mitigation.

A valued component (VC) is a component that could be particularly vulnerable to the effects of a Project, or that is ecologically, culturally, socially, or economically important. Because the proposed Project will divert water that would naturally flow through the Fond du Lac River between Black Lake and Middle Lake, fish and fish habitat in these watercourses and waterbodies are expected to be vulnerable to Project effects. Fish and fish habitat were selected as a VC because of the ecological, social, cultural, and economic value of fish populations in the area. The overall determination of significance of effects from the Project on fish and fish habitat is predicted by linking residual effects on measurement endpoints to the associated assessment endpoint.

The assessment endpoint is the key property that should be protected for use by future human generations. For fish and fish habitat this is considered to be the maintenance of self-sustaining fish populations. The assessment endpoint for fish and fish habitat is focused on the maintenance of fish populations that have been identified as important to the Black Lake First Nation (BLFN) or the outfitter at Camp Grayling; fish species that have been identified as potentially sensitive also are included (Table 12.1-1). Fish species that are harvested commercially or domestically in the Project area include lake whitefish (*Coregonus clupeaformis*), lake trout (*Salvelinus namaycush*), northern pike (*Esox lucius*), walleye (*Sander vitreus*), suckers (*Catostomus* sp.), and Arctic grayling (*Thymallus arcticus*). Arctic grayling have been identified as an important recreational species for local anglers and visitors to Camp Grayling. The three populations of Arctic grayling inhabiting the Fond du Lac River between Black Lake and Middle Lake are expected to be particularly vulnerable to Project effects, based on their life history (i.e., spawning) requirements. Black Lake ciscoes have been identified as potentially vulnerable to Project effects. Specimens having some characteristics of shortjaw cisco (*Coregonus zenithicus*) and common cisco (*Coregonus artedi*) are known to inhabit Black Lake (Annex III). Shortjaw cisco are listed as a potentially threatened species under Schedule 2 of the federal *Species At Risk Act* (SARA) and are identified as a threatened species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Government of Canada 2012a).

Table 12.1-1: Assessment and Measurement Endpoints Associated with the Fish and Fish Habitat Valued Component

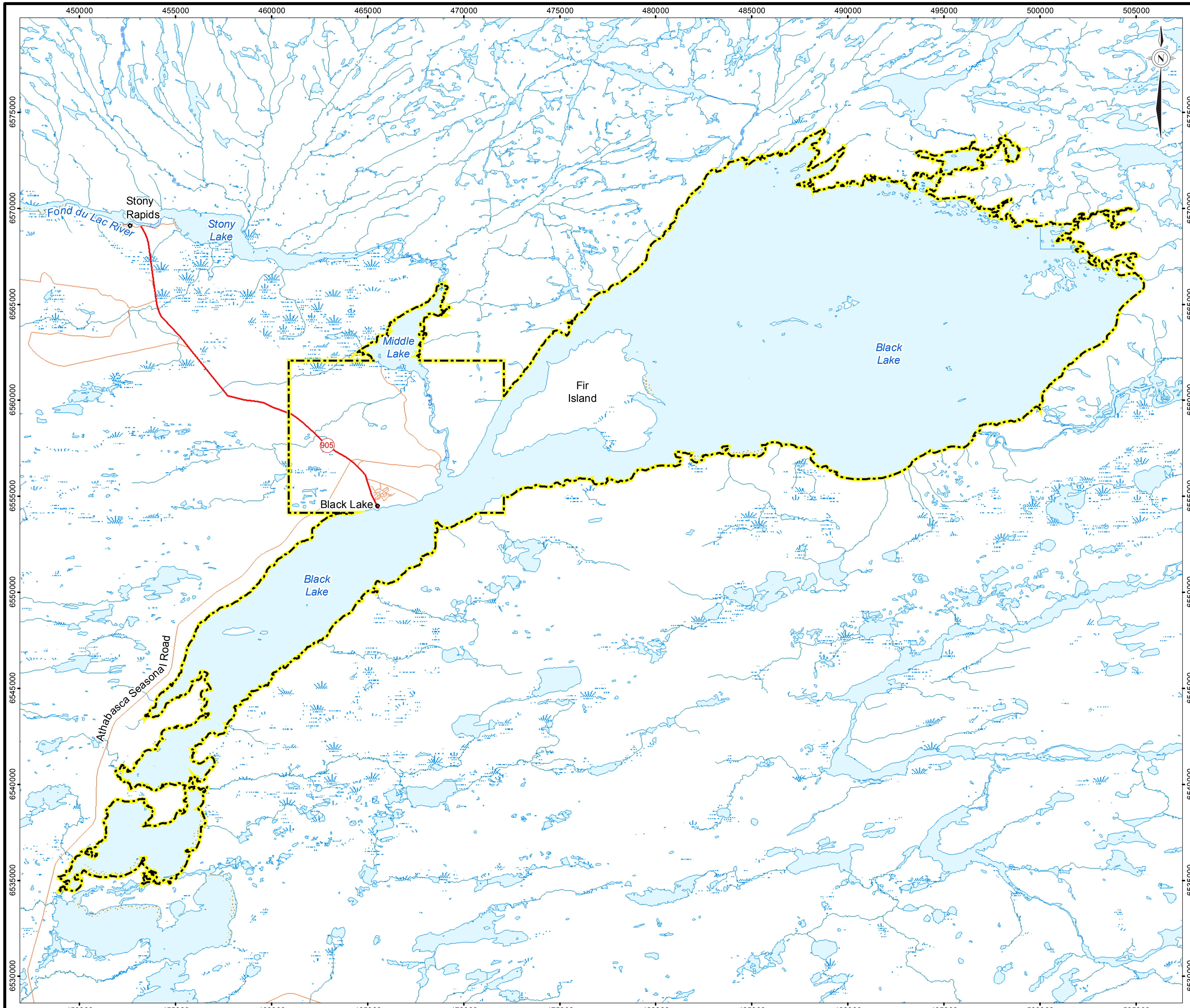
Valued Component	Assessment Endpoint	Measurement Endpoints
Fish and Fish Habitat	Maintenance of self-sustaining fish populations in: ■ Black Lake: ▪ Arctic grayling ▪ Cisco sp. ▪ Lake trout ▪ Lake whitefish ▪ Longnose sucker ▪ Northern pike ▪ Walleye ▪ White sucker ■ Fond du Lac River: ▪ Arctic grayling (three populations) ■ Middle Lake: ▪ Arctic grayling ▪ Lake whitefish ▪ Longnose sucker ▪ Northern pike ▪ Walleye ▪ White sucker	■ Relative abundance and distribution of fish species ■ Fish movements ■ Hydrology and spatial distribution of water (i.e., riparian flows in the bypassed river section) ■ Presence and characteristics of sensitive fish species ■ Fish habitat quantity and connectivity ■ Fish habitat quality (overwintering, spawning, and foraging) ■ Survival and reproduction ■ Fish health (e.g., condition) ■ Water quality

Measurement endpoints are quantifiable (i.e., measureable) or qualitative expressions of change to the assessment endpoint. The maintenance of self-sustaining fish populations is linked to the measurement endpoints listed in Table 12.1-1. Measurement endpoint information is generally the basis for discussions of uncertainty of effects on VCs, as well as for identification of the variables to be used in monitoring and follow-up programs.

12.2 Spatial Boundaries

A local study area (LSA) and regional study area (RSA) were defined for the fish and fish habitat component of the environmental assessment so that baseline conditions and potential environmental effects of the Project could be evaluated. The LSA is based on the anticipated direct and small-scale indirect effects from the Project on fish and fish habitat. Loss of fish habitat within the Project's water intake footprint is an example of a direct environmental effect. Potential small-scale indirect environmental effects might include changes to habitat quantity from reduced riparian flows in the bypassed section of the Fond du Lac River or changes to habitat quality or fish health resulting from aerial dust deposition or soil erosion in upland areas.

Potential direct effects and small-scale indirect effects of the Project to fish and fish habitat are expected to occur in three major waterbodies: Black Lake, the section of the Fond du Lac River between Black Lake and Middle Lake, and Middle Lake. Upland areas associated with site infrastructure (i.e., the Project footprint) and their associated downstream areas are included in the LSA. These portions of the LSA represent approximately 90 square kilometres (km^2) and encompass preferred and alternative locations for Project infrastructure (Figure 12.2-1).



LEGEND

- HAMLET OR COMMUNITY
- RIVER
- HIGHWAY
- ROAD
- WETLAND
- WATERBODY
- LOCAL STUDY AREA

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6

5 0 5
SCALE 1:200,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATION OF THE LOCAL STUDY AREA FOR FISH AND FISH HABITAT

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	07/11/13	FIGURE: 12.2-1
CHECK	AO	07/11/13	
REVIEW	BT	07/11/13	

The RSA is expected to be large enough to capture the maximum predicted spatial extent of combined direct and indirect effects from the Project on fish and fish habitat. Cumulative and incremental Project effects are also expected to be captured within the RSA.

Waterbodies and watercourses were included in the fish and fish habitat RSA to a distance that was conservatively estimated based on potential effects on hydrology. No Project effects on fish and fish habitat are anticipated for areas where hydrological changes do not occur. Because water levels in Black Lake will be maintained within historically normal variations and water levels in Black Lake tributaries will not be affected by the Project, no direct or indirect effects on fish and fish habitat are expected to occur in waterbodies or watercourses upstream of Black Lake. However, larger-scale direct effects and indirect effects could propagate into aquatic environments located downstream. The region of the Project area located downstream of Middle Lake selected for inclusion in the RSA is defined so that the spatial extent of the assessment is sufficiently large to include all areas where potential adverse hydrological changes could occur, but not so large as to include areas where no direct and indirect effects from the Project are anticipated. Therefore, the downstream limit of the Project area is considered to be Fond du Lac, on Lake Athabasca, which is approximately 50 kilometres (km) downstream of the Project. At Fond du Lac, Lake Athabasca begins to widen and becomes increasingly lacustrine. The narrower Fond du Lac River influenced section of Lake Athabasca is included in the RSA because minor hydrologic effects could extend to this section of Lake Athabasca. Operation of the Project is expected to dampen the effects of natural high and low flow extremes in baseline Fond du Lac River flows. Beyond this location, seasonal changes in flushing rate that might result from the Project become negligible and any associated potential effects on fish and fish habitat are expected to cease. Waterbodies, watercourses, and upland areas included in the RSA are presented in Figure 12.2-2.

12.3 Existing Environment

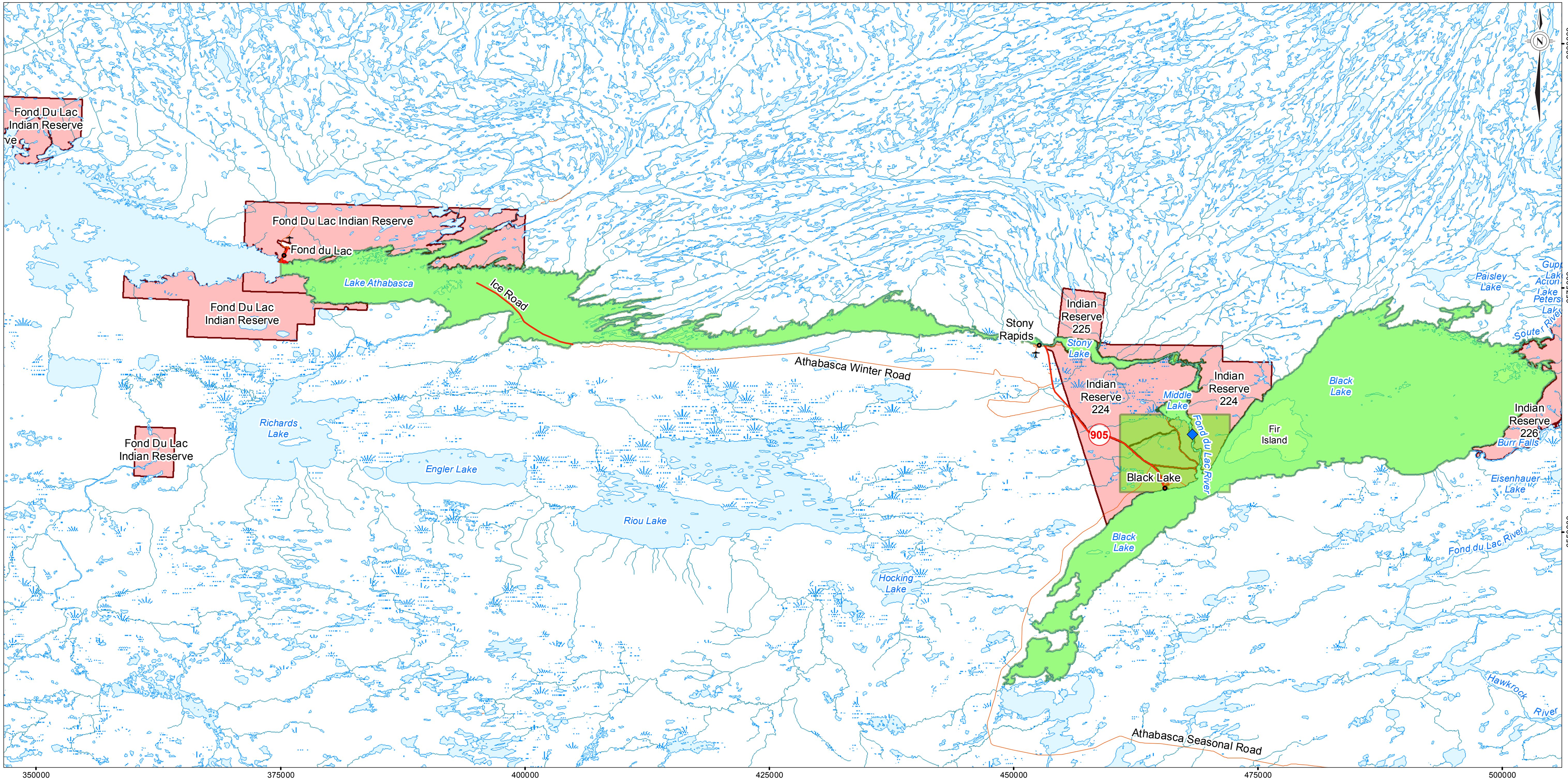
Baseline fisheries investigations for the Fond du Lac River, Black Lake, and Middle Lake were completed between May 2010 and October 2012. Other surveys have been completed in and around the Project LSA and include those of Johnson (1971), Envirocon (1974), and Merkowsky (1989).

Baseline studies completed in the LSA between 2010 and 2012 included the characterization of aquatic habitat and fish communities in the Fond du Lac River, Black Lake, and Middle Lake; spring spawning surveys in the Fond du Lac River; spring, fall, and winter spawning surveys in Black Lake; mark-recapture population estimates for Arctic grayling in the Fond du Lac River; and radio telemetry movement studies of Arctic grayling in the Fond du Lac River. Baseline studies completed for the Project are summarized in the following sections, and details are provided in Annex III.

12.3.1 Aquatic Habitat Surveys

12.3.1.1 Fond du Lac River

Baseline surveys identified major habitat types for 23 habitat reaches or channel units (i.e., sections of channel having relatively homogenous water depth, velocity, and cover) in the Fond du Lac River between the Black Lake outflow and Middle Lake (Figure 12.3-1). Deep, fast-flowing runs were the most common channel unit type identified, followed by areas of rapids, deep pools, and waterfalls. By relative area contribution, flat water habitat located primarily in the Fond du Lac River outflow to Middle Lake was most abundant, followed by deep pool habitat located at the outlet of Black Lake and in several other reaches. Extensive riffle habitat and back eddies were present in many of the channel units. Elizabeth Falls and two additional waterfall-type habitats within the river were identified as barriers or potential barriers to upstream fish migration.



LEGEND

HAMLET OR COMMUNITY	ELIZABETH FALLS
HIGHWAY	REGIONAL STUDY AREA
ROAD	
RIVER	
WETLAND	
WATERBODY	
INDIAN RESERVE	

10 0 10

SCALE 1:400,000 KILOMETRES

REFERENCE

DMTI HIGHWAYS AND ROADS
NTS MAPSHEET 74I, 74J, 74O, 74P
DATUM: NAD 83 PROJECTION: UTM ZONE 13

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

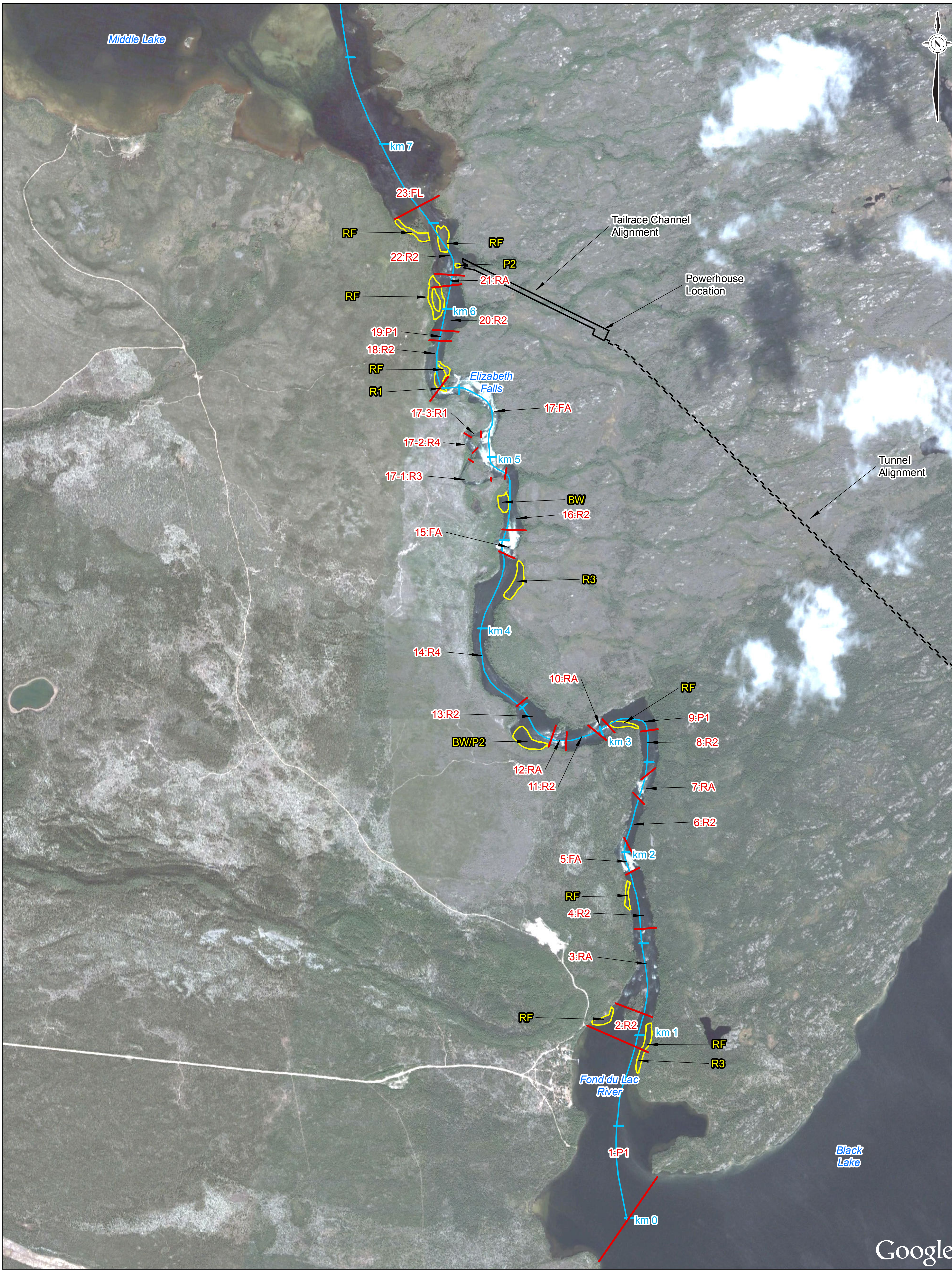
TITLE

REGIONAL STUDY AREA FOR FISH AND FISH HABITAT

Tazi Twé
Hydroelectric Project

PROJECT	10-1365-0004	FILE No.	
DESIGN		SCALE AS SHOWN	REV. 2
GIS	SM	11/11/13	
CHECK	BC	11/11/13	
REVIEW	MM	11/11/13	

FIGURE: 12.2-2



LEGEND

PRIMARY CLASSIFICATION (REACH NUMBER : CLASSIFICATION)

DISTANCE CHAIN (0.5 KM INTERVAL)

SECONDARY CLASSIFICATION (CLASSIFICATION)

SYMBOL KEY

P - POOL 1, 2
R - RUN 1, 2, 3, 4
RA - RAPIDS
FA - FALLS
FL - FLAT
RF - RIFFLE
BW - BACKWATER/EDDY

REFERENCE

GOOGLE EARTH IMAGE © 2010 DIGITAL GLOBE
NAD 83 UTM ZONE 13

400 0 400
SCALE 1:20,000 METRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATION OF FOND DU LAC RIVER REACH BREAKS AND ASSOCIATED HABITAT CLASSIFICATION

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	LR/SM	10/07/13	**FIGURE: 12.3-1**
CHECK	LT	25/07/13	
REVIEW	BC	25/07/13	

12.3.1.2 Black Lake

Bathymetric and aquatic habitat surveys of Black Lake were undertaken in 2010 and 2012. Satellite imagery of Black Lake was examined as part of the baseline survey. Areas of interest within Black Lake included the main lake basin, the channel between the northwest shore and Fir Island (including the proposed water intake area), Cree Bay, Chipman Bay, and Pluto Bay.

Shoreline substrate near the proposed water intake location in Black Lake is comprised primarily of cobble and boulder, with some gravel. The narrow, rocky littoral zone transitions quickly to deep water habitat that is characteristic of the area. A 30 metre (m) deep trough runs parallel with the shoreline between the northern extent of Black Lake and Fir Island. Emergent aquatic vegetation and low shrubs were the predominant vegetation identified along the shoreline near the proposed water intake during the aquatic habitat surveys (Annex III).

Surveys completed in the main basin of Black Lake indicate that cobble and boulder are the dominant substrate types, with some gravel and sand components. Numerous cobble and boulder shoals were identified in the shallow water around Fir Island and along the shoreline of Black Lake. Extensive littoral habitat, with sand, gravel, cobble, and occasional boulder substrates, was identified along the southern shoreline of Black Lake. This shallow area drops off to water depths of 10 to 15 m (Annex III). Submergent and emergent aquatic vegetation were present adjacent to shore throughout the surveyed area.

Fish habitat was assessed in bay areas of Black Lake as part of the baseline survey (Annex III). Cree Bay, which is located in the south-west portion of Black Lake, was characterized by shallow littoral zones, fine substrates (i.e., silt and sand), and abundant submergent aquatic vegetation. Chipman Bay is located on the north shore of Black Lake and has substrates dominated by sand and other fine materials. Extensive littoral habitat with dense emergent vegetation was identified within the southeastern section of the bay. Pluto Bay was located along the north shore of Black Lake. The littoral area of Pluto Bay consisted primarily of fines and sand; emergent and submergent vegetation were present.

12.3.1.2.1 Black Lake Tributary Assessment

Fish habitat potential of Black Lake tributary streams was evaluated in 2010 (Annex III). About half of the streams were dry or had low flow but potentially could provide spring spawning and rearing habitat during high water years. Several streams that were flowing at the time of the assessment were actively used by spawning fish (i.e., longnose sucker [*Catostomus catostomus]*, white sucker [*Catostomus commersonii*], and northern pike).

12.3.1.3 Middle Lake

Fish habitat and bathymetric surveys of Middle Lake were conducted in 2010 and 2011 (Annex III). Substrate in Middle Lake consisted of sand and silt, with areas of cobble and boulder. Mean depth recorded during the bathymetric surveys was less than 2.5 m. Lake depth generally increased along the Fond du Lac River channel, which flows adjacent to the eastern shore. A maximum water depth of 14 m was observed near Middle Lake's outflow to the Fond du Lac River. Aquatic vegetation was present throughout much of the lake and became very dense along both sides of the main Fond du Lac River channel.

12.3.2 Fish Community Surveys

Seventeen fish species were identified in the LSA during the 2010 to 2012 aquatic baseline programs (Annex III) (Table 12.3-1). Lake chub (*Couesius plumbeus*), ninespine stickleback (*Pungitius pungitius*), and yellow perch

(*Perca flavescens*) have been reported in the Fond du Lac River (Saskatchewan Parks and Renewable Resources [SPRR] 1991) but were not captured there during the 2010-2012 aquatic baseline surveys. No lake trout were captured in Middle Lake during the 2010 to 2012 aquatic baseline programs. However, area residents have reported the presence of this species in the lake. Similarly, shortjaw cisco (SPRR 1991) and deepwater sculpin (*Myoxocephalus thompsoni*) have been reported in Black Lake (SPRR 1991; Johnson 1971) and walleye have been reported in Middle Lake (Envirocon 1974; SPRR 1991). A taxonomic assessment of cisco specimens collected from Black Lake was completed to verify the presence or absence of shortjaw cisco (Paul Vecsei, Yellowknife, NT). The results of the assessment were inconclusive; specimens exhibited morphometric and meristic features characteristic of both shortjaw cisco and the common cisco. Deepwater sculpin and walleye were not captured in Black Lake or Middle Lake, respectively, during the 2010-2012 surveys. However, walleye captured at the Fond du Lac River outflow to Middle Lake are expected to be residents of Middle Lake that entered the outflow area to feed on drifting prey. Life history information and habitat requirements of large-bodied fish species captured from the LSA during 2010-2012 are summarized in Section 12.3.3.

None of the fish species identified during the 2010 to 2012 aquatic baseline surveys are considered endangered, threatened, or species of special concern under the *Saskatchewan Wildlife Act*, the federal *SARA*, or by COSEWIC (Government of Canada 2012a). However, fish exhibiting features characteristic of shortjaw cisco have been reported in the LSA (SPRR 1991). Shortjaw cisco are listed as a potentially threatened species under Schedule 2 of *SARA* and are identified as a threatened species by COSEWIC.

Table 12.3-1: Fish Species Identified in the Fond du Lac River, Black Lake, and Middle Lake, 2010 to 2012

Common Name	Scientific Name	Fond Du Lac River			Black Lake	Middle Lake
		Upstream Section	Mid-section	Downstream Section		
		Total No. Captured	Total No. Captured	Total No. Captured	Total No. Captured	Total No. Captured
Arctic grayling	*Thymallus arcticus*	1,545	433	612	46	7
Burbot	*Lota lota*	1	-	15	112	25
Cisco sp.[(a)]	*Coregonus artedii* *Coregonus zenithicus*	-	-	24	15	-
Lake chub	*Couesius plumbeus*	-	-	-	135	4
Lake trout	*Salvelinus namaycush*	-	-	-	519	-
Lake whitefish	*Coregonus clupeaformis*	-	1	18	305	32
Longnose dace	*Rhinichthys cataractae*	-	-	33	-	-
Longnose sucker	*Catostomus catostomus*	1	2	247	272	23
Ninespine stickleback	*Pungitius pungitius*	-	-	-	13	28

Table 12.3-1: Fish Species Identified in the Fond du Lac River, Black Lake, and Middle Lake, 2010 to 2012 (continued)

Common Name	Scientific Name	Fond Du Lac River			Black Lake	Middle Lake
		Upstream Section	Mid-section	Downstream Section		
		Total No. Captured	Total No. Captured	Total No. Captured	Total No. Captured	Total No. Captured
Northern pike	*Esox lucius*	-	-	10	44	49
Round whitefish	*Prosopium cylindraceum*	-	6	-	23	-
Slimy sculpin	*Cottus cognatus*	1	149	424	86	31
Spottail shiner	*Notropsis hudsonius*	-	-	12	6	-
Trout-perch	*Percopsis omiscomaycus*	-	-	1	7	-
Walleye	*Sander vitreus*	1	2	3	40	-
White sucker	*Catostomus commersonii*	46	1	168	375	50
Yellow perch	*Perca flavescens*	-	-	-	7	-
Total		**1,595**	**594**	**1,567**	**2,005**	**249**

[a] Cisco specimens collected from Black Lake had morphometric and meristic features characteristic of both shortjaw cisco (*Coregonus zenithicus*) and common cisco (*Coregonus artedi*).
No. = number; - = species was not captured at that location

The most abundant fish species captured from the Fond du Lac River and Black Lake during the 2010 to 2012 baseline surveys were Arctic grayling and lake trout, respectively (Annex III). White sucker and northern pike were the most abundant species captured from Middle Lake during baseline sampling. The high catch of Arctic grayling in the Fond du Lac River and lake trout in Black Lake was likely influenced by intensive sampling for these species during spawning surveys.

For Black Lake, the proportion of lake trout in the 2010-2012 catch (26 percent [%]) was higher than the value reported by Johnson (1971) for fisheries investigations conducted in 1969 (9%). In contrast, the relative abundance of lake whitefish captured from Black Lake was higher in 1969 (58%) than during the baseline surveys (%). The proportion of longnose sucker, northern pike, walleye, round whitefish (P*rosopium cylindraceum*), and burbot (*Lota lota*) captured from Black Lake during the baseline survey and historical surveys were generally similar. Abundance of northern pike and Arctic grayling in Middle Lake were also similar between baseline and historical survey results (i.e., Envirocon 1974), but were appreciably lower in 2010 for lake whitefish and longnose sucker. Burbot and white sucker were captured at higher densities during 2010 baseline sampling compared to the historical survey results.

Condition factors (*K*) were calculated for different life stages (i.e., young-of-the-year [YOY], juvenile, and adult) and species of fish captured from the LSA during the 2010-2012 baseline surveys (Annex III). Fish species captured from the Fond du Lac River generally had condition factors greater than or equal to (≥) 1.0, which would indicate the various life stages captured were in a good state-of-health. Condition factors were relatively low (i.e., *K* less than [<]1.0) for adult burbot captured from the upstream section of the river in 2010, for YOY and juvenile burbot captured in the downstream section during 2012, and for adult northern pike captured in the downstream section during summer 2010 and summer 2012 (Annex III). Condition factors for burbot and northern pike captured from Black Lake and Middle Lake during the baseline surveys were generally indicative of a less robust physical condition.

12.3.3 Life Histories and Habitat Requirements of Large-bodied Fish Species

12.3.3.1 Arctic Grayling

Arctic grayling are found in many of the larger, fast-flowing rivers of northern Saskatchewan (Scott and Crossman 1973). They can exhibit lacustrine, adfluvial and riverine life histories (Richardson et al. 2001). In Saskatchewan, their preferred habitat is clear, fast-flowing rivers.

The Fond du Lac River between Black Lake and Middle Lake contains high quality, year-round habitat for Arctic grayling, and populations in this section of the river have been studied by a number of investigators (Envirocon 1974; Annex III; Johnson 1971; Kratt 1977; Kratt and Smith 1977; Merkowsky 1989; Rawson 1950). Suitable over-wintering habitat is prevalent in the Fond du Lac River, because much of the channel remains ice-free during the winter months and there are numerous large pools that exceed 5 m in depth.

Male and female Arctic grayling have been noted to reach maturity at four years of age, but most spawners are between six and nine years of age (Bishop 1971; Scott and Crossman 1973). Arctic grayling spawn a number of times throughout their lives; however, spawning does not always occur every year. Most spawners over the age of nine years tend to be females and maximum ages for both sexes are between 11 to 12 years (Scott and Crossman 1973).

Spawning occurs shortly after ice break up; however, timing can vary from April to June depending on latitude (Scott and Crossman 1973). The Arctic grayling populations in the Fond du Lac River between Black Lake and Middle Lake typically begin spawning between the third week of May and mid-June when water temperatures consistently exceed 3 degrees Celsius (°C). Spawning often coincides with most of Black Lake becoming ice-free (Annex III).

During spring break up, adults of some Arctic grayling populations will begin their migration from lakes and larger rivers to smaller streams and tributaries with areas of small gravel or rocky substrates (Scott and Crossman 1973) to spawn. The Black Lake outflow to the Fond du Lac River contains extensive shallow water habitat that is used by spawning Arctic grayling. Arctic grayling also spawn in riffle habitat near the river outflow to Middle Lake and in similar habitats found throughout the Fond du River between Black Lake and Middle Lake (Annex III). Arctic grayling do not prepare a redd; however, males are territorial on the spawning grounds and will chase away other intruding males by displaying their large raised dorsal fin (Scott and Crossman 1973). Spawning can occur over several weeks in the spring.

In migratory Arctic grayling populations, post-spawning adults return to the lakes or rivers from which they migrated (Scott and Crossman 1973). The eggs hatch approximately 13 to 18 days post-spawn. The alevin require an additional eight days to completely absorb their egg sacs. Newly hatched fry display rapid growth (Scott and Crossman 1973). Lakes can provide important rearing habitat for YOY Arctic grayling. Lakes tend to have higher summer water temperatures than sub-basins with few or no lakes and these higher water temperatures can contribute to increased growth rates in YOY Arctic grayling (Luecke and MacKinnon 2008). In the Fond du Lac River, YOY Arctic grayling were captured in the summer months in slow-flowing, shallow water habitat near the spawning areas (Annex III).

Young Arctic grayling feed primarily on zooplankton, shifting to immature insects as they grow in size. Adult grayling are primarily planktivorous (Schmidt and O'Brien 1982), although they will feed on a large assortment of invertebrates, including aquatic and terrestrial insects (Scott and Crossman 1973). The insects consumed include caddisflies, midges, bees, wasps, grasshoppers, ants, and a variety of beetles. They also will feed on small fishes, eggs, and crustaceans (Scott and Crossman 1973).

12.3.3.2 Burbot

Burbot occur in deep-water lakes and large, cool rivers throughout Saskatchewan (Scott and Crossman 1973). In northern Saskatchewan, burbot can be found in turbid rivers that rarely exceed 18°C in summer (McPhail 1997). Burbot using northern riverine habitats are associated with turbid waters in main channels, but enter tributaries in fall (Breeser et al. 1988). They prefer areas of moderate to high turbidity, low velocities (less than or equal to [≤] 0.46 metres per second [m/s]), and shallow depths (≤ 0.76 m) (Suchanek et al. 1984). The turbidity of the water is used as cover (Ford et al. 1995). Because of their body shape, adult burbot struggle to maintain position in current velocities greater than (>) 0.25 m/s (McPhail and Paragamian 2000). Adult burbot tend to avoid shallow water sandbars and side channels except during high water conditions (Ford et al. 1995). In the Qu'Appelle River in southern Saskatchewan, adult burbot are found over rocky substrates in non-vegetated areas (Saskatchewan Environment and Resource Management [SERM] – unpublished data 2001).

Burbot grow rapidly during the first four years and usually reach sexual maturity at three to four years of age (Scott and Crossman 1973). In Canada, spawning occurs in winter, usually between January and March, when the water temperature is between 1 and 4°C (Nelson and Paetz 1992; Scott and Crossman 1973). River spawning typically occurs in shallow (<2 m) quiet-water areas behind depositional bars and over fine gravel, sand, or silt (McPhail 1997). In areas with higher water velocities, the eggs can be transported and deposited in silty substrates, which often causes eggs to suffocate (Sorokin 1971). After fertilization, the eggs settle into interstices of the substrate (Ford et al. 1995; Scott and Crossman 1973). The eggs incubate from three weeks to three months, depending on water temperature (Goodyear et al. 1982; Scott and Crossman 1973). Upon hatching, sac-fry are found primarily over sand and rubble substrates in quiet-water areas and deep pools (McPhail 1997; Ford et al. 1995). Burbot are sensitive to sub-surface illumination and will seek shelter under stones, roots, and in aquatic vegetation during the day (McPhail and Lindsey 1970). Young-of-the-year burbot are known to seek shelter under debris, undercut banks, and woody debris (Girsa 1972). In the Fond du Lac River, a large number of juvenile burbot were captured in the cobble substrate of a shallow channel between the shore and an island (Annex III).

Burbot become more active at night and feed predominantly during this time. Young burbot will feed on aquatic insects, crayfish, molluscs, and invertebrates. Juvenile burbot are known to forage on benthic invertebrates in shallow regions of rivers and streams (Hartmann 1977). Adults feed on eggs, invertebrates, and numerous species of fish (Scott and Crossman 1973).

12.3.3.3 Cisco (*Coregonus sp.*)

Common cisco (also known as lake herring) have the most extensive North American distribution of any cisco species and are found throughout much of Canada (Scott and Crossman 1973). Common and shortjaw cisco are predominantly lacustrine, but can occur in larger rivers. However, rivers generally do not provide suitable habitat for these cisco species. Common cisco primarily inhabit the pelagic zone of lakes but move below the thermocline in the summer and into shallow waters as the water temperature cools in fall (Scott and Crossman 1973). Shortjaw cisco prefer deeper lakes but move into shallow areas to spawn (Department of

Fisheries and Oceans Canada [DFO] 2013). They are generally found at deeper depths than common cisco where these species occur together (Stewart and Watkinson 2004). In the Qu'Appelle drainage system of southern Saskatchewan, adult common cisco are found in emergent vegetation over silty substrate during spring and in non-vegetated sand and rock areas during fall (SERM – Unpublished data 2001). Low numbers of juvenile and fry cisco were captured in a small side channel near the Fond du Lac River outflow to Middle Lake (Annex III). The cisco were captured in emergent macrophytes over a cobble and boulder substrate.

Common cisco mature at three years of age and begin spawning in the fall when water temperatures drop to between 2 and 5°C (Nelson and Paetz 1992). During the spawn, large numbers of fish gather in shallow water (one to three m deep) to deposit their eggs over gravel or stony substrates (Nelson and Paetz, 1992; Scott and Crossman 1973). Due to low winter temperatures, eggs do not hatch until breakup of surface ice in spring (Scott and Crossman 1973). In the Qu'Appelle system, juvenile common cisco are found in habitats containing sparse vegetation and rocky substrates (SERM – Unpublished data 2001).

Shortjaw cisco are generally fall spawners; however, spring spawning has been reported for Lake Superior populations (Todd 2003). Fall spawning usually occurs between September and December, depending on location (Steinhilber 2002). Eggs are broadcast over clay or other substrates and are left unattended until they hatch in spring (Steinhilber 2002; DFO 2013). Maturity is reached at two to six years of age (DFO 2013).

The diet of common cisco is comprised of a variety of food items. Once hatched, fry begin feeding on dead zooplankton, algae, and copepods (Scott and Crossman 1973). Young cisco feed on algae, copepods, and cladocerans (Pritchard 1930). As adults, common cisco feed on copepods, small minnows, crustaceans, aquatic insects (mayflies and caddisflies), water mites, zooplankton, their own eggs, and eggs of other fish species (Scott and Crossman 1973).

Shortjaw cisco are opportunistic particulate feeders (Todd 2003). They have been known to feed on copepods, cladocerans, and the larvae of benthic invertebrates (DFO 2013). Cisco are a primary part of the diet of many other fishes. Common cisco are a preferred food source for lake trout (Scott and Crossman 1973); shortjaw cisco are a common prey item for burbot (DFO 2013).

12.3.3.4 Lake Whitefish

Lake whitefish are found throughout much of Saskatchewan (McPhail and Lindsey 1970; Scott and Crossman 1973). They are most commonly found in lakes, although they can be found in larger rivers and brackish waters. They can exhibit lacustrine, adfluvial, or anadromous life histories (Richardson et al. 2001). Lacustrine populations occur in two differing forms, normal and dwarf; however, differential habitat use by the two forms has not been documented and it has been assumed they exhibit similar habitat preferences (Richardson et al. 2001). During the 2010 and 2012 aquatic baseline data collection programs, lake whitefish were captured in Black Lake, the Fond du Lac River, and Middle Lake (Annex III). In the Fond du Lac River, lake whitefish were captured in deep pools and in shallow, slow-flowing back-water habitats.

In northern populations of lake whitefish, individuals might only spawn every two or three years (Scott and Crossman 1973). Lake whitefish could spawn from late summer to December; however, spawning usually occurs from mid-September to mid-October in northern regions (Richardson et al. 2001). They may spawn in lake or river systems and over a variety of substrates from large boulders to gravel and occasionally sand (Richardson et al. 2001). Although lake whitefish appear to avoid using soft bottomed substrates for spawning, spawning in areas with silt substrates or emergent vegetation has been documented (Richardson et al. 2001).

Spawning usually takes place in shallow water areas at depths less than 8 m, but deeper spawning has been reported (Scott and Crossman 1973). Eggs are released over the hard or stony substrate (Scott and Crossman 1973) and settle into crevices where they incubate for several months before hatching in approximately March to May (Richardson et al. 2001).

Juvenile lake whitefish are commonly found near the surface in shallow water close to spawning areas. Within these shallow water zones, young lake whitefish are frequently associated with boulder, cobble, or sand substrates, as well as emergent vegetation and woody debris (Ford et al. 1995).

Adult lake whitefish tend to leave the spawning grounds shortly after spawning, and return immediately to deepwater habitat to over winter (Ford et al. 1995). They are often found at depths >10 m for most of the year and can occur at depths in excess of 100 m (McPhail and Lindsey 1970). Despite being primarily bottom dwelling, they may be occasionally found in the pelagic zone of lakes (Ford et al. 1995).

Lake whitefish are known to move into shallow water habitats at night to feed (McPhail and Lindsey 1970). The diet of lake whitefish includes snails, clams, terrestrial insects, aquatic insects, plankton, and small fish (Scott and Crossman 1973). The types of food consumed by lake whitefish are associated with the number and length of gill rakers. Fish with shorter and more plentiful rakers have been shown to eat a higher proportion of benthic food sources (Scott and Crossman 1973).

Lake whitefish are preyed upon by lake trout and burbot in both the juvenile and adult life-stages (Scott and Crossman 1973). They are one of the most valuable commercial freshwater fish species in Canada (Scott and Crossman 1973).

12.3.3.5 Longnose Sucker

The longnose sucker occurs throughout Saskatchewan and is found in a variety of freshwater habitats including lakes, rivers, and streams. Longnose sucker can exhibit lacustrine, adfluvial, and riverine life history types (Richardson et al. 2001).

Sexual maturity occurs at approximately five years of age for males and six years for females (Richardson et al. 2001). Longnose suckers spawn in the spring (April to June), shortly after the ice cover on lakes has melted (Richardson et al. 2001). Longnose sucker spawn primarily in streams and rivers, and are broadcast spawners. Small schools of longnose sucker were observed in riffle habitat with cobble substrate in the Fond du Lac River between Black Lake and Middle Lake in May 2010 (Annex III). However, no active spawning was observed; water temperatures (3°C) were less than temperatures generally required for spawning (5°C) (Stewart and Watkinson 2004).

Lake spawning can occur along shallow, rocky, wind-swept shorelines. Spawning usually occurs in water depths of 15 to 30 centimetres (cm) over gravel or sand substrates (Richardson et al. 2001). Eggs are adhesive and require 11 to 15 days of incubation before hatching (Richardson et al. 2001). Young remain in the gravel substrate for 7 to 14 days before emerging, depending upon water temperature. Young will then occupy shallow areas of lakes that contain vegetation and sandy substrates. Juveniles are known to inhabit shallow weedy areas (Richardson et al. 2001). Young-of-the-year longnose sucker were collected from riffle habitat at different locations in the Fond du Lac River between Black Lake and Middle Lake during 2010 baseline surveys (Annex III). During the same time, juvenile longnose sucker where found along shorelines in Black Lake where large cobble and boulder substrates were prevalent. Adult longnose sucker often inhabit deeper waters than other sucker species, and have been known to occur at water depths of up to 183 m (Richardson et al. 2001). In

Black Lake, longnose sucker were collected near the potential water intake locations at depths approaching 30 m during summer and winter sampling programs (Annex III).

The diet of longnose sucker consists mostly of amphipods, chironomids and other midge larvae, caddisfly larvae, and sphaeriid clams (Richardson et al. 2001). Their ventral mouth and large papillose lips aid in suction as they feed on invertebrates from stream and lake beds (Mecklenburg et al. 2002).

12.3.3.6 Northern Pike

Northern pike occur throughout Saskatchewan and are found in freshwater lakes and rivers. During the 2010-2012 baseline surveys, northern pike were captured from Black Lake, the furthest downstream section of the Fond du Lac River, and Middle Lake (Annex III).

Spawning occurs in spring, usually in April to early May, after the ice-cover has melted and water temperatures have reached approximately 4.4 to 11.1°C (Scott and Crossman 1973). Northern pike may ascend tributaries to spawn, and typically seek out flooded marshes or shallow areas that contain abundant aquatic or terrestrial vegetation (Inskip 1982). Each female is generally accompanied by one or two males. Females broadcast their adhesive eggs over the vegetation; eggs are fertilized as they are released from the female (Scott and Crossman 1973; Stewart and Watkinson 2004). The eggs sink and stick to vegetation or the substrate. Hatching occurs approximately two weeks later (Billard 1996). After emerging, the young attach themselves to nearby vegetation and remain relatively inactive for 6 to 10 days, until the yolk sac is absorbed (Harvey 2009; Scott and Crossman 1973).

Northern pike are most commonly found in near-shore areas of lakes and slow-moving rivers that are relatively shallow (<4 m) and contain vegetative cover (Harvey 2009). Where pike are found in rivers, they are likely to seek out areas with low velocities, such as side channels, back waters, or sloughs. In summer, their habitat may be limited by high surface temperatures, as well as inadequate oxygen concentrations in the cooler, deeper water (Inskip 1982).

Young-of-the-year northern pike start out on a diet of zooplankton. As they grow larger, they rely more heavily on aquatic insects and small fish (Scott and Crossman 1973). Adult northern pike are opportunistic predators; they typically hide within aquatic vegetation and ambush potential prey (Harvey 2009). Northern pike are primarily piscivorous, but have been known to consume a variety of prey, including crayfish, frogs, aquatic mammals, and birds (Stewart and Watkinson 2004).

Eggs and young northern pike may be eaten by other predatory fishes, birds, and mammals. Northern pike are a popular species among recreational anglers.

12.3.3.7 Round Whitefish

Round whitefish populations can be fluvial, adfluvial, or anadromous. In Saskatchewan, round whitefish occur in large northern rivers and lakes. In the LSA, round whitefish were captured in Black Lake near the Fond du Lac River outflow, and in middle reaches of the Fond du Lac River between Black Lake and Middle Lake (Annex III).

Round whitefish spawning occurs from fall to early winter, when water temperatures cool to <2.5°C. Gravel and cobble-sized rubble substrates are preferred for spawning (Normandeau 1969; Richardson et al. 2001). Males usually arrive on the spawning grounds first. Once the females arrive, the fish will form pairs, rather than large spawning schools (Scott and Crossman 1973). Round whitefish broadcast their eggs over the substrate, in 15 to 200 cm of water (Normandeau 1969). Hatching time will vary depending upon water temperatures, but generally occurs between March and May (Goodyear et al. 1982). After emerging from the eggs, the young are generally found near the bottom and are associated with rock, sand, and gravel substrates (Goodyear et al. 1982).

Adult round whitefish tend to be found over rocky substrates and often in association with boulders (McPhail and Lindsey 1970). They are commonly found in shallow areas of lakes or slow-flowing rivers and streams and in brackish waters (McPhail and Lindsey 1970; Scott and Crossman 1973). Small numbers (n=6) of round whitefish in the Fond du Lac River between Black Lake and Middle Lake were captured in deep pools during the 2010 and 2012 summer surveys (Annex III).

The diet of round whitefish consists of a variety of benthic invertebrates, primarily mayfly, caddisfly, and chironomid larvae, as well as small crustaceans, fishes, and molluscs (Scott and Crossman 1973). Round whitefish are suspected to feed on the eggs of other fish species (Scott and Crossman 1973). They are known to be a small component of the diet of lake trout in northern environments (Scott and Crossman 1973).

12.3.3.8 Slimy Sculpin

Slimy sculpin (*Cottus cognatus*) are found throughout northern Saskatchewan (Scott and Crossman 1973). They exhibit both lacustrine and riverine life-histories and can be found in deep lakes, cool-water rivers, and rocky or gravely streams (Craig and Wells 1976; Lee et al. 1980; McPhail and Lindsey 1970; Scott and Crossman 1973). Slimy sculpin are usually associated with coarser substrates that provide in-situ cover (Nelson and Paetz 1992). During the 2010 and 2012 aquatic baseline data collection programs, slimy sculpin were captured in Black Lake, the Fond du Lac River, and Middle Lake (Annex III). In the Fond du Lac River, slimy sculpin were captured in large numbers in shallow water areas dominated by cobble substrate.

Slimy sculpin mature at approximately three years of age and spawn in May, usually over sand, gravel, and rock substrates in shallow water areas when water temperatures reach 5 to 10°C (Scott and Crossman 1973). Males select a spawning site under a rock or submerged root, one or more females deposit their adhesive eggs to the ceiling and the male then fertilizes the eggs. The male guards the eggs for approximately four weeks until they hatch (Goodyear et al. 1982; Lee et al. 1980; Scott and Crossman 1973). After emerging, the fry are found over shallow gravel and sand substrates; as they mature they move to deeper waters (Mohr 1984; Mohr 1985).

Adult slimy sculpin feed on a variety of benthic invertebrates, small fishes, and some plant materials (McPhail and Lindsey 1970; Mohr 1984; Scott and Crossman 1973). Slimy sculpin are eaten by a variety of predaceous fishes including burbot, lake trout, and northern pike (Scott and Crossman 1973).

12.3.3.9 Walleye

Walleye occur in rivers and lakes throughout Saskatchewan. They can be found in large lakes and rivers where the depth or turbidity of the water provides cover from bright sunlight (Scott and Crossman 1973). In rivers, walleye move into deep, still pools that are up to 3.5 m deep or into shallow current breaks and regions with slight currents over gravel, cobble, and boulder substrates (Colby et al. 1979; McPhail 2007; Paragamian 1989; Scott and Crossman 1973). In the Fond du Lac River, adult walleye were found in deep pools over boulder substrates (Annex III). In Black Lake, walleye were found along a deep drop-off near the proposed water intake location.

Male walleye reach maturity at two to four years and females at three to six years of age (Scott and Crossman 1973). Spawning occurs in the early spring, shortly after ice breaks up, when water temperatures reach 6.7 to 8.9°C (Scott and Crossman 1973). Northern populations may not spawn every year if water temperatures are not favourable (Scott and Crossman 1973). Spawning in rivers occurs at night in rocky areas below rapids and impassable falls (Scott and Crossman 1973). Eggs fall into crevices of the substrate where they remain for 12 to 18 days before hatching (Scott and Crossman 1973). Once hatched, the fry remain in the low flow areas for 10 to 15 days until they disperse, become pelagic, and begin feeding in the limnetic zone (Pratt and Fox 2001). In late summer, YOY move toward the bottom and are found in about 3 to 9 m of water, where they forage on invertebrates (Scott and Crossman 1973).

Walleye are known to feed throughout the day in turbid waters but in clear water feeding is restricted to twilight or dark (Scott and Crossman 1973). Walleye feed primarily on forage fishes and juvenile large-bodied fishes, but have been known to feed on mayflies, chironomids, crayfish, frogs, and snails (Scott and Crossman 1973).

Juvenile walleye are preyed upon by a variety of predatory fish, including adult walleye (Scott and Crossman 1973). Walleye are considered the most valuable and sought-after fish species in Canada's inland waters (Scott and Crossman 1973).

12.3.3.10 White Sucker

White sucker are found in lakes, streams, and rivers throughout Saskatchewan (Scott and Crossman 1973). White sucker are commonly found along the bottom in deep pools or rivers, and in deep-water areas of lakes (Durbin and Fernet 1979; Bradbury et al. 1999). In lakes, white sucker are often associated with rubble, sand, silt-clay, and detritus substrates (SERM – Unpublished data 2001). During the 2010 and 2012 aquatic baseline data collection programs, white sucker were captured in Black Lake, the Fond du Lac River, and Middle Lake (Annex III). In the Fond du Lac River, adult white sucker were captured in deep pools and in a shallow riffle near the outflow to Middle Lake. Juvenile and fry white sucker were found in shallow water areas of the river.

White sucker mature at five to six years of age and spawn in mid-May to early July when water temperatures reach approximately 10°C (Nelson and Paetz 1992). Prior to spawning, fish usually move from lakes into streams. Spawning takes place over gravel in shallow sections of streams (<1 m deep) (Scott and Crossman 1973). In riverine systems, spawning occurs most often in shallow gravel areas, although it has also been documented in fast-flowing rapid areas with velocities >0.6 m/s (Schneberger 1972; Symons 1976). Eggs are released into the water where they either adhere to the substrate or drift downstream (Bradbury et al. 1999). Eggs hatch after approximately two weeks (Scott and Crossman 1973) and after four weeks fry begin moving out of the small streams back into the lakes (Bradbury et al. 1999). In the Fond du Lac River, fry were observed congregating in areas with lower water velocities, such as pools, eddies, and backwaters (Annex III).

White sucker fry have a terminal mouth that allows them to feed on plankton and other small invertebrates near the surface. As fry mature, their mouths become more ventrally located and their diets subsequently become more dependent on benthic invertebrates (Scott and Crossman 1973). Feeding occurs throughout the day, but peaks during sunrise and sunset when white sucker move into shallow water areas of the lakes to forage (Scott and Crossman 1973). White sucker are a very valuable food source for many predatory fish species including northern pike, walleye, and burbot (Scott and Crossman 1973).

12.3.3.11 Yellow Perch

Yellow perch occur in every major river drainage in Saskatchewan (Atton and Merkowsky 1983). They inhabit a wide variety of habitats from large lakes to slow rivers and small ponds (Nelson and Paetz 1992). Yellow perch are a shallow water species (<10.5 m) that prefers warmer water temperatures between 21°C and 24°C (Scott and Crossman 1973). Yellow perch are commonly found in schools over gravel, clay, sand, and silt substrates;

they are less common over rubble, boulder, and cobble substrates (Lane et al. 1996; SERM – Unpublished data 2001). No yellow perch were captured from the Fond du Lac River during 2010-2012; however, several juvenile perch were captured in Black Lake, which would suggest this species is potentially present in the river (i.e., as a result of downstream drift; Annex III).

Spawning usually occurs in the spring, along shorelines of lakes and in tributary rivers when water temperatures are between 6.7°C and 12.2°C (Scott and Crossman 1973). Spawning occurs most commonly at night or early morning over submerged vegetation, fallen woody debris, and occasionally over sand or gravel (Scott and Crossman 1973). Eggs are laid in large masses that adhere to the vegetation or substrate and undulate with the water current (Scott and Crossman 1973; SERM – Unpublished data 2001). Incubation lasts eight to ten days on average. After hatching, the juvenile perch remain in areas <5 m deep throughout the spring and into summer. In summer, they form schools of 50 to 200 fish (Scott and Crossman 1973).

Yellow perch feed on a variety of food items including insects, invertebrates, and the eggs and young of a variety of fish species. Feeding occurs throughout the day and into the early evening, but does not occur during the night (Scott and Crossman 1973). Adult and juvenile perch are a food source for a variety of predatory fishes, including northern pike and lake trout (Scott and Crossman 1973).

12.3.4 Spawning Surveys

12.3.4.1 Arctic Grayling

Arctic grayling spawning surveys of the Fond du Lac River were undertaken in the spring of 2010 and 2012. Three key sampling areas (i.e., outflow of Black Lake, middle section upstream of Elizabeth Falls, and upstream of Middle Lake) were investigated.

Arctic grayling captured from each of the key Fond du Lac River sampling areas were predominantly ripe (i.e., sexually mature adults in spawning condition). A smaller relative proportion of fish were in pre-spawning condition and a small number of individuals were spent (i.e., in "post-spawning" condition). Catch data and sexual maturity of Arctic grayling captured from the Fond du Lac River during the 2010 and 2012 spawning surveys are summarized in Table 12.3-2.

Table 12.3-2: Numbers and Sexual Maturity of Arctic Grayling (*Thymallus arcticus*) Captured from the Fond du Lac River during Spring 2010 and Spring 2012 Spawning Surveys

Sample Location	Black Lake Outlet		Middle Section	Upstream of Middle Lake	
Year	**2010**	**2012**	**2012**	**2010**	**2012**
Total No. Captured	436	369	307	331	16
Total No. Examined	254	62	258	241	16
Total No. of Ripe Fish	151	50	241	137	11
% Ripe Fish	59	81	93	57	69
Total No. of Pre-Spawn Fish	86	12	16	103	4
% Pre-Spawn Fish	34	19	6	43	25
Total No. of Spent Fish	16	0	1	0	1
% Spent Fish	6	0	<1	0	6

No. = number; % = percent; < = less than.

Egg searches conducted within the Fond du Lac River during spring 2010 and spring 2012 indicate that Arctic grayling spawn in all sections of the river (i.e., upstream, mid, and downstream) (Annex III). In the upstream section, eggs were found primarily in areas where pebble, cobble, and gravel were the dominant substrates. Eggs were not generally recovered from areas with predominantly sandy substrates and low water velocities (e.g., <0.08 m/s). Egg searches conducted in the middle (2012 only) and downstream sections of the Fond du Lac River produced similar results. Eggs were found at sampling sites that were dominated by cobble, pebble, and boulder substrates and had moderate flow velocities (i.e., averaging between 0.22 and 0.74 m/s).

12.3.4.2 Lake Trout

A lake trout spawning survey for Black Lake was completed in the fall of 2010. Most of the captured male (95%) and female (97%) lake trout that were examined for sexual maturity were in spawning condition (i.e., ripe). Spawning lake trout were captured on rocky shoals or in littoral areas associated with islands in the main basin of Black Lake. Traditional knowledge from BLFN residents suggests the southwest section of Black Lake contains limited spawning habitat for lake trout.

12.3.4.3 Lake Whitefish

A spawning survey for lake whitefish was also conducted in Black Lake during the fall of 2010 (Annex III). Sixty percent of the male lake whitefish that were captured and assessed for sexual maturity were ripe; the remainder were classified as being in a state of rest (i.e., adults that have spawned in previous years, but likely will not spawn in the coming spawning season), pre-spawning, or seasonal development (i.e., period of gamete formation). Of the female lake whitefish captured from Black Lake during the 2010 survey, 10% were identified as being ripe and 43% were considered pre-spawning; the remainder (47%) were classified as resting (Annex III).

Lake whitefish assessed as part of the 2010 baseline spawning survey in Black Lake were generally captured in deeper water near the entrance to the Black Lake outflow bay. Fish were not usually captured along shoals.

12.3.4.4 Burbot

A spawning survey for burbot was conducted in Black Lake during winter 2011 (Annex III). Catch numbers for burbot were low (i.e., n=30) relative to other species assessed during spawning surveys. Captured burbot were in variable conditions of sexual maturity. Most male burbot were in pre-spawning (45%) or ripe (36%) condition; the remainder were not in reproductive condition and were classified as resting. Female burbot captured were in pre-spawning condition (67%) or resting (33%).

Spawning locations of burbot in Black Lake could not be determined from the 2011 survey.

12.3.5 Fish Population Estimates

Population estimates for Arctic grayling in the Fond du Lac River were first made in 1974 (Envirocon), in 1989 (Merkowsky), and 2010 (Annex III). For each study, population sizes were estimated for the upstream and downstream areas of the Fond du Lac River based on the presence of Elizabeth Falls as a likely barrier to upstream fish passage.

The 2010 Fond du Lac River Arctic grayling population estimates for the Grayling Island area near the outlet of Black Lake (upstream of Elizabeth Falls) and the section of Fond du Lac River just upstream of Middle Lake (downstream of Elizabeth Falls) compare favourably with population estimates from the two previous studies at these locations (Table 12.3-3). Based on a comparison of the 2010 results with those from the 1989 and 1974 reports, there is no indication that Arctic grayling populations in the Fond du Lac River are in decline.

Table 12.3-3: Arctic Grayling (*Thymallus arcticus*) Population Estimates for the Fond du Lac River

Mark-Recapture Study (year)	Grayling Island Area			Upstream of Middle Lake		
	Population Estimate	High Estimate[(a)]	Low Estimate[(a)]	Population Estimate	High Estimate[(a)]	Low Estimate[(a)]
Envirocon (1974)	7,776	9,292	6,260	5,269	6,509	4,029
Merkowsky (1989)	5,024	50,240	897	3,844	12,012	1,643
Golder (Annex III) - Petersen Method[(b)]	9,067	14,498	3,635	4,558	9,951	-833.8
Golder (Annex III) - Chapman Method[(c)]	9,090	13,671	4,509	4,575	8,097	1,053

[(a)] High and low population estimates (confidence intervals) were determined such that the actual population size will fall between these values 19 times out of 20 (P=0.95).
[(b)] The Petersen method is a simple, commonly used method for calculating fish population size (Everhart and Youngs 1981).
[(c)] The Chapman method is a simple, commonly used method for calculating fish population size, and is recommended for use by the American Fisheries Society (AFS) (Hayes et al. 2007).

12.3.6 Fish Movement Studies

The fisheries baseline investigations completed from 2010 to 2012 included surveys during which fish were tagged or examined for previous tags so that the extent of movement of large-bodied fish species within the LSA could be determined. A radio-telemetry study was carried out in the Fond du Lac River to gather detailed information on Arctic grayling movement patterns in the river and to document Arctic grayling use of the river for adult holding, feeding, and overwintering activities. Results of the radio-telemetry study were used to evaluate the importance of potential barriers to fish movement (i.e., Elizabeth Falls and other high velocity flow areas) in structuring the distribution of Arctic grayling populations in the river. Arctic grayling were captured, radio-tagged, and released in October 2011. Locations of tagged fish were obtained using mobile ground surveys, aerial surveys, and fixed-receiver antennas.

Results of the tagging and radio telemetry surveys indicate that Arctic grayling in the Fond du Lac River make only small localized movements within the river. In general, the data suggest that Arctic grayling that use the Black Lake outlet and outflow to Middle Lake areas of the Fond du Lac River for spawning in spring usually remain at these locations throughout summer and fall (Annex III). Recapture data were not available for winter months; however, radio-telemetry results suggest that during winter, Arctic grayling seek out deeper pool habitats near their respective spawning areas (e.g., fish tagged near Grayling Island may move towards deeper habitats at the Black Lake outlet).

12.4 Screening of Project Interactions and Mitigation

This section identifies and evaluates the interactions between Project components or activities, and the corresponding potential environmental effects on the maintenance of self-sustaining fish populations, including listed species (i.e., the assessment endpoint). The process begins with the identification of all potential interactions (or linkages) for the Project. To provide a robust assessment of potential effects, each interaction is initially considered to have a linkage to a change in the aquatic environment and associated potential effect on fish and fish habitat.

Each potential interaction is evaluated to determine if mitigation can be developed and incorporated to remove the interaction or limit the potential effects on fish and fish habitat. Mitigation includes Project design elements, environmental best practices, and management policies and procedures, and is developed through an iterative process between the Project's engineering and environmental teams. Knowledge of the aquatic environment and mitigation is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for a residual effect on fish and fish habitat.

Interactions are determined to be primary, secondary, or as having no linkage using scientific knowledge, professional judgment of technical specialists, experience with similar developments, and mitigation (Table 12.4-1). Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by environmental design features and mitigation so that the Project results in no detectable (measurable) change and no residual effects on fish and fish habitat relative to baseline or guideline values;
- secondary – interaction could result in a minor change, but would have a negligible residual effect on fish and fish habitat relative to baseline or guideline values and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary – interaction is likely to result in a measurable change that could contribute to significant residual effects on fish and fish habitat relative to baseline or guideline values.

Primary interactions are anticipated to result in a residual effect on the maintenance of self-sustaining fish populations (including listed species) and require further analysis to determine the significance of the residual effect. Interactions with no linkage to a change or changes that are considered minor (secondary) will not be analyzed further or classified in the EIS because mitigation and environmental design features will remove the interaction (no linkage) or because residual effects can be determined to be negligible through a simple qualitative or quantitative evaluation. Project interactions determined to have no linkage or those that are considered secondary are not predicted to result in significant effects on the maintenance of self-sustaining fish populations.

Project components and activities, and the associated mitigation implemented during the various Project phases, including accidents, malfunctions, and unplanned events are summarized for fish and fish habitat in Table 12.4-1. Potential effects on fish and fish habitat from each Project interaction and its associated classification are summarized in Table 12.4-1, with more detailed descriptions provided in the subsequent sections.

Table 12.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Fish and Fish Habitat

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Fish and Fish Habitat	Environmental Design Features and Mitigation	Interaction Classification
■ Infrastructure footprints ▪ temporary infrastructure – construction camp – overburden disposal areas – construction area and materials laydown area ▪ operational infrastructure – power generation station – water intake structure – power tunnel – tailrace channel – submerged weir – bridge – transmission line – waste rock disposal areas – water diversion structures around the Project footprint – potable water and wastewater intake and discharge structures – site access roads (including source material)	Construction Operations Closure	Site clearing, contouring, and excavation can cause soil erosion, which can change surface water and sediment quality, and affect fish habitat.	■ A site-specific assessment will be completed prior to soil salvage to identify surficial stripping depths and develop a site-specific soil salvage plan. ■ An Erosion and Sediment Control Plan will be developed based on industry standard Best Management Practices (BMPs) and federal and provincial regulatory requirements. Site clearing during construction of the Project infrastructure (e.g., roads, laydown areas) and salvage of soil materials will be completed during dry or frozen conditions, where and when practical. ■ Site drainage and surface runoff will be managed through the incorporation of erosion control methods (e.g., ditch blocks, silt fences) so that overland flow does not direct sediment-laden water into any natural watercourses. ■ Culverts will be incorporated into the design where necessary to maintain local drainage patterns. ■ Salvaged topsoil will be stored on-site and away from surface waterbodies. ■ Disturbed areas (e.g., access roads and banks) will be graded to a stable angle after work is completed, reclaimed and revegetated. ■ Erosion control practices will be applied to salvaged topsoil to reduce potential erosion and sediment transport off-site.	No Linkage
	Construction	Dewatering of the power tunnel during construction could change groundwater quantity, which can alter hydrology, and affect fish habitat.	■ Not applicable	Secondary
■ Site Access	Construction Operations Closure	Increased access to the site and areas on the east side of the Fond du Lac River can affect fish habitat and fish populations.	■ A shuttle will be used to transfer incoming and outgoing workers between Stony Rapids and Black Lake to the site to reduce the use of personal vehicles. ■ A “no hunting, trapping, harvesting, or fishing policy” will be developed and enforced for Project employees. The no fishing policy will be developed in consultation with Black Lake First Nation. ■ All public access to the construction, laydown, and camp areas will be restricted to the public until Project construction is completed. ■ An Access Management Plan will be developed for the construction camp and worksite. ■ The use of recreational all-terrain vehicles will be prohibited at the site.	No Linkage

Table 12.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Fish and Fish Habitat (continued)

Project Component/Activity	Expected Project Phase	Potential Interactions to Fish and Fish Habitat	Environmental Design Features and Mitigation	Interaction Classification
■ Construction of In-water works ▪ water intake structure ▪ tailrace channel outlet ▪ submerged weir ▪ bridge	Construction	Construction of the water intake structure, submerged weir, tailrace channel outlet, and bridge abutments may disturb sediment, which can change surface water quality and affect fish and fish habitat.	■ In-water works will be completed in accordance with conditions outlined in the DFO authorization. ■ DFO In-Water Construction Timing Windows will be followed during the Project. ■ An environmental monitor will be on site during in-water work to monitor that compliance with the construction specifications and a Project approval is achieved. ■ Cofferdams or turbidity curtains will be used to contain sediment released during in-water construction. ■ In-water work will be isolated from flowing water and adjacent lake or river habitats to reduce downstream or offsite effects. ■ A Sediment and Erosion Control Plan will be developed. ■ Any materials used for shoreline stabilization will be clean and free of fine sediments and contaminants. ■ A turbidity/total suspended solids (TSS) regression will be developed and a Turbidity Monitoring Program will be implemented. ■ Dewatering operations will be directed to settling ponds prior to discharge to watercourses. ■ Water will be discharged to watercourses in a manner that does not cause erosion or other damage to adjacent areas. ■ No in-water construction activities will begin until fish salvage activities for the associated in-water work area are complete. ■ Construction of the water intake will comply with conditions outlined in the Aquatic Habitat Protection Permit.	Secondary
	Construction	Direct loss or alteration of fish habitat from the Project footprint or activities can affect fish.	■ Permanent alteration or destruction of fish habitat will be offset by restoration of shoreline and fish habitat; details will be included in a Fisheries Offsetting Plan. ■ Compact layout of the surface facilities within local watersheds will limit the area that is disturbed by construction and operation. ■ Best management practices for erosion and sedimentation (e.g., ground cover, silt fences and curtains) will be implemented, where needed. ■ A submerged weir at the outlet of Black Lake will be used to maintain water levels in the lake and subsequently reduce effects of fluctuating water levels on fish habitat in Black Lake. ■ The water intake will be located to avoid sensitive fish habitat in Black Lake.	Primary
	Construction	Fish salvage from exclusion zones may result in incidental mortality of fish.	■ Fish will be relocated from work isolation areas to adjacent sections of the Fond du Lac River, or outside the work location if in Black Lake. ■ The fish salvage will be completed by qualified biologists. ■ Handling time will be kept to a minimum as per Saskatchewan Ministry of Environment (MOE) recommendations in the fishing permit; only a small number of captured fish will be measured for length and weight in order to decrease handling times and improve survival. ■ Appropriate non-lethal sampling methods (e.g., fyke traps, minnow traps and beach seines) will be used, in addition to short-duration small-mesh gillnet sets.	Secondary
	Construction Operations	Installation of the submerged weir in the Fond du Lac River may block or delay movements of migratory fish species, which can affect fish populations.	■ The submerged weir will be designed with a triangular cross section with a 5H:1V slope on the upstream face and a 20H:1V slope on the downstream face that will allow for safe fish passage. The weir will slope to a v-notch in the centre to concentrate flows during low flow periods and facilitate fish passage under those conditions. ■ Flow velocities at the submerged weir will not exceed swimming thresholds of fish species identified as VCs.	No Linkage

Table 12.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Fish and Fish Habitat (continued)

Project Component/Activity	Expected Project Phase	Potential Interactions to Fish and Fish Habitat	Environmental Design Features and Mitigation	Interaction Classification
■ Blasting Activities	Construction	Use of explosives near fish-bearing water can cause injury or mortality to fish, which can affect fish populations.	■ A detailed Blasting Plan will be developed for the Project and set-back distances during blasting of the water intake foundation and tailrace channel will be included as part of this plan. ■ Best practices, as outlined in the Blasting Plan for the Project, will be applied to blasting activities to reduce any potential for enhanced nitrogen loading of groundwater inflows due to the placement and use of ammonium nitrate/fuel oil (ANFO) during construction. ■ DFO's Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters (Wright and Hopky 1998) will be used for this Project. ■ A Site Water Management Plan will be developed for the Project. ■ Construction and monitoring of settling ponds or water treatment areas will be part of the Site Water Management Plan.	Secondary
		Use of explosives near surface waterbodies can change surface water quality, and thus, fish habitat.		Secondary
■ Air Emissions ▪ emission of dust from blasting activities and hauling waste rock to waste rock disposal areas. ▪ emission of standard pollutants from vehicles and heavy equipment operation	Construction Operations Closure	Deposition of criteria air contaminants can change surface water and soil quality, which can affect the health of fish.	■ Equipment will be regularly maintained for compliance with provincial and federal air emission standards. ■ The equipment used for hauling and mucking operations will operate using diesel fuel with an ultra-low sulfur diesel content less than 15 parts per million (ppm). ■ The heavy-duty stationary and mobile diesel-fueled equipment fleet will meet or exceed Environmental Protection Agency (EPA) Tier 2/3 air quality emissions standards. ■ The gasoline-fueled equipment fleet will meet or exceed EPA Tier 2 Bin 6 air quality emissions standards. ■ A forced air method of ventilation will be used for venting of dust, gases and fumes from inside the power tunnel following blasting. ■ Implementation of a Water Quality Monitoring Program.	No Linkage
		Dust deposition can change the chemical properties of surface water and soil, which can affect fish habitat.	■ An Environmental Protection Plan (EnvPP) will describe material handling protocols including dust management. ■ Soil piles or exposed soils will be seeded with non-aggressive annual species appropriate for the area. ■ All unpaved roads will be watered on a regular basis to prevent wind driven fugitive dust. ■ A speed limit will be enforced on unpaved roads on site. ■ A forced air method of ventilation will be used for venting of dust, gases and fumes from inside the power tunnel following blasting.	No Linkage
■ Power Generation Activities ▪ water withdrawal for power generation ▪ diversion of water through the power tunnel to the powerhouse ▪ discharge of tailrace channel flows	Operations	Water withdrawal from Black Lake for power generation may impinge or entrain fish, resulting in fish injury or mortality, which can affect fish populations.	■ An "exclusion bar rack" will be used to prevent entry of debris into the power tunnel and to provide a visual deterrent for fish entrainment at the water intake. ■ Design and operation of a shallow water intake will reduce entrainment of deep-water fishes. ■ The water intake location was selected to avoid sensitive fish habitat. ■ The soffit (ceiling) of the water intake passage will be set low enough to prevent entrainment of air into the power tunnel and subsequently reduce the potential for gas bubble trauma in entrained fish.	Primary

Table 12.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Fish and Fish Habitat (continued)

Project Component/Activity	Expected Project Phase	Potential Interactions to Fish and Fish Habitat	Environmental Design Features and Mitigation	Interaction Classification
■ Power Generation Activities ▪ water withdrawal for power generation ▪ diversion of water through the power tunnel to the powerhouse ▪ discharge of tailrace channel flows	Operations	Discharge of tailrace channel flows may attract fish to the tailrace channel outlet channel.	■ Under normal tailrace channel outlet discharges (up to 190 m^3/s) flow velocities in the tailrace channel (1.4 m/s) exceed prolonged swimming speeds of fish and are above preferred spawning velocities. This will prevent prolonged occupation of the tailrace channel by fish. ■ The tailrace channel design lacks velocity refugia that would allow fish to rest as they attempt to migrate up the tailrace channel. ■ There are no sources of cover (e.g., substrate, vegetation) incorporated into the tailrace channel design that would make it attractive habitat for fish.	No Linkage
		Withdrawal, diversion, and discharge of water for power generation may change hydrology, which can affect fish habitat.	■ A weir will be constructed on the Fond du Lac River at the outlet of Black Lake and will be designed to maintain the range of water levels in Black Lake and in the uppermost section of the Fond du Lac River with the historical range, for all powerhouse operating flow conditions. ■ The tailrace channel outlet will be located upstream of important fish spawning habitat near the Fond du Lac River outflow to Middle Lake to maintain minimum required flows at this location. ■ For planned or unplanned shutdowns longer than 15 minutes duration during the spring spawning and rearing period (May 15 to July 15) and low winter flow period, downstream flows will be maintained by bypassing water around the powerhouse turbine generator units using a bypass conduit. ■ A spring spawning trigger flow of 70 m^3/s will be implemented to support successful spawning of Arctic grayling and other spring spawners in the Fond du Lac River. ■ Project site runoff resulting from rainfall, snowmelt, and groundwater releases will be managed by directing runoff around work site infrastructure by using appropriately sized ditches, channels, and culverts.	Primary
		Diversion of water through the power tunnel may change groundwater quantity, which can change hydrology and affect fish habitat.		No linkage
		Diversion of water through the power tunnel may change groundwater and surface quality, which can and affect fish habitat.	■ The proposed Project has been designed to incorporate a subsurface intake as part of the tunnel diversion, which will prevent air entrainment into the tunnel by the intake. ■ Rock material used to construct the submerged weir will consist of rock with low potential for acid generation or radioactive materials.	No linkage
		Withdrawal and discharge for power generation may change the temperature of the water, which can affect fish habitat.	■ A wide, shallow water intake approach is expected to withdraw water from the surface of the lake to reduce temperature differences between the water entering the river at the tailrace channel outlet and what naturally enters the Fond du Lac River through the Black Lake outlet.	Secondary
		Maintenance shutdowns of power generation activities can change surface hydrology, which can affect fish and fish habitat.	■ Scheduled maintenance shutdowns will occur annually on a unit-by-unit basis and are estimated to last from a few days up to two weeks. ■ Only one unit at a time will be removed from service for maintenance. ■ Maintenance shutdowns will be timed to limit downstream effects, for example during winter months, during other periods when there is less flow available to pass through the powerhouse turbine generator units, or during summer when sufficient in-river flows are available. ■ Each unit may be taken out of service, once per month for less than 8 hours, to perform minor adjustments, inspections, and maintenance. ■ The power tunnel will be drained for inspection for one to two weeks approximately every five years. ■ Major overhaul work on the turbine and generator units will be completed approximately every 30 years. ■ During planned maintenance shutdowns, downstream flows will be maintained by bypassing water around the powerhouse turbine generator units using a bypass conduit, if required.	Secondary

Table 12.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Fish and Fish Habitat (continued)

Project Component/Activity	Expected Project Phase	Potential Interactions to Fish and Fish Habitat	Environmental Design Features and Mitigation	Interaction Classification
■ Potable and Industrial Water Supply	Construction	Water withdrawal for domestic (e.g., potable water) and industrial (e.g., dust suppression) purposes can change hydrology, which can affect fish and fish habitat.	■ Potable water for the construction camp is anticipated to be sourced from one or more new wells located near the camp, although this water could potentially be drawn from either Black Lake or the Fond du Lac River.	No Linkage
		Impingement or entrainment of fish in water intake pumps used for domestic and industrial purposes can result in injury or mortality, which can affect fish populations.	■ Pump intakes would be screened to prevent entrainment of fish in accordance with DFO's "Freshwater Intake End-of-Pipe Fish Screen Guideline" (DFO 1995).	No Linkage
■ Site Water Management ▪ collection and treatment of surface runoff within the Project footprint ▪ discharge of wastewater ▪ collection and treatment of groundwater in the power tunnel	Construction Operations	The interception and collection of direct precipitation and surface runoff within the Project footprint may change hydrology, which can affect fish and fish habitat.	■ Surface runoff will be diverted around and away from waste rock disposal areas as much as possible. ■ The site will be properly graded and will be surrounded by ditches and berms to capture runoff from the waste rock disposal areas. ■ The waste rock disposal areas will be placed in locations that are easily modified to control run-on and run-off. Runoff from the waste rock disposal areas will be directed to settling ponds prior to discharge to the Fond du Lac River; water quality will be confirmed before release to the environment (e.g., Fond du Lac River). ■ Runoff and drainage from within and around Project roadways and structures will be managed through the incorporation of erosion control methods (e.g., ditch blocks, silt fences) so that overland flow does not direct sediment-laden water into natural watercourses. ■ Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns. ■ Ditch capacities will be sized to accommodate an extreme daily rainfall event. ■ Riprap energy dissipaters and ditch lining will be installed in areas where runoff velocities are deemed excessive to reduce soil erosion. ■ Runoff from areas unaffected by the Project will be directed away from construction areas and allowed to discharge through natural channels. ■ A Site Water Management Plan will be developed for the Project. ■ Power tunnel seepage water will be monitored for quality and quantity and treated or managed to acceptable standards before discharge to the environment.	No Linkage
		Surface water diversions (e.g., berms, ditches, waste rock disposal areas) around the Project footprint can change drainage areas, runoff characteristics, and local and downstream hydrology, which can affect fish and fish habitat.		No Linkage

Table 12.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Fish and Fish Habitat (continued)

Project Component/Activity	Expected Project Phase	Potential Interactions to Fish and Fish Habitat	Environmental Design Features and Mitigation	Interaction Classification
■ Site Water Management ▪ collection and treatment of surface runoff within the Project footprint ▪ discharge of wastewater ▪ collection and treatment of groundwater in the power tunnel	Construction Operations	Collection and disposal of wastewater from the site can cause changes to hydrology, which could affect fish habitat.	■ A Site Water Management Plan will be developed for the Project. ■ Implementation of Water Quality Monitoring Program. ■ Construction and monitoring of settling ponds or water treatment areas will be part of Site Water Management Plan. ■ Groundwater originating from construction of the power tunnel will be collected, treated if required, and monitored to meet applicable water quality guidelines (CCME) at the end of the mixing zone in the river. ■ Runoff from the waste rock disposal areas will be directed to settling ponds prior to discharge to the Fond du Lac River. ■ Wastewaters released from the settling ponds will meet applicable water quality guidelines (CCME) at the end of the mixing zone. ■ Contingency plans for off-site disposal of dewatered settling pond sludge will be included in an EnvPP. ■ Sewage and grey water will be hauled off-site and disposed of at the Black Lake lagoon.	Secondary
		Collection and disposal of wastewater from the site can cause changes to surface water quality, which could affect fish health and habitat.		Secondary
		Discharge of sewage and grew water can affect surface water quality, which can affect fish and fish habitat.		No Linkage
■ Waste Rock Disposal Areas	Construction and Operations	Seepage from waste rock disposal areas can change groundwater, surface water, and soil quality, and affect fish habitat.	■ A Waste Rock Management Plan will be prepared and will include a Project Site Drainage Plan. ■ Excavated material will be stored away from watercourses or lakes. ■ Excavated rock and aggregate materials will be tested to confirm that this material will not have negative effects on the surrounding environment. Specific mitigation measures will be applied if the material is identified to be acid-generating or contain elevated levels of metals or radionuclides. ■ Construction and monitoring of settling ponds or water treatment areas will be included in the Site Water Management Plan. ■ Additional site investigation and laboratory testing of excavated materials will be completed upon completion of the final Project design and during construction of the Project.	Secondary
■ Closure Activities	Closure	Cessation of power generation activities, including the withdrawal, diversion, and discharge of water, can change hydrology and surface water quality, which can affect fish and fish habitat.	■ A Decommissioning and Reclamation Plan will be developed for the Project. ■ A series of concrete bulkheads will be placed in the power tunnel, if necessary, to isolate mineralized bedrock zones and to reduce potential for mineralized groundwater to discharge through the power tunnel. ■ Quality of groundwater discharging through the power tunnel at the decommissioning phase will be monitored and sampled, if required.	Secondary

Table 12.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Fish and Fish Habitat (continued)

Project Component/Activity	Expected Project Phase	Potential Interactions to Fish and Fish Habitat	Environmental Design Features and Mitigation	Interaction Classification
	Operations	Emergency shutdowns of power generation activities can change surface hydrology, which can affect fish and fish habitat.	■ During planned or unplanned shutdowns longer than 15 minutes duration during the spring spawning and rearing period (from May 15 to July 15) and low winter flow period, downstream flows will be maintained by bypassing water around the powerhouse turbine generator units using a bypass conduit.	Secondary
■ Accidents, Malfunctions, and Unplanned Events ▪ emergency shutdowns of power turbines ▪ hazardous materials spills ▪ failure of embankment dykes	Construction Operations Closure	Release or spills of hazardous substances (e.g., fuel and oil) can change surface water, sediment, and soil quality, which can affect fish and fish habitat.	■ All fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard; a lined and dyked containment area around these tanks will be provided to contain any potential fuel spills. The design of the containment area will be based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. ■ The storage containers will be regularly inspected for leaks or damage and replaced when necessary. ■ Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double-walled and located in lined and bermed containment areas. ■ Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers. ■ Construction equipment will be maintained regularly. ■ Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired near waterbodies. ■ Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills of fuel would flow to the sump, which would be pumped out to a container for shipment off-site. ■ An Emergency Response Plan will be developed. ■ Spill response material (e.g., sorbent pads) will be stored on-site in designated areas and in vehicles. ■ Contaminated (impacted) soils will be removed and disposed of in an approved landfill or waste management facility.	Secondary
	Construction Operations Closure	Failure of the embankment dykes around the settling ponds can change surface water quality, which can affect fish and fish habitat.	■ Embankment dykes will be stripped of vegetation, topsoil, and roots to expose the mineral soil subgrade as necessary to accommodate the size of the footprint. ■ Fill material will be clean mineral soil with sufficient moisture to allow for proper compaction. ■ The embankment will be topsoiled, seeded, or protected with gravel or riprap immediately following construction. ■ The settling pond will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway.	No Linkage

m/s = metres per second; m^3/s = cubic metres per second; US = United States; CCME = Canadian Council of Ministers of the Environment

12.4.1 Interactions with No Linkage to Effects

A Project interaction may have no linkage to effects if the activity does not occur (e.g., site runoff is not released), or if the interaction is removed by mitigation or environmental design features so that the Project results in no detectable (i.e., measurable) change in measurement endpoints. Subsequently, no residual effect on the maintenance of self-sustaining fish populations (including listed species) is expected. The following interactions are anticipated to have no linkage to effects on fish and fish habitat and therefore will not be carried through the residual effects assessment.

- **Site clearing, contouring, and excavation can cause soil erosion, which can change surface water, and affect fish habitat.**

Site clearing, contouring, and excavation during construction have the potential to cause soil erosion, which could cause soil to enter waterbodies within the LSA and result in changes to surface water quality. Changes to surface water quality may have subsequent effects on fish and fish habitat. Increased sediment runoff as a result of site clearing, contouring, and excavation may result in increased TSS and trace metal (e.g., aluminum, cadmium, chromium, copper, iron, mercury, and silver) concentrations in receiving and downstream waterbodies. An Erosion and Sediment Control Plan will be developed based on industry standard Best Management Practices (BMPs) and federal and provincial regulatory requirements.

The adverse effects of soil erosion can be reduced by implementing recommended mitigation practices, which include the following:

- conducting site clearing, soil salvage, and construction and decommissioning of Project infrastructure (e.g., roads or laydown areas), during dry or frozen conditions, where and when practical;
- applying erosion control practices (e.g., seeding soil salvage stockpiles or silt fences) to salvaged topsoil to reduce potential erosion and sediment transport to surface waterbodies;
- storing salvaged topsoils on-site and away from surface waterbodies;
- applying coarse riprap or other erosion control measures to the banks of watercourses to prevent soil erosion after the removal of culverts;
- conducting site-specific assessments to identify appropriate surficial stripping depths and develop a site-specific soil salvage plan;
- adhering to the Erosion and Sediment Control Plan.

With the implementation of the mitigation techniques described above, it is anticipated that the changes to surface water quality from soil erosion will not be detectable. Therefore, this interaction is expected to have no linkage to effects on fish populations.

- **Installation of the submerged weir in the Fond du Lac River may block or delay movements of migratory fish species, which can affect fish populations.**

A submerged weir spanning the width of the Fond du Lac River will be constructed at the natural outflow of Black Lake in order to maintain historical water levels in Black Lake during Project operation. The Fond du Lac River is approximately 200 m wide at the location of the proposed weir, including the 35 m wide section of Grayling Island that the weir will intersect (Figure 12.4-1). The weir will be completely submerged during the open water period and will be designed with a triangular cross section. It will have a 5H:1V slope on the upstream face and a 20H:1V slope on the downstream face. Thus, the fluvial distance or length of the submerged weir will be approximately 50 m.

None of the fish species in Black Lake, with the exception of some out-migrating Arctic grayling, are known to undertake annual or regular downstream migrations for spawning, rearing, or foraging purposes. Individuals of some species may drift downstream out of Black Lake into the Fond du Lac River, resulting in passive dispersal (see Table 12.3-1 in Section 12.3.2 for a list of Black Lake fish species). Upstream movements of fish from the Fond du Lac River into Black Lake are highly unlikely, with the exception of some individuals in the local Arctic grayling population.

The submerged weir will be designed to facilitate safe downstream passage for all fish species at the Black Lake outflow to the Fond du Lac River and at all lake levels and discharges. Similarly, the weir will be designed to allow for upstream movements of adult Arctic grayling (i.e., individuals having fork lengths [FLs] >200 millimetres [mm]) in the Fond du Lac River to Black Lake (see Table 12.4-2). The crest of the weir will be V-shaped, sloping to a mid-point notch to concentrate flows and facilitate fish passage during low flow periods. The crest of the weir (centre of notch) will be set at an elevation of 275.70 metres above sea level (m ASL) (i.e., less than the historical mean elevation of Black Lake [277.159 m ASL]). Flow velocities at the weir are not anticipated to exceed the prolonged swimming speeds (i.e., critical, moderate swimming speeds that can be maintained for up to 200 minutes) of Arctic grayling as they move into Black Lake from the Fond du Lac River.

Prolonged swimming speed is a type of critical swimming speed that can be maintained for a longer duration than burst or startle speeds (i.e., greatest swimming speed that can be achieved and maintained for up to 15 seconds). Because anaerobic energy is required to maintain a prolonged swimming speed, fatigue occurs within 20 seconds to 200 minutes (Peake 2008). Burst and prolonged swimming speeds reported for Arctic grayling are provided in Table 12.4-2.

Table 12.4-2: Burst Swimming Speeds and Prolonged Swimming Speeds of Arctic Grayling (*Thymallus arcticus*)

Reported Fish Length[(a)]	Burst Swimming Speed[(b)] (m/s)	Prolonged Swimming Speed[(c)] (m/s)		Reference(s)
		Speed (m/s)	Duration (s)	
203 to 305 mm FL	2.1 to 4.3	-	-	Bell 1991
200 mm FL	0.90 to 4.0	0.5 to 0.9	1,800	Shumilak and Remnant 1999
70 to 370 mm	-	0.52 to 0.72	600	Katopodis 1992

(a) Attainable swim speeds within a species are often dependent on the fish size (Peake et al. 2000).
(b) Burst or startle speed is the greatest swimming speed that can be reached and maintained for less than 15 seconds (Katopodis 1992).
(c) Prolonged speed is a moderate swimming speed that can be maintained for up to 200 minutes (Katopodis 1992); speeds and the duration over which fish can maintain the reported speed are included in the table.
m/s = metres per second; s = seconds; mm = millimetres; FL = fork length; - = no data available

LEGEND

SUBMERGED WEIR FOOTPRINT

50 0 50

SCALE 1:3,000 METRES

REFERENCE

2012 GOLDER FIELD SURVEY
FLYSASK ORTHOIMAGERY © Saskatchewan Geospatial Imagery Collaborative, 2008 - 2011
NAD83 UTM ZONE 13

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATION AND FOOTPRINT OF PROPOSED WEIR AT GREYLING ISLAND NEAR BLACK LAKE OUTFLOW TO THE FOND DU LAC RIVER

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	27/08/13	FIGURE: 12.4-1
CHECK	AO	27/08/13	
REVIEW	BC	27/08/13	

Placement and design of the submerged weir will facilitate the upstream and downstream movement of Arctic grayling so they can readily access their traditional spawning habitat. Because the weir structure is not expected to cause injury or mortality to fish or affect fish movements, this interaction is expected to have no linkage to effects on fish populations. Although an increase in velocities is expected over a short distance at the proposed weir location, this change is not predicted to be measureable, and therefore, no linkage to effects on Arctic grayling is predicted.

- **Increased access to the site and areas on the east side of the Fond du Lac River can affect fish habitat and fish populations.**

Construction of the bridge over the Fond du Lac River will improve access to the east side of the river. Greater access can lead to increased use of the areas along the east side of the river by local anglers, as well as fishers from Camp Grayling. Increased angler access could increase rates of fish injury (i.e., incidental injuries related to catch-and-release fishing), fish mortality, or degradation of fish habitat.

Practices that could be used to mitigate the effects of increased traffic and improved access to fishing areas on the east side of the Fond du Lac River will be included in an Access Management Plan and will include implementation of site-specific fishing prohibitions and additional site security features. A "no hunting, trapping, harvesting, or fishing policy" during construction will be developed and enforced for Project employees. Contractor and contractor employees working on site who are not members of the BLFN will be banned from fishing in designated Project areas after work-hours. These areas will be determined based on engagement with members of the BLFN. The use of recreational all-terrain vehicles will be prohibited on site; this will help to reduce the potential for degradation of riparian habitats (e.g., ruts or damage to vegetation) and to manage site access. Site security features implemented for the site will include the following:

- public access to the construction, laydown, and camp areas will be restricted until Project construction is completed; and
- using a shuttle to transfer incoming and outgoing workers from Stony Rapids and Black Lake to the site to reduce the use of personal vehicles.

A measureable increase in domestic fishing within the vicinity of the Project is not expected to occur because of increased access to the east side of the Fond du Lac River. Most domestic fishing within the area takes place on Stony Lake; some fishing occurs on Black Lake, which supports a small commercial fishery, as well as on Middle Lake. Stony Lake and Black Lake are used for ice fishing. Middle Lake is not typically used during winter due to thin ice and open water conditions; however, some residents in the area use the lake in spring before the ice on Black Lake has melted. The cabin owner on Middle Lake is the main year-round domestic fisher on the lake.

Domestic fishing is primarily done by net and is non-selective. Preferred species include lake whitefish, lake trout, northern pike, walleye, suckers (*Catostomus* sp.), and Arctic grayling. Arctic grayling are commonly captured in the Fond du Lac River (Golder 2012). Arctic grayling and northern pike are commonly targeted by recreational anglers at Camp Grayling.

Due to the implementation of site-specific fishing bans and restricting site access within designated areas throughout the construction and operation phases of the Project, it is anticipated that this Project interaction will have no linkage to effects on fish populations.

- **Deposition of criteria air contaminants can change the surface water and soil quality, which can affect the health of fish.**

Construction and operation of the Project will generate air emissions such as carbon monoxide (CO), oxides of sulphur (SO_x, includes sulphur dioxide [SO_2]), oxides of nitrogen (NO_x), particulate matter ($PM_{2.5}$, PM_{10}), and total suspended particulates (TSP). Air quality modelling was completed to predict the spatial extent of air and dust emissions and deposition from the Project (Section 8.5). Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates (Section 8.5).

Air emissions (i.e., sulphur dioxide [SO_2] and nitrogen dioxide [NO_2]) can result from the use of fossil fuels in generators, vehicles, and machinery during construction and operation of the Project. Deposition of SO_2 and NO_2 can lead to acidification of waterbodies (Bobbink et al. 1998). Environmental design features will be incorporated into the Project to limit the effects of air emissions on fish and fish habitat. Motorized diesel equipment used for hauling and mucking operations will operate using ultra-low sulphur diesel fuel (less than 15 parts per million [ppm] sulphur). The heavy-duty stationary and mobile diesel-fueled equipment fleet will meet or exceed Environmental Protection Agency (EPA) Tier 2/3 air quality emissions standards. The fleet of gasoline-fueled equipment used on-site will meet or exceed EPA Tier 2 Bin 6 air quality emissions standards. Equipment will be kept in optimal working order; scheduled maintenance will be completed to meet federal and provincial air emissions standards. Electric powered hydraulic drill jumbos will be used in the power tunnel during construction to limit air emissions. A forced air ventilation system will be used in the power tunnel to clear dust, gases, and fumes from inside the power tunnel.

Results of the air quality modelling indicate that the maximum ground-level concentrations of CO, SO_2, and NO_x are all below the Saskatchewan Ambient Air Quality Standards (SAAQS 1996) and the Canada Wide Standard (CCME 2000; Section 8.5.1), and are limited to the immediate vicinity of the Project. Air emissions are expected to result in non-detectable changes to fish habitat; therefore, this interaction is determined to have no linkage to residual effects on fish populations.

- **Dust deposition can change the chemical properties of surface water and soil, which can affect fish habitat.**

Project construction and use of vehicles during Project operation have the potential to create dust (particulate matter [$PM_{2.5}$, PM_{10}]). Increased dust production and subsequent deposition to aquatic environments has the potential to affect fish habitat. Dust deposition in waterbodies may lead to increased total suspended solids (TSS) concentrations in water and increased trace metal (e.g., aluminum, cadmium, chromium, copper, iron, mercury, and silver) concentrations in water, sediment, and biota.

Construction of an all-season gravel access road and associated traffic for the Project could increase dust deposition to nearby habitats. Transportation routes, particularly unpaved roads that would be used to access the Project, are a suspected potential source of dust (Farmer 1993; Harrison et al. 2003; Peachey et al. 2009). Studies by Walker and Everett (1987) and Everett (1980) found that effects of road dust are confined to within 50 m of the roadway; however, dust deposited along roadways during the winter has the potential to be transported into nearby waterbodies during spring freshet. Dust abatement methods will be used on roads to reduce dust creation and will be consistent with practices carried out by the Saskatchewan Ministry of Highways and Infrastructure. Speed limits will be enforced on unpaved roads to reduce the production of dust.

The effects of dust emissions and deposition may be further reduced by implementing additional recommended mitigation practices, including:

- development of an Environmental Protection Plan (EnvPP) for the site that describes material handling protocols, including dust management;
- watering unpaved roads to prevent wind-driven fugitive dust; and
- enforcing a speed limit on unpaved roads on site.

Most of the traffic to the Project will occur during construction. All unpaved roads will be watered regularly to prevent wind driven fugitive dust. Speed limits will be enforced to reduce dust generation from roads. Once construction is complete, all temporary access roads will be removed and the numbers of vehicles travelling to and from the Project are expected to decrease (Section 5.5.1). Modelling results indicate that the maximum predicted TSP and $PM_{2.5}$ concentrations are 114.4 micrograms per cubic metre ($\mu g/m^3$) and 22.8 $\mu g/m^3$, respectively, which do not exceed the SAAQS and Canada-Wide Standard (Section 8.5.1.2.3). Minor Project-related increases in TSS could occur in association with the spring freshet, when accumulated dust deposited over winter migrates with melted snow; however, this increase would be very short in duration (i.e., over the duration of the freshet) and would likely only occur during the three year construction phase when dust deposition is expected to be greatest.

Blasting activities and the removal of waste rock during Project construction could potentially increase dust deposition to surrounding waterbodies. A forced air ventilation system will be used during construction of the power tunnel to clear dust, gases, and fumes from inside the power tunnel. Water pipes will be installed along the side of the power tunnel with water being used to spray waste rock after each blast to reduce dust. The finalized Blasting Plan will follow DFO's Guidelines for the Use of Explosives in or Near Canadian Waters (Wright and Hopky 1998) to enable construction of the Project to proceed with minimal effect on water quality. The Blasting Plan will also mitigate the detrimental effects on fish and fish habitat from fugitive dust created by excavation and material transportation.

Due to the implementation of appropriate environmental design features, it is anticipated that changes to fish habitat from dust deposition will not be detectable. As such, this interaction is determined to have no linkage to residual effects on fish populations.

- **Water withdrawal for domestic (e.g., potable water) and industrial (e.g., dust suppression) purposes can change hydrology which can affect fish and fish habitat.**

The withdrawal of water for domestic and industrial purposes during Project construction and operation has the potential to change hydrology, which in turn can affect fish habitat. Water usage will vary depending on the number of workers on-site and is expected to be greatest during the construction phase of the Project when up to 250 people are expected to be on-site. Water requirements for the construction phase can reach up to 4,700,000 litres (L) per year (i.e., approximately 13 m^3/d) for industrial water and potable water use is expected to be between 30,000 and 45,000 litres/day). .Potable water for the construction camp is anticipated to be sourced from one or more new wells located near the camp, although this water could be drawn from either Black Lake or the Fond du Lac River. Pump intakes would be screened to prevent entrainment of fish in accordance with the "Freshwater Intake End-of-Pipe Fish Screen Guideline" (DFO 1995).

During operations, approximately 365,000 L/year (i.e., 1 m^3/d) of water will be required for the Project. Potable water will be drawn from the penstock and treated for use. Industrial water (i.e., used for fire suppression, preparing concrete, and controlling road dust) will be taken from Black Lake (i.e., intake location) and the Fond du Lac River (i.e., bridge location). Pump intakes will be screened appropriately to prevent entrainment of fish.

A supply of industrial water will be required for dust suppression and fire-protection during Project operation. Industrial water will be diverted from power generation flows passing through the power station. Storage tanks will provide the appropriate storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (2 hours of available water at 750 US gallons per minute).

Water withdrawal from Black Lake or the Fond du Lac River for domestic and industrial use during construction and operations will be of extremely low volume compared to the lake volume and river flow rate is not expected to have a measureable effect on water volumes or flow rates. Black Lake has a waterbody volume of 6,610,000,000 m^3 and the Fond du Lac River has an average baseline flow rate of 304 m^3/s. Withdrawal of 21,125 m^3/year from these waterbodies will account for less than 0.0001% of the corresponding waterbody volume and flow rate. Because water requirements during operations are lower than those for construction, potential effects during operations are expected to be much lower, despite the reductions in riparian flows that will occur as a result of power generation.

Based on the results of the hydrology assessment, the potable and industrial water supplies for the Project are not predicted to have a measureable change in hydrology. Therefore, this Project interaction is expected to have no linkage to residual effect on fish populations.

- **Impingement or entrainment of fish in water intake pumps for domestic and industrial purposes can result in injury or mortality, which can affect fish populations.**

Water intake pumps used to withdrawal water for domestic and industrial purposes during Project construction and operation have the potential to impinge or entrain fish. Water currents may draw fish (including eggs and larvae) against the intake surfaces, resulting in impingement; fish may also be drawn into and entrained within the water pump. Fish impingement and entrainment may result in injury or mortality to fish.

Water intake pumps may be required to provide potable and industrial water for the Project. Potable water may be sourced from one or more wells constructed near the camp or potentially from Black Lake or the Fond du Lac River.

Any temporary or permanent water withdrawal facility or pump used for provision of construction or industrial water, potable water, or emergency fire response water will include appropriate fish exclusion screens and comply with DFO's Freshwater Intake End-of-Pipe Fish Screen Guidelines (DFO 1995). The appropriate fish exclusion screen mesh size will minimize entrainment or impingement of fish during water withdrawal. Selection of the appropriate mesh size will also take into account the maximum approach velocity for water at the screen surface to reduce the likelihood that fish will be impinged on the intake screen.

By using the appropriate fish exclusion screens and complying with DFO's Freshwater Intake End-of-Pipe Fish Screen Guidelines (DFO 1995), injury and mortality of fish due to impingement on the intake screen or entrainment into water intake pumps can be mitigated. Therefore, this Project interaction was determined to have no linkage to effects on fish populations.

- **Discharge of tailrace channel flows may attract fish to the tailrace channel outlet and result in entrainment, injury, or mortality.**

Discharge of water from the tailrace channel outlet in the Fond du Lac River may have the potential to attract fish, particularly during the spawning season when individuals of some species would typically ascend watercourses to spawn. Fish that are able to enter the tailrace channel outlet may become entrained, injured, or killed.

The proposed tailrace channel outlet has a designed water depth of 5.5 m and is expected to have an approximate flow velocity of 1.4 m/s based on a discharge rate of up to 190 cubic metres per second (m^3/s). The channel will be blasted into the bedrock or excavated in overburden and will have a relatively smooth, regular bottom with steeply sloping sides and no instream velocity refugia (e.g., slack water areas behind boulders or baffles). The 1.4 m/s flow velocity predicted for the tailrace channel outflow exceeds the prolonged swimming speeds (i.e., the critical, moderate swimming speed that can be maintained for up to 200 minutes) of all fish species present in the Fond du Lac River (Table 12.4-3). Not only is the 1.4 m/s flow too fast to swim against for prolonged periods, the lack of instream refugia makes it very difficult for fish to work their way up to the power station by using slack water areas behind boulders or other structures to rest.

Arctic grayling in the Fond du Lac River prefer to spawn in moderate velocities under 0.8 m/s, with optimum velocities less than 0.6 m/s (Annex III; Appendix 12.1). Under conditions of Project operation, flows in the tailrace channel are too fast to support spawning. Should a plant shutdown occur during the spawning period, a bypass flow of 80 m^3/s will be initiated and velocities in the tailrace channel will decrease to levels preferred by spawning Arctic grayling (i.e., 0.55 m/s). However, occupation of the tailrace channel by fish under bypass conditions will be temporally limited; shutdowns of power generation are expected to be infrequent and relatively brief, typically ranging from a few minutes to four or five hours. In addition, the tailrace channel will lack suitable cover and substrates required by fish for spawning, rearing, and other activities, regardless of whether the plant is operating or bypass flows are initiated. It is anticipated that fish will not find suitable habitat in the tailrace channel and will be inclined to descend back down to suitable habitats in the river, such as the known spawning areas located immediately downstream of the tailrace channel outlet.

Due to the high water velocities and its relatively smooth, featureless design, it is anticipated that there will be no suitable fish habitat within the tailrace channel. Without suitable foraging, rearing, or spawning habitat, fish will have no reason to be attracted to the tailrace channel. If fish do attempt to swim up the channel, high flows will prevent them from reaching the powerhouse where they may be entrained, injured, or killed. Therefore, no linkage to effects on fish populations are expected.

Table 12.4-3: Burst Swimming Speeds and Prolonged Swimming Speeds of Selected Fond du Lac River and Black Lake Fish Species

Common Name	Scientific Name	Reported Fish Length[(a)]	Burst Swimming Speed[(b)] (m/s)	Prolonged Swimming Speed[(c)] (m/s)		Reference(s)
				Speed (m/s)	Duration (s)	
Salmonids and walleye	*Salmonidae* and *Percidae*, respectively	100 mm	1.0 to 3.9	0.4 to 1.6	600	Gervais and Katopodis 2012
		250 mm	1.2 to 4.4	0.5 to 1.8	600	
		400 mm	1.2 to 4.7	0.5 to 1.9	600	
Arctic grayling	*Thymallus arcticus*	203 to 305 mm FL	2.1 to 4.3	-	-	Bell 1991
		200 mm FL	0.90 to 4.0	0.5 to 0.9	1800	Shumilak and Remnant 1999
		70 to 370 mm	-	0.52 to 0.72	600	Katopodis 1992
Cisco species[(d)]	*Coregonus* spp.	133 mm[(e)]	-	0.46 to 0.63	433 to 1800	Katopodis 1992
Lake chub	*Couesius plumbeus*	-	-	-	-	Peake 2008 [(f)]
Lake trout	*Salvelinus namaycush*	455 to 895 mm TL	0.46 to 3.2	-	-	Dunlop et al. 2010
Lake whitefish	*Coregonus clupeaformis*	152 to 457 mm	0.91 to 1.2	-	-	Jones et al. 1974
		60 to 510 mm	-	0.34 to 0.59	72 to 1278	Katopodis 1992
Longnose sucker	*Catostomus catostomus*	100 to 460 mm	1.2 to 2.4	-	-	Bell 1991
		40 to 530 mm FL	-	0.23 to 0.91	600	Katopodis 1992
Northern pike	*Esox lucius*	100 mm	0.9 to 2.0	0.3 to 0.6	600	Gervais and Katopodis 2012
		250 mm	1.0 to 2.3	0.3 to 0.7	600	
		400 mm	1.0 to 2.5	0.4 to 0.8	600	
		412 mm (average FL)	2.8 to 3.4	-	-	Frith and Blake 1995
		170 to 200 mm	1.5 to 2.1	-	-	Wolter and Arlinghaus 2003 as cited in KGS and North/South Consultants Inc. 2008
		120 to 620 mm	-	0.19 to 0.47	600	Jones et al. 1974
Round whitefish	*Prosopium cylindraceum*	-	-	-	-	-
Walleye	*Sander vitreus*	180 to 670 mm FL	1.60 to 2.60	0.30 to 0.73	3600	Peake et al. 2000
		80 to 380 mm	-	0.38 to 0.84	600	Katopodis 1992
White sucker	*Catostomus commersonii*	170 to 370 mm FL	-	0.48 to 0.73	600	Katopodis 1992
Yellow perch[(g)]	*Perca flavescens*	95 mm	-	0.02 to 0.34	-	Beamish 1978 as cited in KGS and North/South Consultants Inc. 2008

[(a)] Attainable swim speeds within a species are often dependent on the fish size (Peake et al. 2000).
[(b)] Burst or startle speed is the greatest swimming speed that can be reached and maintained for less than 15 seconds (Katopodis 1992).
[(c)] Prolonged speed is a moderate swimming speed that can be maintained for up to 200 minutes (Katopodis 1992); speeds and the duration over which fish can maintain the reported speed are included in the table.
[(d)] Specimens exhibited characteristics of shortjaw cisco (*Coregonus zenithicus*) and the common cisco (*Coregonus artedi*).
[(e)] Prolonged swim speed data is for anadromous common cisco (*Coregonus artedi*).
[(f)] No burst speed data could be found for lake chub (*Couesius plumbeus*); the lack of data was reiterated by Peake 2008.
m/s = metres per second; s = seconds; mm = millimetres; FL = fork length; TL = total length; - = no data available

- **Diversion of water through the power tunnel may change groundwater quality, and alter surface water quality, which can affect fish habitat.**

Withdrawal of water from Black Lake, diversion of water into the power tunnel, and subsequent discharge of water to the Fond du Lac River for power generation during operation could change surface water quality in Black Lake, the Fond du Lac River, or Middle Lake. As water passes through a hydroelectric facility, it could become super-saturated with dissolved gases (Becker et al. 2003). The proposed Project has been designed to incorporate a subsurface intake as part of the tunnel diversion, which will prevent air entrainment into the tunnel (CEA 2001).

Characteristics (e.g., depth, turbulence) of the receiving waters immediately downstream of the power plant discharge determine the rate of degassing for water released from the power generating facility. Gases in super-saturated waters dissipate rapidly in shallow, well-mixed areas of rivers; degassing potential is much lower in river reaches or lakes that are deep or calm (Parametrix Inc. [Parametrix] 2005). The tailrace channel is expected to be approximately 800 m long, 25 m wide, and contain flows 5.5 m deep, with a design velocity predicted to be around 1.4 metre per second (m/s). Because air entrainment within the tailrace channel flows is expected to be minimal, it is anticipated that mixing of Project and riparian flows below the tailrace channel outlet will limit the potential for super-saturated conditions downstream in Middle Lake.

The proportion of groundwater inflows within the power tunnel flows is expected to be minimal during operation of the Project (e.g., 680 m^3/d; Section 9.0, Appendix 9.2). These groundwater inflows will represent a very small fraction of the total operational flows through the tunnel (i.e., 0.004% of the flow through the tunnel, up to 190 m^3/s for a 50 MW facility). Therefore, release of mineralized groundwater to the surface water environment from the power tunnel during operations is anticipated to have only a negligible effect on surface water quality in Middle Lake. Water flowing through the power tunnel from Black Lake is not expected to seep out of the power tunnel and mix with groundwater during operations. Therefore, no changes to groundwater quality are anticipated.

Successful diversion of water into the power tunnel, while maintaining historical water levels within Black Lake, will require the construction of a submerged weir. Rock used to construct the weir will consist of un-weathered rock with low potential for acid generation or radioactive materials. Therefore, the quality of water flowing through the Fond du Lac River during operations is not expected to be affected by the presence of the weir.

Withdrawal of water from Black Lake, diversion of water into the power tunnel, and subsequent discharge of water to the Fond du Lac River during Project operation is not expected to change groundwater quality, and consequently, surface water quality. Therefore, there is no linkage between the withdrawal, diversion, and discharge of water for power generation during operations and effects on fish populations.

- **Diversion of water through the power tunnel may change groundwater quantity, which can change hydrology, and affect fish habitat.**

Construction and operation of the Project may also affect groundwater quantity, which can change hydrology. Some inflow of groundwater to the power tunnel flows may occur during Project operation. Therefore, withdrawal of water from Black Lake during operations has the potential to change groundwater infiltration and subsequently the water levels in Black Lake, the Fond du Lac River, Middle Lake, and a small lake (Lake A) identified just north of the proposed power tunnel alignment (Figure 12.4-2). Changes in water levels beyond the natural range of variability may lead to changes in fish habitat availability. Shoreline erosion and re-suspension of sediments may affect the quality of remaining fish habitat.

The water table is anticipated to be near the ground surface in the Project area, based on the relatively low hydraulic conductivity of the bedrock at this location. Little infiltration from precipitation is expected. The general regional groundwater flow directions are expected to be similar to the topographic grade. Groundwater is expected to flow from high elevation areas in a radial pattern towards Black Lake, Fond du Lac River, and Middle Lake.

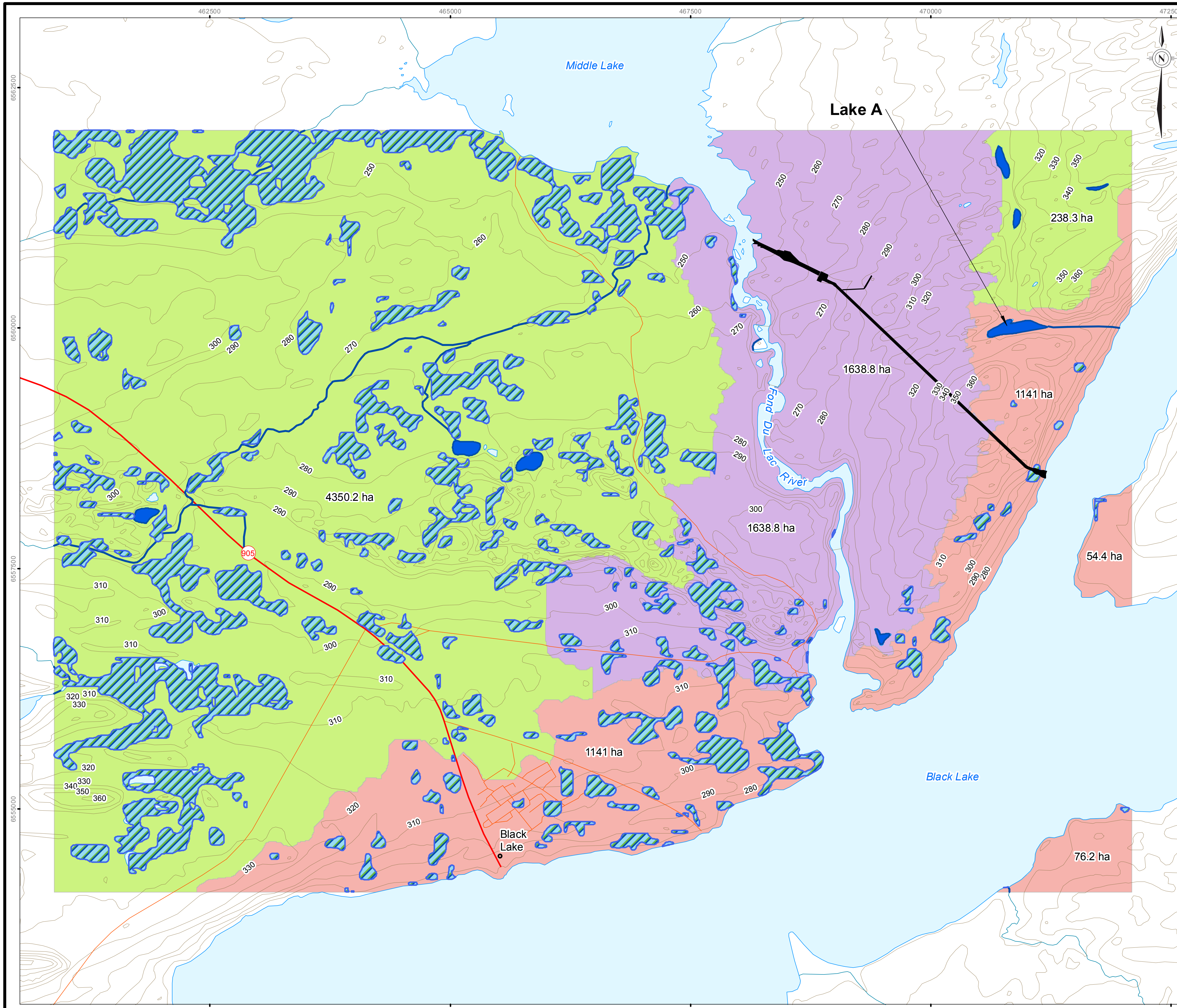
The results of the hydrological assessment (Section 10.4.2) indicate that the diversion of water through the power tunnel is not predicted to change groundwater quantity and hydrology. Therefore, this interaction is determined to have no linkage to effects on fish populations.

- **Discharge of sewage and grey water can affect surface water quality, which can affect the health of fish.**

Sewage and grey water from the Project will be transported to the Black Lake Lagoon for treatment. The amount of sewage and grey water produced at the site during Project construction and operation will be dependent upon the number of workers on site. The exact number of people employed will be determined when the design of the generating station is finalized. During the peak construction period, it is expected that the workers will produce about 30,000 L/day of sewage and grey water (e.g., the equivalent of two truckloads a day). Based on similar facilities located in remote northern regions, it is anticipated that between six and eight people could be required to operate the plant. Therefore, it is estimated that the Project will produce approximately 1,400 L of wastewater per day. Sewage and grey water from plumbing fixtures will be directed to the sanitary system and pumped to an outdoor buried fiberglass sewage-holding tank. A local sewage hauling service will pump out this sewage-holding tank as required (about once a week).

The new Black Lake Lagoon was completed in 2009, and at the time of design had a design horizon to 2018 (Lukey 2013, pers. comm.). The lagoon will have the capacity to accommodate the peak Project camp requirements (Lukey 2013, pers. comm.). The storage cell at the lagoon has a volume of 165,500 m^3, while the primary cell has a volume of approximately 100,000 m^3 (Keleman 2013, pers. comm.). Treated water is released to the west of the Black Lake Lagoon into a wetland/swamp area once every six months (in spring and in fall). Prior to release, the treated water must meet applicable water quality criteria as per Wastewater Systems Effluent Regulations (Government of Canada 2013).

As sewage and grey water will be managed on-site during construction and operations and disposed off-site at the new Black Lake Lagoon, no linkage to residual effects on fish populations are expected.



LEGEND

	VILLAGE		UPLAND AREA STREAM
	HIGHWAY		CONTOUR LINE (10M INTERVAL)
	ROAD		TUNNEL AND TAILRACE ALIGNMENT
	RIVER		DRAINS TO BLACK LAKE
	WATERBODY		DRAINS TO FOND DU LAC RIVER
			DRAINS TO MIDDLE LAKE
			UPLAND AEA WATERBODY
			UPLAND AREA WETLAND

REFERENCE

DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEET: 74P/03, 04

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

UPLAND AREA WATERBODY POTENTIALLY AFFECTED BY GROUNDWATER ENTRAINMENT IN THE POWER TUNNEL

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	08/11/13	**FIGURE: 12.4-2**	
CHECK	AO	08/11/13		
REVIEW	BC	08/11/13		

- **The interception and collection of direct precipitation and surface runoff within the Project footprint may change hydrology, which can affect fish and fish habitat.**
- **Surface water diversions (e.g., berms, ditches, waste rock disposal areas) around the Project footprint can change drainage areas, runoff characteristics, and local and downstream hydrology, which can affect fish and fish habitat.**

The Project footprint and proposed surface water diversions have the potential to change the local hydrology, such as surface runoff characteristics, which can affect available fish habitat. The footprint of the Project will be as compact as possible to limit the area affected by Project activities and subsequent changes to hydrology. The total area to be cleared is approximately 869 hectares (ha). Of this 869 ha, 589 ha will be reclaimed immediately following construction and approximately 250 ha will be required for operation. Following closure of the Project, the entire area will be reclaimed.

Protecting and managing surface drainage water (and sediment) will be addressed through implementation of a Site Water Management Plan. Surface runoff from areas unaffected by the Project will be directed away from construction areas and into natural drainage courses. Runoff that is redirected from roadways, construction laydown areas, and other areas affected by construction, including groundwater collected during construction of the power tunnel, will be collected in settling ponds. Surface runoff will also be diverted away from waste rock disposal areas as much as possible; locations of waste rock disposal areas will be such that run-on and run-off can be easily controlled. Runoff from waste rock disposal areas and power tunnel seepage water will be monitored to confirm site-specific water quality objectives are met before discharge to the environment and that effluent discharges will comply with CCME guidelines at the end of the mixing zone in the Fond du Lac River. Ditches will be sized to accommodate extreme rainfall events and riprap energy dissipaters and ditch liners will be installed in areas where runoff velocities are deemed excessive. Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns.

The preferred design and location of the traffic bridge across the Fond du Lac River is a single-pier bridge located approximately 600 m upstream of Elizabeth Falls. The abutments for the bridge will be installed so that they extend below the current high water mark, but above the high-water mark anticipated for the Project. Therefore, no changes to flows in the Fond du Lac River are expected.

Given the footprint size and design and lack of small, fish-bearing streams near the proposed Project, it is expected that there will be no changes to flows for small, fish bearing streams in the LSA and no measureable infrastructure or footprint related changes on flows of the Fond du Lac River. Effects on fish habitat from the single-pier bridge will be offset as part of the Fisheries Offsetting Plan. Therefore, the Project infrastructure-related changes on downstream flows was determined to have no linkage to residual effect on fish populations.

- **Seepage from waste rock disposal areas can change groundwater, surface water, and soil quality, and affect fish habitat and fish health.**

Construction of the powerhouse/switchyard, roads, water intake, power tunnel, and tailrace channel will produce approximately 475,000 m^3 of waste rock and 58,000 m^3 of overburden that will need to be stored on-site. The waste rock disposal areas will be placed in locations that are easily modified to control seepage and a Waste Rock Management Plan will be prepared for the Project. Excavated material will be stored near the Project construction areas, and located away from watercourses or lakes. Site grading, ditches, and berms will be used to capture runoff from the waste rock disposal areas, which will be sent to settling ponds. Surface water will be diverted around and away from waste rock disposal areas as much as possible. This runoff will be collected and water quality will be confirmed before release to the environment.

Some portion of the waste rock excavated from the power tunnel could be acid-generating, have elevated concentrations of various metals, or contain uranium mineralization, particularly waste rock from the section of the power tunnel within, or near, the Black Lake Shear Zone. The power tunnel waste will be tested for susceptibility to generate ARD and potential for metal leaching (ML) prior to being placed in waste rock disposal areas. Previous geological testing has confirmed that radioactive waste rock is not likely to be encountered in the LSA (Hatch 2005, 2012). However, waste rock will be tested for radioactivity as construction progresses. Any rock waste that is found to be radioactive will be disposed of according to provincial and federal guidelines.

If bedrock materials are ARD-generating or susceptible to ML, the rock will be segregated for special management. In this case, environmental design features will be required to limit seepage from the waste rock disposal areas. A containment system will be designed to control seepage from the waste rock disposal areas to groundwater or underlying aquifers. The design will control shallow horizontal migration. Potentially contaminated wastewater from waste rock disposal areas run-off will be collected in on-site settling ponds. The Proponent will test and treat on an on-going and regular basis to confirm that water meets guidelines as it is released to the environment. Wastewater will meet applicable effluent discharge criteria prior to being released into a nearby waterbody (i.e., Fond du Lac River); applicable water quality guidelines will be met at the end of the mixing zone in the river

If no adverse characteristics are identified in the waste rock, this material can be used as aggregate for road construction and concrete production. It can be used as riprap to armour the walls of the tailrace channel or to construct the submerged weir across the Fond du Lac River at Grayling Island. Re-use of “clean” waste rock at the Project site will reduce the overall volume stored in the waste rock disposal areas.

Ongoing monitoring requirements outside of those specified within the Project license would default to terms outlined within the relevant federal and provincial acts, regulations, and standards applicable at the time. In addition, implementation of the abovementioned mitigation is expected to result in no detectable changes in groundwater, surface water, and soil quality. Therefore, this interaction was determined to have no linkage to fish populations.

12.4.2 Interactions with Secondary Linkages

In some cases, both a source and an interaction exist, but because the change caused by the Project is anticipated to be minor, it is expected to have a negligible residual effect on fish and fish habitat relative to baseline values. The following interactions are expected to be minor and will not be carried through the residual effects assessment for fish and fish habitat.

- **Dewatering of the power tunnel during construction may change groundwater quantity, which can change hydrology, and affect fish habitat.**

During the construction of the power tunnel, water intake, and tailrace channel, work will be completed “in the dry” and potential seepage into these areas will require dewatering. The period of dewatering could continue throughout construction (i.e., three years), but is not expected to reach maximum drawdown rates until the latter stages. Dewatering activities may drawdown the local groundwater table and affect water volumes in surface waterbodies located within the zone of influence. Changes to water volumes may affect the quantity or quality of available fish habitat, as well as the ability of fish to migrate among waterbodies.

The only surface waterbody within the zone of influence and potentially affected by dewatering activities is Lake A, which is located approximately 1.5 km north of the proposed intake structure (Figure 12.4-2). This lake is assumed to be fish-bearing on the basis that its outflow to Black Lake has no known barriers to fish passage. Lake A has a drainage area of 637,000 square metres (m^2) and flows into Black Lake at an estimated average annual rate of 0.036 m^3/s; however flow rates are likely higher during the spring and summer, and lower during the late winter.

Groundwater modeling results predict an incremental flux out of Lake A at up to 0.001 m^3/s during construction. This flux rate is approximately 3% of the average annual flow though rate, indicating that the outflow channel should remain active for the majority of its flow season and that any drawdown that occurs during low inflow periods will be replenished annually.

The amount of drawdown that is expected to occur within Lake A because of power tunnel dewatering is a maximum of 5 cm and is within the range of natural variation associated with estimated annual outflow rates. Therefore, the quantity and quality of fish habitat in Lake A is not expected to exhibit a measureable deviation from baseline because of power tunnel construction and dewatering. In addition, because the outflow channel of Lake A will remain active for much of its flow season, any impediments to fish movements between Lake A and Black Lake are expected to be minor. Therefore, this Project interaction is expected to have negligible residual effect on fish populations.

- **Construction of the water intake structure, submerged weir, tailrace channel outlet, and bridge abutments may disturb sediment, which can change surface water quality, and affect fish habitat.**

Construction of the water intake in Black Lake, submerged weir, tailrace channel outlet in the Fond du Lac River, and bridge abutments will include in-water work and will therefore require an Authorization from DFO. Disturbance of sediments during in-water work can affect foraging, spawning, and rearing habitats used by fish. Settling of sediments resuspended during construction or decommissioning of in-water works can change the characteristics of habitats used by benthic macroinvertebrates that some fish species rely on for food (Steele and Smokorowski 2000). Sediment can settle and fill the interstitial spaces within the substrate, thereby affecting the food and shelter required by macroinvertebrates and young fish (Griffiths and Walton 1978). Direct physical damage to macroinvertebrates can occur by way of abrasion or clogging of gills and feeding structures (Griffiths and Walton 1978).

Appropriate precautions will be taken during in-water construction works to reduce potential effects on fish and fish habitat. These include the following:

- completing in-water construction works in accordance with the conditions outlined in the DFO Authorization;
- completing fish salvages for in-water work areas prior to the commencement of in-water works;
- using cofferdams or turbidity barriers to contain sediment released during in-water construction work to isolate in-water works from flowing water and adjacent lake habitats, thereby reducing the potential for downstream or off-site impacts;
- developing a turbidity/TSS regression and implementing a Turbidity Monitoring Program during in-water construction work to identify if further mitigation is required at the excavation site or at any sensitive receptor near the excavation site;

- having an environmental monitor on site during in-water work to monitor compliance with the construction specifications and Project approvals;
- directing dewatering operations toward sediment control devices (e.g., settling ponds) or natural attenuation areas prior to discharge to watercourse;
- discharging water to watercourses in a manner that does not cause erosion or other damage to discharge areas; and
- developing and implementing a Sediment and Erosion Control Plan for the Project.

Changes to surface water quality from the release of sediment during construction of the water intake, submerged weir, tailrace channel outlet, and bridge abutments are expected to be minor due to mitigation, use of appropriate construction methods, and adherence to regulatory guidance and of short duration. Consequently, this Project interaction is anticipated to have negligible residual effects on fish and fish habitat.

- **Fish salvage from exclusion zones may result in incidental mortality of fish.**

Construction of in-water works will require work areas to be effectively isolated from the surrounding waterbody or watercourse. Isolation devices such as turbidity curtains could be used to reduce the potential effects of sediment releases to fish and fish habitat located downstream or at a distance from the work site. During construction of turbidity isolation barriers, some fish could be trapped within the work area, and therefore, isolated from the remainder of the waterbody or watercourse. Fish salvage operations usually are completed to prevent injury or mortality to fish stranded within work isolation areas.

Qualified biologists will oversee fish salvage operations with properly trained staff to remove fish from the in-water work isolation area, and mitigate negative effects of construction activities to trapped fish. Fish salvage operations will begin once isolation barriers are in place. In-water construction works at the Black Lake water intake and the tailrace channel outlet location will not begin until the fish salvages for these areas are complete.

The primary objective of the fish salvage will be to recover trapped fish and return them to the surrounding waterbody or watercourse without injury or mortality. Appropriate non-lethal fish capture methods (e.g., fyke traps, minnow traps, and beach seines) could be used in addition to short-duration small-mesh gillnet sets and will be selected based on site conditions. Only a small number of captured fish will be measured for length and weight to decrease handling times and increase fish survival. If conditions allow, a fish recovery pen will be set up outside of the isolation area to allow fish to recover while safe from predation. Fish will be released from the holding pen periodically throughout the day.

It is unlikely that 100% of the trapped fish will be captured during the salvage due to the size and depths of the isolated work areas, and fish sampling and handling will likely result in some incidental mortality. Although some incidental mortalities are expected to occur, it is anticipated that this Project interaction will have a negligible effect on fish populations.

- **Use of explosives near fish-bearing waters can cause injury or mortality to fish, which can affect fish populations.**
- **Use of explosives near surface waterbodies can change surface water quality and affect fish habitat quality.**

Ammonium Nitrate/Fuel Oil (ANFO) and water resistant bulk emulsion explosives will be used during the construction phase of the Project. Use of explosives near fish-bearing waters has the potential to injure or kill fish. Detonation of explosives in or near water creates compressive shock waves that rapidly rise to high peak pressures then rapidly decrease to below ambient hydrostatic pressure (Wright and Hopky 1998). The rapid decrease in pressure produced by blasting has the potential to negatively affect fish in the vicinity by damaging the swim bladder and other soft organs (Wright 1982; Keevin et al.1999). Blasting overpressures greater than 100 kilopascals (kPa) are expected to cause these types of injuries in juvenile and adult fish. Fish eggs in the area affected by pressure waves can be damaged by the movement of the substrate in which they are embedded (Wright 1982). Fisheries and Oceans Canada guidelines state that "No explosive is to be detonated that produces, or is likely to produce, a peak particle velocity >13 millimetres per second (mm/s) in a spawning bed during the period of egg incubation" (Wright and Hopky 1998).

A detailed Blasting Plan will be developed for the Project and will contain contingencies and mitigations to reduce the potential for harm to fish and fish habitat. The Blasting Plan will comply with DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters (Wright and Hopky 1998). Restrictions will be placed on blasting during critical fish spawning periods so that adult fish are not deterred from using regular spawning areas and to protect fish fry and larvae. Set-back distances required for blasting of the water intake foundation, powerhouse foundation, and tailrace channel will be determined and included in the Blasting Plan. Charge sizes, blasting sequences, and any additional measures required to deaden vibrations (i.e., strategic positioning of aggregate material) will be described in the Blasting Plan.

Use of explosives during the construction phase of the Project could affect surface water quality (see Section 11.5.2 and Appendix 11-1), therefore fish, and fish habitat. Blasting activities and the removal of waste rock could increase dust deposition in surrounding waterbodies. Dust deposition in waterbodies can affect fish and fish habitat by increasing the TSS and trace metal (e.g., aluminum, cadmium, chromium, copper, iron, mercury, and silver) concentrations. Some types of explosives used in blasting also have the potential to release substances (e.g., ammonia and nitrate) which may affect surface water quality in nearby waterbodies. Therefore, a Site Water Management Plan will be developed for the Project and seepage water will be collected in sumps and pumped to settling ponds. Wastewaters discharged into receiving waterbodies will meet applicable water quality guidelines (i.e., CCME) at the end of the mixing zone.

The use of explosives near surface waterbodies in the LSA has the potential to affect health and survival of some fish. However, many of the effects of blasting can be mitigated by following DFO guidelines and modifying the blast schedule based on critical fish spawning windows. It is therefore anticipated that this interaction will have a negligible residual effect on fish populations.

- **Withdrawal, diversion, and discharge of water for power generation may change hydrology, which can affect fish habitat (in reaches 2 and 22 of the Fond du Lac River).**

Construction and operation of the Project will reduce water flows in some areas of the Fond du Lac River between Black Lake and Middle Lake (i.e., during commissioning of the plant and installation of the weir). It is anticipated that reduced flows and associated reductions in water surface area and volume may result in the loss of fish habitat or changes to the quality of available fish habitat. Some side channel areas or pools may become isolated during reduced flows and potentially prevent fish movement back into the main river channel. Reduced velocities in some areas of the river may make some habitats more accessible or more suitable for fish. Changes to the quantity and quality of overwintering, spawning, and foraging habitats available to Arctic grayling (i.e., the VC) in the Fond du Lac River may affect abundance and distribution of this species. Mitigation incorporated into the Project to limit changes to hydrology and the subsequent loss and alteration of Arctic grayling habitat in Reaches 2 and 22 of the Fond du Lac River between Black Lake and Middle Lake include the following:

- constructing a submerged weir at Grayling Island to maintain water levels in Black Lake and the uppermost section of the Fond du Lac River for all powerhouse operating flow conditions;
- selecting a tailrace channel outlet location that is upstream of important spawning habitat near the Fond du Lac River outflow to Middle Lake to maintain minimum required flows at this location during the Arctic grayling spawning and rearing periods (from May 15 to July 15);
- scheduling planned outages for power plant maintenance for times outside of the spring spawning and rearing period (May 15 to July 15);
- installing a flow bypass conduit to maintain riparian flows during unplanned maintenance shutdowns that may occur during the spring spawning and rearing period (from May 15 to July 15) and low winter flow period; and
- developing a Fisheries Offsetting Plan in conjunction with DFO.

Changes to water levels within Reach 2 are expected to be limited because the proposed submerged weir at Grayling Island is designed to maintain historical water levels within Black Lake and the uppermost section of the Fond du Lac River (i.e., Reach 2 in Figure 12.3-1 and Appendix 12.1, Figures 1 and 2). Therefore, minor changes to Arctic grayling habitat expected to occur are assessed as a secondary effect interaction for Reach 2. Changes to fish habitat in Reach 22 are assessed as a secondary interaction because water diverted for the Project will re-enter the Fond du Lac River at Reach 22 (Figure 12.3-1 and Appendix 12.1, Figures 1 and 2). Flows and water levels in the Fond du Lac River are expected to return to historically normal values at this location. Changes to Arctic grayling habitat in Fond du Lac River reaches 3 through 21 (Figure 12.3-1 and Appendix 12.1, Figures 1 and 2) are considered to be a primary Project interaction and are discussed in Sections 12.4.4 and 12.5.2.

Overwintering and spawning habitats available to Arctic grayling in the Fond du Lac River between Black Lake and Middle Lake were assessed based on flow data for winter (i.e., the lowest annual flow period) and the spring spawning season. Details of the assessment are presented in Appendix 12.1. It is anticipated that withdrawal, diversion, and discharge of water during winter will not have an effect on the quantity or quality of overwintering habitat available to Arctic grayling in Reach 2 due to the stabilizing effect of the submerged weir on Black Lake outlet water levels. However, it is anticipated that power generation and changes to hydrology in the Fond du Lac River will result in a general increase in suitable overwintering habitat for age-0, juvenile, and adult Arctic grayling in Reach 22, relative to normal baseline conditions. During conditions of low (i.e., Q10 average low) and high (i.e., Q90 average high) spring flows, Project operation will result in a net increase in the quantity of suitable Arctic grayling spawning habitat in reaches 2 and 22. The amount (m^2) of suitable Arctic grayling spawning habitat in reaches 2 and 22 is expected to remain relatively stable (i.e., gains of 1.1% and 3.8%, respectively) when the Project is operating under conditions of historically normal average spring flows (i.e., at 210 m^3/s riparian flows with a water diversion and discharge rate of up to 190 m^3/s).

It is anticipated that changes to hydrology within the bypassed section of the Fond du Lac River will have implications for the foraging habitats available to fish, as well as the sources and types of foods consumed. Arctic grayling feed primarily at the surface and tend to consume drifting prey items (Stewart et al. 2007). Young Arctic grayling feed primarily on zooplankton, shifting to immature insects as they grown in size. Adult grayling are primarily planktivorous (Schmidt and O'Brien 1982), although they will feed on a large assortment of invertebrates, including aquatic and terrestrial insects (Scott and Crossman 1973). The insects consumed include caddisflies, midges, bees, wasps, grasshoppers, ants, and varieties of beetles. They also will feed on small fishes, eggs, and crustaceans (Scott and Crossman 1973). Arctic grayling position themselves within the water flow so that the energy expended while feeding is minimized and the amount of energy gained from consumption of drifting organisms is maximized (Stewart et al. 2007). O'Brien et al. (2001) reported that the width of a fish's search window (i.e., the area or territory a fish would use while feeding) is likely to increase with decreasing flow velocities, and fish are more likely to efficiently locate drifting prey. Hughes and Dill (1990) also reported that prey capture efficiency of Arctic grayling increases with decreases in stream velocities. This is attributed, in part, to the fact that at faster velocities, prey items are swept downstream at a rapid rate, and fish must therefore react swiftly to capture prey before it is swept past their search window and carried downstream (Hughes and Dill 1990). Therefore, the abundance of drifting prey items at higher velocities is often offset by a fish's reduced ability to capture prey at high velocities. Because flow velocities will be reduced in the Fond du Lac River, it is anticipated that drift-feeding Arctic grayling will spend less time and energy moving back and forth between velocity refugia and preferred feeding positions, and will be more efficient at capturing drifting prey. Therefore, it is anticipated that reduced flow velocities within many areas of the Fond du Lac River will result in a net increase in suitable (i.e., easily used) foraging habitat.

Changes to flow velocities at the Black Lake outflow to the Fond du Lac River and in the bypassed sections of the river during Project operation can affect the amount and types of drifting food available to downstream Arctic grayling. Because a minor increase in velocities is expected to occur over a short distance at the proposed weir, it is possible that a greater number of invertebrates will be dislodged from the substrate at this location and will drift downstream. Conversely, some reaches in the bypassed river sections could have reduced velocities such that benthic invertebrates are not dislodged from the substrates and carried downstream (Stantec 2010). It is anticipated that production of some small insect nymphs and invertebrates that are not tolerant of high-velocity flows will increase in slower-moving areas of the Fond du Lac River and could therefore serve as a localized, abundant food source for Arctic grayling and other species (Bunn and Arthington 2002).

Reductions in the wetted width of the river may reduce the quantity of habitat available to macroinvertebrates that some fish depend upon for food (Stantec 2010). However, displaced invertebrates are expected to recolonize other areas of the river that are suitable or become suitable post-project because many species have winged adult life stages that can move among river sections (Lessard and Hayes 2003). In addition, decreased depths and velocities within the bypassed section of the Fond du Lac River could improve productivity within the permanently wetted channel. Food items sourced from within the river could be increasingly important relative to drifting food items during Project operation.

In summary, it is anticipated that changes in hydrology within Reaches 2 and 22 from water withdrawal, diversion, and discharge will be minor and therefore, negligible residual effects on fish populations are expected. Changes to Arctic grayling habitat in Fond du Lac River Reaches 3 through 21 are considered to be a primary Project interaction and are discussed in Sections 12.4.4 and 12.5.2.

- **Withdrawal and discharge for power generation may change the temperature of the water, which can affect fish habitat.**

Diversion of water for hydroelectric power generation can affect surface water quality, and subsequently fish and fish habitat. Changes to water temperatures at the water intake site and in waterbodies downstream of the discharge location are often among the most prevalent surface water quality issues encountered at hydropower facilities (Oak Ridge National Laboratory [ORNL] et al. 2010). Water diverted for power generation is often withdrawn from near the reservoir bottom; in temperate regions where lakes and reservoirs tend to be thermally stratified, this can lead to withdrawal of cooler water in the summer and relatively warm water in the winter (ORNL et al. 2010). Withdrawal and discharge of cooler bottom water in the summer, for example, may cause water temperatures at the water intake site to increase and water temperatures downstream of the power generation facility to decrease (Department of Electricity Development [DOED] 2002). The opposing phenomenon would be expected during winter, when inverse stratification is likely to occur in lakes and reservoirs. These untimely changes to water temperatures at the water intake and locations downstream of the discharge site can affect overwintering, spawning, and foraging habitats, as well as the processes and behaviors that are important to survival of fish (Scotland and Northern Ireland Forum for Environmental Research [SNIFFER] 2011).

The water intake for the Project has been designed to reduce the thermal effects of water withdrawal and discharge, and subsequently, mitigate potential environmental effects on fish and fish habitat. The water intake approach channel will be designed and constructed so that diverted water is withdrawn from near the surface of the lake, thereby reducing temperature differences between Project water and water entering the river through the natural Black Lake outlet (Appendix 12.3). Because Black Lake will not be impounded, the volumes and temperatures of water flowing out of the lake during operation (i.e., through the natural outflow and the intake) will be similar to current values (i.e., volumes and temperatures of water flowing out the natural outflow) throughout much of the year. However, it is possible that during winter, water withdrawn from greater depths (i.e., closer to 5 m deep) in Black Lake could be slightly warmer than water draining naturally at the outlet to the Fond du Lac River. Overall, no measureable changes to water temperature in Black Lake are anticipated.

Water withdrawn from Black Lake will pass through a 2.95 km long power tunnel to the powerhouse and then discharge into an open tailrace channel, which flows into the Fond du Lac River approximately 5 km downstream of the natural Black Lake outlet and about 1 km upstream of Middle Lake. The tailrace channel will be approximately 800 m long. It is anticipated that water passing through the Project facility will not have the same opportunity to cool (winter) or warm (summer) as water passing down the Fond du Lac River under open channel flow conditions. During winter, water entering the Fond du Lac River from the tailrace channel may cool slightly when exposed to cold air, but is expected to be slightly warmer than the natural flow in the Fond du Lac River where the two flows converge, upstream of Middle Lake (Golder 2013a). The tailrace channel is expected to remain open over its entire length during winter, due to the velocity of the flows as well as the temperature of the discharge.

Because flows in the bypassed Fond du Lac River reaches will be reduced, it is anticipated the rate of heat exchange between the water remaining in the river channel and ambient air will increase, thereby potentially altering water temperatures. The most extreme temperature effects of the Project would be expected to occur during the periods of lowest riparian flow and extreme cold (i.e., winter), as well as periods of extreme heat (summer). The model analysis presented in Appendix 5.1 predicts that the river water temperature will decrease as water flows from the Black Lake outlet to the tailrace discharge area between November and March, and increase slightly in April. The modelled data also indicates that riparian flow temperatures could fall as low as 0.0 degrees Celsius (°C) when the Project is operating during winter and riparian flows in the Fond du Lac River are reduced to approximately 40 m^3/s (Golder 2013a). This could result in some formation of ice cover in the Fond du Lac River between the outlet of Black Lake and the junction with the tailrace outlet. Of note, the temperature modelling was carried out using the recorded temperature data associated with the Water Survey of Canada water level recorder at the outlet of Black Lake. Because the accuracy of the WSC water temperature recorder is plus or minus 3°C, the modelling outputs must be interpreted with caution due to the small potential temperature changes being considered (less than 0.5°C). Project related water temperature increases in the Fond du Lac River due to reduced flows during summer are anticipated to be negligible due to higher flow volumes than in winter, more rapid transit through the reduced flow portion of the river, and less temperature difference between river water temperature and ambient air temperature than during winter.

To confirm the water temperature modelling results and remove some the uncertainty associated with the water temperature data used in the modelling, more accurate temperature loggers were installed in the Fond du Lac River near Grayling Island (four) and upstream of the tailrace channel outlet (three) in fall 2013. The objectives are to monitor winter water temperatures in the river at the outlet of Black Lake and just upstream of the proposed tailrace outlet location, compare water temperatures recorded by the new temperature monitoring loggers with those measured at the Water Survey of Canada (WSC) station, and determine the statistical variance among stations. Instantaneous and daily average water temperature values will be compared for the sensors over the period of record. These data will also be compared to WSC station temperature data for the same period. Statistics describing averages and variance among stations will be provided in a technical memorandum. If the results show insignificant differences between the temperature loggers and the WSC daily temperature data, then no further modelling is likely necessary. Monitored results from sensors at the downstream location will be used to confirm modelled results. This information will be available in June 2014.

Water temperatures were previously monitored at several locations in the river between Black Lake and Middle Lake during the open water period. To date, the only winter water temperature data available was collected at the Black Lake outlet Hydrometric Station 07LE002. Therefore, the additional water temperature data will be used to verify previous WSC station temperature data that were used for water temperature modelling, and to compare the modelled temperature changes between the Black Lake outlet and the river section immediately upstream of the tailrace confluence.

Water temperatures downstream of the tailrace channel outlet in the Fond du Lac River will be governed by mixing of water that has passed through Project infrastructure (i.e., water intake, power tunnel, and tailrace channel) and water that has flowed through the bypassed river reaches. The maximum difference between the river temperature upstream of the tailrace channel outlet in the Fond du Lac River and the mixed river temperature downstream of the tailrace channel discharge is expected to be approximately 0.5°C, given a conservative scenario with minimum river flows (i.e., 40 m^3/s). Based on this riparian flow rate, the temperature of water entering Middle Lake in the winter months is expected to be approximately 0.3°C warmer than under current conditions (again, assuming conservative low flow conditions).

In winter, cooler ambient air temperatures and reduced riparian flow volumes resulting from Project operation could affect overwintering habitat of fish by reducing water temperatures and increasing the potential for ice formation (Stantec 2010) in the bypassed section of the Fond du Lac River. Formation and buildup of frazil ice has the potential to damage fish habitat and may be a direct cause of fish injury and mortality. Because riparian flow temperatures could fall as low as 0.0°C in winter when flows in the river are low (i.e., less than 50 m^3/s), there is potential for frazil ice to form in the river reaches below Elizabeth Falls and upstream of the tailrace channel outlet. The potential for formation of frazil ice will be reassessed following analysis of the temperature data currently being collected (winter 2013/2014). This information will be available in June 2014. Formation of anchor ice (i.e., submerged ice that is anchored to the bottom) is not reported to occur in Black Lake, Middle Lake, or the connecting section of the Fond du Lac River under current temperature and flow conditions. Formation of frazil ice and anchor ice is not expected to be an issue downstream of the tailrace channel outlet when the Project is operating because the mixed water is expected to be slightly warmer during winter. Because the water entering Middle Lake during winter may be slightly warmer than under current conditions, it is anticipated that the period and spatial extent of ice cover on Middle Lake may be somewhat reduced.

In spring and summer, the reduced flow of water in the bypassed reaches of the Fond du Lac River could become heated by relatively warm ambient air. Elevated water temperatures during spring may affect onset of fish spawning or duration of egg incubation. Excessive heating in summer (i.e., the warmest part of the annual cycle) could result in heat stress and direct mortality of fish or could alter biological productivity within the river reaches and therefore affect the food and foraging habitats of fish (DOED 2002). Increased water temperatures in the bypassed section of the Fond du Lac River are expected to result in a net increase in productivity at the lower trophic levels (e.g., plankton, macroinvertebrates; Rader and Ward 1988). However, composition of these communities may change based on the temperature tolerances of resident species (Lessard and Hayes 2003). Changes to water temperature regimes could affect the timing associated with emergence of macroinvertebrates (Bunn and Arthington 2002); this could affect what prey items may be available at certain times of the year for young and adult fish.

Changes to water temperature from withdrawal and discharge of water for power generation are expected to have negligible residual effects on fish populations due to implementation of environmental design features and maintenance of minimum instream flow requirements.

- **Maintenance shutdowns of power generation activities can change surface hydrology, which can affect fish and fish habitat.**

Scheduled maintenance shutdowns of the Project's power generating facility have the potential to change surface hydrology, which could affect fish and fish habitat. Scheduled shutdowns are expected to occur:

- once per month to perform minor adjustments, inspections, and maintenance;
- annually, on a unit-by-unit basis;
- every five years for routine tunnel inspection; and
- every 30 years for major overhaul work on the turbine and generator units.

It is anticipated that only one generating unit at a time will be removed from service during scheduled maintenance shutdowns. Maintenance shutdowns will be completed during winter months, during other periods when there is less flow available to pass through the powerhouse turbine generation units, or during summer when sufficient water is available. Planned shutdowns will not be scheduled during the spring spawning and rearing period (from May 15 to July 15).

The monthly maintenance shutdowns for minor adjustments, inspections, and maintenance are expected to last for less than eight hours. Annual inspections would be scheduled to avoid spawning periods and are expected to last for periods of up to two weeks. To accommodate the power tunnel inspections, the entire plant would be shut down for approximately 1.5 to 2 weeks every five years. Major overhaul work that will be conducted on a 30-year cycle will be completed over a period of approximately two to three months. This maintenance routine is based on the Project design engineer's experience with hydroelectric plant operations. The Proponent may choose, if required, to undertake scheduled maintenance in a manner that is not consistent with the schedule presented above.

Currently, there are no specific regulatory guidelines for ramping rates in the Province of Saskatchewan and no protocols are available for evaluating independent site-specific ramping studies. However, following discussions with DFO biologists, it is believed that a water level reduction rate between 5 and 10 centimetres per hour (cm/h) might be considered acceptable (Golder 2013b). Water levels downstream of the Project will be managed using a bypass conduit.

During scheduled power tunnel inspection and maintenance (approximately every five years), flow through the power tunnel (including bypass flow) will cease for approximately 1.5 to 2 weeks. Shutdown will result in the maximum reduction in downstream flows that is expected to occur below the tailrace channel during Project operations. Effects to fish and fish habitat would be expected to be reduced if power tunnel inspections were scheduled for early May to coincide with the start of the spring freshet when flows are increasing, but prior to the start of spring fish spawning. During this period, flows in the Fond du Lac River would be rapidly increasing and the change in flow would be proportionately lower than during other times of the year (Golder 2013b).

By timing turbine and power tunnel maintenance around flow requirements of aquatic biota, removing only one turbine at a time from operation where possible, employing a bypass conduit where possible, and limiting the duration of the shutdowns, minor changes to hydrology are expected from maintenance shutdowns. Therefore, this Project interaction is expected to have negligible residual effects on fish populations.

- **Collection and disposal of wastewater from the site can cause changes to hydrology, which could affect fish habitat.**
- **Collection and disposal of wastewater from the site can cause changes to surface water quality, which could affect fish health and habitat.**

Discharge of wastewater during Project construction and operation can change hydrology, as well as surface water quality, which in turn can affect fish and fish habitat. Site wastewater will be of several types, including waste rock runoff, groundwater collected and treated during the construction of the power tunnel, general site runoff, and water in settling ponds. To mitigate effects on fish habitat and fish health, a Site Water Management Plan will be developed for the Project.

Three settling ponds have been included in the construction plan for the Project and will act as environmental design features for the treatment and management of the Project's wastewater (other than site runoff and sewage and grey water). One settling pond will be located near the water intake to collect the intake construction water along with a portion of the power tunnel dewatering flows and waste rock runoff from the waste rock disposal area south of the intake (Figure 5.1-1). A second settling pond will be located near the powerhouse excavation to collect the remainder of the tunnel and powerhouse dewatering. A third settling pond, beside the downstream end of the tailrace channel, will collect the tailrace channel dewatering and any runoff directed from the main waste rock disposal areas to the northeast of the tailrace channel (Figure 5.1-1). Water collected in disturbed areas located away from the settling ponds will be pumped to these locations. Surface water diversions could also be constructed to maintain natural drainage characteristics, whereas other structures could be designed to actively divert water away from its natural flow path to prevent the interaction with site infrastructure, potentially contaminated water, or areas sensitive to erosion.

Retention of runoff in the settling ponds will allow suspended sediments and associated parameters (e.g., some metals) to settle out. This water will eventually be discharged downstream to its natural receiving waterbody (the Fond du Lac River through the tailrace channel). Water quality in the settling ponds will be tested and will meet appropriate discharge criteria (if required) prior to release into the environment. A Water Quality Monitoring Program will be implemented to determine the nature of potential changes to the water quality of the Fond du Lac River receiving discharge from the settling ponds. Waste water in the settling ponds will be discharged to the Fond du Lac River at one of the potential discharge locations in Figure 5.3-3 after the water has been tested and confirmed to meet appropriate discharge criteria. Discharge criteria will be developed during the permitting process, if required. Contingency plans for off-site disposal of dewatered settling pond sludge will be included in an EnvPP.

During power tunnel construction, it is estimated that a maximum of 4,700 m^3 of groundwater will seep into the power tunnel each day (m^3/day). The volume of groundwater inflow is expected to be 680 m^3/day during operations. Power tunnel seepage water will be pumped into above ground settling ponds where it will be treated, if required, and monitored to confirm discharge criteria are met prior to release into the environment.

The results of the water quality modelling indicate that only minor, short-term changes would occur to the water chemistry of the Fond du Lac River during the construction phase because of discharge from the settling pond (Section 11.0, Appendix 11.1). For example, predicted concentrations of various parameters are within the range of baseline concentrations measured in 2010 and 2011. As well, these changes would not involve exceedences of applicable water quality guidelines under fully mixed conditions, or at the edge of the applicable mixing zone in the river.

Discharging settling pond water to the Fond du Lac River has the potential to affect fish and fish habitat; however, based on the proposed mitigations and water quality modelling results (Section 11, Appendix 11.1), it no measureable effects to fish and fish habitat are anticipated. Treated effluent discharges will only be released during the construction phase of the Project, and not during operation when riparian flows are reduced. Therefore, areas of moderately suitable or suitable overwintering and spawning habitat identified for the pre-Project winter (210 m^3/s) and spring (302 m^3/s, 400 m^3/s, and 510 m^3/s) flow scenarios, respectively, were examined to determine if the discharge plumes in the Fond du Lac River are likely to affect critical habitats. During winter, when flows in the river are approximately 210 m^3/s, adult Arctic grayling will have access to extensive areas of suitable overwintering habitat upstream of the discharge location and in areas downstream of the plume, based on a plume that extends a distance of 1.2 km below the discharge location. Some small pockets of suitable overwintering habitat for age-0 and juvenile Arctic grayling occur along the shorelines at the discharge location. However, effluent plumes below the discharge locations will be entrained with riverine flows and mixed such that the plume will move down the centre of the river. The expanding and diluting plume is not expected to reach shoreline areas for some distance downstream (i.e., several hundred metres) of the discharge location. Therefore, discharges are unlikely to affect fish and fish habitat during winter. The same principles apply during spring when flows in the river are in the average (400 m^3/s) to low (302 m^3/s) range. Small pockets of potentially suitable spawning habitat along the shorelines at the discharge/plume location are unlikely to be reached by the plume. At 510 m^3/s, there is no suitable spawning habitat in the vicinity of the discharge, or within 1.2 km downstream.

Access roads within the site will be kept to a minimum (i.e., limit the number of roads) to reduce effects on the environment. Surface water will be directed into natural flows by means of swales, culverts, and ditches where necessary to maintain local drainage patterns. Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns and ditch capacities will be sized to accommodate an extreme daily rainfall event. Riprap energy dissipaters and ditch lining will be used in areas where the predicted runoff velocities are deemed excessive to reduce soil erosion.

Overall, surface water runoff and wastewater within the Project footprint are expected to result in minor changes to hydrology and surface water quality. Therefore, these interactions were determined to have negligible residual effects on fish populations.

- **Cessation of power generation activities, including the withdrawal, diversion, and discharge of water, can change hydrology and surface water quality, which can affect fish and fish habitat.**

The assessment boundary for Project operation is 90 years. It is anticipated that cessation of power generation and removal of the submerged weir at the outlet of Black Lake will allow for the re-establishment of natural (i.e., pre-development) flow regimes in the Fond du Lac River. This is expected to have effects on terrestrial vegetation and the habitats available to fish. Areas that dried and became colonized by terrestrial vegetation over the course of Project operation would be re-flooded. Inundated terrestrial vegetation may provide some additional cover for some species and life-stages of fish in the river. Returning flows in the Fond du Lac River to pre-Project levels is expected to increase the maximum depths of bypassed river reaches and increase flow velocities to pre-Project (i.e., historical) values.

A Decommissioning and Reclamation (D&R) Plan will be developed for the Project. Decommissioning, when it occurs, is expected to be completed in compliance with all federal and provincial acts, regulations, and standards applicable at the time, and in discussion with BLFN. Plans for development of habitat restoration plans and additional monitoring plans will be discussed prior to cessation of power generation and commencement of site decommissioning. It is anticipated that a series of concrete bulkheads will be placed in the power tunnel, if necessary, to isolate mineralized bedrock zones and reduce potential for mineralized groundwater to discharge through the power tunnel. Quality of groundwater discharging through the power tunnel could be monitored, if required.

Because Project closure is expected to comply with applicable and timely regulations, standards, and guidelines, and provisions for design and implementation of reclamation and restoration plans will be in place, it is anticipated that this Project interaction will have negligible residual effects on fish populations.

12.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events occurring on-site have the potential to affect fish and fish habitat. The following events were identified as having a potential interaction with fish and fish habitat.

- **Emergency shutdowns of power generation activities can change surface hydrology, which can affect fish and fish habitat.**

It is estimated that the power plant will undergo between 10 and 50 emergency shutdowns per year, with most of these occurring during the summer months (i.e., weather-related). The power plant will be shut down without advance notice if there is a load rejection in the transmission system due to transmission line failure. These unplanned shutdowns are expected to be relatively brief, typically from a few minutes to four or five hours. On occasions during the spring fish spawning and rearing period (May 15 to July 15), when the unplanned shutdown exceeds 15 minutes, the bypass facility at the powerhouse will begin releasing flow to reduce drawdown effects on the Fond du Lac River below the tailrace outlet and upstream of Middle Lake. During these periods, flows through the natural outlet would slowly increase as water levels in Black Lake respond to reduced power tunnel outflows.

Construction and operation of a control structure at the outlet of Black Lake was considered as a flow-bypass option for the Project. However, the structure would require manual operation and it is estimated that water bypassed at this location would take approximately two hours to reach downstream spawning areas. The BLFN also indicated that a control structure at this location would decrease the aesthetic appeal of the river. The turbine generator units for the proposed power plant will be equipped with turbine inlet valves (TIV) to start and stop flows. These will act as the spigot at the end of the power tunnel and control the flow into the powerhouse. The TIVs will be designed to close at a rate that will avoid undesirable increases in water pressure in the power tunnel.

A surge facility (adit) will be incorporated into the Project conveyance system to control hydraulic transient pressures. The surge facility will limit the rise and fall of pressure when the turbine and generator units experience a load rejection by quickly reducing the water flow. The surge facility will limit the reduction in pressure when the units are started or when the load quickly increases. Due to the length of the power tunnel, the units would not maintain a constant speed while reacting to load changes if there was no surge facility.

The surge facility will be an inclined tunnel branching off the power tunnel and emerging at the surface at an elevation sufficient to contain the highest water pressures during operation, which will be above the surface level of Black Lake. The surge facility will provide access to the power tunnel during construction. An alternate design option being considered uses a raised bore vertical shaft excavated in the rock to the surface above the level of Black Lake. The surge facility will connect to the power tunnel a short distance upstream of the powerhouse.

Modelling has been completed to simulate a worst-case scenario wherein all turbine units are shut down for an extended period. Water levels at a key Arctic grayling spawning and rearing area located on the west shore of the Fond du Lac River downstream of the tailrace channel outlet are expected to decrease from 0.2 to 0.5 m within 10 to 15 minutes of a full plant shutdown. Water levels in Middle Lake would also begin to drop immediately following a full plant shutdown; however, any changes to water levels in the lake would be almost undetectable during the first hour of the outage. The maximum rate of water level drop in Middle Lake is estimated to be 5 centimetres per hour (cm/h). The modelled results suggest that if an outage occur when total combined flows in the lower portion of the Fond du Lac River are near 245 m^3/s, bypass of plant flows needs to commence within 10 to 15 minutes to prevent water levels at the Arctic grayling spawning bed from dropping below target levels for the protection of eggs and fry. During larger combined river flows (i.e., when flows below the tailrace channel are greater than 245 m^3/s), the necessary response time would be increased. It is recommended that ramping rates below the tailrace channel in the Fond du Lac River be monitored and the time between cessation of power generation and start of bypass flows be adjusted accordingly to prevent loss of eggs and fry.

River2D analyses and modelled flows for the 48 years of record indicate that the key Arctic grayling spawning and rearing area located on the west shore of the Fond du Lac River downstream of the tailrace channel outlet is naturally dry during the spring period in some low-flow years (i.e., 13% of the time). Spawning is expected to be unsuccessful at this location approximately one year in ten under natural conditions; however, the overall rate of reproduction is sufficient to sustain the Arctic grayling population. If no bypass conduit were installed for the Project, it is estimated that this spawning area would be dry for approximately one in every three years (i.e., 31% of the time). With the Project operating and the 80 m^3/s proposed bypass conduit in place, it is estimated that the spawning area downstream of the tailrace channel in Reach 22 will be dry 23% of the time that unplanned outages occur during the spawning period. This is equivalent to the current natural spawning failure rate resulting from low flows (13%) plus a 10% incremental spawning failure rate due to Project-induced low flows. Spawning at this location is expected to be unsuccessful for two out of ten years when the Project is operational.

Environmental design features are expected to mitigate changes to surface flows during an emergency shutdown and therefore minor detectable changes to hydrology are expected. At most, a 10% incremental spawning failure rate is expected should a plant shutdown occur during the Arctic grayling spawning period. The loss of spawning habitat and the associated predicted increase in the rate of spawning failure will be addressed in the Fisheries Offsetting Plan. Offsetting activities under consideration include construction of Arctic grayling spawning habitat near the tailrace outlet at an elevation where eggs and fry would not be lost at low riparian flows (Appendix 12.2). Because adverse effects on fish will be reduced by mitigation measures or offset as part of the Fisheries Offsetting Plan, this interaction was determined to have a negligible residual effect on fish populations.

- **Release or spills of hazardous substances (e.g., fuel, oil) can change surface water, sediment, and soil quality, which can affect fish habitat and fish health.**

Spills during construction, operations, or decommissioning and reclamation activities following closure have the potential to change surface water, sediment, and soil quality, which can adversely affect fish and fish habitat. Spills that occur in high enough concentrations could contaminate runoff and surface water and cause direct toxicity to fish and their food items. Spills are generally preventable and local in nature. Spills will be promptly reported and managed according to the procedures identified in the Emergency Response Plan. Mitigation identified in the EnvPP will be implemented to reduce the likelihood and extent of spills associated with the Project.

The powerhouse will be equipped with an oil containment and separation system to prevent the release of petroleum-based wastes into waterways. The turbine governor pumping systems will be surrounded by trenches or curbs to allow drainage through a trench or sumps to catch and to transfer wastes to the powerhouse oil separation system. Any room with the potential to produce an oil spill will also be equipped with containment curbs and door ramps. Additionally, the governor hydraulic power units will be high-pressure systems to reduce the potential for spills by minimizing the total volume of hydraulic oil in the system. The main transformers will be removed from the main tailrace channel deck and surrounded by oil spill containment walls to reduce the potential for spills to interact with the waterways. Double-walled heat exchangers will be used for the turbine and generator cooling systems to reduce the risk of cooling coil failure will discharge oil into the water. Self-lubricated bushings will be employed throughout the design to eliminate sources of water pollution typical of greased bushings.

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks and to limit the effects of spills and leaks on fish and fish habitat. Spill containment supplies will be available in designated areas and within Project vehicles. An Emergency Response Plan will be developed and will include instruction for the rapid response, control, and management of spills or release of hazardous substances occurring on site. All spills will be isolated and immediately cleaned up. Spills will be reported to the appropriate agency if the spill exceeds reportable volumes for the material spilled as outlined in the provincial Environmental Spill Control Regulations (Government of Saskatchewan 1981, with amendments). In the unlikely event of a large spill, disposal of all contaminated soil will be handled by a licensed contractor and will be hauled off-site to an approved disposal facility. Alternative approaches for in-situ treatment of contaminated soils may also be considered (e.g., phyto- or bio- remediation), depending on the substance spilled and capacity to treat the volume of material affected.

Storage facilities for hazardous wastes will meet regulatory requirements. All fuel storage tanks will be designed and constructed based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. The storage containers will be regularly inspected for leakage or damage, and replaced when necessary. Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double-walled and located in lined and bermed containment areas. Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers.

Vehicles will be regularly maintained and will carry fire extinguishers and standard emergency clean-up kits. Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired near waterbodies. Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills on the fueling stations would flow to the sump, which would be pumped out to a container for shipment off-site.

Implementation of the above mentioned environmental design features are expected to reduce the likelihood and extent of the release or spills of hazardous materials occurring on-site. No detectable changes to surface water and soil quality relative to baseline conditions are anticipated. Therefore, these interactions are determined to have no linkage to effects on fish populations.

- **Failure of the embankment dykes around the settling ponds can change surface water quality, which can affect fish and fish habitat.**

Failure of embankment dykes around the settling ponds could result in the release of sediment laden water and potential contaminants to the surface water and terrestrial environments. Environmental controls will be in place to limit the potential for embankment dyke failure. For example, water from the waste rock disposal areas will be diverted to the settling ponds by gravity. The settling ponds will be engineered to provide adequate storage of process streams under normal and extreme operating conditions. Maximum operating levels will be developed to provide adequate storage volumes for the design storm event. In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling pond would be provided by the inclusion of an overflow spillway in the embankment.

The embankment dyke will be constructed around the settling pond to contain wastewater from site and from the waste rock disposal areas. Embankment dykes will be stripped of vegetation, topsoil, and roots to expose the mineral soil subgrade as necessary to accommodate the size of the settling pond. Fill material used for constructing the dyke will be clean mineral soil with sufficient moisture to allow for proper compaction and will be placed in lifts not exceeding 150 mm in compacted thickness and compacted to a minimum of 95% standard proctor maximum dry density. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap immediately following construction.

The settling pond will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. During the detailed design stage, additional mitigation will be identified and included as part of the EnvPP and the Emergency Response Plan. Consequently, embankment dyke failure was determined to have no linkage to effects on fish populations.

12.4.4 Primary Interactions

The following interactions were determined to be primary for effects on the maintenance of self-sustaining fish populations (including listed species) and are carried forward to the residual effects analysis.

- **Water withdrawal from Black Lake for power generation may impinge or entrain fish, resulting in fish injury or mortality, which can affect fish populations.**
- **Direct loss or alteration of fish habitat from the Project footprint or activities can affect fish.**
- **Withdrawal, diversion, and discharge of water for power generation may change hydrology, which can affect fish habitat (in reaches 3 through 21 of the Fond du Lac River).**

12.5 Residual Effects Analysis

The residual effects analysis considered all primary Project interactions that likely result in measureable environmental changes and effects on fish and fish habitat after implementing environmental design features and mitigation. The residual effects assessment is completed by calculating and estimating changes to measurement endpoints associated with the primary Project interactions. These measurement endpoints include:

- habitat quantity;
- habitat quality;
- relative abundance and distribution of fish species; and
- survival and reproduction.

The effects on the traditional use fish species are assessed in this section; however, changes to traditional use species is a measurement endpoint for land use (Sections 17.0).

Assessment cases are defined for the effects analysis and include the baseline case, application (Project case, which includes construction, operations, and closure), and future case (if applicable). The baseline case considers the current conditions in the RSA such as natural disturbances (e.g., fire) and previous and existing human developments and activities. The regional area surrounding the Project has experienced little industrial human development and activity. Previous activity includes exploration work for the Nisto uranium deposit (mineral property #1621), which is located on the west shore of Black Lake, approximately 23 km east of Stony Rapids (Government of Saskatchewan 2013). In 1950, two adits were driven and lateral work was completed. Ore was mined from the shoots accessible from the northeast adit in 1959. Only exploration work has been completed in the area since 1959. Existing human-related disturbance includes trails, roads, cabins, the Black Lake sewage lagoon, and the communities of Black Lake and Stony Rapids. Populations and communities in aquatic and terrestrial ecosystems have likely adapted to the low level of human industrial activity over the last 50 to 60 years. Therefore, current (baseline) conditions in the RSA are expected to reflect the cumulative influence of previous and existing human industrial activities on aquatic and terrestrial ecosystems relative to reference conditions. Reference conditions represent no to little human development, except for First Nation communities, which are assumed part of the historical natural ecosystems.

The application case occurs during the start of construction of the Project through closure and the associated duration of predicted effects (i.e., until effects are reversed or are deemed irreversible). The magnitude of effects from the Project are expected to be strongest during construction and the initial period of operation. For example, the magnitude of some effects, such as the changes from blasting activities are expected to stop at the end of construction and the duration of these effects likely will end within the initial period of operation. Physical disturbance expected to occur at the beginning of construction and most of the disturbed area will be reclaimed immediately following construction. Reclamation activities following construction will include the removal of portions of the temporary construction infrastructure that are not required during operation. Temporary infrastructure includes the construction camp, contractor's work areas, material laydown areas, and overburden disposal areas

The duration of some effects from the Project have the potential to last over the 90-year operation period. For example, the presence of the water intake structure in Black Lake may have long-term effects on the habitat suitability for fish species that may use this area. Because the differences in the magnitude and geographic extent of effects are expected to be measurable between construction and operation, the analyses examined both phases. Analyses were quantitative where possible and qualitative where necessary. There is potential for this Project to operate beyond the expected 90-year operational period; however increasing the duration of the operation phase of the Project would have little influence on effects predictions.

Closure is when power production operations end and decommissioning and reclamation of the final infrastructure (i.e., water intake, power tunnel, powerhouse, tailrace channel, switchyard, access roads, waste rock disposal areas, and distribution line) is completed.

Both Project-specific (incremental) and cumulative effects from the Project and existing human developments and activities are analyzed in this section. The future case includes baseline and the Project, plus reasonably foreseeable developments or designated projects. The geographic extent (zone of influence) of residual effects from the Project on fish and fish habitat is expected to be limited to the RSA. No other major developments in the region are located within the RSA. Therefore, the zones of influence associated with the Project and existing developments are not expected to overlap and generate cumulative effects on fish and fish habitat. Currently, there are no reasonably foreseeable developments that could have an overlapping temporal boundary with the Project and potential to generate cumulative effects on fish and fish habitat.

12.5.1 Injury and Mortality of Black Lake Fish from Impingement or Entrainment

Water withdrawal from Black Lake for power generation is expected to cause some injury and mortality to fish as a result of impingement or entrainment at the water intake. Mitigation incorporated into the Project to limit fish injury and mortality resulting from impingement or entrainment include:

- selecting a Kaplan–style turbine;
- selecting an intake location away from sensitive fish habitat (i.e., areas where fish may congregate to spawn);

- constructing a shallow intake to reduce the entrainment of deep-water species such as lake trout, whitefish, and cisco;
- sizing the water intake opening so water velocities in the approach channel are below burst speeds of resident fish, thereby promoting avoidance behavior;
- fitting the water intake opening with an “exclusion bar rack” to reduce the potential for fish entrainment by presenting a visual barrier; and
- configuring the water intake structure so that the soffit (ceiling) of the intake passage will be set low enough to prevent entrainment of air into the power tunnel and subsequently reduce the potential for gas bubble trauma in entrained fish.

The shoreline habitat near the proposed water intake location consists of a cobble and boulder shelf that extends approximately 50 m outward from shore before dropping off rapidly into a 25 to 30 m deep zone. Along the shelf, the substrate size increases as the depth increases and becomes boulder-dominant at the drop-off. At depths of 20 to 30 m, the bottom levels off with substrates becoming depositional in nature (i.e., fine sand/silt).

In 2012, a focused fish survey was completed at the proposed water intake location in Black Lake (Annex III). Species captured at this location included cisco, lake chub, lake trout, lake whitefish, longnose sucker, round whitefish, walleye, white sucker, and yellow perch. Cobble and boulder substrates along the shelf provide suitable cover for lake chub and juvenile large-bodied fish. The habitat along the steep drop-off was found to support adult large-bodied fish. Lake trout, cisco species, and whitefish change their vertical distribution in the water column based on seasonal temperature changes (Scott and Crossman 1973). During spring and fall, when Black Lake is relatively homothermous, these species may be found at all depths. When the lake stratifies in summer, they descend to cool water below the thermocline.

Black Lake fish species that were not captured during the 2012 survey of the intake location included Arctic grayling, burbot, ninespine stickleback, northern pike, slimy sculpin, spottail shiner, and trout-perch (Annex III). Although no burbot were captured within the intake area, it is possible this species inhabits depths within the 25 to 30 m deep zone (i.e., well below the intake structure opening and out from the shoreline). The proposed water intake location is unlikely to provide suitable habitat for northern pike because aquatic vegetation at this site is limited, even in the shallow-water areas.

Spawning surveys that were conducted in Black Lake to identify potentially sensitive, shallow water fish habitats that would provide suitable spawning and rearing habitats for lake trout, lake whitefish, and burbot did not provide any evidence of spawning activity at the proposed intake location (Annex III). It is anticipated that because the new intake channel will be deeper than the current shoreline and will have higher water velocities, this area will no longer provide suitable spawning, rearing, and foraging habitat for small-bodied fish species or rearing habitat for juvenile large-bodied fish. These species and life-stages likely will be displaced to other similar habitats on either side of the proposed water intake location.

It is anticipated that most fish species in Black Lake will have the potential to interact with the water intake at some point throughout the annual lake temperature cycle, regardless of water intake depth. However, it was determined that construction of a 5 m deep water intake may be more protective of lake trout, cisco species, and whitefish species that generally seek cooler, deeper water during the late spring, summer, and early fall. Because the area does not contain suitable habitat for northern pike and none were captured during the focused fisheries survey, it is not anticipated that the development of a 5 m deep water intake would affect populations of this species in Black Lake. A detailed assessment of the water intake depths proposed for the Project is provided in Appendix 12.3.

The proposed intake structure will include two submerged water passages (each 7.2 m wide and 10.0 m high) separated by a middle pier; an "exclusion bar rack" will be located in front of these passages and will reduce entrainment of debris into the power tunnel. The "exclusion bar rack" is also intended to be a visual deterrent for fish. The design of the "exclusion bar rack" will be consistent with design practices currently used at other facilities in Canada that are of similar configuration, aquatic setting, function, hydraulics, and endemic species. The panels of the "exclusion bar rack" will include steel bars 10 mm thick by 150 mm deep, with an anticipated bar spacing of 80 to 160 mm on center and a clear opening of approximately 70 to 150 mm.

None of the fish species documented in Black Lake are known to undertake annual or regular downstream migrations for spawning, rearing, or foraging purposes. However, some fish currently drift downstream out of Black Lake into the Fond du Lac River via the Black Lake outflow. It is anticipated that some Black Lake fish will passively drift into the vicinity of the water intake where they could be potentially impinged on the "exclusion bar racks" or entrained with power tunnel inflows. However, the total number of fish leaving the Black Lake fish community is not expected to change over the current level of out-migration because overall Black Lake outflow rates and volumes will not change with the development of the Project. Out-migration of fish from Black Lake once the Project is operating is expected to be similar to current levels. Although Black Lake effectively will have two outlets when the power plant is in operation, each will only carry approximately one-half of the current Black Lake outflow total. Flow velocity data modelled in River2D indicates water velocities at the natural Black Lake outflow will be greater than flow velocities at the water intake; therefore, it is anticipated more fish will be entrained at the natural Black Lake outlet than at the water intake during Project operation. For example, flow velocities in the channel on the west side of Grayling Island may reach approximately 2.1 to 2.5 m/s by the time water passes the downstream end of Grayling Island, given riverine flows are between 302 and 510 m^3/s. Maximum water velocities modelled on the east side of the channel were between approximately 0.9 to 3.7 m/s, depending on location in the channel and flow scenario (i.e., 302 m^3/s, 400 m^3/s and 510 m^3/s). Although half of the lake outflow volume will pass through the water intake, less than half of the out-migrating fish are expected to be entrained or impinged at the intake. With the exception of Arctic grayling, it is not believed that most fish species are able to return to Black Lake after they have been carried downstream into the rapid flows of the Fond du Lac River.

For fish that do enter the water intake channel, the likelihood of impingement or entrainment largely depends on the velocity of water entering the intake, as well as the fish's ability to resist the water flow (CH2M HILL 2007). Reducing velocities in the water intake approach channel and near the face of the "exclusion bar rack" as much as possible likely will reduce the frequency of fish impingement or entrainment. It is anticipated that for the proposed Black Lake water intake design, the approach flow velocity at the "exclusion bar rack" will be below the burst or startle speeds of most adult resident fish. Therefore, fish should be able to effectively avoid the "exclusion bar rack." Some fish may however choose to align their bodies with the flow and then move passively through the "exclusion bar rack" spacing.

Burst or startle speeds (i.e., greatest swimming speed that can be reached and maintained for less than 15 seconds), as well as prolonged swimming speeds (i.e., a moderate speed that can be maintained for up to 200 minutes) for fish species captured within the proposed Black Lake intake area are summarized in Table 12.4-3 in Section 12.4.1. Swimming speeds for Arctic grayling and northern pike also are included.

When fish are unable to avoid the intake structure, impingement is most likely to occur for individuals having body widths or depths greater than the bar spacing on the “exclusion bar rack” (i.e., ≥70 to 150 mm; Northwest Hydraulic Consultants and Focus Environmental, Inc. 2006). Impinged fish can be killed, crushed by debris, descaled, or stressed. Fish that are small enough to pass through the bar spacing will become entrained in the power tunnel flow and will be carried to the turbine units. In general, most of entrained fish are expected to be YOY specimens. Small YOY fish are unlikely to have burst speeds sufficient to avoid hydroelectric water intakes and are often abundant in lake habitats where water intakes are frequently constructed (CH2M HILL 2007).

To determine how “exclusion bar rack” spacing might influence fish mortality for the Project, mortality data for facilities having similar approach velocities, operating capacities, and clear spacing at the trashracks were examined. At the Great Falls Generating Station on the Winnipeg River, approximately 80% of the fish that pass through the trashrack are less than 150 mm total length (Keeyask Hydropower Limited Partnership 2012). The trashrack at the Great Falls Generating Station has a clear bar spacing of 140 mm and approach velocities between 0.73 and 1.03 m/s. Based on the average numbers of fish entrained each month at the Sherman Island facility in New York, approximately 74% of entrained fish are less than 100 mm in length associated with a plant operating capacity of 186.9 m^3/s and a trashrack clear spacing of 79 mm (Niagara Mohawk Power Corporation 1995). Mortality rates for fish this size are expected to -range from less than 5 to approximately 20% (Larinier and Travade 2002; Electric Power Research Institute [EPRI] 1992; SNIFFER 2011); higher mortality rates are expected for larger fish. Ichthyoplankton and small fish carried through the “exclusion bar rack” spacing are generally expected to pass through the turbines unharmed (Čada 1990).

Either Kaplan or Francis turbines are generally used for power generation at hydroelectric facilities in Canada (Canadian Electricity Association [CEA] 2001). A large proportion of the hydroelectric power generated in the United States also comes from low- to medium- head facilities containing one of these turbine types (Becker et al. 2003; Odeh 1999). Both Kaplan and Francis style turbines were considered for the Project. Kaplan style turbines have been selected for the Project as they are considered to be the more fish-friendly of the two turbine types.

The most common causes of injury and mortality for fish that become entrained in hydroelectric turbine facilities are blade strikes and pressure stresses (SNIFFER 2011). Fish can be injured or killed by the shearing forces of moving water masses, turbulence, cavitation, grinding, or collision with fixed structures within the power tunnel (Schilt 2007). Physical injuries sustained by entrained fish may include loss of the protective mucous layer and scales, torn gill covers, decapitation, bruising, rupture of the swim bladder, and hemorrhage (Čada et al. 1997). Fish that survive entrainment might be more susceptible to predation or disease because of physiological stress or disorientation. These indirect effects of entrainment have not been the subject of scientific research and are poorly understood at this time (Halls and Kshatriya 2009).

For Arctic grayling and other species identified as VCs for the Project, entrainment induced mortality is not expected to result in a measureable decrease in recruitment downstream of the tailrace channel outlet. Arctic grayling were not captured during the focused fish survey completed at the water intake location during 2012 and relatively few (n = 46) Arctic grayling were captured in Black Lake between 2010 and 2012 (Annex III). Therefore, it is anticipated that Arctic grayling are unlikely to enter the water intake and become entrained in the power tunnel; no measureable loss to recruitment is expected downstream of the tailrace channel. The remaining fish species that were identified as VCs for Black Lake have life history requirements (i.e., habitat preferences and spawning migration behaviours) that are expected to reduce the potential for entrainment and therefore minimize potential losses to recruitment downstream of the tailrace channel. Life history requirements of Black Lake fish species as they relate to the potential for entrainment are discussed further in Appendix 12.3: Intake Depth Assessment Technical Memorandum.

Details of the effects assessment for fish that become impinged or entrained at the water intake in Black Lake are provided in Appendix 12.4. The results of the assessment indicate that blade strikes and the rapid decrease in pressure immediately behind the turbines will be the predominant causes of fish injury and mortality for the Project. Lake chub, walleye, and yellow perch are expected to be most vulnerable to pressure-related mortality due to their inability to vent their swim bladders under changing pressure conditions. Eggs, larvae, small juvenile fish, and fish species that lack swim bladders are expected to be relatively insensitive to pressure changes.

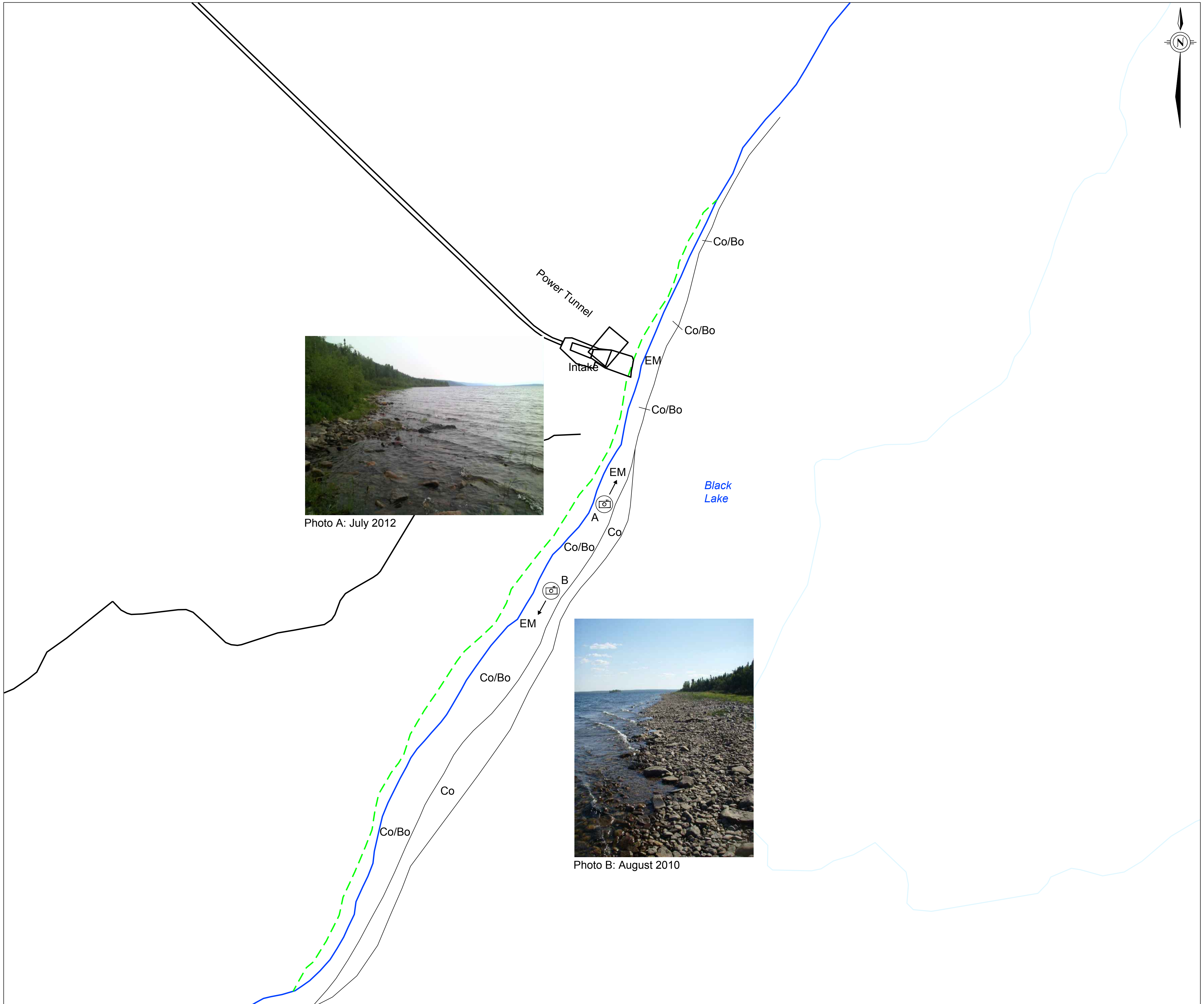
12.5.2 Loss of Fish Habitat Resulting From the Project Footprint

Components of the Project footprint and infrastructure that are expected to result in the direct loss or alteration of fish habitat include the water intake, the submerged weir structure at the outlet of Black Lake, the tailrace channel outlet in the Fond du Lac River, the single-pier bridge that will be constructed to improve access to the east side of the Fond du Lac River, and site roads that may affect stream crossings used by fish.

Because construction and operation of the Project is expected to result in some permanent alteration or destruction of fish habitat in Black Lake and the Fond du Lac River, a conceptual Fisheries Offsetting Plan was developed for the Project (Appendix 12.2). The Fisheries Offsetting Plan will be finalized in conjunction with DFO, and will be implemented to offset any permanent alteration or destruction of fish habitat that could adversely affect fish populations in the LSA. A number of design features and mitigation practices will be employed during Project design and construction to reduce the permanent alteration or destruction of fish habitat. These mitigation practices include the following:

- selection of a water intake location in Black Lake that avoids sensitive fish habitat (i.e., spawning areas) within the lake;
- construction of a submerged weir at the outlet of Black Lake to maintain water levels within the lake and reduce the effects of fluctuating water levels on fish habitat;
- implementation of BMPs for erosion and sedimentation (i.e., ground cover, silt fences and curtains), where needed; and
- development of a compact layout for surface facilities within local watersheds so that the area lost or disturbed by the Project can be limited.

The water intake in Black Lake will be located on the north shore and will be pushed back into the bedrock by 100 to 150 m. When constructed, the water intake structure in Black Lake is expected to destroy fish habitat along an approximately 80 m length of shoreline (Figure 12.5.1). The shoreline habitat near the proposed water intake is relatively homogeneous and consists of a cobble and boulder shelf that extends out from the shore approximately 50 m; the shelf drops off rapidly to depths of 25 to 30 m. Along the shelf, the substrate size increases as the depth increases and becomes boulder-dominant at the drop-off. At 25 to 30 m depths, the lake bottom levels out and becomes more depositional, with finer sand/silt substrates. Large cobble and boulder substrates along the shelf provide suitable cover for small-bodied fish and juvenile large-bodied fish (Annex III). Habitat along the steep drop-off supports a variety of large-bodied fish, including cisco, lake trout, round whitefish, lake whitefish, longnose sucker, white sucker, and walleye (Annex III). Areas of emergent vegetation and terrestrial vegetation (i.e., shrubs) are located along the shoreline at the intake location.



REFERENCE
NAD83 UTM ZONE 13.

200 0 200
SCALE 1:10,000 METRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

AQUATIC HABITAT MAP OF PROPOSED WATER INTAKE AREA IN BLACK LAKE

Tazi Twé
Hydroelectric Project

PROJECT	10-1365-0004	
DESIGN		
CADD	BDS	01/11/12
CHECK	LT	24/07/13
REVIEW	BC	24/07/13

FILE No.
SCALE AS SHOWN REV. 0

FIGURE: 12.5-1

Legend - Lakes, Wetlands, Ponds

Substrate Types	
Cl	Clay
Si	Silt
Sa	Sand
Gr	Gravel
Co	Cobble
Bo	Boulder
Bd	Bedrock
Or	Organic

Habitat Features		
XXXX	BD	Beaver Dam
	MD	Man-Made Dam
	BL	Beaver Lodge
	BG	Boulder Garden
		Bridge
		Culvert
	DP	Debris Pile
	EM	Emergent Vegetation
		Flow Direction
	ISC	Instream Cover
	IV	Instream Vegetation
	INV	Inundated Vegetation
	LWD	Large Woody Debris
	LE	Ledge
	LJ	Log Jam
	LS	Landslide
	MIL	Multiple Island
	OHV	Overhanging Vegetation
	OHC	Overhead Cover
	RW	Root Wad
		Sand Bar
	SIL	Singular Island
	SWD	Small Woody Debris
	SM	Submergent Vegetation
	UCB	Undercut Bank
	USB	Unstable Bank

Sample Type Symbols		
		Water
		Sediment
		Benthic
		Fish

Bank/Upland Vegetation Types		
	BA	Bare Ground
	OT	Open Tundra
	MU	Muskeg/Bog
	DF	Deciduous Forest
	CF	Coniferous Forest
	MW	Mixedwood Forest
	GS	Grassland
	GF	Grass/Forbs
	GF/SH	Grass/Forbs/Shrubs
	SE	Sedge
	SH	Shrubs
	EM	Emergent Vegetation
	MO	Moss
	OR	Organic

Bank Slope	
	Shallow Slope (0-5%)
	Intermediate Slope (6-30%)
	Steep Slope (31-70%)
	Very Steep Slope (>70%)

Bank Instability Ratings	
A	Aggrading
E	Eroding
S	Slumping
G	Gullying

Capture Methods		
	BP	Electrofishing - Backpack
	EF	Electrofishing - Boat
	GN	Gill Net
	SN	Seine
	FF	Fish Fence
	MT	Minnow Trap
	AN	Angling
	HN/TN	Hoop Net/Trap Net

General	
C	Photo Location/Direction
	Habitat Type Divider
	Fish Bearing/Potential Bearing Watercourse
	Width
	Depth

Site Summary Symbol

Lake (L), Wetland (W) or Pond (P)
Surface Area (ha)
Main Shoreline Perimeter (m)
Max Depth (m)
Secchi Depth (m)
Dissolved Oxygen (mg/L)
Conductivity (µS/cm)
pH

Fish Species

Notes:
ha = hectares
m = metres
mg/L = milligrams per litre
µS/cm = microseimens per centimetre
Max depth was the depth recorded at sampling locations.

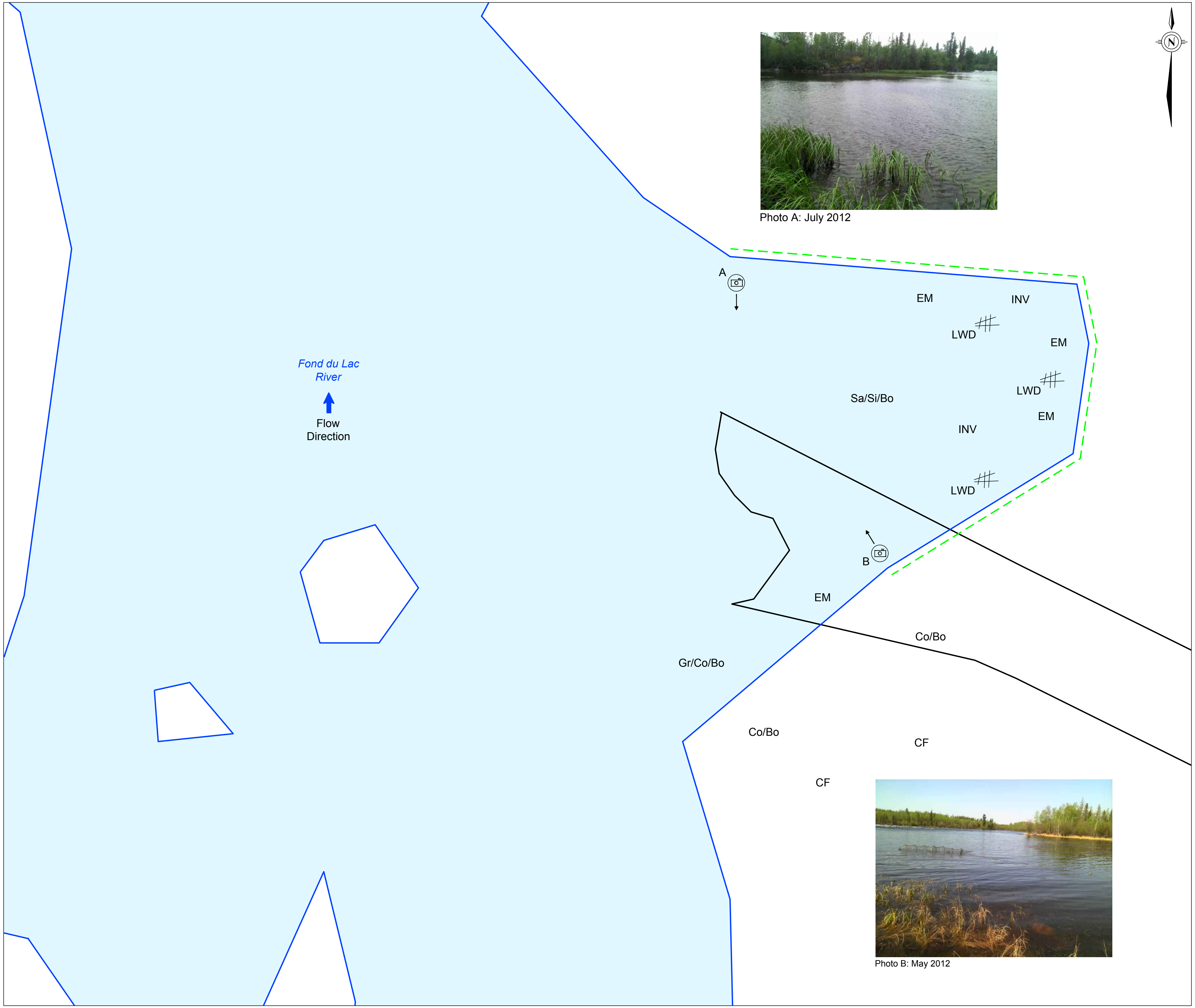
Aquatic habitat surveys and focussed spawning surveys conducted at Black Lake suggest that the proposed intake location is not likely to be sensitive or critical fish habitat (Annex III). Similar types of habitats that might be used by small-bodied fish and juvenile large-bodied fish are abundant throughout Black Lake (i.e., the intake footprint would affect a relatively small proportion of this habitat type) (Annex III). Spawning surveys that were conducted in Black Lake to identify potentially sensitive, shallow water fish habitats that would provide suitable spawning and rearing habitats for lake trout, lake whitefish, and burbot did not identify any evidence of spawning activity near the water intake (Annex III).

Additional fish habitat will be temporarily altered during in-water works associated with construction of the water intake. Construction of the water intake and approach channel will require installation of a turbidity barrier to prevent suspended sediments from entering the main body of Black Lake. Installation of the turbidity barrier and in-water construction activities within the boundaries of the turbidity barrier may temporarily alter some fish habitat or make it temporarily unavailable to resident fish. These types of temporary alteration are not likely to require offsetting under the new *Fisheries Act* regulations (see Appendix 12.2).

The proposed submerged weir at the Fond du Lac River outlet of Black Lake is a source of mitigation (i.e., will maintain water levels in Black Lake), but because of its footprint and construction, can result in the direct loss or alteration of fish habitat. The submerged weir is designed to maintain the historical range of water levels in Black Lake, and subsequently, maintain fish habitat that would have otherwise been affected by reduced water depths and volumes resulting from Project-related water withdrawal. The proposed weir will be constructed across the Fond du Lac River at the location indicated in Figure 12.4-1. The Fond du Lac River is approximately 200 m wide at this location, including the 35 m wide Grayling Island that the submerged weir will intersect. The length of the weir to the east of the island is approximately 80 m; the section west of Grayling Island will be approximately 85 m.

It is anticipated that Arctic grayling spawning areas immediately upstream of the proposed weir will not be affected by sedimentation. Sufficient wave action is expected to keep the spawning substrates clear of fine sediments. This phenomenon was observed at a nearby boat launch; Arctic grayling would spawn over the substrates at the boat launch as waves kept the substrates clean.

The footprint of the tailrace channel outlet in the Fond du Lac River is expected to disturb (i.e., permanently alter or destroy) fish habitat within a bay on the east shore of Reach 22. A fish habitat map of the tailrace channel outlet bay is shown in Figure 12.5-2, along with the orientation and footprint of the tailrace channel outlet channel. The bay at the proposed tailrace channel outlet is composed of a large slack water area along the east shore of the Fond du Lac River during average or higher flows, as well as an area with faster flows located along the downstream outlet of the bay. Northern pike and lake whitefish were captured in the slack water and northern pike are known to spawn at this location. During lower flows the slack water area dries or becomes very shallow. Arctic grayling were captured in the faster flowing water near the mouth of the bay. The habitats used by these species at this location may be affected by the tailrace channel outlet. However, any change to Arctic grayling habitat will be offset in the Fisheries Offsetting Plan. It is anticipated that northern pike and lake whitefish displaced from this area will move the short distance downstream to suitable habitats in Middle Lake as they currently do during lower than average flows.



REFERENCE

NAD83 UTM ZONE 13.

20 0 20

SCALE 1:1000 METRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

AQUATIC HABITAT MAP OF PROPOSED TAILRACE CHANNEL OUTLET BAY IN THE FOND DU LAC RIVER

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004
DESIGN		
CADD	BDS	01/11/12
CHECK	LT	24/07/13
REVIEW	BC	24/07/13

FILE No.

SCALE AS SHOWN REV. 0

FIGURE: 12.5-2

Legend - Rivers and Streams

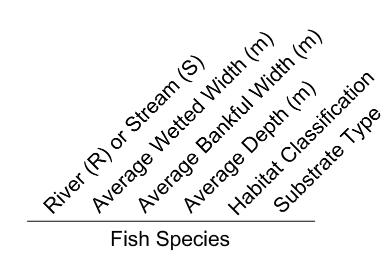
Substrate Types	
Cl	Clay
Si	Silt
Sa	Sand
Gr	Gravel
Co	Cobble
Bo	Boulder
Bd	Bedrock
Or	Organic

Habitat Features		
XXXX	BD	Beaver Dam
	MD	Man-Made Dam
	BL	Beaver Lodge
	BG	Boulder Garden
		Bridge
		Culvert
	DP	Debris Pile
	EM	Emergent Vegetation
		Flow Direction
	ISC	Instream Cover
	IV	Instream Vegetation
	INV	Inundated Vegetation
	LWD	Large Woody Debris
	LE	Ledge
	LJ	Log Jam
	LS	Landslide
	MIL	Multiple Island
	OHV	Overhanging Vegetation
	OHC	Overhead Cover
	RW	Root Wad
		Sand Bar
	SIL	Singular Island
	SWD	Small Woody Debris
	SM	Submergent Vegetation
	UCB	Undercut Bank
	USB	Unstable Bank

Sample Type Symbols		
		Water
		Sediment
		Benthic
		Fish

General	
C	Photo Location/Direction
	Habitat Type Divider
	Fish Bearing/Potential Bearing Watercourse
	Width
	Depth

Site Summary Symbol



Notes:
m = metres

Bank/Upland Vegetation Types		
	BA	Bare Ground
	OT	Open Tundra
	MU	Muskeg/Bog
	DF	Deciduous Forest
	CF	Coniferous Forest
	MW	Mixedwood Forest
	GS	Grassland
	GF	Grass/Forbs
	GF/SH	Grass/Forbs/Shrubs
	SE	Sedge
	SH	Shrubs
	EM	Emergent Vegetation
	MO	Moss
	OR	Organic

Bank Slope	
	Shallow Slope (0-5%)
	Intermediate Slope (6-30%)
	Steep Slope (31-70%)
	Very Steep Slope (>70%)

Bank Instability Ratings	
A	Aggrading
E	Eroding
S	Slumping
G	Gullying

Capture Methods		
	BP	Electrofishing - Backpack
	EF	Electrofishing - Boat
	GN	Gill Net
	SN	Seine
	FF	Fish Fence
	MT	Minnow Trap
	AN	Angling
	HN/TN	Hoop Net/Trap Net

Habitat Classification and Rating System			
Fast Water	Turb.	FA	Falls
		CA	Cascade
		CH	Chute
		RA	Rapids
		RF	Riffle
		RF/BG	Riffle/Boulder Garden
	Non-Turb.	R	Run (glide)
		R1	Run Class 1
		R2	Run Class 2
		R3	Run Class 3
		FL	Flat
Slow Water	Pool	P	Pool
		P1	Pool Class 1
		P2	Pool Class 2
		P3	Pool Class 3
	Impound (dammed pool)	IP	Impound
		IP1	Impound Class 1
		IP2	Impound Class 2
		IP3	Impound Class 3
Other Features		BW	Backwater
		SN	Snye
		BG	Boulder Garden
		SH	Shoal
		SL	Slough, Oxbows

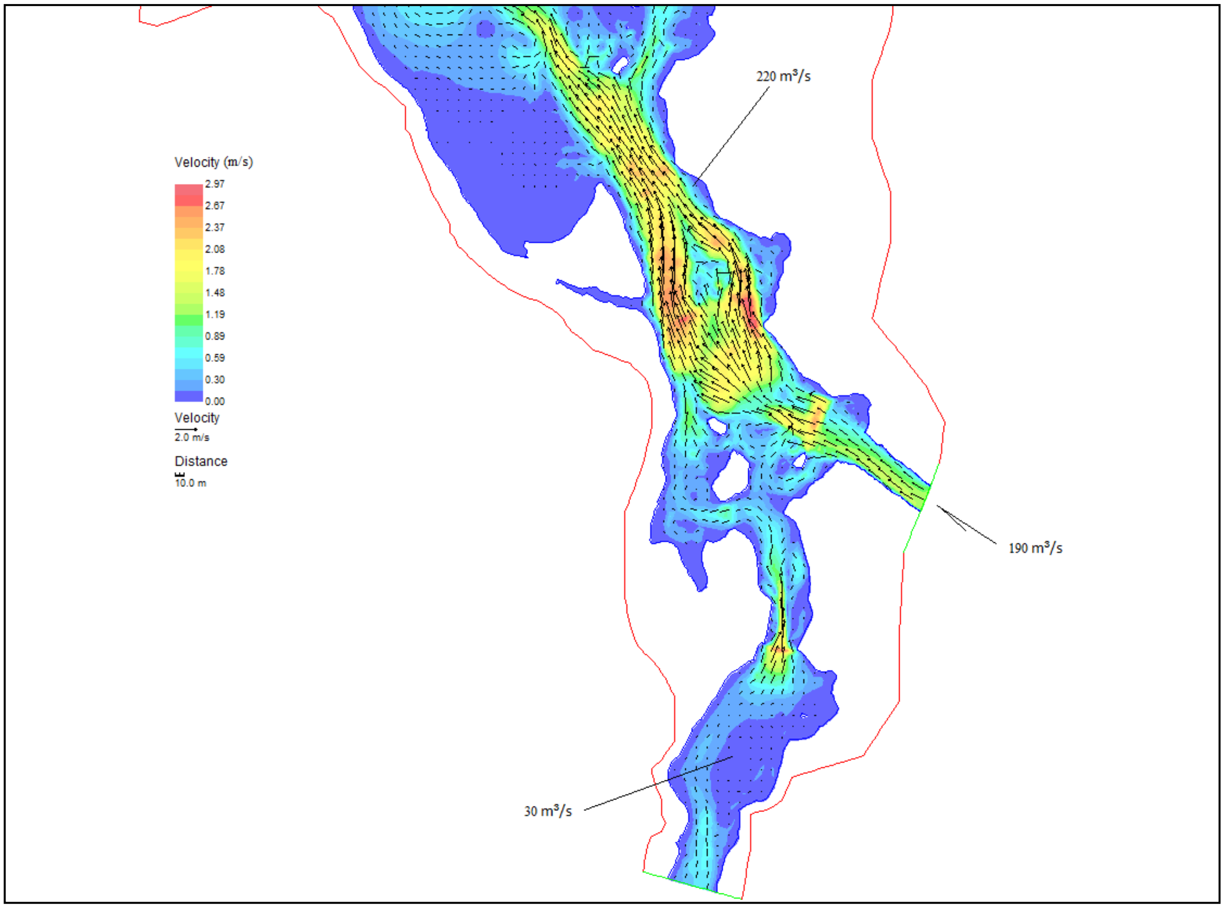


Figure 12.5-3: Modelled Velocity Vectors for the Tailrace Channel Outlet Location in the Fond du Lac River Based on a 30 m^3/s Riparian Flow and 190 m^3/s Tailrace Channel Outlet Flow

An additional area of fish habitat at the tailrace channel outlet location is expected to be adversely altered by construction activities. These alterations are likely to be temporary (i.e., reversible at the end of construction) and therefore will not require offsetting. A turbidity curtain will be installed around the work area and a fish salvage will be carried out within the work isolation area with salvaged fish being placed back into the Fond du Lac River outside of the work area.

The potential for erosion of shoreline habitat opposite the tailrace channel outlet in Reach 22 was assessed based on flow vector diagrams and critical velocities for substrate types at this location. Although the proposed winter flow rate is 40 m^3/s, a flow vector diagram was created based on a worst-case, extreme low winter riparian flow scenario (i.e., 30 m^3/s) that was modelled for the Project (Appendix 12.1). This flow scenario was selected because it represents the largest modelled difference between riparian flows (30 m^3/s) and tailrace channel outlet flows (i.e., 185 to 190 m^3/s; Appendix 12.1), and would therefore facilitate a more conservative assessment of erosion potential in the river. The flow vector diagram was used to assess whether combined riparian and tailrace channel outlet flows would have sufficient velocities and direction to potentially result in shoreline erosion. The direction and magnitude of the velocity vector arrows in Figure 12.5-3 demonstrate that water velocities in the natural river channel downstream of the tailrace outlet are expected to run parallel to the river shore and have low velocities adjacent to the shore. Higher velocity flows are expected to remain in the deeper section of the channel where they currently exist.

A site-visit of the proposed Project location was completed on October 9, 2013. Because flows in the river were relatively low (i.e., approximately 200 m^3/s) at the time of the site-visit, representative substrate types at the tailrace channel location could be identified. Large cobbles and boulders were the dominant substrate types in the area. Based on the classification system in Table 12.5-1, it is anticipated that the proposed tailrace channel outlet flow velocity of 1.4 m/s will be insufficient to move the cobbles and boulders present in the river channel.

Table 12.5-1: Modified Wentworth Classification of Substrate Types Based on Particle Size and Critical Velocity

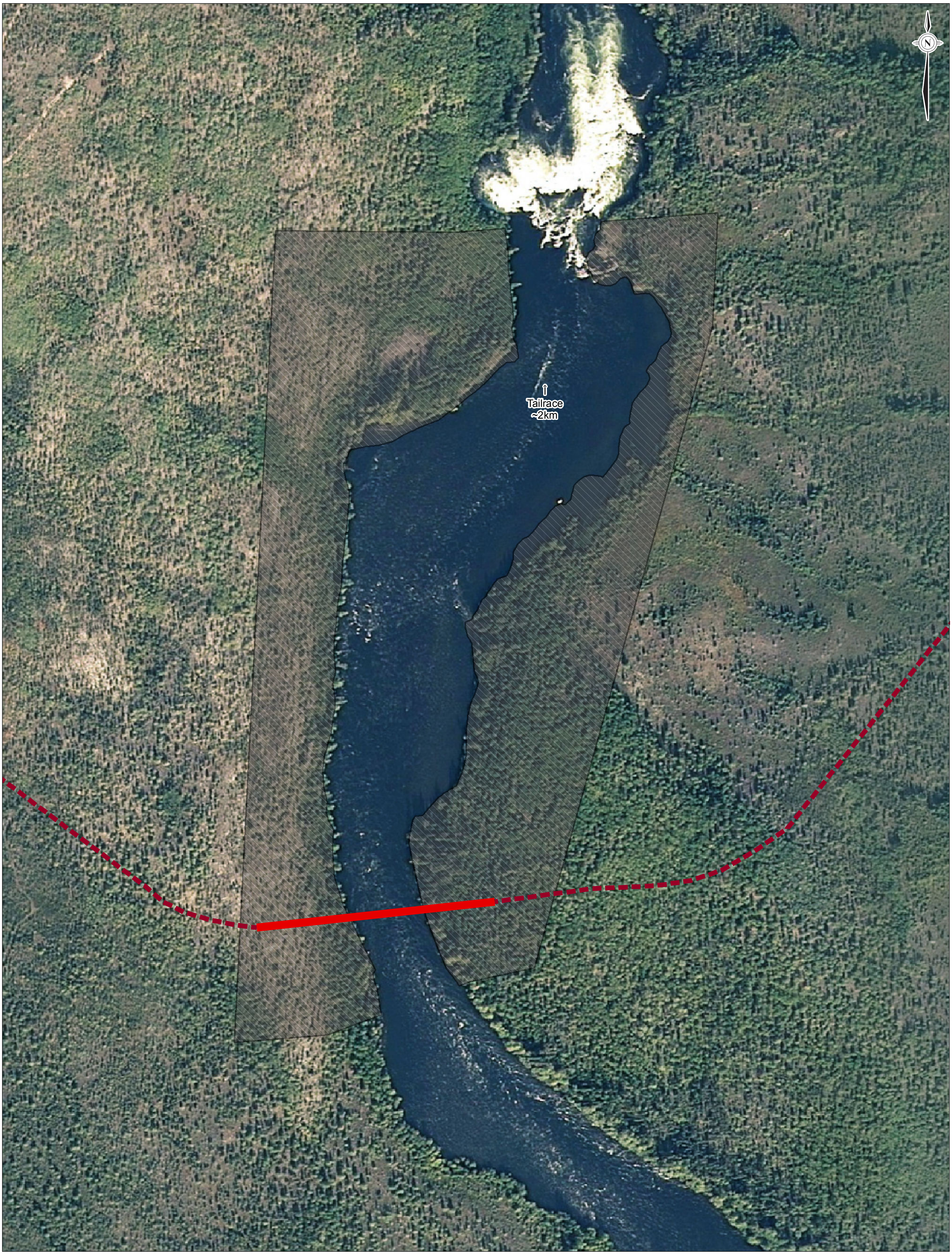
Substrate Type	Lower Size	Upper Size	Lower Velocity	Upper Velocity
	mm	mm	m/s	m/s
Clay/silt	-	<0.059	-	<0.22
Sand	0.06	1	-	<0.22
Gravel	2	15	0.22	0.62
Pebble	16	63	0.62	1.24
Cobble	64	256	1.24	2.48
Boulder	>256	-	>2.48	-

mm = millimetres; m/s = metres per second; < = less than; > = greater than; - = not applicable.

Because tailrace channel outlet flows will combine and align with riparian river flows, and will be insufficient in velocity to move predominant substrate types, erosion of shoreline habitats opposite the tailrace channel outlet is not expected to occur.

It is also anticipated that diversion of water for power generation will have no environmental effect on spawning activities of Arctic grayling in the Fond du Lac River downstream of the tailrace channel outlet. The current location of the proposed tailrace channel outlet would return Project water to the Fond du Lac River upstream of areas that are important for spawning Arctic grayling. These spawning areas should receive relatively normal flows.

A new bridge will be constructed to provide access to the construction site on the east side of the Fond du Lac River. It will be located approximately 600 m upstream of Elizabeth Falls (Figure 12.5-4). The bridge will have a single-pier design; however, two additional temporary piers could be required during bridge construction Installation of the bridge pier will require construction of a temporary groin or work platform that will extend approximately half way across the river to provide access to the pier installation site. The groin will be constructed of coarse rock and will allow water to percolate. The final single pier may result in the loss of a small amount of overwintering habitat for large-bodied fish in the Fond du Lac River. It is anticipated the permanent bridge abutments will be located below the historically normal high-water mark, but above the high-water mark anticipated for the period of Project operation.



LEGEND

- POTENTIAL BRIDGE ALIGNMENT
- PERMANENT ROAD
- POTENTIAL BRIDGE ALIGNMENT AREA

50 0 50

SCALE 1:3,000 METRES

REFERENCE

2012 GOLDER FIELD SURVEY
FLYSASK ORTHOIMAGERY © Saskatchewan Geospatial Imagery Collaborative, 2008 - 2011
NAD83 UTM ZONE 13

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATION OF THE SINGLE-PIER BRIDGE PROVIDING ACCESS TO THE EAST SIDE OF THE FOND DU LAC RIVER

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	22/01/14	**FIGURE: 12.5-4**	
CHECK	BC	22/01/14		
REVIEW	ML	22/01/14		

Bridge construction is expected to occur during winter (i.e., under low flow conditions and outside spawning timing windows for VCs) and will require a DFO Authorization. It is anticipated that the major fraction of overall disturbance in the river resulting from the bridge will occur during construction and residual disturbance is expected to be minor. Fish habitat lost because of bridge construction is addressed in the conceptual Fisheries Offsetting Plan (Appendix 12.2). Because similar overwintering habitat is available throughout this section of river, habitat lost to the bridge footprint is not considered to be critical to the maintenance of self-sustaining fish populations in the river.

The layout and extent of the permanent site access road and temporary construction access routes are not finalized at this time, but will be determined by the Proponent and general contractor, respectively, during the final Project design phases. Culverts will be installed along roadways where drainage crossings have been identified as non-fish-bearing. If fish movement at these drainage crossings becomes apparent during construction, culvert design will be altered to accommodate fish passage.

Although appropriate and applicable mitigation practices will be used and sensitive habitats will be avoided to the best extent possible, construction and operation of the Project is expected to result in some permanent alteration or destruction of fish habitat. However, with successful design and implementation of the Fisheries Offsetting Plan, it is not expected that there will be a net loss of fish habitat resulting from the Project footprint or construction of Project components.

12.5.3 Loss and Alteration of Fish Habitat Resulting From Changes to Hydrology in Reaches 3 through 21

Construction and operation of the Project will reduce water flows in some areas of the Fond du Lac River between Black Lake and Middle Lake. It is anticipated that reduced flows and associated reductions in water surface area and volume could result in the loss of fish habitat or changes to the quality of available fish habitat. Some side channel areas or pools could become isolated during reduced flows and potentially prevent fish movement back into the main river channel. Reduced velocities in some areas of the river could make some habitats more accessible or more suitable for fish. Changes to the quantity and quality of overwintering, spawning, and foraging habitats available to Arctic grayling in the Fond du Lac River could have implications for the maintenance of self-sustaining populations in the river.

Changes to hydrology resulting from Project operation are expected to have the greatest effect on fish habitat quantity and quality in Fond du Lac River Reaches 3 through 21 (Figure 12.3-1 and Appendix 12.1, Figures 1 and 2). Therefore, these reaches are considered in the assessment of primary interactions. Mitigation incorporated into the Project to limit changes to hydrology and the subsequent permanent alteration or destruction of Arctic grayling habitat in Fond du Lac River Reaches 3 through 21 include:

- scheduling planned outages for power plant maintenance for times outside of the spring spawning and rearing period (from May 15 to July 15);
- implementing a spring spawning trigger flow of 70 m^3/s that is timed to match the natural rise in the hydrograph and will support successful spawning of Arctic grayling and other spring spawners; and
- developing Fisheries Offsetting Plan in conjunction with DFO.

Because the effects on fish habitat in the Fond du Lac River from changes to hydrology cannot be entirely eliminated by the proposed mitigations, a Fisheries Offsetting Plan will be required for the Project. A conceptual Fisheries Offsetting Plan is included in Appendix 12.2. This plan will be finalized in conjunction with DFO.

Reaches 3 through 21 are located downstream of the proposed submerged weir at Grayling Island and upstream of the proposed tailrace channel outlet location in Reach 22. The submerged weir is expected to maintain historically normal water levels in Black Lake and Reach 2 of the Fond du Lac River; riparian flows and water levels are expected to return to relatively normal levels below the tailrace channel outlet in Reach 22. Therefore, Reaches 2 and 22 were classified as secondary interactions (Section 12.4.2) and Reaches 3 through 21 are discussed as primary interactions for effects on fish and fish habitat.

Details of the effects assessment are presented in Appendix 12.1. Overwintering and spawning habitats available to Arctic grayling in the Fond du Lac River between Black Lake and Middle Lake were assessed based on flow data for winter (i.e., the lowest annual flow period) and the spring spawning season. Overwintering and spawning habitats available to longnose sucker and white sucker in the Fond du Lac River were also evaluated (Appendix 12.1). Suitability Index (SI) curves were developed over the ranges of depths and velocities that may be encountered by fish that overwinter (adult and age-0/juvenile), or spawn in areas between Black Lake and Middle Lake. Habitat Suitability Indices (HSIs) based on SI values for depth and velocity were used to rank available habitats and determine if a particular combination of habitat variables is "suitable" for the species (e.g., Arctic grayling), life-stage (e.g., adult), and activity (e.g., spawning) of interest. Habitat suitability index (HSI) values range from zero (0; "unsuitable habitat") to one (1; "suitable habitat").

The results of the HSI analyses for Arctic grayling indicate that there will be an overall decrease in unsuitable overwintering habitat for age-0, juvenile, and adult fish when riparian flows are reduced because of Project operation; the total areas of suitable habitat will increase. This is because much of the unsuitable overwintering habitat available to Arctic grayling under historical winter flow conditions will be lost as water surface areas and volumes in Reaches 3 through 21 decrease because of Project operation. The overall increase in suitable overwintering habitat for Arctic grayling is largely attributable to the decreases in flow velocity that are expected to occur throughout the river when riparian flows are reduced from historically normal values to proposed Project flows.

For the spring flow scenarios assessed, suitable spawning habitat for Arctic grayling was generally most abundant at riparian flows between 302 m^3/s (i.e., Q10 average low spring flow) and 400 m^3/s (i.e., normal average spring flow). Under Q90 average high spring flows (i.e., 510 m^3/s), the amount of suitable habitat available to Arctic grayling is less than that available under historically average (i.e., 400 m^3/s) or historically low (302 m^3/s) spring flows. At very high flow rates, increases in water depth and changes in water velocity may work in combination to render some traditional spawning areas temporarily unusable. Therefore, Project operation during high flow years is expected to result in a general improvement (or maintenance) of suitable spawning habitat. However, operation of the Project during conditions associated with historical Q10 average low spring flows is expected to result in an overall decrease (28.9%) in suitable spawning habitat for Arctic grayling in Reaches 3 through 21. Water surface areas and wetted channel widths are expected to recede under such conditions, and therefore influence the depths and velocities in some of the nearshore spawning areas. Project operation is expected to result in a general improvement to spawning habitats available to longnose sucker and white sucker in Reaches 3 through 21 of the Fond du Lac River.

A spring riparian flow increase (i.e., from 40 m^3/s to 70 m^3/s) is proposed for the Project to help support successful spawning of Arctic grayling in the Fond du Lac River between Black Lake and Middle Lake. Natural (i.e., pre-Project) flows in the Fond du Lac River reach a minimum during winter, then begin to increase in late April. Because rapid increases in river flow are likely to initiate spawning activities of long-lived riverine fish species, it is anticipated that an increase in Fond du Lac River flows during spring will cue the onset of spawning behaviours (i.e., migration and pre-spawning congregation) in Arctic grayling (Nesler et al. 1988; Poff et al. 1997). Once adult Arctic grayling have congregated on the spawning areas and water temperatures are consistently above 3°C, spawning begins. Arctic grayling populations in the Fond du Lac River between Black Lake and Middle Lake typically begin spawning between the third week of May and mid-June.

The 70 m^3/s spring spawning incentive ("trigger") flow will be initiated on May 1 to match the increase in flows associated with the natural hydrograph and therefore mimic the natural cues that help trigger the onset of spawning behaviours in the Fond du Lac River. Because initiation of the spawning trigger flow on May 1 is expected to mimic the increase in flows associated with the natural hydrograph and responses of fish to spawning cues are expected to remain relatively unchanged, it is anticipated that potential negative effects on Arctic grayling reproduction will be reduced.

The use of a temperature-based threshold for initiating the spring spawning trigger flow was considered but is not recommended for the Project. Although water temperature can regulate, in part, maturation in some species, additional stimuli, such as aggregation of spawning groups, might be required to initiate the final stages of spawning (Nesler et al. 1988). Monitoring of water temperatures within the river may also come at an additional cost (i.e., equipment, personnel) and could be a comparatively less reliable basis for initiating spawning trigger flows. Data loggers located upstream and downstream of Elizabeth Falls were used to collect water temperature data during the 2010 spring spawning season. The data indicates that temperatures tend to vary on a spatial scale within the river; water temperatures upstream were generally warmer than water temperatures at the downstream location at any given day and time. On this basis, selection of temperature data logger locations would have to be carefully considered in order to set protective temperature-based thresholds for initiating spawning trigger flows.

It is anticipated that changes to hydrology within the bypassed section of the Fond du Lac River will have implications for the foraging habitats available to fish, as well as the sources and types of foods consumed. Arctic grayling feed primarily at the surface and tend to consume drifting prey items (Stewart et al. 2007). Young Arctic grayling feed primarily on zooplankton, shifting to immature insects as they grown in size. Adult grayling are primarily planktivorous (Schmidt and O'Brien 1982), although they will feed on a large assortment of invertebrates, including aquatic and terrestrial insects (Scott and Crossman 1973). The insects consumed include caddisflies, midges, bees, wasps, grasshoppers, ants, and varieties of beetles. They also will feed on small fishes, eggs, and crustaceans (Scott and Crossman 1973). Arctic grayling position themselves within the water flow so that the energy expended while feeding is minimized and the amount of energy gained from consumption of drifting organisms is maximized (Stewart et al. 2007). O'Brien et al. (2001) reported that the width of a fish's search window (i.e., the area or territory a fish would use while feeding) is likely to increase with decreasing flow velocities, and fish are more likely to efficiently locate drifting prey. Hughes and Dill (1990) also reported that prey capture efficiency of Arctic grayling increases with decreases in stream velocities. This is attributed, in part, to the fact that at faster velocities, prey items are swept downstream at a rapid rate, and fish must therefore react swiftly to capture prey before it is swept past their search window and carried downstream (Hughes and Dill 1990). Therefore, the abundance of drifting prey items at higher velocities is often offset by a fish's reduced ability to capture prey at high velocities. Because flow velocities will be reduced in the Fond du Lac River, it is anticipated that drift-feeding Arctic grayling will spend less time and energy moving back and forth between velocity refugia and preferred feeding positions, and will be more efficient at capturing drifting prey.

Therefore, it is anticipated that reduced flow velocities within many areas of the Fond du Lac River will result in a net increase in suitable (i.e., easily used) foraging habitat.

Changes to flow velocities at the Black Lake outflow to the Fond du Lac River and in the bypassed sections of the river during Project operation can affect the amount and types of drifting food available to downstream Arctic grayling. Because a minor increase in velocities is expected to occur over a short distance at the proposed submerged weir, it is possible that a greater number of invertebrates will be dislodged from the substrate at this location and will drift downstream. Conversely, some reaches in the bypassed river sections could have reduced velocities such that benthic invertebrates are not dislodged from the substrates and carried downstream (Stantec 2010). It is anticipated that production of some small insect nymphs and invertebrates that are not tolerant of high-velocity flows will increase in slower-moving areas of the Fond du Lac River and could therefore serve as a localized, abundant food source for Arctic grayling and other species (Bunn and Arthington 2002).

Reductions in the wetted width of the river may reduce the quantity of habitat available to macroinvertebrates that some fish depend upon for food (Stantec 2010). However, displaced invertebrates are expected to recolonize other areas of the river that are suitable or become suitable post-project because many species have winged adult life stages that can move among river sections (Lessard and Hayes 2003). In addition, decreased depths and velocities within the bypassed section of the Fond du Lac River could improve productivity within the permanently wetted channel. Food items sourced from within the river could be increasingly important relative to drifting food items during Project operation.

Project operation is expected to result in a general increase to the amount of suitable white sucker habitat in the Fond du Lac River (Appendix 12.1), which can lead to an increase in white sucker numbers and effects on Arctic grayling populations. It is possible that larger white sucker populations could reduce survival of Arctic grayling eggs (i.e., predation) or compete with Arctic grayling for food (Scott and Crossman 1973; Stewart et al. 2007). Predation of fish eggs by white sucker has been reported for other systems, although the accuracy of this data is considered equivocal (Holey et al. 1979; Scott and Crossman 1973). Scott and Crossman (1973) identified a study where no eggs were found in the stomach contents of 100 white sucker that were captured from a lake whitefish spawning area during the spawning season. Similarly, Stewart (1926) reported that no eggs were found in the stomachs of over 200 white sucker that were captured over brook trout (*Salvelinus fontinalis*) redds. Holey et al. (1979) completed a review of the relevant literature and determined that even in situations where white sucker have been known to consume eggs and fry of other species, predation was not of sufficient magnitude to cause effects on populations.

Young white suckers can compete with Arctic grayling in the event that food supplies in the river become scarce (Holey et al. 1979) as there is some overlap in preferred food items. Young Arctic grayling and white sucker fry feed within the water column; the former consumes zooplankton and immature insects and the latter consumes plankton and small invertebrates (Scott and Crossman 1973). However, because adult Arctic grayling tend to feed on food items found drifting in the water column (mostly plankton) and adult white sucker feed primarily at the bottom, there is expected to be only minor overlaps in feeding strategies and therefore minimal opportunity for competition.

The quantity of suitable overwintering habitat available to age-0, juvenile, and adult Arctic grayling in the bypassed section of the Fond du Lac River during Project operation is expected to be greater than that available under historically normal flow conditions (i.e., without the Project in place). During high-to-average spring flow conditions, withdrawal of water for power generation is expected to alter the hydrologic conditions in the Fond du Lac River such that the quantity of suitable spawning habitat available to Arctic grayling will increase or remain relatively stable. However, it is anticipated that during average-to-low spring flows, water withdrawal for power generation will result in a net loss of suitable spawning habitat for Arctic grayling. Changes to the types and quantity of foraging habitat, as well as the species and types (e.g., drifting) of prey available to Arctic grayling and other fish species, are expected because of Project operation and changes to hydrology. Therefore, residual environmental effects on fish and fish habitat are expected to occur because of Project operation and changes to hydrology in the bypassed reaches of the Fond du Lac River.

12.5.4 Management of Uncertainty

Like all scientific results and inference, residual effects predictions will have uncertainty associated with the data and current knowledge of the system. The confidence in residual effects predictions is related to the following:

- the adequacy of baseline data for understanding conditions in the Project area;
- the accuracy of predicted and modeled data; and
- the understanding of Project-related residual environmental effects on the system.

There is a high degree of confidence that some fish and fish habitat will be disturbed, altered, or destroyed because of Project construction and operation. The affected areas have been identified based on the Project footprint and changes to hydrology that are expected to occur within LSA waterbodies and watercourses.

One source of uncertainty for the Project is the degree to which residual effects may occur (e.g., magnitude and duration). There is a high degree of confidence that construction and operation of the Project will result in some destruction or alteration of fish habitat, as well as some fish injury and mortality. However, the time required for fish habitats, as well as fish species distribution and abundance, to return to pre-Project levels following cessation of power generation is unknown. Since the result of final closure are uncertain, it cannot be assumed that fish habitats disturbed by the Project will return to the original type and quality. Similarly, distributions and relative abundance of fish species might not return to pre-Project levels. In addition, there are uncertainties in the direction, magnitude, and spatial extent of future fluctuations in fish habitats and fish populations, independent of residual effects from the Project.

There is some uncertainty associated with the hydrodynamic data and the HSI models used to evaluate the quantity and quality of fish habitat available to VCs (i.e., Arctic grayling) in the Fond du Lac River. The hydrodynamic data used in the fish habitat assessments were simulated using the River2D hydrodynamic model. Field ground-truthing surveys, model calibration, and professional experience and judgement were used to reduce uncertainty in the hydrodynamic data produced for the Fond du Lac River. Development of HSIs for the species, life-stages, and activities of interest was based on professional experience, thorough reviews of the relevant literature and site-specific data for fish species in the LSA. A sensitivity analysis (Appendix 12.1) was completed to determine how different sources of uncertainty in the HSI model inputs contributed to the overall uncertainty of the HSI model outputs (i.e., how robust are the results of the HSI analyses given there is uncertainty associated with the inputs).

Uncertainty was addressed in the fish and fish habitat assessment by incorporating information from available and applicable literature, as well as using knowledge gained from past experiences with similar locations, species, and project types. Conservative estimates were used so that residual effects were not underestimated. In addition, proven BMPs will be implemented to mitigate residual effects on fish and fish habitat during construction, operation, and reclamation activities. Loss or alteration of fish habitat will be offset as part of the Fisheries Offsetting Plan for the site.

12.6 Determination of Significance

The determination of significance considers all primary Project interactions that are expected to result in residual effects on fish and fish habitat after implementing environmental design features and mitigation. The classification of residual effects from primary interactions provides the foundation for determining environmental significance from the Project and other developments on self-sustaining fish populations (including listed species).

12.6.1 Residual Effects Criteria

The purpose of the residual effects classification is to describe the incremental and cumulative effects from the Project and other developments on VCs using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment. The following criteria will be used to classify the residual effects from the Project in the EIS:

- direction;
- magnitude;
- geographic extent;
- duration;
- reversibility;
- frequency; and
- likelihood.

Definitions for each of the criteria for determination of significance of residual effects on fish and fish habitat used in this assessment are provided below and summarized in Table 12.6-1.

Direction – Direction indicates whether the residual effect on fish and fish habitat is negative (i.e., less favourable), positive (i.e., more favourable), or neutral (i.e., no change). The focus of the residual effects assessment is to predict whether the Project is likely to cause significant residual effects on fish and fish habitat or to cause public concern. The positive changes associated with the Project also are reported. Neutral changes are not assessed.

Magnitude – Magnitude is a measure of the intensity of a residual environmental effect of the Project on fish and fish habitat. It represents the degree of change observed for a measurement endpoint relative to baseline conditions, a guideline, or objective. Magnitude is classified into three categories: negligible to low, moderate, or high. Because effects threshold levels associated with the abundance and distribution of fish populations have not been estimated for the Project area, the magnitude of residual effects on fish is assessed qualitatively. The magnitude of residual environmental effects on fish habitat are assessed qualitatively as well, except where predicted changes from baseline conditions could be modeled (e.g., quantity of total spawning habitat available to Arctic grayling in the bypassed section of the Fond du Lac River).

Table 12.6-1: Definitions of Terms Used in the Determination of Significance for Residual Effects to Fish and Fish Habitat

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood
Negative: There is a less favourable change relative to baseline values or conditions. **Positive:** There is an improvement over baseline values or conditions.	**Negligible to Low:** There is no measureable residual effect on fish and fish habitat, or the change is expected to be less than the applicable guidelines or objectives. **Moderate:** The residual effect on fish and fish habitat is measureable, but within the anticipated resilience limits of the fish population, or within applicable guidelines/objectives and less than two standard deviations from baseline conditions. **High:** The residual effect on fish and fish habitat is near or exceeding the anticipated resilience limits of the population, or is predicted to be above applicable guidelines/objectives and greater than two standard deviations from baseline conditions.	**Local:** The residual effect is limited to the LSA. **Regional:** The residual effect is limited to the Project area, and can include cumulative environmental effects from the Project and other developments. **Beyond Regional:** The residual effect will extend beyond the Project area and includes cumulative effects from the Project and other developments.	**Short-term:** The residual effect is reversible at the end of construction. **Medium-term:** The residual effect is reversible at closure, during initial decommissioning and reclamation activities. **Long-term:** The residual effect is reversible within a defined length of time beyond closure and early decommissioning and reclamation activities. **Permanent:** The residual effect is irreversible within the temporal boundary of the assessment (95 years).	**Reversible:** The time (i.e., duration) required for the Project to no longer influence fish and fish habitat. **Irreversible:** The residual environmental effect is not reversible within the temporal boundary of the assessment (95 years) or the duration of the residual effect is undefined or permanent.	**Isolated:** The residual effect is confined to a specific discrete period (i.e., the construction phase) or Project activity. **Periodic:** The residual effect occurs intermittently, but repeatedly over the temporal boundary of the assessment (95 years). **Continuous:** The residual environmental effect will occur continually over the temporal boundary of the assessment (95 years).	**Unlikely:** The residual effect is possible, but unlikely, within the temporal boundary of the assessment (95 years; < 10% chance of occurring). **Possible:** The residual effect is possible within a year, or has a chance of occurring within the temporal boundary of the assessment (95 years). **Likely:** The residual effect is probable within a year, or has a chance of occurring at least within the next 10 years (> 80% chance of occurring). **Highly Likely:** The residual effect is certain.

LSA = local study area; % = percent.

For a change of state from baseline conditions (or an exceedance of guideline or threshold values) to occur, the magnitude of alterations in the physical environment, population, and community processes and properties must be large enough so that there is a significant residual effect on the maintenance of self-sustaining fish populations. The characteristics of a particular fish population could provide it with defences and strategies to withstand stresses associated with landscape change, which could include physical damage, changes to hydrology and surface water quality, and increased competition or predation. Alternatively, species with low resilience might respond by declining in abundance over the short- or long-term. For the fish and fish habitat assessment, quantitative measures of the change in the physical environment were used, where possible, to aid in assessing the qualitative magnitude of change.

Geographic Extent – Geographic extent refers to the area affected by the Project, and is categorized according to three scales: local, regional, and beyond-regional. Local-scale residual effects represent changes that are directly related to the Project footprint and activities, but may also include small-scale indirect residual effects, such as air emissions and dust deposition. Changes at the regional scale are largely associated with indirect residual effects from the Project and represent the maximum predicted spatial extent of direct and indirect residual effects from the Project. Regional scale residual effects could include the cumulative residual effects from other developments on fish and fish habitat. The beyond regional scale includes cumulative residual effects from the Project and other developments that extend beyond the Project area.

Duration – Duration is the amount of time (years) from the onset of a residual environmental effect on when the residual environmental effect on fish and fish habitat is reversed. By definition, residual environmental effects that are considered short-term, medium-term, or long-term in duration are reversible (i.e., effects that are not considered permanent).

In some cases, available scientific information and professional judgment can predict that the residual effect is irreversible (i.e., permanent). Alternately, the duration of the residual effect may not be known, except that it is expected to be extremely long and well beyond the temporal boundary of the assessment (90 years). As such, any number of factors could result in effects on fish and fish habitat that will never return to a state that is unaffected by the Project. In other words, science and logic predict that the likelihood of reversibility is so low that the residual effect is irreversible.

Reversibility – Reversibility refers to the likelihood that a Project activity or stressor will no longer influence fish and fish habitat once the Project activity or stressor has ceased or been removed. The influence of an activity or stressor may be either reversible or irreversible. If a residual environmental effect is reversible, then there must be some associated period (i.e., duration). Permanent residual environmental effects are considered irreversible.

Frequency – Frequency is a measure of how often a residual environmental effect is expected to occur. Frequency of occurrence may be classified as isolated (i.e., confined to a discrete period), periodic (occurs intermittently, but over the temporal boundary of the assessment), or continuous (i.e., occurring continuously over the temporal boundary of the assessment). Timing of the residual effect (e.g., only once during construction at the beginning of the Project) must be identified, and if the frequency is periodic in nature, the length of time between occurrences must be considered.

Likelihood. Likelihood is the probability of an effect occurring and is described in parallel with uncertainty. Likelihood is classified into four categories: unlikely (residual effect is possible, but unlikely to occur within the temporal boundary of the assessment [less than 10% chance of occurring within the temporal boundary of 95 years]), possible (residual effect is possible within a year, or a has a chance of occurring within the temporal boundary of the assessment, although its occurrence is not certain); likely (residual effect is likely to occur within the first year or at least within the next 10 years [>80% chance of occurring]) or highly likely (the residual effect is certain).

12.6.2 Classification of Residual Effects from the Project

The classification of residual effects from the Project on fish and fish habitat is reported in Table 12.6-2.

Fish injuries and mortalities that are expected to occur because of impingement or entrainment of fish in the water intake during Project operations are predicted to have residual effects that will be moderate in magnitude. Some fish currently drift downstream out of Black Lake into the Fond du Lac River via the Black Lake outflow; during Project operation, fish are expected to drift downstream via the natural river outflow and the water intake. However, the total number of fish leaving the Black Lake fish community is not expected to change over the current level of out-migration because overall Black Lake outflow rates and volumes will not change with the development of the Project. Out-migration of fish from Black Lake once the Project is operating is expected to be similar to current levels and therefore within the resilience limits of Black Lake fish populations. Selection of a shallow-water (i.e., 5 m deep) water intake design is thought to be protective of deep-water species, such as lake trout, whitefish, and cisco, during specific periods of the annual cycle. Black Lake cisco have some features characteristic of common cisco and shortjaw cisco; shortjaw cisco are listed as a potentially threatened species under Schedule 2 of *SARA* and are identified as a threatened species by COSEWIC.

Table 12.6-2: Summary of the Classification of Residual Effects to Fish and Fish Habitat

Residual Effect	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood
Injury and mortality of Black Lake fish from impingement or entrainment in the power tunnel	Negative	Moderate	Local	Permanent	Irreversible	Continuous	Highly likely
Loss and alteration of fish habitat resulting from the Project footprint	Negative	Negligible	Local	Short-term	Reversible	Continuous	Highly likely
Loss and alteration of fish habitat resulting from changes to hydrology	Negative	Moderate	Local	Long-term	Reversible	Continuous	Highly likely

Although the number of fish moving downstream out of Black Lake is not expected to change because of Project development, a higher rate of injury and mortality is expected for fish that are impinged at or entrained by the water intake structure versus fish that pass downstream through the natural Black Lake outflow. Fish that drift into the Fond du Lac River through the natural Black Lake outflow could become integrated into downstream populations of the same species, assuming they are not harmed or killed during passage down the turbulent river, and could therefore have the opportunity to spawn and pass on their genetic material. Fish that are entrained with water flows into the power tunnel could be more likely to be killed or injured; injured fish could become easier prey for birds and piscivorous fish downstream of the tailrace channel outlet. Therefore, fish that pass through the power tunnel and powerhouse turbine generator units could be less likely to survive and reproduce. The frequency of residual effects for injury and mortality of impinged or entrained Black Lake fish is expected to be continuous and permanent; however, the potential for future effects will cease immediately following the cessation of power generation.

Loss and alteration of fish habitat is expected due of the Project footprint. Although appropriate and applicable mitigation practices will be used and sensitive habitats will be avoided to the best extent possible, construction and operation of the Project is expected to result in some permanent alteration or destruction of fish habitat. This permanent alteration and destruction of fish habitat that supports a commercial, recreational, or Aboriginal (CRA) fishery is discussed in the Fisheries Offsetting Plan (Appendix 12.1); with successful design and implementation of the Plan, the Project footprint or construction of Project components will not affect CRA fisheries. Therefore, the magnitude of residual effects from the Project footprint is expected to be negligible. Following closure, Project infrastructure will be decommissioned and reclaimed. Design and implementation of the Fisheries Offsetting Plan early in the Project development will offset serious harm to fish that could result in effects to the productivity of CRA fisheries; therefore, the effects are considered to be reversible in the short-term.

The loss and alteration of fish habitat that is expected because of changes to hydrology in the Fond du Lac River between Black Lake and Middle Lake during Project operations is predicted to have both positive and negative residual effects that are moderate in magnitude. The quantity of suitable overwintering habitat available to Arctic grayling in the bypassed section of the Fond du Lac River during Project operation is expected to be greater than that available under historically normal flow conditions (i.e., without the Project in place). Under average to below-average spring flow conditions, Project operation is expected to result in a net decrease in the quantity of suitable spawning habitat available to Arctic grayling. This may be partly offset by the increase in quantity of suitable spawning habitat under high flows. Foraging habitat is expected to improve under reduced riparian flows proposed for the Project. It is anticipated that hydrological changes in the Fond du Lac River will alter the relative abundance of prey items available to Arctic grayling and other fish species. Overall, positive and negative residual effects from the Project are predicted to be measureable, but within the anticipated resilience limit of the fish populations in the Fond du Lac River. The frequency of residual effects for loss and alteration of fish habitat in the Fond du Lac River because of Project operation and changes to hydrology is expected to be continuous. Effects will cease within a few years following the cessation of power generation, and are therefore considered reversible over the long-term.

12.6.3 Significance of Residual Effects

The classification of residual effects from the primary interactions provides the foundation for determining environmental significance from the Project and other developments on self-sustaining fish populations (including listed species). Magnitude, geographic extent, and duration (which includes reversibility) are the principal criteria used to predict significance (Federal Environmental Assessment and Review Office [FEARO] 1994). Other criteria, such as frequency and likelihood are used as modifiers (where applicable) in the determination of significance. Significance is determined for the residual effect of the Project overall, as well as for the cumulative effects from the Project and previous and existing developments (there are currently no known, reasonably foreseeable developments that overlap the spatial and temporal boundaries of the assessment [Section 12.5]).

Environmental significance is used to identify predicted effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to the abundance, distribution, and state of fish populations. A number of high magnitude and long-term or irreversible effects at the population and community levels (beyond local scale) would likely be significant. Non-significant effects are strong enough to be detectable at the population and community levels, but are not likely to decrease resilience or alter the state and increase the risk to self-sustaining fish populations.

In summary, the following information was used to evaluate the significance of residual effects from the Project on fish and fish habitat:

- results of the residual effects classification;
- magnitude, geographic extent, and duration of the effect as principle criteria, with frequency and likelihood as modifiers; and
- application of professional judgement and ecological principles, such as resilience, to predict the duration and associated reversibilty of residual effects.

The residual effects from the Project are not predicted to be large enough to alter the state of fish health, abundance, distribution, or habitat, and therefore, influence the maintentance of self-sustaining fish populations. The scale of residual effects from the Project interactions, independently or combined, should not be large enough to cause irreversible changes at the population level or decrease the resilience of fish communities within the local or regional study areas. Overall, the residual effects from the Project as a whole on maintentance of self-sustaining fish populations are not significant.

12.7 Environmental Management, Monitoring, and Follow-up

Construction and operation of the Project will result in serious harm to fish (injury and mortality to fish that become impinged or entrained at the water intake in Black Lake. The Project also will affect hydrology within the bypassed section of the Fond du Lac River and subsequently result in the destruction and permanent alteration of fish habitat within the river. These changes to fish and fish habitat will occur during Project operation. It is anticipated that monitoring of fisheries offsetting activities, as defined in the Fisheries Offsetting Plan, will be required during the Project operation. The objectives and methods used to offset serious harm to fish within the LSA will be determined with input from regulators and local communities.

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12.9 Glossary

Term	Description
Abundance	The quantity or amount of something in a particular area or volume.
Acidification	The decrease of acid neutralizing capacity in water, caused by natural or anthropogenic processes. Acidification is exhibited as the lowering of pH.
Adfluvial	Life history strategy where adult fish spawn, and juveniles rear, in flowing water but move back into lakes to feed.
Alevin	Newly hatched fish living off stored yolk sac.
Anadromous	Moving into rivers from the sea to spawn.
Annex	Separate stand-alone document that has been attached as more detailed supplementary information.
Appendix	Supporting information added at the end of a section that is directly referred to in the text of the section.
Aquatic biota	The collection of organisms living in the water.
Assessment endpoints	Qualitative expressions used to assess effects on valued components. They represent the key properties of the valued component that reflect its ecological status or societal value.
Back-water	Area of standing or slow moving water partially isolated from the flow of the main river channel.
Barriers	Any physical or biological obstacle to migration or disbursement of fish.
Baseline	A quantitative value or quality to which other data values and observations of a similar nature are compared.
Bathymetry	Measurement of the depth of a waterbody.
Benthic	Living on or near the bottom of the waterbody.
Bio-remediation	The process of applying corrective action to unbalanced systems through the use of

Term	Description
	biological means.
Black-water	Water containing feces and urine, also referred to as sewage.
Boulder	Refers to the particle class size of substrate that is >256 mm in size.
Brackish	Water which is more saline than freshwater, but less saline than saltwater.
Cardiovascular	Refers to the circulatory system which circulates blood and lymph throughout the body.
Channel	The main component of a given watercourse; it typically has flowing water, on at least a seasonal basis, and is usually defined by the area of the stream substrate.
Cobble	Refers to the particle class size of substrate that is 64 to 256 mm in size.
Commercial Fishery	Fishing for the purpose of sale or bartering.
Condition Factor (*K*)	A mathematical measurement of robustness or health of an individual fish or group of fish calculated using the fish length and weight.
Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	A committee of experts that assesses and designates which wildlife species are in some danger of disappearing from Canada.
Cubic metres per second (m^3/s)	The standard measure of water flow in rivers (i.e., the volume of water in cubic metres that passes a given point in one second).
Cumulative Effects	All effects on the environment from a Project and previously existing and reasonably foreseeable developments.
Decommissioning	To remove from active service or shut down and dismantle.
Department of Fisheries and Oceans Canada (DFO)	Federal Government Department responsible for policies and programs in support of Canada's economic, ecological and scientific interests in oceans and inland waters; for the conservation and sustainable utilization of Canada's fisheries resources in marine and inland waters; for leading and facilitating federal policies and programs on oceans; and for safe, effective and environmentally sound marine services responsive to the needs of Canadians in a global economy.
Depositional	Refers to sediment types (i.e., fines) or areas containing sediment types that were previously eroded, carried by water, and deposited on the bottom of a waterbody.
Distribution	The occurrence, position, or arrangement of fish within an area.
Domestic Fisheries	Fishing for personal use and not for sale or barter.
Eddy	Circular current of water diverging from and flowing against the main river current.
Emergent vegetation	Rooted aquatic plants with parts that extend above the water surface.
Entrainment	The transport of fish (including eggs and larvae) out of their normal watercourse or waterbody and into a structure; transport is the result of water currents.
Environmental Assessment	A method of analysis that attempts to predict the possible impacts of a proposed major development on the biophysical and human environments both within the vicinity of the site and the region; offering a means of settling conflicts and mitigating significant negative impacts.
Environmental Impact Statement (EIS)	The document prepared by the proponent of a project that summarizes the results of an Environmental Assessment.
Erosion	The wearing away of riverbanks and adjacent material by flowing water.
Fertilization	Fusion of male and female gametes to form a new individual organism.
Fish	Fish, as defined in the *Fisheries Act*, includes parts of fish, shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.
Fish salvage	Process of removing and relocating fish from isolated in-water work areas.

Term	Description
Flushing rate	Time required for a volume of water equivalent to the lake volume to be discharged from the lake (lake volume divided by daily river discharge).
Fluvial	Life history strategy where adult fish spawn, and juveniles rear, in tributaries but move back into main river channels to feed.
Foraging	The act of looking for food.
Francis turbine	An inward-flow reaction turbine that combines radial and axial flow components to generate power.
Frazil ice	Small, needle-like or thin, flat ice crystals suspended in water that form when sub-freezing air cools the surface of the water to below the freezing point (supercooling). In rivers with turbulent flow, the supercooled water mixes into a thicker layer and frazil ice forms, suspended in the supercooled layer.
Fry	A young, newly hatched fish which has used up its yolk sac and has started active feeding.
Fugitive dust	Dust released into the atmosphere as a result of the mechanical disturbance of granular material exposed to air.
Gill rakers	A series of bony projections along the anterior end of the gill arch.
Gravel	Refers to the particle class size of substrate that is 2.0 to 64 mm in size.
Grey-water	Drainwater from dishwater, showers, sinks and baths.
Groundwater	Water held underground in the soil or in pores and crevices in rock.
Homothermous	Water body that has the same water temperature throughout.
Hydrology	The science of waters of the earth, their occurrence, distribution, and circulation; their physical and chemical properties; and their reaction with the environment, including living beings.
Impingement	The drawing and holding of fish (including eggs and larvae) against a structure by water currents.
Incubate	The development and hatching of fish eggs.
Invertebrates	An animal, such as an insect, that lacks a spinal column.
Juvenile	A fish that is grown, but that has not reached a state of sexual maturity enabling it to reproduce.
Kaplan turbine	A propeller-type turbine with adjustable blades that is used to generate power.
Lacustrine	Relating to or associated with lakes.
Large-bodied fish	Fish species that, as an adult, is large enough to be commercially or recreationally sought after.
Life history	The series of changes an organism undergoes during the period between fertilization of the egg and death.
Littoral zone	The shallow area of a lake that extends from the water line to the lake-ward limit of rooted aquatic vegetation.
Local Study Area (LSA)	Defines the immediate spatial extent directly or indirectly affected by a project.
Macrophyte	An aquatic plant that can be viewed without the aid of optics; types include submergent, emergent, or floating macrophytes.
Mark-recapture	A method to estimate a population size by capturing then marking individuals, returning them to the population, and then recapturing a portion of the marked individuals.
Mean	Centroid value of a data population when viewing its probability distribution function (or histogram) as a mass distribution.

Term	Description
Measurement endpoint	A quantitative or quantifiable (i.e., measurable) expression of the changes to assessment endpoints compared to guidelines, benchmarks, or baseline values.
Migration	Movement of fish from one area to another.
Mineralization	The process through which organic substances becomes impregnated by inorganic substances.
Mitigation	An action or design intended to reduce the severity or extent of an environmental impact.
Mortality	The process of dying.
Neurological	Refers to the nervous system including the brain, spinal cord, and nerves.
Osmoregulatory	Refers to the active regulation of fluid pressure within an organism.
Overburden	Waste material overlying the area of interest.
Over-wintering habitat	Habitat which supports fish survival throughout the winter.
Papilose	Lips covered with small fleshy projections or ridges.
Pelagic organisms	Organisms which live at or near the surface of the water away from the bottom or shoreline.
pH	The degree of acidity (or alkalinity) of soil or solution. The pH scale is generally presented from 1 (most acidic) to 14 (most alkaline). A difference of one pH unit represents a ten-fold change in hydrogen ion concentration.
Physoclistous	A fish which has its swim bladder isolated from the oesophagus.
Physostomous	A fish which has its swim bladder connected to the oesophagus by a pneumatic duct.
Phyto-remediation	Use of green plants to extract heavy metals from contaminated soils and water.
Piscivorous	A fish species whose diet consists largely of other fish.
Planktivorous	A fish species whose diet consists largely of plankton.
Pool	Aquatic habitat which is normally deeper and wider than aquatic habitats immediately above and below it.
Population	The number of individuals of a given species that live in the same geographical area and have the capability of interbreeding.
Potable water	Water which is suitable or safe for drinking according to established health standards.
Predatory	An organism which lives by hunting, catching, and eating other organisms for food.
Pre-spawn	A short term condition in sexually mature fish that extends from the time when gonads are fully developed until the start of spawning.
Project footprint	Upland areas associated with project infrastructure.
Proponent	A person, group, or organization that advocates a theory, proposal, or project.
Q10 flow	Flow value at which 10% of annual mean stream values will be below this flow value, and 90% of mean stream flow values will be greater than this value.
Q90 flow	Flow value at which 90% of annual mean stream values will be below this flow value, and 10% of mean stream flow values will be greater than this value.
Qualitative	Research information gathered in situations where quantitative measurements cannot provide an understanding.
Radio-telemetry	Tracking animal movements using transmitters that are attached to the animal and that send signals to remote receivers.
Rearing habitat	An area where larval and juvenile fish find food and shelter to live and grow.
Reclamation	The process of reconverting disturbed areas to their previous natural states.
Recreational Fishery	Fishing for pleasure or competition.
Redd	A nest in the gravel, stones, or sand of a stream bed that is prepared by male or female fish of some species. Where fish eggs are deposited.

Term	Description
Regional Study Area	Defines the spatial extent related to the cumulative effects resulting from the project and other regional developments.
Residual Effect	Generally refers to a remaining effect; in the case of the Tazi Twé Hydroelectric Project it means the effect remaining after mitigation has been considered.
Respiratory	Refers to the system that performs gas exchange throughout the body.
Riffle	High velocity shallow water flowing over coarse substrate. Water surface is broken due to submerged or exposed bed material.
Riparian	The interface between land and a watercourse or waterbody where sufficient soil moisture supports vegetation typically adapted for life in saturated soil conditions.
Ripe	Fish which are sexually mature and are actively spawning.
Riprap	The placement of rocks along the edge of a watercourse or waterbody for shoreline stabilization or to support culverts, piers, or other structures.
Riverine	Related to or associated with rivers or streams, including riverbanks.
Run	High velocity, deep water with a largely unbroken surface.
Runoff	The portion of water from rain and snow that flows over land to streams, ponds or other surface waterbodies and watercourses. It is the portion of water from precipitation that does not infiltrate into the ground or evaporate.
Sand	Refers to the particle class size of substrate that is 0.06 to 2.0 mm in size.
Seasonal development	Fish which are sexually mature and whose gonads are growing and developing between spawning seasons.
Sediment	Solid material that is transported by, suspended in, or deposited from water. It originates mostly from disintegrated rocks; it also includes chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics, and cause of the occurrence of sediment in streams are influenced by environmental factors. Some major factors are degree of slope, length of slope, soil characteristics, land usage, and quantity and intensity of precipitation.
Self-sustaining population	A population of animals which has sufficient numbers to maintain the population level over the long-term.
Sexual maturity	Fish which have the ability to reproduce.
Shoal	A localized shallow area in a water body isolated from shore. Shoals may be depositional (e.g., submerged, deposited sediment) or erosional (e.g., a rocky shoal that is formed as finer material is washed away by wave action).
Silt	Refers to the particle class size of substrate that is <0.06 mm in size.
Slough	Non-flowing water body isolated from flowing waters except during flood events.
Spawning	The reproductive activity of adult fish that includes fertilization and deposition of eggs.
Species At Risk Act (*SARA*)	Federal government legislation to prevent wildlife species from becoming extinct and to secure the necessary actions for their recovery.
Stratification	Separating of water into layers. In stratified lakes, there may be mixing within a layer but little mixing occurs between layers. Layers have different densities which may be caused either by temperature or salinity.
Submergent vegetation	Plants that occur completely beneath the water's surface.
Substrate	Refers to the material that comprises the bottom of the observed watercourse within the study reach (including all wetted and unwetted areas).
Surface water	Water that collects on the surface of the ground.
Swale	A natural depression or wide shallow ditch used to convey runoff.
Taxonomic assessment	The act of determining the classification of an organism based on biological criteria (e.g., morphometric characteristics) and expert knowledge.

Term	Description
Temperate	Region or climate characterized by mild temperature.
Terminal mouth	Mouth which is located at the foremost point of the head allowing for feeding throughout the water column.
Thermocline	Stratum between the epilimnion, where warmer, less dense oxygen-rich water is mixed as a result of wind and wave action, and the hypolimnion, where dense cool water is removed from major surface influences. The thermocline is a zone where water exhibits a rapid temperature decrease from the warm epilimnion to the colder hypolimnion. The thermocline can also be referred to as the mesolimnion and metalimnion.
Total dissolved solids (TDS)	The total concentration of all dissolved compounds and solids found in a water sample.
Total suspended solids (TSS)	The amount of suspended substances in a water sample; solids found in wastewater or in a stream that can be removed by filtration. The suspended matter may be from artificial or anthropogenic wastes or natural sources, such as silt.
Toxicity	The magnitude of harmful effects in organisms from the alteration of natural environmental conditions.
Tributaries	Streams which flow into larger streams or other water bodies.
Turbid	Opaque water resulting from the stirring up of sediment or introduction of foreign particles.
Turbidity	An indirect measure of suspended particles, such as silt, clay, organic matter, plankton, and microscopic organisms, in water.
Velocity	Speed at which water moves downstream.
Ventral mouth	Mouth which is located under the head; allows fish to feed on bethic food sources.
Water discharge	The volume rate of water flow passing through a given cross-sectional area of a stream channel. The units typically used to express discharge are cubic metres per second (m^3/s).
Waterbody	A general term that refers to ponds, bays, lakes, estuaries, and marine areas.
Watercourse	A general term that refers to riverine systems such as creeks, brooks, streams, and rivers.
Waterfall	Very high water velocities involving water falling over a vertical drop.
Watershed	The area of land bounded by topographic features that drains water to a larger waterbody such as a river, wetland, or lake. Watersheds can range in size from a few hectares to thousands of kilometres.
Weir	A barrier across a river designed to alter the river’s flow characteristics.
Zooplankton	Small animals, generally under 2 mm, suspended in the water column and carried by currents and waves. Primarily protozoans and small crustaceans.

Notes: pH = potential hydrogen; > = greater than; mm = millimetres

12.10 List of Acronyms

Acronym	Definition
AANDC	Aboriginal Affairs and Northern Development Canada
Acres	Acres International Corporation
AFS	American Fisheries Society
ANFO	ammonium nitrate/fuel oil
ARD	acid rock drainage
BLFN	Black Lake First Nation
BMP	Best Management Practice

Acronym	Definition
CCME	Canadian Council of Ministers of the Environment
CEAA	*Canadian Environmental Assessment Act*
CEA	Canadian Electricity Association
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRA	commercial, recreational, or Aboriginal
DOED	Department of Electricity Development
DFO	Fisheries and Oceans Canada
EIS	Environmental Impact Statement
EnvPP	Environmental Protection Plan
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
FEARO	Federal Environmental Assessment and Review Office
FL	fork length
Golder	Golder Associates Ltd.
HSI	Habitat Suitability Index
K	condition factor
LSA	local study area
ML	metal leaching
MOE	Saskatchewan Ministry of Environment
NO_2	nitrogen dioxide
ORNL	Oak Ridge National Laboratory
PM	particulate matter
RSA	regional study area
SARA	*Species at Risk Act*
SERM	Saskatchewan Environment and Resource Management
SI	suitability index
SPPR	Saskatchewan Parks and Recreation Resources
SNIFFER	Scotland and Northern Ireland Forum for Environmental Research
SO_2	sulphur dioxide
Stantec	Stantec Consulting
Project	Tazi Twé Hydroelectric Project
TL	total length
TSS	total suspended solids
US	United States
USACE	United States Army Corps of Engineers
VC	valued component
YOY	young-of-the-year

12.11 List of Units

Unit	Definition
°C	degrees Celsius
%	percent
≥	greater than or equal to
<	less than
≤	less than or equal to
>	greater than
cm	centimetre
cm/h	centimetres per hour
ha	hectare
km	kilometre
km^2	square kilometre
kPa	kiloPascals
L	litre
L/day	litres per day
m	metre
m^2	square metres
m^3	cubic metres
m^3/day	cubic metres per day
m^3/s	cubic metres per second
m^3/y	cubic metres per year
m/s	metres per second
mm	millimetre
mm/s	millimetres per second
ppm	parts per million
s	seconds

13.0 SOILS

13.1 Introduction

The purpose of the soils section is to describe the terrestrial environment that could be affected by the Tazi Twé Hydroelectric Project (Project) and to assess the effects on soils. The scope of this section includes an analysis of Project-related changes to soils during construction, operation, and closure, and considers accidents, malfunctions, and unplanned events. The overall residual effects from the Project and potential for cumulative residual effects from the Project and previous, existing, and reasonably foreseeable developments on soils are also assessed.

Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples, and the public. The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development, and therefore, are used predict the effects of the Project on all environmental components. Rationale for selection of soils as a VC is as follows:

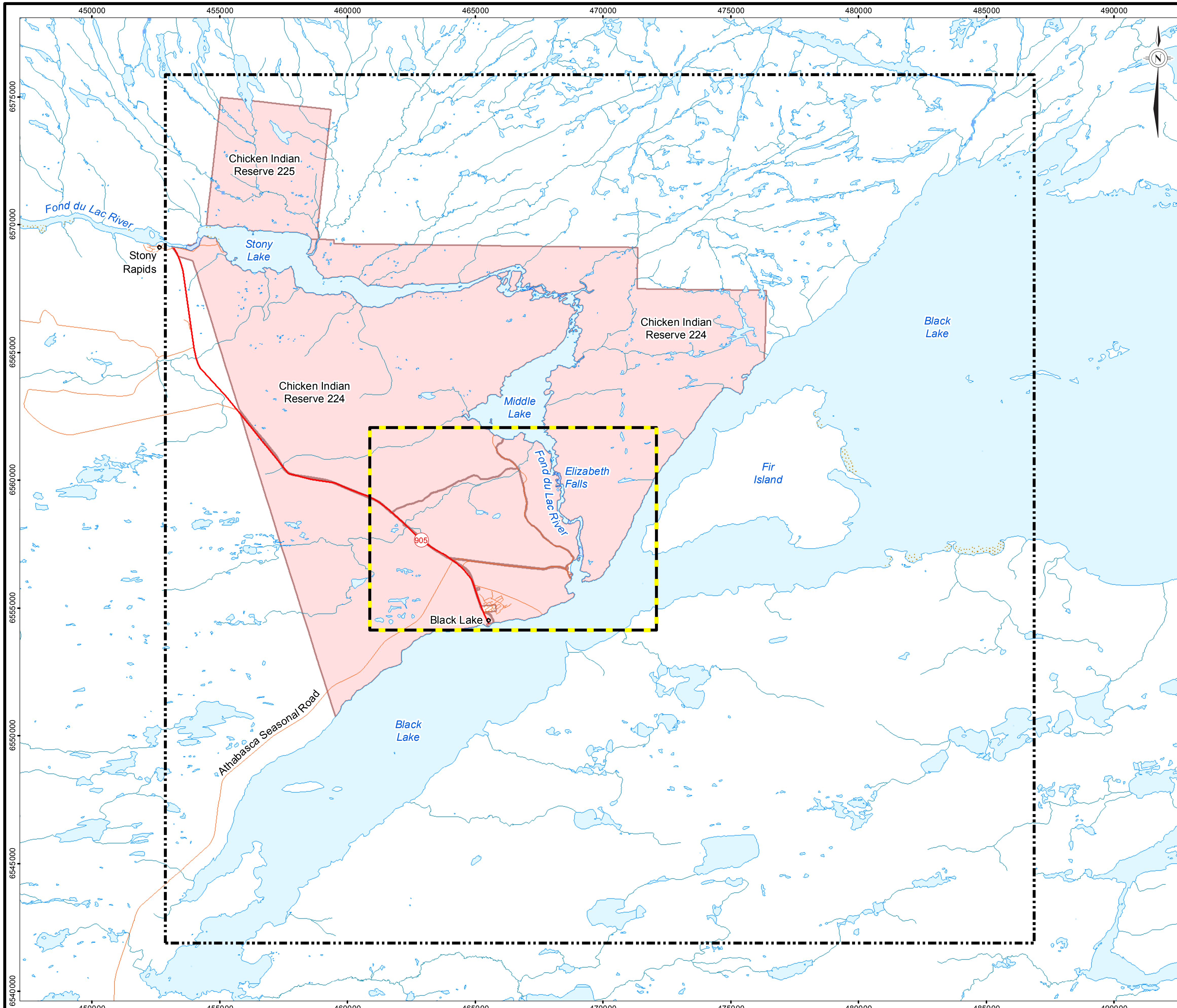
- close links among soils and other VCs (i.e., vegetation, wildlife, wildlife habitat, and surface water quality);
- natural and human-related disturbances can change the interactions between the soil and other VCs; and
- changes in soils and other VCs can influence the opportunity for traditional and non-traditional human use of natural resources (e.g., gathering, hunting, trapping, and fishing).

The assessment endpoint is the key property that should be protected for use by future human generations and although soil was selected as a VC, it does not have an independent assessment endpoint (Section 7.2). The results of this assessment are provided to support the effects assessment for other VCs (e.g., water quality, vegetation, and human health). The measurement endpoints are quantifiable and qualitative expressions of change and for soils include terrain and slope stability, soil quality, quantity, and distribution, and permafrost distribution.

13.2 Spatial Boundaries

To quantify baseline conditions and assess Project-related effects on the terrestrial environment, a regional study area (RSA) and a local study area (LSA) were defined for all terrestrial components (soil and terrain, vegetation, and wildlife).

The LSA is approximately 89 square kilometres (km^2) (8,881 hectares [ha]), and includes the Project infrastructure and the main access road (Figure 13.2-1). The LSA was based on the predicted direct and small-scale indirect effects from the Project on the terrestrial environment. Direct effects on soils include removal of soil from the Project footprint. Indirect effects on soils include changes to soil from dust deposition, air emissions, and surface water levels and flows.



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- INDIAN RESERVE
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA

REFERENCE

DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6

5 0 5
SCALE 1:150,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATION OF THE LOCAL AND REGIONAL STUDY AREAS FOR SOILS

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	07/11/13	**FIGURE: 13.2-1**
CHECK	JF	15/11/13	
REVIEW	DD	15/11/13	

The Project is located in an area with a relatively low level of human-related disturbance. The area north of Black Lake and the Fond du Lac River is influenced by isolated fishing camps and cabins. The community of Black Lake is located approximately 7 kilometres (km) southwest of the Project and the Northern Hamlet of Stony Rapids is located approximately 25 km northwest. Camp Grayling is a fishing camp located approximately 2.5 km south of the Project. Other human-related disturbances near the Project include various small developments (less than 8 ha), such as old gravel and borrow pits, cabins, the Black Lake sewage lagoon, and linear features such as all-terrain vehicle and snowmobile trails. Highway 905, an all-season road, connects the communities of Black Lake and Stony Rapids. The RSA selected for the terrestrial environment consisted of a 1,156 km^2 (115,600 ha) area centred on the Project (Figure 13.2-1).

The assessment of soils only considers the RSA in a qualitative context, and assessment of effects at the RSA scale is not completed. This is because the effects to soils are expected to be confined to the LSA, and are relevant mainly to areas of direct disturbance associated with the Project and small-scaled indirect effects.

13.3 Existing Environment

The purpose of this section is to describe the existing terrain and soil conditions within the RSA and LSA as a basis to assess the potential Project-specific effects on soils. The detailed methods and results for the baseline surveys are located in Section 3.0 of Annex IV.

13.3.1 Field Program

A baseline field program was completed from June 1 to 12, 2012. The field program was designed as a level four survey intensity (broad reconnaissance survey) that identified common soil subgroups used to delineate soil map units (Agriculture Canada 1987). At each site, soil profiles were characterized to a maximum depth of 120 centimetres (cm). Terrain and soil data collected during the field program were used for soil classification and mapping descriptions.

Terrain and soil data collected at each site included landform, slope position, slope class, slope length, land use, drainage, horizonation, colour, texture, structure, consistence, root presence, coarse fragment content, presence of carbonates, moisture regime, and vegetation cover as per The Canadian Soil Information System Manual for Describing Soils in the Field (Agriculture Canada 1982).

During the field program, 56 sites were surveyed within the RSA, with 35 locations occurring in the LSA; sample sites in the RSA are used to support the mapping of soil units within the LSA. Of the 56 sites surveyed, 30 were mineral soils, 15 were organic soils, and 11 were bedrock outcrop sites. Terrain and soils information for each survey site are available in Annex IV, Appendix IV.1 (Table IV.1-1 and Table IV.1-2).

13.3.2 Soil Classification and Mapping

13.3.2.1 Soil Classification

Soils were classified according to the Canadian System of Soil Classification (Soil Classification Working Group [SCWG] 1998) based on information obtained during the 2012 field program. Mineral soils identified during the baseline field program included Brunisolic (15 total), Gleysolic (11 total, 3 of which were peaty phase), Regosolic (3 total), and Podzolic (1 total) soils. Soils at 11 locations were classified as Organic, and included subgroups within the Fibrisol, Mesisol, and Folisol great groups. Eleven of the sites surveyed were identified as Bedrock (classified as a non-soil).

Brunisolic and other mineral soils (excluding Gleysols) were generally found at upland landscape positions. Gleysolic soils were generally found in transition areas between upland landscape positions and depressional landscape positions (i.e., wetlands). Organic soils were found in wetlands in depressional areas.

13.3.2.2 Soil Mapping

Soil mapping was completed following guidelines outlined in *A Soil Mapping System for Canada: Revised* (Agriculture Canada 1981). Soils were generally grouped into four landscape (terrain) areas including upland landscape positions for well drained soils; depressional (wetland) landscape positions for very poorly drained soils; transition landscape positions (between upland and wetland positions) for poorly to imperfectly drained soils (possibly exhibiting peaty phase characteristics); and bedrock landscape positions for bedrock sites void of soil development.

Soil mapping involved the correlation of field observations and soil classification to topographic maps and mapped ecological landscape classification (ELC) vegetation units. Landsat satellite imagery (30 metre [m] by 30 m resolution collected June 24, 2010) was used to classify vegetation units for the ELC map for the LSA (Annex IV, Section 4.2.2). Topographic maps (1:50,000 National Topographic System maps) were used to identify general relief and changes in terrain. Soil inspection information was applied considering principles of geomorphology and surficial geology, in combination with ground-truthed soil and vegetation patterns. The primary characteristics used to group soil types into map units included dominant soil texture and parent material, soil moisture regime, soil subgroup, and terrain (slope and surface expression). Map units (soil polygons) were created for the LSA after considering relationships between map resources, ELC vegetation units, satellite imagery, and field data. As there are no published soil surveys for the LSA, soil map unit names were assigned based on the dominant parent material (mineral, organic, or bedrock) within the map unit area.

Due to the coarse resolution of the ELC data, many soil map units include both mineral and organic soil subgroups. Soil subgroups (or groups of multiple soil subgroups) within map units are defined as dominant, co-dominant, sub-dominant, or inclusions based on the proportion of each soil subgroup present in the map unit. Dominant soil subgroups represent the most common soil subgroup within the map unit and typically occupied between 60 percent (%) to 100% of the map unit. Co-dominant soil subgroups are defined as soil subgroups that occur in near equal proportion (approximately 40% to 60% of the map unit), and sub-dominant soil subgroups represent a minor proportion of the map unit (typically 20% to 40%). Inclusions represent soil subgroups that occupy a minor amount (approximately 15% to 20%) of the map unit area and are generally found sporadically and infrequently. Soil subgroups that represented less than 15% of the map unit were not mapped. Although bedrock is not a soil subgroup, it was listed as dominant, co-dominant, sub-dominant, or inclusion where applicable.

Existing Disturbance map units encompass areas of existing disturbance that are a result of human activity, such as roads, the community of Black Lake, the Black Lake sewage lagoon, Camp Grayling, and borrow/gravel pits. These disturbances were mapped based on visual identification of roads from satellite imagery and the ELC map. Not all Existing Disturbance map unit areas identified on the vegetation ELC map were applied to the soil map because disturbance contributing to changes in vegetation (e.g., cut lines) do not necessarily result in disturbance to soil.

Within the LSA, seven soil map units, an Existing Disturbance map unit, and an Open Water (ZW) map unit were delineated based on correlations with ELC vegetation classes, soil characteristics, and terrain features. The seven soil map units include four mineral map units (Mineral-1 [M1], Mineral-2 [M2], Mineral-3 [M3], and Mineral-4 [M4]), two organic map units (Organic-1 [O1], Organic-2 [O2]), and one bedrock map unit (Bedrock-1 [R1]), all of which capture the range of variability in soil subgroups present in the LSA.

The distribution and area (ha and %) of each map unit within the LSA is shown in Table 13.3-1 and Figure 13.3-1. The majority of the LSA is comprised of mineral soil map units, with the Mineral-1 (M1) map unit encompassing the largest proportion of the LSA (approximately 2,462 ha or 27.7% of the LSA). The Organic-2 (O2) map unit covers the smallest area of the LSA (approximately 46 ha or 0.5% of the LSA). Detailed descriptions of each soil map unit are provided in Annex IV (Section 3.3.2).

13.3.3 Soil Sensitivities in the Local Study Area

13.3.3.1 Water and Wind Erosion Sensitivity

The risk of soil erosion from water or wind is influenced by many factors including soil particle size, organic matter content, water content, permeability, topography, slope gradient, vegetation cover, natural events (e.g., freeze-thaw), as well as human activities that cause soil disturbance (Cruse et al. 2001; Campbell et al. 2002; Transportation Association of Canada [TAC] 2005). Erosion from water and wind differ by the processes that move detached soil particles, and each process of erosion affects soil differently. The outcome of soil erosion is important because of potential off-site effects, including the sedimentation of adjacent waterbodies and the release of chemicals from the soil into surface water, which can alter water quality (Kuhn and Bryan 2004).

Soil erosion risk is one of the primary concerns for disturbed soils because the removal of vegetation cover exposes soil materials to wind and water. Depending on terrain and soil characteristics, with continuous exposure of soil to wind or rain, soil materials can be eroded, washed, or blown away and this can result in the loss of topsoil and a reduction in soil quality. Soil erosion potential by water is based on methods described by TAC (2005). Mineral soil sensitivity to wind erosion was based on the uppermost mineral soil horizon texture and a dimensionless index described by Coote and Pettapiece (1989). Wind erosion ratings for Organic soils were assigned based on degree of peat decomposition (Campbell et al. 2002).

Brunisolic soils at upland landscape positions within the LSA have a Low sensitivity to water erosion. At transition and depressional landscape positions, poorly drained Gleysolic and peaty phase Gleysolic soils have Low to Moderate sensitivity to water erosion. In areas of Organic soils that are not deep and organic surface horizons are removed and subsurface materials are exposed, the water erosion potential of the underlying material would be Low if sandy and Moderate if silty. If slope percentage or slope length increases, the water erosion potential for soils within all the map units will increase.

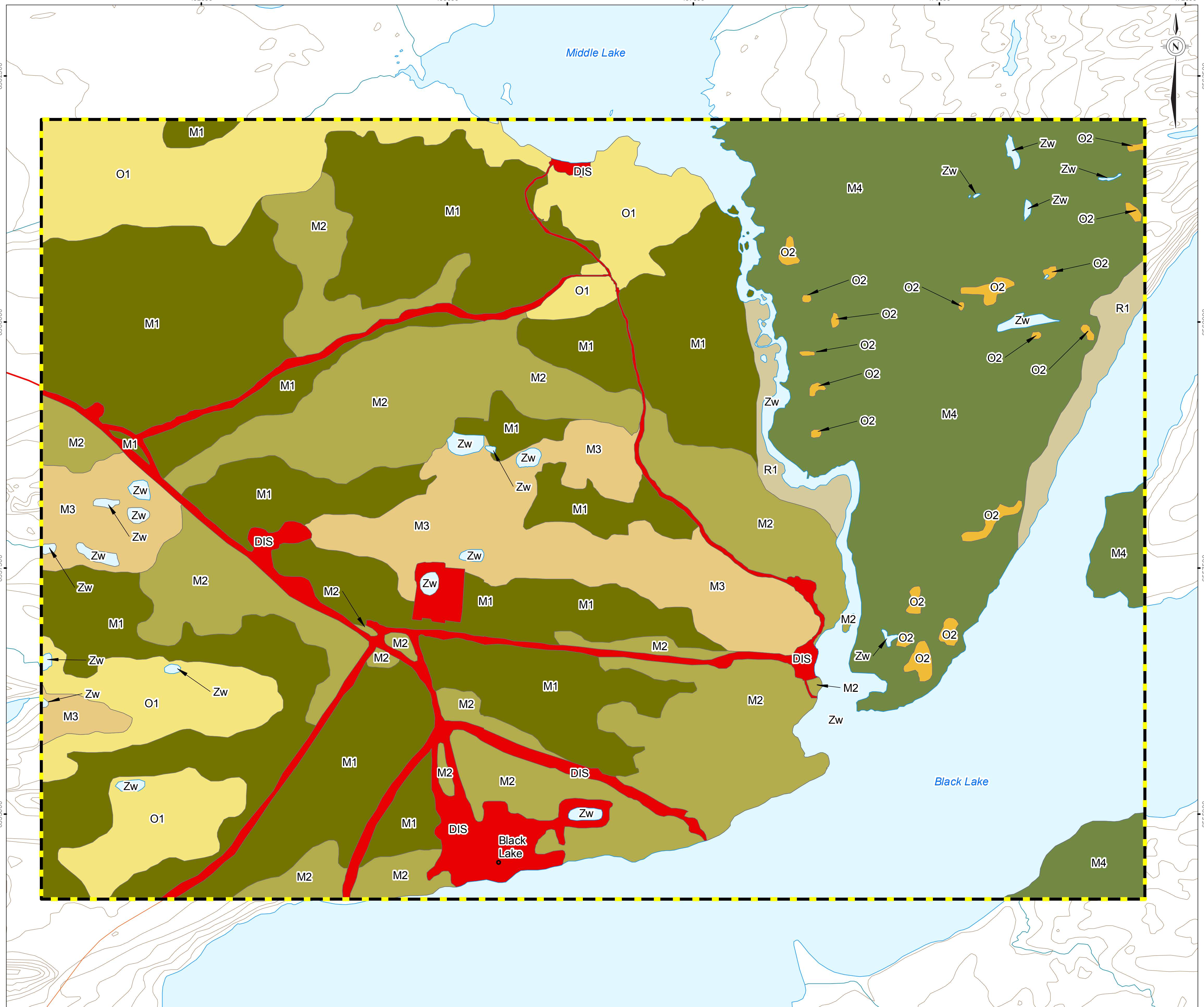
Wind erosion ratings for dominant soil subgroups in all map units was High, based on either sandy textured mineral upper soil horizons or disturbed, dry organic (folic) upper soil horizons. Soils with Low to High wind erosion ratings potential were associated with silt and silt loam texture upper mineral soil horizons (Low rating) or sandy or disturbed and dry organic (fibric) upper soil horizons (High rating). Soils most sensitive to wind erosion include sandy Brunisolic soils and Folisols. In the event Organic surface materials are removed and underlying mineral soil horizons are exposed, the wind erosion ratings remain High because of the sandy textures. Areas containing Organic Fibrisols and peaty phase Gleysolic soils with silt or silt loam uppermost mineral horizons have a Low sensitivity to wind erosion.

Table 13.3-1: Distribution of Soil Map Units within the Local Study Area

Map Unit Name	Map Unit Symbol	Proportion of LSA		Soil Subgroups in Map Unit[a]
		Area (ha)	Percent (%)	
Mineral-1	M1	2,462	27.7	Dominantly Eluviated Dystric Brunisols and Eluviated Eutric Brunisols
				Inclusions of Rego Gleysols and Terric Fibrisols
Mineral-2	M2	1,397	15.7	Dominantly Eluviated Dystric Brunisols and Eluviated Eutric Brunisols
				Sub-dominantly Rego Gleysols and Terric Fibrisols
Mineral-3	M3	604	6.8	Co-dominantly Eluviated Dystric Brunisols and Eluviated Eutric Brunisols
				Co-dominantly Rego Gleysols and Terric Fibrisols
Mineral-4	M4	1,639	18.5	Dominantly Eluviated Dystric Brunisols and Eluviated Eutric Brunisols
				Inclusions of Hemic Folisols, Terric Fibrisols, and bedrock outcrop and fragmental material
Organic-1	O1	800	9.0	Dominantly Terric Fibrisols
				Sub-dominantly Eluviated Dystric Brunisols and Eluviated Eutric Brunisols
Organic-2	O2	46	0.5	Dominantly Typic Fibrisols and Terric Fibrisols
				Inclusions of Gleysols
Bedrock-1	R1	127	1.4	Dominantly bedrock outcrop and fragmental material
				Inclusions of Terric Fibrisols and Gleysols
Existing Disturbance	DIS	377	4.2	N/A
Open Water	ZW	1,428	16.1	N/A
Total	**-**	**8,881**	**100**	**-**

[a] Dominant soil subgroup(s) = cover 60% to 100% of map unit area; co-dominant soil subgroup(s) = near equal proportion of map unit area covered; sub-dominant soil subgroup(s) = cover 20% to 40% of map unit area; inclusions = cover 15% to 20% of the map unit area

ha = hectares; % = percent; LSA = local study area; N/A = not applicable; DIS = Existing Disturbance; M1 = Mineral-1; M2 = Mineral-2; M3 = Mineral-3; M4 = Mineral-4; O1 = Organic-1; O2 = Organic-2; R1 = Bedrock-1



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- CONTOUR LINE
- RIVER
- WATERBODY
- TERRESTRIAL LOCAL STUDY AREA

SOIL MAP UNIT

- M1 (MINERAL-1)
- M2 (MINERAL-2)
- M3 (MINERAL-3)
- M4 (MINERAL-4)
- O1 (ORGANIC-1)
- O2 (ORGANIC-2)
- R1 (BEDROCK-1)
- ZW (OPEN WATER)
- DIS (EXISTING DISTURBANCE)

REFERENCE

DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEET: 74P/03, 04

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

SOIL MAP UNITS IN THE LOCAL STUDY AREA

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM/LMR	07/11/13	**FIGURE: 13.3-1**
CHECK	JF	15/11/13	
REVIEW	DD	15/11/13	

13.3.3.2 Sensitivity to Acidification

The sensitivity of mineral soils to acid deposition was evaluated using the chemical criteria published by Holowaychuk and Fessenden (1987). Because soils were not analysed for cation exchange capacity (CEC), an estimation of the range of CEC related to soil texture was compiled based on data presented in Holowaychuk and Fessenden (1987). The sensitivity rating for Organic soil is based on the type of wetland (i.e., bog, poor fen, moderate rich fen, and extreme rich fen) (Turchenek et al. 1998).

In general, moderate rich and extreme rich fens (moderate to high nutrient status and neutral pH or higher [greater than pH 6]) tend to be least susceptible to acidification. Organic soils that occur in moderate and rich fens are least susceptible to acidification and therefore have a Low sensitivity rating. Bogs are hydrologically isolated, and therefore these wetlands mainly get water from precipitation and are very low in nutrients and more acidic. Poor fens, although slightly higher in nutrient status and pH than bogs, represent an intermediate between bogs and rich fens. Organic soils that occur in bogs and in poor fens are most susceptible to acidification and therefore have a Medium sensitivity rating.

Brunisolic soils had a sand or loamy sand surface texture. These soil textures are generally associated with a low CEC. Brunisolic B-horizon pH ranged from 4.35 to 6.14; therefore, surface horizons would also be somewhat acidic. Surface material in Brunisolic soils in the LSA was assumed to have a pH less than 6.0. Brunisolic soils would have a High sensitivity to acidification because of their low CEC and low pH.

Organic soils within all map units have Low to Moderate sensitivity to acidification depending on the associated wetland type. Moderate, rich, and extreme rich fens have a low sensitivity to acidification. Bogs and poor fens are rated as Medium.

Gleysolic soils generally had sand, sandy loam and silty textures, which are associated with low to high CEC. These soils occur in transitional areas adjacent to wetlands; therefore, their pH would be influenced by water associated with the adjacent wetland type. Even in areas that are considered peaty phase, the overlying shallow organic layer would be influenced by underlying materials. In general, these soils would be considered to have a Medium to Low sensitivity to acidification; this rating would increase to Medium to High where they are occurring adjacent to acidic bogs or where textures are sandy.

Overall, in the LSA upland landscape positions containing well drained, sandy soils are predicted to be most sensitive to acidification, whereas wetland containing Organic soils (within bogs, fens, and swamps) have a Low to Medium sensitivity to acidification. Gleysolic and peaty phase Gleysolic soils would generally have a Low to Medium sensitivity, except where they have sandy textures they are rated as High.

13.3.3.3 Permafrost Potential

Permafrost potential was assigned to soil map units within the LSA. Permafrost potential ratings for each soil subgroup were assigned based on soil type, drainage, soil texture, and topography observed during the field program. Location of the Project, with respect to the permafrost zone in which it occurs, was also considered. Poor to imperfectly drained soils were rated as having a Low to Moderate permafrost potential, whereas moderate to rapidly drained soils were rated as having a Very Low potential for permafrost.

The LSA is within the sporadic discontinuous permafrost zone, where permafrost can occupy approximately 10% to 50% of the area (Natural Resources Canada 1995). The distribution and occurrence of permafrost is highly variable in the sporadic discontinuous permafrost discontinuous zone.

Brunisolic soils in the LSA have a Very Low permafrost potential. Peaty phase Gleysolic and Folisolic soils with poor drainage have a Low permafrost potential. Areas of treed bogs containing Organic (peat) soils would be the most likely to contain permafrost. Overall, Fibrisolic soils have a Moderate potential to contain permafrost.

13.3.3.4 Sensitivity to Compaction

Generally, well-drained, coarse and medium textured soils (loams, sandy loam, loamy sand, loam) are less prone to compaction than fine-textured soils (silty clay loam, silty clay, clay loam, and clay). However, sensitivity to compaction can change based on soil moisture conditions (Lewis et al. 1989). For example, loamy-textured soils under wet conditions are more prone to compaction than the same soil texture under dry conditions. In finer-textured soil (i.e., clayey), saturated conditions can exist due to poor drainage (i.e., the smaller soil pore sizes related to these textures can reduce water movement through the soil) and as soil moisture increases, so does soil sensitivity to compaction.

Compaction ratings for map units in the LSA were determined using criteria outlined by Lewis et al. (1989) under moist conditions. Gleysolic soils and their peaty phases were assigned compaction ratings based on soil texture under wet (saturated) soil conditions. Organic soils were not assigned compaction ratings but should be treated with special management practices (e.g., rig matting) or avoided during construction. Bedrock was not assigned a compaction rating.

Sandy and loamy sand textured Brunisols have a Low sensitivity to compaction under moist soil conditions. Gleysolic soils, including peaty phase Gleysolic soils, generally had sandy, sandy loam, silt, and silt loam textures in the upper and lower mineral soil horizons, indicating Moderate to Very High sensitivity to compaction under wet soil conditions.

13.3.4 Soil Chemistry

Chemical constituents of underlying bedrock and associated rock leachate have the potential to be present in the upper soil strata because of soil formation from bedrock parent material, as well as upward leaching of metals from rock (Turk et al. 2012). Geochemistry results can give some indication of the presence of metals, metalloids, and radionuclides in underlying materials (Golder 2012). If these constituents are present in underlying materials, they have potential to be present in the overlying soil, and therefore identify potential soil chemistry sensitivities that can be associated with the presence of those metals, metalloids, and radionuclides.

Initial geochemistry results (Golder 2012) indicate metals, including aluminum, chromium, selenium, arsenic, cadmium, copper, nickel, silver, zinc, lead, and iron, have been detected in in some rock leachate samples, and are at levels that exceed Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines for the protection of freshwater aquatic life. Although these results do not necessarily mean that these metals will be present in soil, it does indicate that they are present in bedrock parent material and therefore have the potential to be present in soil.

13.4 Screening of Project Interactions and Mitigation

This section identifies and evaluates the interactions between Project components or activities with potential to cause changes to soils, and the corresponding potential effects to other VCs (e.g., vegetation and wildlife). The process begins with the identification of all potential interactions for the Project. To provide a robust assessment of potential effects, each interaction is initially considered to have a linkage to a change in the terrestrial environment and associated potential effects on soil.

Each potential interaction is evaluated to determine if mitigation can be developed and incorporated to remove the interaction or limit the potential effects to soils. Mitigation includes Project design elements, environmental best practices, and management policies and procedures, and is developed through an iterative process between the Project's engineering and environmental teams. Knowledge of the terrestrial environment, and mitigation is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for a residual effect on soils.

Interactions are determined to be primary, secondary, or as having no linkage using scientific knowledge, professional judgment of technical specialists, experience with similar developments, and mitigation (Table 13.4 1). Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by environmental design features and mitigation so that the Project results in no detectable (measurable) change and residual effects to soils relative to baseline or guideline values;
- secondary – interaction could result in a minor change to measurement endpoints, but would have a negligible residual effect on soils relative to baseline or guideline values and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary – interaction is likely to result in a measurable change that could contribute to significant residual effects on soils relative to baseline or guideline values.

Primary interactions are anticipated to result in a residual effect on soil. Changes to soil can cause changes to other VCs (e.g., vegetation and wildlife). Because soils do not have assessment endpoints, residual effects are assessed for primary interactions that will be used to support the assessment of effects to other VCs. The determination of the significance of the residual effects is not completed for soils. Project interactions determined to have no linkage or those that are considered secondary are not predicted to result in significant effects to the soil capability to support other VCs (e.g., vegetation and wildlife).

Project components, activities, and the associated mitigation implemented during the various Project phases, including accidents and malfunctions, are summarized in Table 13.4-1. Potential effects on soils from each Project interaction and its associated classification are summarized in Table 13.4-1, with more detailed descriptions provided in the subsequent sections.

Table 13.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Soils

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Soils	Environmental Design Features and Mitigation	Interaction Classification
■ Infrastructure Footprints ▪ Temporary infrastructure – construction camp – overburden disposal areas – construction area and materials laydown area ▪ Operational infrastructure – power generation station – water intake structure – power tunnel – tailrace channel – submerged weir – bridge – transmission line – waste rock disposal areas – water diversion structures around the Project footprint – potable water and wastewater intake and discharge structures – site access roads (including source material)	Construction Operations Closure	Loss or alteration of permafrost can change terrain and affect soil quality.	■ The access road will be as narrow as possible, while maintaining safe construction and operation practices. ■ Organic or topsoil horizons will not be stripped in areas containing ice-rich permafrost to reduce potential for an increase in thaw depth and related thaw subsidence. ■ Soil disturbance will be limited to only those areas required for construction and operation of the Project. ■ Siting and construction of the Project will be planned to avoid environmentally sensitive areas (e.g., critical wildlife habitat, rare plants and wildlife species, and wetlands) as much as possible. ■ Location of the settling ponds will be based on topography (i.e., a low area) that is not in a sensitive feature such as a wetland or floodplain. ■ A qualified environmental monitor will be employed during clearing operations and will inspect the surrounding area for any damage following clearing. ■ Topsoil will be salvaged (i.e., seed bank) and replaced on areas to be reclaimed to enhance regeneration of vegetation. ■ An Erosion and Sediment Control Plan will be implemented prior to grubbing activities. ■ A Reclamation Plan will be developed for the Project to be reviewed and approved by agencies. ■ Progressive reclamation is expected to occur during construction and operations. ■ Depressions created by grubbing will be graded or filled with suitable material to the level of the surrounding ground.	No Linkage
	Construction Operations Closure	Direct loss or alteration of local soil from the Project footprint.		Primary
	Construction	Site clearing, contouring, and excavation can cause admixing, compaction, and erosion to soils, and change soil quality.	■ A site-specific assessment will be completed prior to soil salvage to identify surficial stripping depths and develop a site-specific soil salvage plan. ■ An Erosion and Sediment Control Plan will be developed based on industry standard Best Management Practices (BMPs) and federal and provincial regulatory requirements. ■ Soil disturbance will be limited to only those areas required for construction and operation of the Project. ■ Site clearing during construction of the Project infrastructure (e.g., roads, laydown areas) and salvage of soil materials will be completed during dry or frozen conditions, where and when practical. ■ Soil (growth medium) will be salvaged separately from overburden materials and saved for reclamation. ■ Matting (e.g., timber or rig mats) will be placed in sensitive areas to avoid rutting. ■ Salvaged topsoil will be stored on-site and away from areas that could be subject to travel, storage of equipment/material or future disturbances (i.e., reduce soil handling). ■ Experienced equipment operators will be used for topsoil salvage operations, and experienced environmental personnel will be used to supervise the process to maintain quality control. ■ Diversion structures will be installed around soil salvage stockpiles to control runoff, if necessary, and to divert surface runoff from exposed soils. ■ Disturbed areas (e.g., access roads and banks) will be graded to a stable angle after work is completed, reclaimed, and revegetated. ■ Erosion control practices will be applied to salvaged topsoil to reduce potential erosion and sediment transport off-site such as seeding soil salvage stockpiles to provide a cover of temporary or permanent vegetation to protect against wind and water erosion, as well as to maintain soil quality and volume. ■ The height of soil salvage stockpiles will be adjusted so that the size and shape reduces changes to quality, erosion, and loss (e.g., slumping). ■ Topsoil will be replaced on reclaimed areas as soon as feasible. Any surplus salvaged soil from construction will be stored on-site for future activities prior to closure.	Secondary
		Soil salvage, stockpiling and transport can change physical, biological, and/or chemical properties of soils, and increase erosion potential.		Secondary

Table 13.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Soils (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Soils	Environmental Design Features and Mitigation	Interaction Classification
■ Blasting Activities	Construction	Use of explosives can cause changes to soils quality.	■ A detailed Blasting Plan will be developed for the Project. ■ Best practices, as outlined in the Blasting Plan for the Project, will be applied to blasting activities to reduce any potential for enhanced nitrogen loading in the environment due to the placement and use of ammonium nitrate/fuel oil (ANFO) during construction. ■ A Site Water Management Plan will be developed for the Project. ■ Construction and monitoring of settling ponds or water treatment areas will be part of Site Water Management Plan.	Secondary
■ Air Emissions and Noise Levels ▪ emission of dust from blasting activities and hauling waste rock to storage piles. ▪ emission of standard pollutants from vehicles and heavy equipment operation	Construction, Operations, and Closure	Deposition of criteria air contaminants can change soil quality.	■ Equipment will be regularly maintained for compliance with provincial and federal air emission standards. ■ The equipment used for hauling and mucking operations will operate using diesel fuel with an ultra-low sulfur diesel content (less than 15 parts per million [ppm]). ■ The heavy-duty stationary and mobile diesel-fueled equipment fleet will meet or exceed EPA Tier 2/3 air quality emissions standards. ■ Gasoline-fueled equipment fleet will meet or exceed EPA Tier 2 Bin 6 air quality emissions standards. ■ An Environmental Protection Plan (EnvPP) will describe material handling protocols including dust management. ■ Soil salvage stockpiles or exposed soils will be seeded to reduce wind erosion. ■ All unpaved roads will be watered on a regular basis to prevent wind driven fugitive dust. ■ Water will be applied to waste rock disposal areas or soil salvage stockpiles when necessary to reduce fugitive dust. ■ A speed limit will be enforced on unpaved roads on site.	Secondary
		Dust deposition can change soil quality.		Secondary
■ Power Generation Activities ▪ water withdrawal for power generation ▪ diversion of water through the power tunnel to the powerhouse ▪ discharge of tailrace channel flows	Operations	Withdrawal, diversion, and discharge of water for power generation may change hydrology, which can affect soils.	■ A submerged weir will be constructed on the Fond du Lac River at the outlet of Black Lake and will be designed to maintain the range of water levels in Black Lake and in the uppermost section of the Fond du Lac River within the historical range for all powerhouse operating flow conditions. ■ Project site runoff resulting from rainfall, snowmelt, and groundwater releases will be managed by directing runoff around work site infrastructure by using appropriately sized ditches, channels, and culverts.	No Linkage
		Diversion of water through the power tunnel may change groundwater quantity, which can change hydrology, and affect soils.		No Linkage

Table 13.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Soils (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Soils	Environmental Design Features and Mitigation	Interaction Classification
■ Site Water Management ▪ collection and treatment of surface runoff within the project footprint ▪ discharge of wastewater ▪ collection and treatment of groundwater in the power tunnel	Construction Operations	Collection and disposal of wastewater from the site can affect soil quality and quantity.	■ A Site Water Management Plan will be developed for the Project. ■ The site will be properly graded and be surrounded by ditches and berms to capture runoff from the waste rock disposal areas. ■ Surface runoff will be diverted around and away from waste rock disposal areas as much as possible. ■ Runoff water in contact with the waste rock disposal areas will be sent to settling ponds. ■ The waste rock disposal areas will be placed in locations that are easily modified to be controllable in terms of run-on and run-off. ■ Runoff and drainage from within and around Project roadways and structures will be managed through the incorporation of erosion control methods (e.g., ditch blocks, silt fences). ■ Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns. ■ Ditch capacities will be sized to accommodate an extreme daily rainfall event. ■ Rock material energy dissipaters and ditch lining will be installed in areas where predicted runoff velocities are deemed excessive to reduce soil erosion. ■ Groundwater originating from construction of the power tunnel will be collected, treated if necessary, and monitored to confirm discharge criteria are met prior to release into the receiving environment. ■ Contingency plans for off-site disposal of dewatered settling pond sludge will be included in an EnvPP.	No Linkage
■ Waste Rock Disposal Areas	Construction Operations Closure	Seepage from the waste rock disposal areas can cause changes to soil quality.	■ A Waste Rock Management Plan will be developed for the Project to assess and manage various waste rock types. ■ Excavated rock and aggregate materials will be tested to confirm that this material will not have negative effects on the surrounding environment. Specific mitigation measures will be applied if the material is identified to be acid generating or to contain unacceptable levels of metals or radionuclides. ■ Additional site investigation and laboratory testing will be completed prior to construction of the Project.	No Linkage

Table 13.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Soils (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Soils	Environmental Design Features and Mitigation	Interaction Classification
■ Accidents and Malfunctions	Construction Operations Closure	Release or spills of hazardous substances (e.g., fuel, oil) can change soil quality.	■ Individuals working on-site and handling hazardous materials will be trained in Workplace Hazardous Materials Information Systems (WHMIS) and Transportation of Dangerous Goods (TDG). ■ Controlled products will not be allowed on-site unless accompanied by approved labels and Material Safety Data Sheets (MSDS). ■ All fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard; a lined and dyked containment area around these tanks will be provided to contain any potential fuel spills. The design of the containment area will be based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. ■ The storage containers will be regularly inspected for leaks or damage, and replaced when necessary. ■ Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled, and located in lined and bermed containment areas. ■ Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers. ■ Regular maintenance of construction equipment. ■ Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. ■ Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills of fuel would flow to the sump, which would be pumped out to a container for shipment off-site. ■ An Emergency Response Plan will be developed. ■ Spill response material (e.g., sorbent pads) will be stored on-site in designated areas and in vehicles. ■ Contaminated (impacted) soils will be removed and disposed of in an approved landfill or waste management facility.	No Linkage
		Failure of the embankment dykes around the settling ponds can change soil quality.	■ Fill material used for constructing the embankment dykes around the settling pond will be clean mineral soil with sufficient moisture to allow for proper compaction. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap as soon as practical following construction. ■ The settling ponds will be engineered to provide adequate storage of wastewater streams under normal and extreme operating conditions (e.g., settling ponds will be designed to contain the 1:100 year storm event). In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling ponds would be provided by the inclusion of an overflow spillway in the embankment. ■ The settling ponds will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. ■ During the detailed design stage, additional mitigation could be identified and included as part of the Environmental Protection Plan and the Emergency Response Plan.	No Linkage
Accidents, Malfunctions, or Unplanned Events	Construction, Operations, and Closure	Fire	■ The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail. ■ Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. ■ Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute).Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. ■ Personnel will be trained in fire prevention and response procedures. ■ Firefighting equipment will be available on site.	Secondary

CCME = Canadian Council of Ministers of the Environment; Project = Tazi Twé Hydroelectric Project; EnvPP = Environmental Protection Plan; DFO = Fisheries and Oceans Canada; mm = millimetre; % = percent; ppm = parts per million

13.4.1 Interactions with No Linkage to Effects

An interaction can have no linkage to effects if the activity does not occur (e.g., site runoff is not released), or if the interaction is removed by mitigation and environmental design features so that the Project results in no detectable change in soil quantity and soil quality. Subsequently, no residual effect on soil is expected. The following interactions are anticipated to have no linkage to effects to soils, and will not be carried through the residual effects assessment.

- **Loss or alteration of permafrost can change terrain and affect soil.**

The LSA is within the sporadic discontinuous permafrost zone, where permafrost could occupy approximately 10% to 50% of the area (Natural Resources Canada 1995). The distribution and occurrence of permafrost is highly variable in the sporadic discontinuous permafrost discontinuous zone. The permafrost in this area is characterized by having low ice content, indicating the ground ice content in the upper 10 to 20 m of the ground has less than 10% ice content by volume of visible ice (Natural Resources Canada 1995).

Clearing of an area and subsequent construction activities can cause permafrost to degrade slowly due to ground thermal changes resulting from removal and disturbance of vegetation. Once permafrost degrades, it can change surface relief and subsequently influence the surface drainage of an area (Lawson 1986).

The amount of ground ice present in permafrost is important for assessing the response of permafrost to clearing, construction, and subsequent recovery of ice conditions following disturbance (Jorgenson et al. 2010). The magnitude of changes to permafrost thermal regimes and potential thaw settlement is directly related to the nature and abundance of ground ice and the type and severity of disturbance at the surface (Lawson 1986; Pullman et al. 2007). Freeze induced displacement of soil (i.e., frost jacking) and thaw induced displacement of soil (i.e., subsidence) are the main issues related to permafrost degradation (i.e., loss and alteration). Changes to thaw penetration and thickness of the active layer can influence surface stability through thaw settlement, frost heave, and bearing capacity, as well as slope stability (Tarnoicai et al. 2004). Changes to the permafrost active layer can also affect vegetation and wildlife habitat by altering local hydrology, soil moisture, and nutrient availability conditions.

Areas with high ground ice content (i.e., terrain with abundant ice wedges) should be avoided where possible. These areas are more sensitive to thaw-settlement and can result in longer-term changes in terrain, soils, and surface hydrology (Jorgenson et al. 2010). Conversely, areas with small volumes of ground ice are not as sensitive to thaw settlement (Lawson 1986).

If permafrost were present in areas to be disturbed, the following mitigation would be applied:

- the access road will be as narrow as possible, while maintaining safe construction and operation practices; and
- organic and upper soil horizons will not be stripped in areas containing ice-rich permafrost to reduce potential for an increase in thaw depth and related thaw subsidence.

Soil present in the LSA ranged from having Very Low potential for permafrost (moderate to rapidly drained Brunisolic soils) to Moderate (imperfect to poorly drained Organic soils). Within the LSA, permafrost, if present, likely occurs in localized areas within treed bogs with poorly-drained Organic soils and would likely have low ground ice content. Because of the relatively low likelihood of permafrost occurring in the LSA and the use of mitigation if permafrost is identified, this interaction was determined to have no linkage to effects on soils.

- **Withdrawal, diversion, and discharge of water for power generation may change hydrology, which can affect soils.**
- **Diversion of water through the power tunnel may change groundwater quantity, which can change hydrology, and affect soils.**

Power generation activities such as water withdrawal, diversion of water through the power tunnel to the powerhouse, and discharge of tailrace channel flows can cause changes to water levels in Black Lake, the Fond du Lac River, Middle Lake, and a small lake (Lake A). Changes in water levels beyond the natural range of variability could lead to alterations in shoreline erosion, thereby affecting soils. In addition to changes in lake water levels, changes in downstream flows (e.g., altered drainage patterns, flow velocities) from water drawdown or re-direction of Black Lake could affect soils downstream.

Alterations to natural water level fluctuations have the potential to influence riparian vegetation by changing soil moisture (Nilsson and Svedmark 2002; Leyer 2005). Although riparian vegetation is adapted to thrive at the aquatic/terrestrial boundary, riparian vegetation is sensitive to changes in soil moisture (Leyer 2005; Nilsson and Svedmark 2002). If water levels change permanently, aquatic and terrestrial vegetation in the riparian area would change in relation to the changes in soil moisture (Shafroth et al. 2002). As soil moisture levels change because of reduction of water level fluctuations, plant species that thrive in more stable soil moisture regimes will out-compete riparian vegetation that relies on these fluctuations (Shafroth et al. 2002; Leyer 2005).

The long-term average annual flow for the Fond du Lac River is 304 m^3/s. Water will be diverted from the water intake at Black Lake through a power tunnel at a flow of up to 190 m^3/s to produce 50 megawatt (MW) of power and discharged into the Fond du Lac River from the tailrace channel upstream of Middle Lake. The remaining 114 m^3/s (on average) will pass through the natural Black Lake outlet into the Fond du Lac River. Simulation of natural conditions over the period of record indicated that Black Lake water levels typically fluctuate approximately 0.865 m over the course of an average year. Over the 40-year record, the maximum annual water level fluctuation was approximately 1.787 m.

During operations, the diversion of water through the power tunnel could interact with local groundwater, which could subsequently affect surface water locally or regionally. During operation of the tunnel, groundwater is predicted to flow into the tunnel at a maximum estimated rate of 680 cubic metres per day (m^3/d) (Section 9.0, Appendix 9.2). This rate is less than 0.0001% of the tunnel and minimum downstream flow rate (190 m^3/s) and is not expected to result in detectable changes to hydrology.

To maintain historical water levels in Black Lake, a submerged weir will be constructed on the Fond du Lac River at the outlet of Black Lake and will be designed to maintain the historical range of water levels in Black Lake and in the uppermost section of the Fond du Lac River, for all powerhouse operating flow conditions. A Site Water Management Plan will be implemented to meet minimum target seasonal riparian flows in the Fond du Lac River and maintain streamflow quantity along natural flow pathways. Downstream of the tailrace channel outlet where water flowing through the Project rejoins the Fond du Lac River, river flows would remain unchanged from baseline conditions.

Overall, the withdrawal, diversion, and discharge of water for power generation are not expected to result in detectable changes to groundwater quantity and hydrology. Therefore, these interactions were determined to have no linkage to effects on soils.

- **Collection and disposal of wastewater from the site can affect soil quality and quantity.**

Collection and disposal of wastewater from the Project site could potentially affect soil quality within and adjacent to the Project footprint, and increase soil erosion. Three settling ponds have been included in the construction plan for the Project for the management of the Project's wastewater (other than site runoff and sewage and grey water; Figure 5.1-1). Waste water produced during construction or runoff through the site will be contained, tested, and treated, if necessary, before release in accordance with regulations. One settling pond will be located near the water intake to collect the intake construction water along with a portion of the power tunnel dewatering flows and waste rock runoff from the waste rock disposal area south of the intake (Figure 5.1-1). A second settling pond will be located near the powerhouse excavation to collect the remainder of the tunnel and powerhouse dewatering. A third settling pond, beside the downstream end of the tailrace channel, will collect the tailrace channel dewatering and any runoff directed from the main waste rock disposal areas to the northeast of the tailrace channel (Figure 5.1-1). Water collected in disturbed areas located away from the settling ponds will be pumped to these locations. Surface water diversions might be constructed to maintain natural drainage characteristics, whereas other structures could be designed to actively divert water away from its natural flow path to prevent the interaction with site infrastructure, potentially contaminated water, or areas sensitive to erosion.

Retention of runoff in the settling ponds will allow suspended sediments and associated parameters (e.g., some metals) to settle out. This water will eventually be discharged downstream to its natural receiving waterbody (the Fond du Lac River through the tailrace channel). Water quality in the settling ponds will be tested and will meet appropriate discharge criteria (if required) prior to release into the environment. A Water Quality Monitoring Program will be implemented to determine the nature of potential changes to the water quality of the Fond du Lac River receiving discharge from the settling ponds. Waste water in the settling ponds will be discharged in the Fond du Lac River (at one of the potential discharge locations identified in Figure 5.3-3) after the water has been tested and treated (if necessary) to meet appropriate discharge criteria. Contingency plans for off-site disposal of dewatered settling pond sludge will be included in an Environmental Protection Plan (EnvPP).

Access roads within the site will be kept to a minimum (i.e., limit the number of roads) to reduce effects on the environment. Surface water will be directed into natural flows by means of swales, culverts, and ditches where necessary to maintain local drainage patterns. Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns and ditch capacities will be sized to accommodate an extreme daily rainfall event. Riprap energy dissipaters and ditch lining will be used in areas where the predicted runoff velocities are deemed excessive to reduce soil erosion.

Overall, surface water runoff and wastewater within the Project footprint are not expected to result in detectable changes to soil quality and quantity. Therefore, these interactions were determined to have no linkage to effects to soils.

- **Seepage from waste rock disposal areas can change soil quality.**

Construction of the powerhouse, water intake, power tunnel, and tailrace channel will produce approximately 1,074,000 m^3 of waste rock and 118,000 m^3 of overburden that will need to be stored on-site. The waste rock disposal areas will be placed in locations that are easily modified to control seepage and a Waste Rock Management Plan will be prepared for the Project. Excavated material will be stored near the Project construction areas, and located away from watercourses or lakes. Site grading, ditches, and berms will be used to capture runoff from the waste rock disposal areas, which will be sent to settling ponds. Surface water will be diverted around and away from waste rock disposal areas as much as possible. This runoff will be collected and water quality will be confirmed before release to the environment.

Some portion of the waste rock excavated from the power tunnel could be acid-generating, have elevated concentrations of various metals, or contain uranium mineralization, particularly waste rock from the section of the power tunnel within, or near, the Black Lake Shear Zone. The power tunnel waste will be screened for the potential to generate ARD and the potential for metal leaching (ML) prior to being placed in waste rock disposal areas. Previous geological testing has confirmed that radioactive waste rock is not likely to be encountered in the LSA (Hatch 2005, 2012). However, waste rock will be tested for radioactivity as construction progresses. Any rock waste that is found to be radioactive will be disposed of according to provincial and federal guidelines.

If bedrock materials are ARD-generating or susceptible to ML, the rock will be segregated for special management. In this case, environmental design features will be required to limit seepage from the waste rock disposal areas. A containment system will be designed to control seepage from the waste rock disposal areas to groundwater or underlying aquifers. The design will control shallow horizontal migration. Potentially contaminated wastewater from waste rock disposal areas run-off will be collected in on-site settling ponds. Once wastewater is collected, it will be tested and treated, if necessary, prior to discharge. Wastewater will meet applicable water quality guidelines (e.g., CCME) prior to being released into a nearby waterbody (i.e., Black Lake, Fond du Lac River, and Middle Lake).

If no adverse characteristics are identified in the waste rock, this material can be used as aggregate for road construction and concrete production. It can be used as riprap to armour the walls of the tailrace channel or to construct the submerged weir across the Fond du Lac River at Grayling Island. Re-use of “clean” waste rock at the Project site will reduce the overall volume stored in the waste rock disposal areas.

Ongoing monitoring requirements outside of those specified within the Project license would default to terms outlined within the relevant federal and provincial acts, regulations, and standards applicable at the time. Effects to soil quality from seepage and long-term contaminant transport from the waste rock disposal areas are expected to be limited using mitigation and environmental design features. Therefore, these interactions are not expected to result in detectable changes in soil quality and were determined to have no linkage to effects to soils.

13.4.2 Interactions with Secondary Linkages

In some cases, both a source and an interaction exist, but because the change caused by the Project is anticipated to be minor, it is expected to have a negligible residual effect on soils relative to baseline values. The following interactions are expected to be minor and will not be carried through the residual effects assessment.

- **Site clearing, contouring, and excavation can cause admixing, compaction, and erosion to soils, and change soil quality.**

- **Soil salvage, stockpiling, and transport can change physical, biological, and/or chemical properties of soils, and increase erosion potential.**

Site clearing and construction for the Project, particularly through soil salvage and stockpiling, could result in changes to soil quality. Soil salvage and stockpiling will occur during the construction phase of the Project. Changes to soil quality can influence the capability of soil to support other VCs (e.g., vegetation and wildlife).

The definition of soil quality encompasses physical, chemical, and biological characteristics that are used to determine the overall soil health. Many indicators can be used to describe soil quality, including properties related to organic matter content (e.g., the carbon to nitrogen ratio), organic carbon fractions, enzymatic activity, or aggregate stability. Changes to soil quality are expected directly and indirectly from Project activities such as soil salvage and stockpiling, which can cause soil erosion, compaction, admixing, and changes to soil chemistry. The extent of changes to soil quality varies depending on existing soil conditions. Ultimately, changes to soil quality can influence a soil's suitability for use during reclamation.

Soil salvage and stockpiling can change physical, chemical, and biological properties of soils, which can change soil quality. For soil in the LSA (i.e., northern forest soils), general soil salvage practices include removing soil material in two layers (lifts; Alberta Agriculture 1987). The surface layer, referred to as the upper lift, includes the surficial organic material and underlying mineral A horizon and/or B horizon, to a maximum depth of 30 cm. The depths of the upper lift are dependent on site-specific soil conditions and can vary according to landscape position and soil drainage conditions. Exceptions for upper lift salvage depth to 30 cm will include areas of deep peat or shallow soil over bedrock. The subsurface soil layer, referred to as the lower lift, includes material below the upper lift to a depth considered practical based on site-specific soil conditions (Alberta Agriculture 1987).

Within the LSA, mineral soils generally have an upper lift that includes a shallow organic layer overlying sandy mineral soil horizons. Soil salvage of a 30 cm upper lift will be suitable in areas containing these mineral soils. Organic soils are suitable for use during reclamation and therefore should be salvaged and considered for use as a soil amendment. Organic soil used as an amendment during reclamation will aid in revegetation through the enhancement of physical, chemical, and biological components of soil. For deep organic soils, the use of rig matting could be necessary if salvage is not possible or the volume of organic material is so large that it would require a substantial area for storage.

Project activities such as site clearing, contouring and excavation, as well as soil salvage, stockpiling and transport can increase potential for soil erosion. Disturbed and stockpiled soil should be protected from wind and water erosion in order to maintain soil quality. Soil erosion can adversely affect quality of stockpiled soils through the removal of fine soil particles and organic materials, which can reduce the overall nutrient content and soil water holding capacity. Soil water erosion ratings for soils in the LSA range from Low to Medium and for wind erosion ranged from Low to High (Section 13.3.3.1). Based on the location of the Project footprint, it is expected that best management practices implemented during construction activities would be sufficient to control erosion. For example, seeding exposed soils can reduce erosion potential by up to 90% (TAC 2005). In locations adjacent to sensitive areas, such as waterbodies, the consequence of erosion will increase, and additional erosion control could be required.

Soil compaction occurs primarily from heavy equipment movement across the soil surface during site clearing, contouring and excavation, and soil salvage and stockpiling. Compaction sensitivity ratings for soils within the LSA range from Low for well-drained, coarse textured soils to Moderate or Very High for fine textured soils prone to wet soil conditions (Section 13.3.3.4). In cases where there is a range of soil textures, the compaction ratings also vary. Topsoil stripping should be carried out when soil is not excessively wet to reduce soil compaction (Ghose 2001). Areas most prone to compaction in the LSA include low-lying, poorly drained areas with fine textured soils. If construction is completed under dry conditions, compaction is less likely to change soil quality and suitability for use during reclamation. As such, site clearing during construction of the Project infrastructure (e.g., roads, laydown areas) and salvage of soil materials will be completed during dry or frozen conditions, where and when practical.

Admixing of the upper and lower lifts can alter physical, chemical, and biological soil properties important for maintaining soil quality. For example, combining upper and lower lift materials can cause structure and texture changes in salvaged topsoil, which can alter soil quality. Changes in soil texture could arise from admixing, particularly in soils with large textural differences between topsoil and subsoil horizons. Admixing can reduce organic matter and carbon content in upper lift materials, which can alter microbiological activity and composition, and increase the rate of organic matter decomposition due to soil aeration (Wick et al. 2009). Admixing with lower lift materials containing undesirable substances can also result in a decrease in soil quality. The depth of upper lift material salvaged could vary according to landscape position and soil drainage conditions, but will be approximately 30 cm unless otherwise identified based on site-specific soil depths.

Soils in the LSA were generally uniform in texture throughout the soil profile. Therefore, it is not anticipated that admixing would result in textural changes in upper lift material. However, the seed bank, soil organic matter, and surface organic horizons would be diluted if upper and lower lift materials were mixed, leading to a decrease in soil quality. It is unknown if lower lift material in the LSA contains undesirable substances, although if subsurface rock material is identified to contain undesirable substances, soil also has potential to contain undesirable substances. A site-specific assessment will be completed prior to soil salvage to identify surficial stripping depths and develop a site-specific soil salvage plan. In addition, the use of appropriate salvage techniques should result in minor changes to soil quality.

Following construction, temporary Project components will be removed and soil reconstruction, contouring, and revegetation will be completed. Following closure, soil will be reconstructed which will be described in the Reclamation Plan.

In summary, key mitigation that will be implemented to reduce changes to soil quality includes the following:

- A site-specific assessment will be completed prior to soil salvage to identify surficial stripping depths and develop a site-specific soil salvage plan.
- Soil (growth medium) will be salvaged separately from overburden materials and saved for reclamation.
- Salvage of soil materials will be completed during dry conditions, where and when practical.
- Salvaged topsoil will be stored on-site and away from areas that could be subject to travel, storage of equipment/material or future disturbances (i.e., reduce soil handling).
- Topsoil will be replaced on reclaimed areas as soon as feasible. Any surplus salvaged soil from construction will be stored on-site for future reclamation activities following closure.
- A conceptual Erosion and Sediment Control Plan will be developed.
- A Reclamation Plan will be developed for the Project.

Overall, site clearing, contouring, excavation, soil salvage, stockpiling, and transport are expected to result in minor changes to soil quality using mitigation. Therefore, these interactions were determined to have a negligible residual effect to soil.

- **Use of explosives can cause changes to soil quality.**

Use of explosives during the construction phase of the Project has potential to change soil quality. At the present time, Ammonium Nitrate Fuel Oil (ANFO) is expected to be used during the construction phase of the

Project. This type of explosive has the potential to release nitrogen residual substances (e.g., ammonia and nitrate). Blasting activities and the removal of waste rock could increase dust deposition, as well, the waste rock is expected to be contain trace metal (e.g., aluminum, cadmium, chromium, copper, iron, mercury, and silver) concentrations and nitrogen residual substances.

A Blasting Plan will be developed for the Project and will describe the type of explosives used and the method of detonation. As part of this plan, best practices will be applied to blasting activities to reduce the potential for enhanced nitrogen loading of soils. Waste rock produced from blasting activities is expected to contain trace amounts of residual substances from use of the ANFO explosives; therefore, surface water runoff from the waste rock disposal areas may also contain residual substances. Surface water runoff from the waste rock disposal areas will be collected and pumped to the settling ponds. Water in settling ponds will be routinely tested prior to release, as part of the Site Water Management Plan that will be developed for the Project. Consequently, the use of ANFO explosives was determined to have a negligible residual effect on soils.

- **Deposition of criteria air contaminants can change soil chemistry.**
- **Dust deposition can change soil chemistry.**

Construction and operation of the Project will generate air emissions such as carbon monoxide (CO), oxides of sulphur (SO_x), includes sulphur dioxide [SO_2]), oxides of nitrogen (NO_x), particulate matter less than 2.5 micrometres ($PM_{2.5}$), particulate matter less than 10 micrometres (PM_{10}), and total suspended particulates (TSP). Air quality modelling was completed to predict the spatial extent of air and dust emissions and deposition from the Project (Section 8.5). Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates.

Air emissions (i.e., SO_2 and nitrogen dioxide [NO_2]) can result from the use of fossil fuels in generators, vehicles, and machinery during construction and operation of the Project. The deposition of SO_2 and NO_2 can alter soil pH, nutrient content, and cause acidification of the soils, which can lead to changes in soil fauna composition (Rusek and Marshall 2000). Changes in soil fauna could lead to changes in vegetation, as there could be alterations in organic matter decomposition rates and nutrient cycling. Deposition of SO_2 and NO_2 can also lead to acidification of wetlands, which can cause changes in plant communities (Bobbink et al. 1998). However, changes from soil acidification to vegetation depend on the buffering capacity of the soil (Bobbink et al. 1998; Barton et al. 2002). Brunisolic soils in the RSA were rated as having a high sensitivity to acidification (Section 13.3.3.2). Gleysolic soils were rated as having a Low to High sensitivity; however, this is dependent on proximity to wetlands. Organic soils that occur in moderate and rich fens are least susceptible to acidification and therefore have a Low sensitivity rating. Organic soils that occur in bogs and in poor fens have a Medium sensitivity rating.

Results of the air quality modelling indicate that the maximum ground-level concentrations of CO, SO_2 and NO_x are all below the Saskatchewan Ambient Air Quality Standards (SAAQS 1996) and the Canada Wide Standard (CCME 2000) (Section 8.5.1) and are limited to the immediate vicinity of the Project. The related change to pH is determined by several complex geochemical factors, which include nutrient uptake by plants, decomposition of vegetation, cation and anion exchanged in soil, and atmospheric inputs (Turchenek et al. 1998). When NO_x is oxidized, it can produce NO_3^-, which is typically limited in poor fens and bogs, and therefore taken up by vegetation. Biological uptake can reduce the effects of nitrogen (N) deposition. Nitrogen is retained in the plant biomass and can result in a neutralizing effect. Sulphur transformations are affected by redox and pH interactions and are biologically mediated. When SO_2 is oxidized, it can produce sulphate (SO_4^{2-}). Higher plants normally take up S as SO_4^{2-}. The results indicate that deposition of SO_2 and NO_x will not likely result in changes to soil pH. Overall, it is expected there will be no changes to soil quality from SO_2 and NO_x.

Dust deposition can also cause chemical loading in soils as dust emissions can include metal particles. Metal particle deposition can also affect soil biota composition (Grantz et al. 2003), which could indirectly affect vegetation. In addition to metals, dust can contain cations and anions. When cations (e.g., ammonium [NH_4^+], sodium [Na^+], potassium [K^+] calcium [Ca^{2+}], magnesium [Mg^{2+}]) are deposited into an ecosystem, the vegetation present can take up the cation; however, other cations, usually hydrogen [H^+], are released into the environment and can decrease soil pH (Turchenek et al. 1998). When anions (e.g., chloride [Cl^-], nitrite [NO_2^-], bromide [Br^-]) are deposited into an ecosystem, anions such as hydroxide [OH^-] can be released. Although OH^- increases pH, cation and anion uptake have generally shown to result in a net production of acidity. The net effect is acidification because the cations are generally retained in the plant biomass and are therefore not mineralized. Ultimately, the concentration and duration of air and dust emissions and the sensitivity of the ecosystems determine the overall influence that air emissions will have on vegetation (Bobbink et al. 1998).

Modelling results indicate that the Project's maximum annual emissions rate is 0.020 tonnes of H+ per day (t/d) and the average for the 2014 to 2017 construction period is 0.014 t/d. These values are well below the Saskatchewan Ministry of Environment's threshold of 0.175 t/d. The Project's potential for acid deposition is low, and therefore, it is expected there will be no change to soils from acidification.

Most of the traffic to the Project will occur during construction. All unpaved roads will be watered regularly to prevent wind driven fugitive dust. Speed limits will be enforced to reduce dust generation from roads. Once construction is complete the numbers of vehicles travelling to and from the Project are expected to decrease (Section 5.5.1). Modelling results indicate that the maximum predicted TSP and $PM_{2.5}$ concentrations are 114.4 µg/m^3 and 22.8 µg/m^3, respectively, which do not exceed the SAAQS and Canada-Wide Standard (Section 8.5.1.2.3). Because PM and TSP predictions are below applicable criteria, it is expected there will be no changes to soil quality.

Overall, air and dust emissions and subsequent deposition are expected to result in minor changes to soil quality; therefore, these interactions were determined to have a negligible residual effect to soil.

13.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events occurring on-site have the potential to affect soils. The following events were identified as having a potential interaction with soils.

- **Release or spills of hazardous substances (e.g., fuel, oil) can change soil quality.**

Spills during construction, operations, or decommissioning and reclamation activities following closure have the potential to change soil quality. Spills that occur in high enough concentrations could contaminate soils and water and cause direct toxicity to aquatic organisms, soil organisms, and vegetation. Spills are generally preventable and local in nature.

The powerhouse will be equipped with an oil containment and separation system to prevent the release of petroleum based wastes into waterways. The turbine governor pumping systems will be surrounded by trenches or curbs to allow drainage via the trench or sumps to catch and transfer wastes to the oil separation system. Any room with the potential to produce an oil spill will be equipped with containment curbs and door ramps.

Additionally, the governor hydraulic power units will be high pressure systems to reduce the potential for spills by maintaining the total volume of hydraulic oil in the system. The main transformers will be removed from the main tailrace deck and surrounded by oil spill containment walls to reduce the potential for spills to interact with the waterways. Double walled heat exchangers will be used for the turbine and generator cooling systems to reduce the risk that cooling coil failure will discharge oil into the water. Self-lubricated bushings will be used throughout the design to eliminate sources of water pollution typical of greased bushings.

Several environmental design features and mitigation practices and policies are planned to limit the effects of spills and leaks to the environment. Spill containment supplies will be available in designated areas and within Project vehicles. An Emergency Response Plan will be developed and will include instruction for the rapid response control, and management of spills or release of hazardous substances occurring on site. All spills will be isolated and immediately cleaned up. Spills will be reported to the appropriate agency if the spill exceeds reportable volumes for the material spilled as outlined in the provincial Environmental Spill Control Regulations. In the unlikely event of a spill, disposal of all contaminated soil will be handled by a licensed contractor and will be hauled off-site to an approved facility. Alternative approaches for in situ treatment of contaminated soils could be considered (e.g., phyto- or bio- remediation), depending on the substance spilled and capacity to treat the volume of material affected. Mitigation identified in the EnvPP will be implemented to reduce the likelihood and extent of spills associated with the Project.

Storage facilities for hazardous wastes will meet regulatory requirements. All fuel storage tanks will be designed and constructed based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. The storage containers will be regularly inspected for leaks or damage, and replaced when necessary. Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled, and located in lined and bermed containment areas. Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers.

Vehicles will be regularly maintained and will carry fire extinguishers and standard emergency clean-up kits. Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills on the fueling stations would flow to the sump, which would be pumped out to a container for shipment off-site.

Implementation of the above environmental design features are expected to reduce the likelihood and extent of the release or spills of hazardous materials occurring on-site. Therefore, no detectable changes to soil quality relative to baseline conditions is expected, and this interaction was determined to have no linkage to effects on soil.

- **Failure of the embankment dykes around the settling ponds can change soil quality.**

Failure of embankment dykes around the settling ponds could result in the release of sediment laden water and potential contaminants to soils. Environmental controls will be in place to limit the potential for embankment dyke failure. For example, the settling pond will be engineered to provide adequate storage of process streams under normal and extreme operating conditions. Maximum operating levels will be developed to provide adequate storage volumes for the design storm event. In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling pond would be provided by the inclusion of an overflow spillway in the embankment.

Embankment dykes will be stripped of vegetation, topsoil, and roots to expose the mineral soil subgrade as necessary to accommodate the size of the settling pond. Fill material used for constructing the dyke will be clean mineral soil with sufficient moisture to allow for proper compaction and will be placed in lifts not exceeding 150 mm in compacted thickness and compacted to a minimum of 95% standard proctor maximum dry density. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap, as soon as practical, following construction.

The settling ponds will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. During the detailed design stage, additional mitigation will be identified and included as part of the EnvPP and the Emergency Response Plan. Consequently, embankment dyke failure was determined to have no linkage to effects to soils.

- **Fire**

Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. Fire safety measures and response will be reviewed with the communities of Black Lake and Stony Rapids. On-site personnel will be trained in established fire prevention and response procedures and appropriate firefighting equipment will be available on-site so that trained personnel will be able to respond promptly. The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail.

Each pump will be sized to meet the full demand of the largest component of the system with the addition of 31.5 litres per second (L/s) for hose demand. Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute). Although a fire may result in loss and alterations to soil, the implementation of the abovementioned mitigation is anticipated to result in negligible residual effects on soils.

13.4.4 Primary Interactions

The residual effect analysis considers all primary interactions that result in expected changes to soils after implementing mitigation. The following interaction was determined to be primary for effects to soils and is carried forward to the residual effects analysis (Section 13.5).

- **Direct loss or alteration of local soil from the Project footprint.**

13.5 Residual Effects Analysis

The residual effects analysis considered all pathways that are expected to result in effects to soils after implementing environmental design features and mitigation. The residual effects assessment is completed by predicting changes to the measurement endpoint with the primary Project interaction. This measurement endpoint includes:

- soil quantity and distribution.

Assessment cases are defined for the effects analysis and include the baseline case, application case (Project case, which includes construction, operations, and closure), and future case (if applicable). The baseline case considers the current conditions in the LSA, such as natural disturbances (e.g., fire) and previous and existing human developments and activities. The regional area surrounding the Project has experienced little industrial human development and activity. Previous activity includes exploration work for the Nisto uranium deposit (mineral property #1621), which is located on the west shore of Black Lake, approximately 23 km east of Stony Rapids (Government of Saskatchewan 2013). In 1950, two adits were driven and lateral work was completed. Ore was mined from the shoots accessible from the northeast adit in 1959. Only exploration work has been completed in the area since 1959. Existing human-related disturbance includes trails, roads, cabins, the Black Lake sewage lagoon, and the communities of Black Lake and Stony Rapids. Populations and communities in aquatic and terrestrial ecosystems have likely adapted to the low level of human industrial activity over the last 50 to 60 years. Therefore, current (baseline) conditions in the LSA are expected to reflect the cumulative influence of previous and existing human industrial activities on aquatic and terrestrial ecosystems relative to reference conditions. Reference conditions represent no to little human development, except for First Nation communities, which are assumed part of the historical natural ecosystems.

The application case occurs during the start of construction of the Project through closure, and the associated duration of predicted effects (i.e., until effects are reversed or are deemed irreversible). The magnitude of effects from the Project is expected to be strongest during construction and the initial period of operation. For example, the magnitude of some effects, such as the changes from blasting activities to dust deposition are expected to stop at the end of construction, and the duration of these effects will likely end within the initial period of operation. With respect to this Project, physical disturbance to soils is expected to only occur at the beginning of construction and the majority of the area disturbed will be reclaimed immediately following construction; therefore, the construction phase and the operations phase were considered separately in the soils residual effect analysis. Reclamation activities following construction will include the removal of portions of the temporary construction infrastructure not required during operation. Temporary infrastructure includes the construction camp, contractor’s work areas, material laydown area, and overburden disposal areas.

The duration of some effects from the Project have the potential to last over the 90-year operation period. For example, the presence of the main access road and powerhouse for the 90-year period represent Project components that will affect soils long-term, but the magnitude and geographic extent of these effects should be much smaller than similar effects during construction because the majority of the area expected to be disturbed will be reclaimed immediately following construction. Because the differences in the magnitude and geographic extent of effects are expected to be measurable between construction and closure, the analysis examined both phases. Analyses were quantitative where possible and qualitative where necessary.

There is potential for this Project to operate beyond the expected 90-year operational period; however increasing the duration of the operation phase of the Project would have little influence on effects predictions. Most of the physical changes to soils from the operations footprint and the effects to the environment from these changes are considered permanent because of the length of operations (i.e., the duration of the change will be well beyond the temporal boundary of the assessment). The outcome of reclamation activities with respect to the operation footprint is highly uncertain, particularly in an environment where natural succession processes are slow, and trajectories can be altered by a number of factors (e.g., climate changes, fire, and unforeseeable human development).

Closure is when power production operations end, and decommissioning and reclamation of the final infrastructure (i.e., water intake, powerhouse, power tunnel, tailrace channel, switchyard, access roads, and distribution line) is completed.

Both Project-specific (incremental) and cumulative effects from the Project and existing human developments and activities are analyzed in this section. The future case includes baseline and the Project, plus reasonably foreseeable developments or designated projects. The geographic extent (zone of influence) of residual effects from the Project on soils is expected to be limited to the LSA. No other major developments in the region are located within the LSA. Therefore, the zones of influence associated with the Project and existing developments are not expected to overlap and generate cumulative effects on soils. Currently, there are no reasonably foreseeable developments that could have an overlapping temporal boundary with the Project and potential to generate cumulative effects on soils.

13.5.1 Loss or Alteration of Soils from the Project Footprint

Development of the Project is expected to change soil quantity and distribution. These changes can affect other VCs (e.g., vegetation and wildlife). The changes to soil quantity and distribution are expressed as changes in area of soil map units.

Site clearing and the movement of soil from the landscape is required to develop facilities for the Project. Site clearing and construction of the Project, particularly through the process of soil stripping and excavation, are expected to result in changes to soil quantity and distribution. Soil removal will occur during the construction phase of the Project. During reclamation activities immediately following construction and following closure, soil will be reconstructed which will be described in the Reclamation Plan. With appropriate soil salvage and reclamation techniques, soils can be returned to the landscape to support other VCs (e.g., vegetation, wildlife). It is anticipated that after closure, all soils will be reconstructed and reclaimed.

13.5.1.1 Changes to Soil Quantity and Distribution

Changes to soil quantity and distribution caused by the Project footprint were quantified in a Geographic Information System (GIS) platform to calculate the areas and predicted changes of soil map units within the LSA. Changes to soil quantity and distribution are assessed for the maximum possible extent of disturbance during construction (disturbance assessment area), which should have the largest geographic extent of residual effects on soils. Progressive reclamation is expected to occur during construction and operations and is anticipated to limit incremental residual effects and therefore, changes during construction and operations are considered. The environmental effects analysis results represent a conservative estimate of residual effects to soil quantity and distribution. These changes were estimated by calculating the net change between the baseline and application (construction phase) and baseline and application (closure phase) in relation to the LSA.

The resulting value is the percent change in area for each soil map unit, and provides both direction and magnitude of the residual effect. For example, a high negative value would indicate a substantial loss of that soil map unit from the LSA, while a low positive value would indicate a slight increase in the soil map unit. Following reclamation activities during operation and after final decommissioning and reclamation of the Project (i.e., closure) it was assumed that there will be a net change to these soil map units relative to the LSA, but it is unknown what soil map units these areas will become in the future. As such, the change following reclamation is classified as Reclaimed Soils.

The maximum possible extent of disturbance during construction (disturbance assessment area) is estimated to be 1,619 ha (16.1% of the LSA; Table 13.5-1; Figure 13.5-1). The soil map units that will likely experience the greatest change during construction are the M4 (Mineral-4), M2 (Mineral-2), and M1 (Mineral-1) map units (Table 13.5-1; Figure 13.5-1). A total of 1,029 ha of the M4 (Mineral-4) soil map unit will be disturbed, representing a decrease of 11.6%, relative to the LSA. A total of 220 ha of the M2 (Mineral-2) soil map unit will be disturbed, representing a decrease of 2.5%, relative to the LSA. A total of 174 ha of the M1 (Mineral-1) soil map unit will be disturbed, representing a decrease of 2.0%, relative to the LSA.

During operations, those areas not disturbed during construction are assumed to remain the same as baseline conditions and those areas not required for operations will be reclaimed. The predicted Project footprint is estimated to be 869 ha and represents approximately 54% of the disturbance assessment area (9.8% of the LSA). Most of the reclamation activities are expected to be concentrated during the period immediately following construction. Reclamation activities following construction will include the removal of portions of the temporary construction infrastructure not required during operation (589 ha; 6.6% of the LSA). The remaining infrastructure required for operations is estimated to cover 280 ha or 3.2% of the LSA. Following closure of the Project, the entire area will be reclaimed and represents 9.8% of the LSA (Table 13.5-1; Figure 13.5-2).

13.5.2 Management of Uncertainty

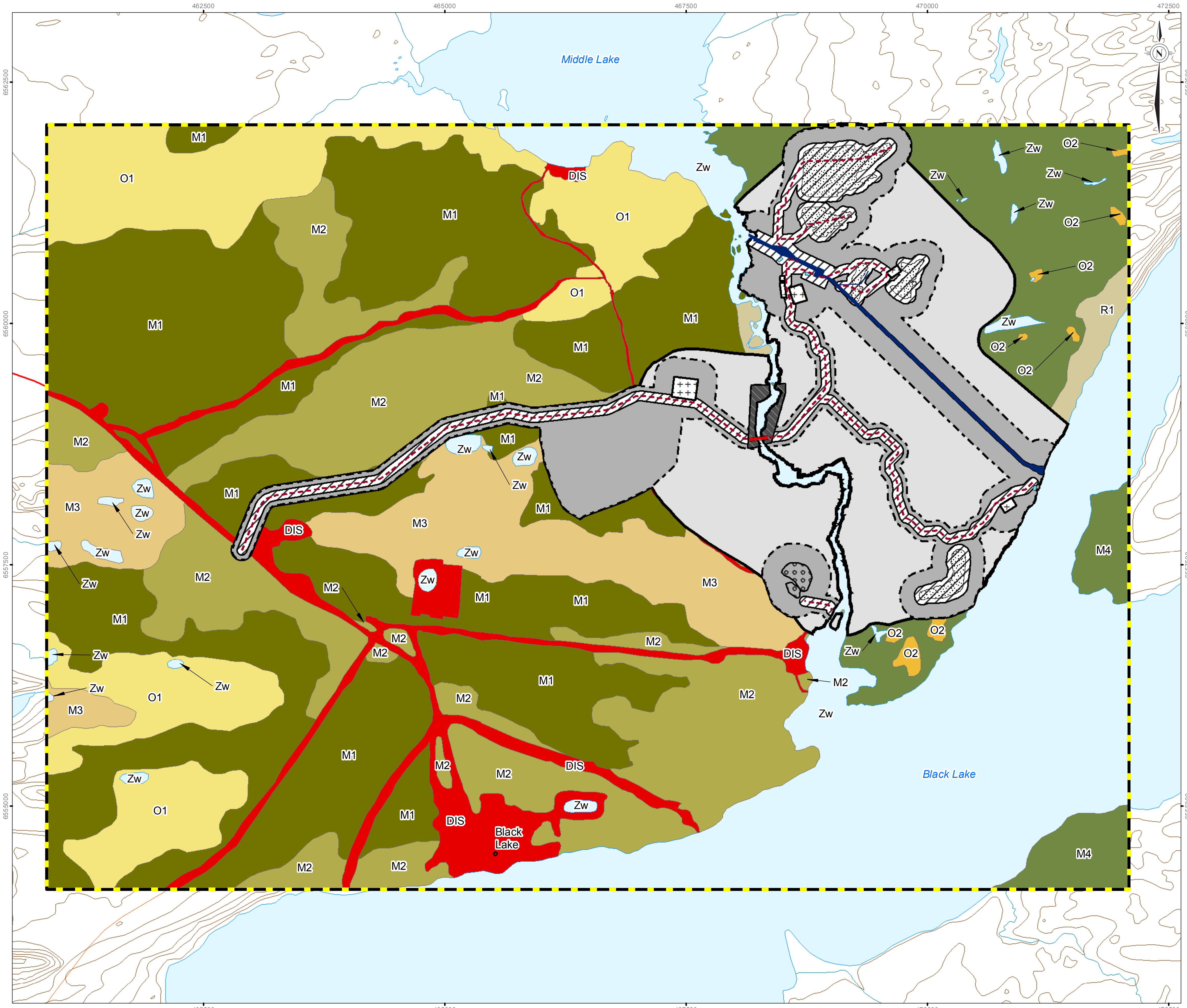
There is a high degree of confidence that surficial materials will be moved, excavated, and re-contoured and soil will be disturbed within the Project footprint. All areas not required for operations will be reclaimed immediately following construction. Following closure, soil will be reclaimed in areas containing the powerhouse, tailrace channel, power tunnel, water intake, and access roads.

Several aspects of soil quality were examined. The effects from soil salvage and stockpiling and other Project activities on soils were assessed. Minor changes in quality due to these processes are predicted with moderate certainty and effects are expected to be localized. Storage effects are not well known for soils in northern climates. Prediction of a minor effect is based on appropriate stockpile design, vegetating the soil salvage stockpiles, and storage being mainly under frozen conditions; however, there is little background information in northern environments to support this assumption.

Table 13.5-1: Net Change in Soil Map Units in the Local Study Area During the Project

Map Unit Name	Map Unit Symbol	Baseline		End of Construction[a]			Closure[b]	
		Area (ha)	Proportion of LSA (%)	Area following Construction (ha)	Net Change from Baseline	Net Change from Baseline (% LSA)	Area following Closure (ha)	Net Change from Baseline (% LSA)
Mineral-1	M1	2,462	27.7	2,288	-174	-2.0	2,335	-1.4
Mineral-2	M2	1,397	15.7	1,177	-220	-2.5	1,300	-1.1
Mineral-3	M3	604	6.8	535	-69	-0.8	537	-0.8
Mineral-4	M4	1,639	18.5	610	-1,029	-11.6	1,120	-5.8
Organic-1	O1	800	9.0	800	0	0	800	0.0
Organic-2	O2	46	0.5	20	-26	-0.3	32	-0.2
Bedrock-1	R1	127	1.4	57	-70	-0.8	102	-0.3
Existing Disturbance	DIS	377	4.2	359	-18	-0.2	363	-0.2
Open Water	ZW	1,428	16.1	1,416	-12	-0.1	1,423	-0.1
Project Footprint	Footprint	n/a	n/a	1,619	1,619	18.2	0	0
Reclaimed Soils	Reclaimed	n/a	n/a	0	0	0	869	9.8

Notes: The total area of the Local Study Area is 8,881 ha
Existing Disturbance soil map unit is the result of existing human-related disturbances such as roads, cut lines, and communities.
A value <0.1 or <-0.1 approaches zero.
Negative numbers indicate a reduction or change in that soil map unit. Positive numbers indicate an increase or gain in that soil map unit.
[a] based on disturbance assessment area
[b] based on actual predicted Project footprint
ha = hectares; % = percent; <= less than; LSA = local study area



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- CONTOUR LINE
- RIVER
- WATERBODY
- TERRESTRIAL LOCAL STUDY AREA

SPECIFIC CONSTRUCTION SITES

- POTENTIAL BRIDGE ALIGNMENT
- PERMANENT ROAD
- CONTRACTOR CAMP / LAYDOWN AREA
- BORROW AREA
- SETTLING POND
- SPOIL DISPOSAL AREA
- POTENTIAL BRIDGE ALIGNMENT AREA
- TUNNEL AND TAILRACE ALIGNMENT
- OPERATIONS FOOTPRINT
- PREDICTED PROJECT FOOTPRINT
- DISTURBANCE ASSESSMENT AREA

SOIL MAP UNIT

- M1 (MINERAL-1)
- M2 (MINERAL-2)
- M3 (MINERAL-3)
- M4 (MINERAL-4)
- O1 (ORGANIC-1)
- O2 (ORGANIC-2)
- R1 (BEDROCK-1)
- ZW (OPEN WATER)
- DIS (EXISTING DISTURBENCE)

REFERENCE

SOIL DATA © SITE SOIL SURVEY, GOLDER 2012
NAD83 UTM ZONE 13
NTS MAPSHEET: 74P/03, 04

1 0 1

SCALE 1:40,000 KILOMETRES

PROJECT

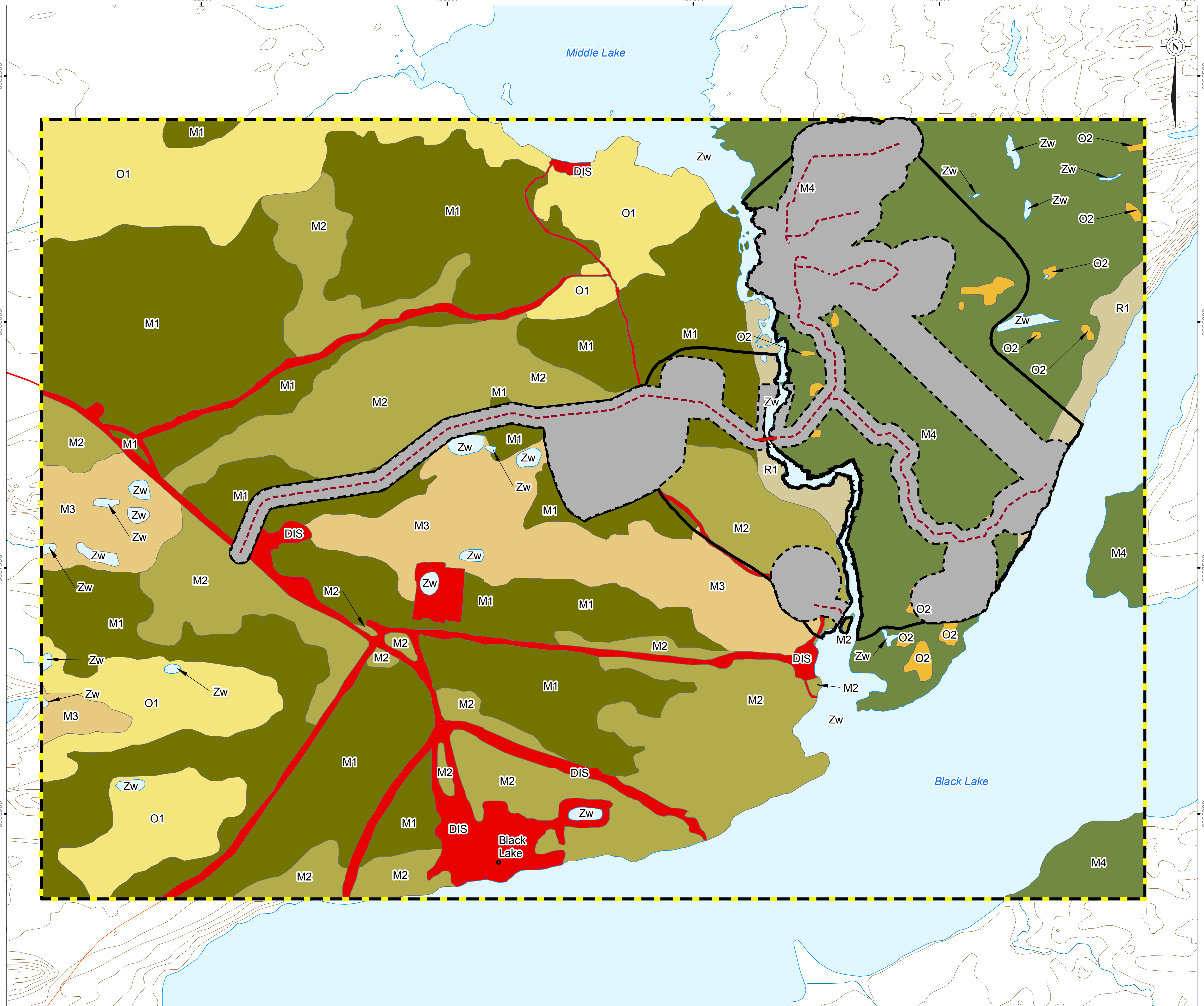
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

SOIL DISTRIBUTION DURING CONSTRUCTION

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	28/10/13	**FIGURE: 13.5-1**	
CHECK	JF	15/11/13		
REVIEW	DD	15/11/13		



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- CONTOUR LINE
- RIVER
- WATERBODY
- TERRESTRIAL LOCAL STUDY AREA
- RECLAIMED

SOIL MAP UNIT

- M1 (MINERAL-1)
- M2 (MINERAL-2)
- M3 (MINERAL-3)
- M4 (MINERAL-4)
- O1 (ORGANIC-1)
- O2 (ORGANIC-2)
- R1 (BEDROCK-1)
- ZW (OPEN WATER)
- DIS (EXISTING DISTURBENCE)

REFERENCE

SOIL DATA © SITE SOIL SURVEY, GOLDER 2012
DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEET: 74P/03, 04

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

SOIL DISTRIBUTION FOLLOWING CLOSURE

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	29/07/13	FIGURE: 13.5-2
CHECK	JF	15/11/13	
REVIEW	DD	15/11/13	

There is uncertainty associated with soil chemistry in areas expected to be disturbed. To reduce this uncertainty, a site-specific soil assessment and chemical analysis of soils would be required prior to construction to identify the presence of metals and other undesirable substances in soil. This will aid in reducing the mixing of soil materials containing metals with soil materials that do not contain metals.

Uncertainty was addressed in the assessment by incorporating information from available and applicable literature, and using past experience in similar areas. In addition, the application of environmental design features and mitigation during construction, operation, and reclamation, and closure, and the Reclamation Plan will be implemented to mitigate effects to soil. Finally, a conservative approach was used when information was limited so that effects are typically overestimated.

13.6 Environmental Management, Monitoring, and Follow-up

Monitoring programs implemented during the Project include a combination of environmental monitoring to track conditions and implement further mitigation as required (e.g., monitoring for soil erosion during construction), and follow-up monitoring to verify the accuracy of effect predictions and adaptively manage and implement further mitigation as required.

A site-specific assessment will be completed prior to soil salvage to identify surficial stripping depths and develop a site-specific soil salvage plan. Soil conditions will be monitored to estimate reclamation success, and soil quality issues such as erosion, admixing, and compaction will be assessed as part of this task. Results from this program will be used to support adjustments to the Reclamation Plan and incorporated into the ongoing reclamation activities. Closure requires input from regulatory agencies and communities to identify closure objectives and strategies; therefore, the precise monitoring required is unknown at this time.

Environmental monitoring data reporting will be undertaken as part of a comprehensive Monitoring and Follow-up Plan. The plan will provide flexibility for SaskPower and MOE to effectively identify and respond to unanticipated changes to habitat quality and quantity, to adapt to new regulatory frameworks such as the Saskatchewan Environmental Code, and to provide appropriate feedback required to improve future environmental assessments. It is anticipated that data reporting will occur yearly, with data analysis being undertaken every five years and communicated in the form of Status of the Environment Reports.

13.7 References

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13.8 Glossary

Term	Description
Acidification	The process of becoming acid or being converted into an acid.
Admixing	Mixing of the upper lift (topsoil, A horizon) with the nutrient deficient lower lift (subsoil, parent material, C horizon) cause a dilution of texture, nutrients and/or organic matter found in the upper lift.
Baseline	A surveyed or predicted condition that serves as a reference point to which later surveys are coordinated or correlated.
Bedrock	The body of rock that underlies gravel, soil or other material.
Bog	A peatland with weakly to moderately decomposed Sphagnum and forest peat material formed in oligotrophic environments. The bog surface is acidic and low in nutrients due to the slightly raised peat surfaces disassociating it from underlying and surrounding mineral rich soil waters.
Brunisolic soil	Brunisolic soils are Boreal forest soils that primarily develop in sandy glacial sediments. These soils have undergone very limited soil formation. The diagnostic horizon is the Bm, which has undergone only slight chemical change from the original parent material although it could have a bright red colour compared to the underlying C horizon.
Buffering capacity	The ability of a soil to resist changes in pH.
Cation	An ion carrying a positive charge of electricity. The common soil cations are calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and hydrogen (H).
Cation exchange capacity	The maximum quantity of total cations that a soil is capable of holding, at a given pH value, for exchanging with the soil solution. Cation exchange capacity is used as a measure of fertility, and nutrient retention capacity.
CCME guidelines	Canadian Council of Ministers of the Environment; body of Environment Canada that sets ambient guidelines for air, water, soil, and contaminants.
Classification, soil	The systematic arrangement of soils into categories according to their inherent characteristics, or on some interpretation of those properties for various uses. Broad groupings are made on the basis of general characteristics, and subdivisions according to more detailed differences in specific properties.
Climate	The prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, cloudiness, and winds, throughout the year, averaged over a series of years.
Compaction	An increase in soil density and a loss of soil pore space because of weight or pressure being placed on soil.
Cryosolic soil	Cryosolic soils have horizons with permafrost. In some soils the frost action causes considerable mixing of soil horizons, which is termed cryoturbation. In these soils the permafrost layer must be within 2 m of the surface. If no strong cryoturbation has occurred the permafrost layer must be within 1 m of the surface.
Disturbed land	Land that has experienced a significant change, usually as a result of human activity or natural processes such as erosion or fire.
Ecological Landscape Classification (ELC)	An ecological mapping process that involves the integration of site, soil, and vegetation information.
Ecoregion	Relatively homogeneous subdivisions of an ecozone, which are characterized by distinctive climatic zones or regional landforms.

Term	Description
Ecosystem	A relatively homogeneous area of organisms interacting with their environment.
Environmental Impact Statement (EIS)	A report that documents the information required to evaluate the environmental effect of a project.
Erosion	(i) The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. (ii) Detachment and movement of soil or rock by water, wind, ice, or gravity.
Fen	A fen is a peat-covered or peat-filled wetland with a high water table which is not hydrologically isolated and receives water from streams and/or groundwater.
Fen, Poor	And ecosite that is transitional between the fen and bog. A poor fen is intermediate in nutrient regime and similar floristic composition to fen and bog. Sedges and peat moss, golden and brown mosses composed the majority of the organic matter content.
Fen, Rich	A peatland with moderate to well-decomposed sedge, grass, and reed peat material from in eutrophic environments. Mineral-rich waters are at or are just above the fen surface.
Fibric material	Materials (primarily mosses, rushes, and woody materials) that are readily identifiable as to botanical origin. A fibric horizon (Of) has 40% or more of rubbed fiber by volume.
Fibrisolic soil	Fibrisolic soils are composed largely of relatively decomposed fibric organic material.
Folisolic soil	Folisolic soils are composed of upland organic (folic) materials, generally of forest origin that are either 40 cm or more in thickness, or are at least 10 cm thick if overlying bedrock or fragmental material.
Geographical information system (GIS)	A computer-based tool for analyzing, displaying and manipulating digital spatial data.
Glaciofluvial	Sediments or landforms produced by melt waters originating from glaciers or ice sheets. Glaciofluvial deposits commonly contain rounded cobbles arranged in bedded layers.
Glaciolacustrine plain	A relatively level depositional area created from the bottom sediments of lake basins deposited by glacial meltwater flowing along the margin of a glacier.
Gleysolic soil	Gleysolic soils are associated with prolonged water saturation of the soil profile. Water saturation leads to depletion of oxygen and the development of soil features associated with oxygen-depleted conditions: blue-gray colours and reddish specks (called mottles) within the soil profile. These features are the diagnostic criteria for Gleysolic soils and occur within 50 cm of the soil surface.
Landform	A particular type of land formation.
Landscape	A heterogeneous land area with interacting ecosystems that are repeated in similar form throughout. From a wildlife perspective, a landscape is an area of land containing a mosaic of habitat patches within which a particular “focal” or “target” habitat patch is embedded.
Lift, lower	Layer below the upper lift generally consisting of the lower B horizon and the parent material (C horizon), defined to a depth dependent on site-specific conditions.
Lift, upper	Uppermost layer in a soil profile comprised of the organic (LFH and/or peat) layer, the A horizon, and the upper B horizon to a maximum depth of approximately 30 cm.
Local study area (LSA)	The area where direct effects and small-scale indirect effects from the Project are expected to occur. Occurs within the regional study area.
Map unit	A combination of kinds of soil, terrain, or other feature that can be shown at a specified scale of mapping for the defined purpose and objectives of a particular survey.

Term	Description
Mesisolic Soil	Mesisolic soils are at a stage of decomposition intermediate between Firisols and Humisols and are dominantly composed of mesic organic materials.
Nutrients	Environmental substances (elements or compounds) such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.
Organic matter	Plant and animal materials that are in various stages of decomposition.
Organic soil	Organic soils are composed of organic materials. They include most of the soils commonly known as peat, or bog/fen soils. Most Organic soils are saturated with water for prolonged periods. These soils occur widely in poorly and very poorly drained depressions and level areas and are derived from vegetation that grows in such sites. The organic layer is greater than 60-cm thick (if fibric) or 40-cm thick (if mesic or humic).
Parent material	Underlying bedrock or drift deposit on which soil horizons form and are made up of consolidated or unconsolidated mineral material that has undergone some degree of physical or chemical weathering.
Permafrost	Permanently frozen soil or rock and incorporated ice and organic material that remain at or below 0°C for a minimum of two years due to natural climatic factors (van Everdingen 2005). The occurrence of permafrost increases with latitude (i.e., more northern areas permafrost is continuous, and more southern areas patches of permafrost alternate with unfrozen ground).
Podzolic soil	A Podzolic soil is characterized by an accumulation of amorphous material composed mainly of humified organic matter combined in varying degrees with Al and Fe, and generally occur in course to medium textured, acidic parent materials.
Polygon	A map delineation that represents a tract of land with certain landform, soil, hydrologic and vegetation features. The smallest polygon on a 1:50,000 scale map is about 0.5 cm^2 and represents a tract of about 12.5 ha.
Reclamation	The process of reconverting disturbed land to its former or other productive uses.
Regional study area (RSA)	A broad area defined for the description of vegetation conditions generally centred on the Project and surroundings, and including areas where indirect effects of the Project might be expected to occur. Includes the Local Study Area.
Regosolic soil	Regosolic soils lack significant soil formation and occur on very young surfaces (e.g., sand dunes or river floodplains) or unstable surfaces (e.g., upper slope positions that experience high rates of soil erosion). Regosolic soils are thin and either completely lack a B horizon or have a thin B less than 5 cm thick.
Riparian	(i) The interface between an upland area and a river or stream. (ii) the floodplain portion of a river or stream corridor.
Sediment	Solid particles of material that have been derived from rock weathering. They are transported and deposited from water, ice or air as layers at the earth's surface.
Soil	The naturally occurring, unconsolidated mineral or organic material at least 10 cm thick that occurs at the earth's surface and is capable of supporting plant growth. Soil extends from the earth's surface through the genetic horizons, if present, into the underlying material to the depth of the control section (normally about 1 to 2 m). Soil development involves climatic factors and organisms, conditioned by relief and water regime, acting through time on geological materials, and thus modifying the properties of the parent material (Agriculture Canada Expert Committee on Soil Survey 1987).

Term	Description
Soil great group	Used in the classification of soil and is the next division of the soil order. These are differentiated on the basis of characteristics that reflect the differences in the strengths of the dominant processes or a major contribution of an additional process.
Soil horizon	A layer of mineral or organic soil material approximately parallel to the land surface that has characteristics altered by processes of soil formation. It differs from adjacent horizons in properties such as colour, structure, texture, and consistence and in chemical, biological, or mineralogical composition.
Soil texture	A soil property used to describe the relative proportion of different grain sizes of mineral particles in a soil.
Swamp	Wooded mineral wetland or a peatland with standing water or water gently flowing through pools or channels that persist for long periods.
Subsoil	The layer of soil under the topsoil on the surface of the ground, the layer of soil under the topsoil on the surface of the ground.
Taiga	A moist, circumpolar, subarctic biome dominated by coniferous species. The taiga is bound to the north by the tundra.
Terrain	The landscape or lay of the land. This term is considered to comprise specific aspects of the landscape, namely genetic material, material composition, landform (or surface expression), active and inactive processes that modify material and form, slope, aspect, and drainage conditions. Terrain analysis is the identification of the above land surface features, to a more or less defined depth and determining their areal extent. The identification of special features such as permafrost, erosion, and landforms indicating subsurface structures are included in such analyses.
Till	An unstratified, unconsolidated mass of boulders, pebbles, sand, and mud deposited by the movement or melting of a glacier.
Topography	The surface features of a region, such as hills, valleys, or rivers.
Topsoil	Uppermost layer of soil, usually the top 5 to 20 cm. It has the highest concentration of organic matter and microorganisms and is where most of the biological activity occurs. Plants generally concentrate their roots in and obtain most of their nutrients from this layer.
Tundra	An area between the polar icecap and taiga that is characterized by a lack of trees and permanently frozen subsoil.
Upland	Areas that have typical ground slopes of 1 to 3% and are better-drainage.

13.9 List of Acronyms

Acronym	Definition
ARD	acid rock drainage
Br^-	bromide
Ca^{2+}	calcium
CCME	Canadian Council of Ministers of the Environment
CEC	cation exchange capacity
Cl^-	chloride
CO	carbon monoxide
DFO	Fisheries and Oceans Canada
ELC	ecological landscape classification
EnvPP	Environmental Protection Plan
GIS	Geographic Information System
H^+	hydrogen
K^+	potassium
LSA	local study area
Mg^{2+}	magnesium
ML	metals leaching
Na^+	sodium
NH_4^+	ammonium
NO_2	nitrogen dioxide
NO_2^-	nitrite
NO_x	oxides of nitrogen
Project	Tazi Twé Hydroelectric Project
RSA	regional study area
SAAQS	Saskatchewan Ambient Air Quality Standards
SO_2	sulphur dioxide
SO_4^{2-}	sulphate
SO_x	oxides of sulphur
TAC	Transportation Association of Canada
TSP	total suspended particulates
VC	valued components

13.10 List of Units

Term	Definition
%	percent
$\mu g/m^3$	micrograms per cubic metre
cm	centimetre
cm/h	centimetres per hour
ha	hectares
kg/ha/year	kilograms per hectare per year
kg/m^3	kilograms per cubic metre
km	kilometre
km^2	square kilometre
L/s	litres per second
m	metre
m^2	square metres
m^3/s	cubic metres per second
PM_{10}	particulate matter concentrations less than 10 micrometres
$PM_{2.5}$	particulate matter concentrations less than 2.5 micrometres
ppm	parts per million

14.0 VEGETATION

14.1 Introduction

The purpose of the vegetation section is to describe the terrestrial environment that could be affected by the Tazi Twé Hydroelectric Project (Project) and to assess the effects on vegetation. The scope of the vegetation section includes an analysis of Project-related changes during construction, operations, and closure, and considers accidents, malfunctions, and unplanned events. The overall residual effects from the Project and potential for cumulative residual effects from the Project and previous, existing, and reasonably foreseeable developments on vegetation are also assessed.

Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal people and the public. The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development, and therefore, are used to predict the effects of the Project on all environmental components. Rationale for selection of vegetation as a VC is as follows:

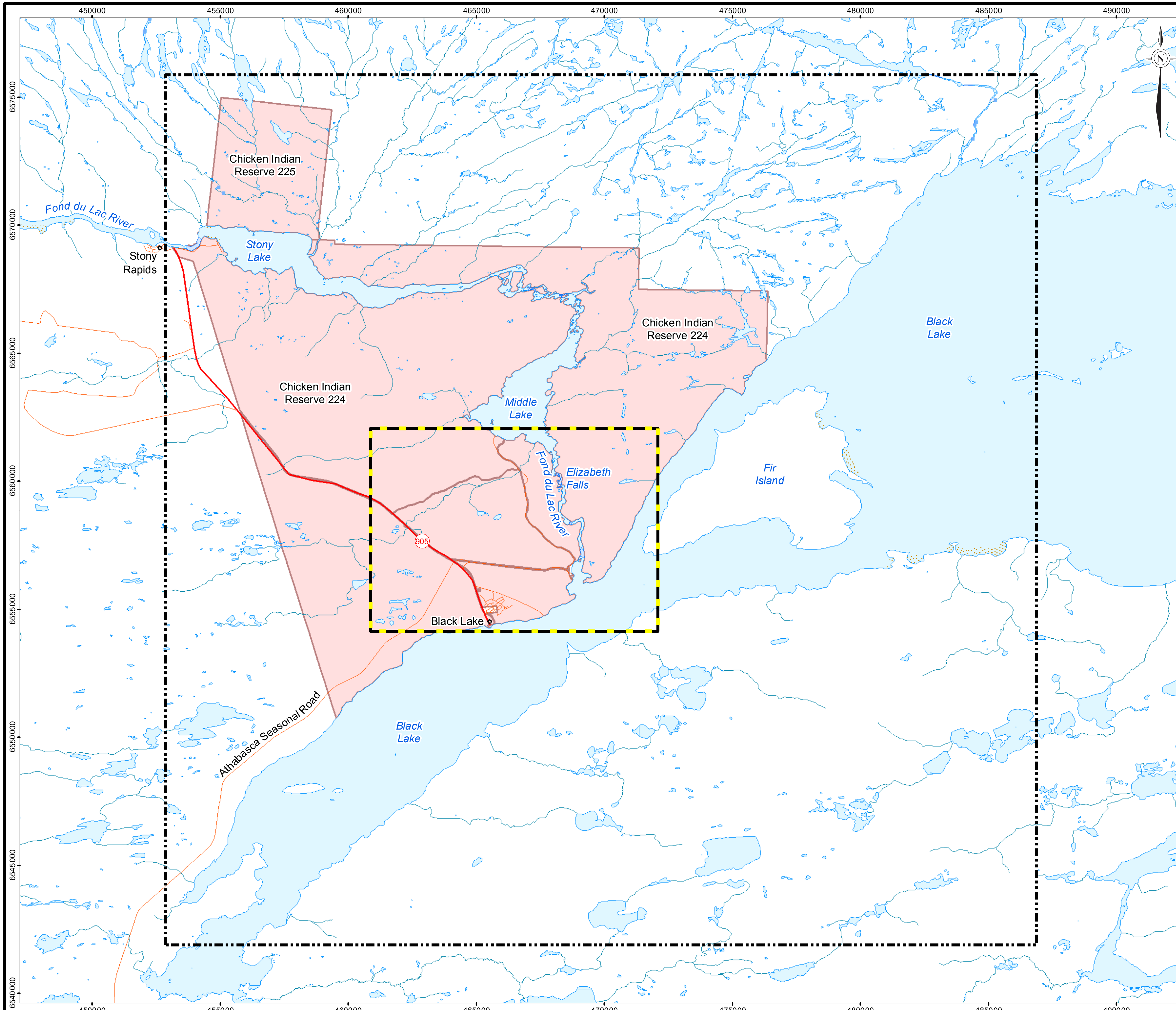
- plant populations and communities provide food and habitat for wildlife;
- protection of listed (rare) plant species designated by federal and provincial legislation; and
- during recent interviews with the local Aboriginal people, several plant species were identified and are considered to be VCs by for traditional and economic purposes, including blueberries (*Vaccinium* spp.), bog cranberries (*Vaccinium* spp.), moss berries (*Vaccinium* spp.), and strawberries (*Fragaria virginiana*), as well as other edible vegetation, such as mushrooms, when available.

The assessment endpoint is the key property that should be protected for use by future human generations and for vegetation considers the maintenance of a self-sustaining plant population and community (including listed plants). The measurement endpoints are quantifiable and qualitative expressions of change to the assessment point, and for vegetation include habitat fragmentation, the relative abundance and distribution of plant species, and plant community diversity and health. The changes to traditional use plants and traditional use plant habitat potential are also assessed in this section; however, changes to traditional use species is also a measurement endpoint for land use (Section 17.0).

14.2 Spatial Boundaries

To quantify baseline conditions and assess Project-related effects on the terrestrial environment, a regional study area (RSA) and a local study area (LSA) were defined for all terrestrial components (soil and terrain, vegetation, and wildlife).

The LSA is approximately 89 square kilometres (km^2) (8,881 hectares [ha]), and includes the Project infrastructure and the main access road (Figure 14.2-1). The LSA was based on the predicted direct and small-scale indirect effects from the Project on the terrestrial environment. Direct effects on vegetation include removal of vegetation from the Project footprint. Small-scale indirect effects include changes to vegetation from dust deposition, air emissions, and surface water levels and flows.



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- INDIAN RESERVE
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA

REFERENCE

DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6

5 0 5
SCALE 1:150,000 KILOMETRES

PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE
LOCATION OF THE LOCAL AND REGIONAL STUDY AREAS FOR VEGETATION

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	05/11/13	
CHECK	JF	15/11/13	
REVIEW	MM	15/11/13	

FIGURE: 14.2-1

The Project is located in an area with a relatively low level of human-related disturbance. The area north of the main body of Black Lake and the Fond du Lac River is influenced by isolated fishing camps and cabins. The community of Black Lake is located approximately 7 kilometres (km) southwest of the Project and Stony Rapids is located approximately 25 km northwest. Camp Grayling is a fishing camp located approximately 2.5 km south of the Project. Other human-related disturbances near the Project include various small developments (less than 8 ha), such as old gravel and borrow pits, cabins, the Black Lake lagoon, and linear features such as all-terrain vehicle and snowmobile trails. Highway 905, an all-season road, connects the communities of Black Lake and Stony Rapids. The RSA selected for vegetation consisted of a 1,156 km^2 (115,600 ha) area centered on the Project (Figure 14.2-1). The RSA was selected based on the predicted spatial extent of the combined direct and indirect effects on vegetation.

The assessment of Project-specific and cumulative effects on vegetation is completed at the scale of the RSA, which is expected to be large enough to include most of the individuals that comprise local plant populations. At this extent, a local or sub-population forms part of the population. A population is defined as a group of individuals of the same species occupying an area of sufficient size so that dispersal is infrequent and changes in abundance and distribution are largely determined by reproduction and survival (Berryman 2002). Analysis of incremental and cumulative changes from the Project and other developments to vegetation types in the RSA is anticipated to be sufficient to assess the ecologically relevant effects on local populations.

14.3 Existing Environment

The purpose of this section is to describe the existing composition and distribution of plant communities within the RSA, with a focus on the LSA, as a basis to assess the potential Project-specific effects on vegetation. The detailed methods and results for the baseline surveys are located in Section 4.0 of Annex IV.

14.3.1 Data Collection

Field surveys were completed during the growing seasons in 2010 and 2012 to obtain a set of baseline data for the LSA and RSA. Field surveys were completed during July 21 to 24, 2010, June 2 to 11, 2012, and July 31 to August 2, 2012 to capture an inventory of both early and late flowering species. Field survey information was used to characterize and map vegetation types (Ecological Landscape Classification [ELC] map units; habitats), compile a vegetation inventory of observed species in each vegetation map unit defined in the ELC map, and document any listed and traditional use species found in the study areas. All field data were used to help ground-truth, classify, and describe the ELC map units for the RSA and LSA. Field surveys were completed by qualified personnel. In total, 160 locations were visited during the field programs, and include 40 detailed vegetation inventory (DVI) plots, 78 listed plant survey plots, and 42 ground truth plots (Annex IV; Appendix IV.2, Table IV.2-1).

Tree species that were recorded in the main canopy are greater than or equal to 5 metres (m). Where a sub-canopy is present, trees are taller than 5 m, but tree heights in the main canopy and the sub-canopy differ by greater than or equal to 3 m. The tall shrub layer includes all trees or shrubs between 2 to 4.9 m. The low shrub layer includes shrubs that are less than 2 m. The forb layer includes all herbaceous flowering plants, ferns, fern allies, and club mosses. The graminoid layer includes grasses, sedges, and rushes. At the ground layer, bryophytes (mosses, liverworts, or hornworts) and ground-dwelling lichens were recorded. Epiphytic lichens, if observed, were also recorded.

Unknown vascular plants were identified in the field using several guidebooks and plant keys including Vascular Plants of Continental Northwest Territories, Canada (Porslid and Cody 1980), Field Guide to the Sedges of the Pacific Northwest (Wilson et al. 2008), Catkin-Bearing Plants of British Columbia (Brayshaw 1996), and Flora of North America – Volume 22 (Brooks and Clemants 2012). Bryophytes (mosses, liverworts, and hornworts) that were collected during the 2012 field programs were classified by a bryophyte taxonomist (Eleanor Edye, Bryologist - Alberta Biodiversity Monitoring Institute). Ground-dwelling and epiphytic lichens were also collected during the 2012 field programs and were classified by a lichen taxonomist (Trevor Goward, Lichenologist - Enlichened Consulting Ltd.).

Scientific names used were obtained from the Saskatchewan Conservation Data Centre (SKCDC) Saskatchewan Vascular, Non-vascular, and Fungi Plant Species Lists (SKCDC 2012a, b, c) and the PLANTS Database (United States Department of Agriculture, Natural Conservation Service [USDA NRCS] 2012). All species names were crosschecked so that species were not counted twice (synonyms).

14.3.2 Ecological Landscape Classification

An ELC was developed to provide information about the abundance and distribution of vegetation types (ELC map units; habitats) within the LSA and RSA. The ELC provides a broad-level inventory of habitats in the LSA and RSA. The ELC also provides a basis for interpreting or modelling listed and traditional use plant habitat potentials.

The ELC map was developed for the LSA and RSA using Landsat satellite imagery (30 m by 30 m pixel imagery acquired on June 24, 2010). The multispectral imagery was cloud-free and captured during the summer. Quality control practices were implemented so that the imagery was correctly calibrated and geo-referenced within the RSA. The imagery was loaded into object-based remote sensing analysis software (eCognition 8.7) for the classification process. The final classification rules for the ELC used a combination of spectral characteristics associated with known ground features in addition to thresholds determined for the multispectral indices and applied for generating the final supervised classification. In recent history, multiple fires have affected the RSA. Therefore, fire history data were obtained from the Government of Saskatchewan and incorporated into the ELC after the completion of the supervised classification. Once the ELC classification was complete, selected vegetation plot locations were compared against the classification for a visual accuracy assessment.

14.3.2.1 Local Study Area

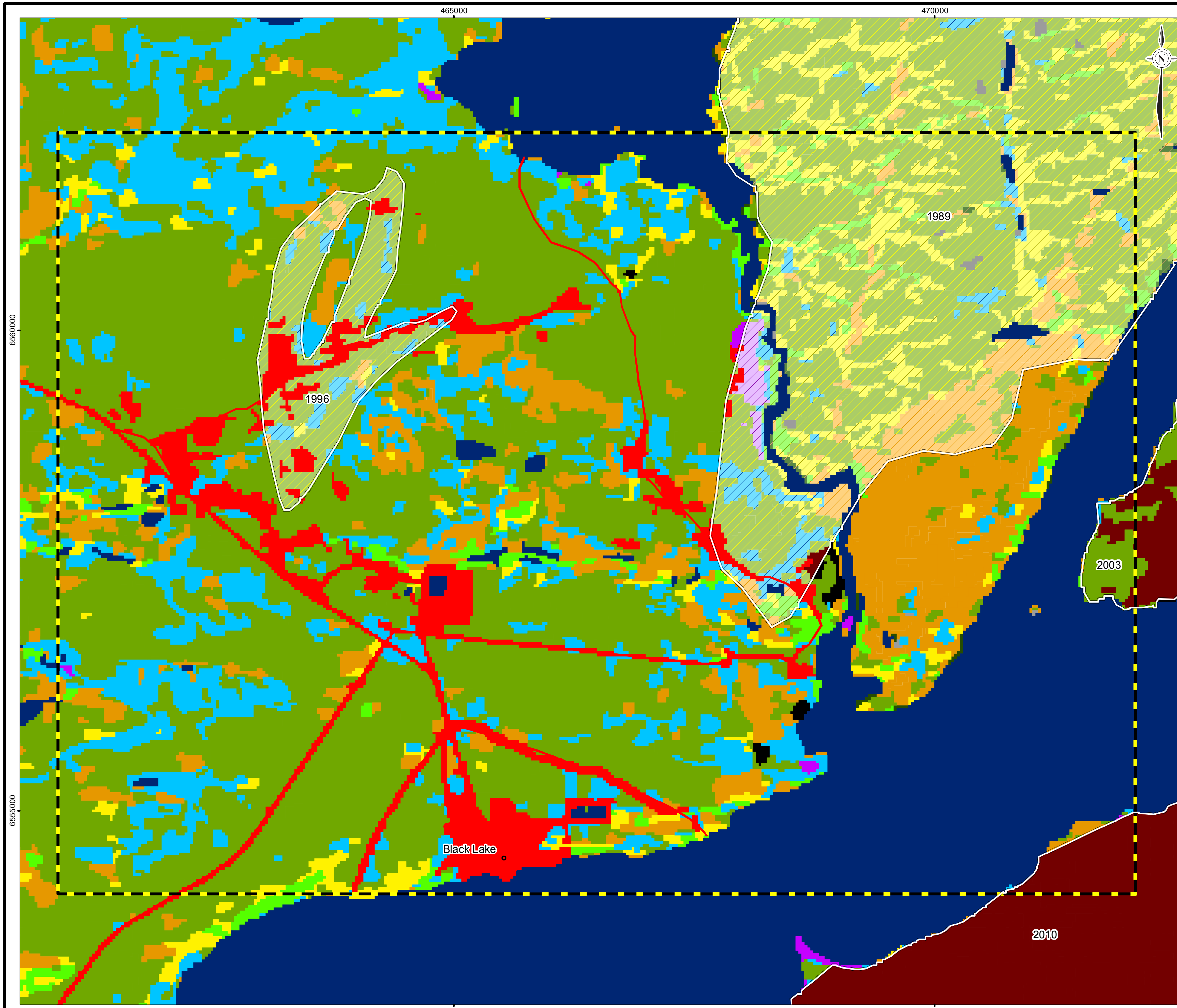
Nineteen ELC map units (habitat types) were classified in the LSA and include Bedrock, Jack Pine, Jack Pine/Black Spruce, Spruce, Mixedwood, Deciduous, Wetland, Riparian, Open Water, Regenerating map units, Recent Burn, Existing Disturbance, and Unclassified (Table 14.3-1). The Existing Disturbance ELC map unit is the result of existing human related disturbances such as roads, cut lines, and communities. This map unit does not include the natural disturbances from fire; fire related disturbances are captured in the Recent Burn and Regenerating map units. The Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique and did not fit into any of the other ELC map units. In addition, these areas could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified. The mapped distribution of ELC map units for the LSA is presented in Figure 14.3-1. The overall accuracy of the ELC classification was 71%.

The primary ELC map unit within the LSA is the Jack Pine and accounts for approximately 35.6% (3,165 ha) (Table 14.3-1; Figure 14.3-1). Regenerating map units within the LSA represent areas that were historically affected by fire in 1989 and 1996 and account for approximately 18.0% (1,601 ha) of the LSA. The Wetland map unit and the Regenerating Wetland map unit cover approximately 11.9% (1,057 ha) of the LSA. The Recent Burn map unit accounts for approximately 0.9% (83 ha). The Existing Disturbance map unit (e.g., roads and communities) account for approximately 5.8% (516 ha) of the LSA. Approximately 16.0% (1,423 ha) of the LSA is covered with Open Water.

Table 14.3-1: Absolute and Relative Area of Ecological Landscape Classification Map Units within the Local Study Area

Ecological Landscape Classification Map Unit	Area (ha)	Proportion of LSA (%)
Bedrock	5	0.1
Jack Pine	3,165	35.6
Jack Pine / Black Spruce	7	0.1
Spruce	809	9.1
Mixedwood	188	2.1
Deciduous	104	1.2
Wetland[(a)]	957	10.8
Riparian	8	0.1
Open water	1,423	16.0
Regenerating Jack Pine	963	10.8
Regenerating Jack Pine / Black Spruce	4	<0.1
Regenerating Spruce	183	2.1
Regenerating Mixedwood	261	2.9
Regenerating Deciduous	67	0.8
Regenerating Wetland[(a)]	100	1.1
Regenerating Riparian	23	0.3
Recent Burn	83	0.9
Existing Disturbance	516	5.8
Unclassified	14	0.2
Total	**8,881**	**100**

Note: Numbers are rounded for presentation purposes. Therefore, it could appear that the totals do not equal the sum of the individual values.
The Existing Disturbance ELC map unit is the result of existing human related disturbances such as roads, cut lines, and communities. The Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique, did not fit into any of the other ELC map units, and could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified.
(a) Wetland includes bogs, fens, and swamps. Regenerating Wetland includes regenerating bogs, fens, and swamps.
LSA = local study area; ha = hectares; % = percent; <= less than.



LEGEND

- HAMLET OR COMMUNITY
- TERRESTRIAL LOCAL STUDY AREA
- FOREST FIRES (1989-2010)
- BEDROCK
- JACK PINE
- JACK PINE / BLACK SPRUCE
- SPRUCE
- MIXEDWOOD
- DECIDUOUS
- WETLAND
- RIPARIAN
- OPEN WATER
- REGENERATING JACK PINE
- REGENERATING JACK PINE / BLACK SPRUCE
- REGENERATING SPRUCE
- REGENERATING MIXEDWOOD
- REGENERATING DECIDUOUS
- REGENERATING WETLAND
- REGENERATING RIPARIAN
- RECENT BURN
- EXISTING DISTURBANCE
- UNCLASSIFIED

REFERENCE

DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
LANDSAT SCENE WAS ACQUIRED ON JUNE 24, 2010. THE CLASSIFICATION SHOWN HAS BEEN CREATED FROM THIS 30 METRE RESOLUTION LANDSAT SCENE.
SASKATCHEWAN FIRE HISTORY DATA OBTAINED FROM THE GOVERNMENT OF SASKATCHEWAN

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

ECOLOGICAL LANDSCAPE CLASSIFICATION FOR THE LOCAL STUDY AREA

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	31/07/13	**FIGURE: 14.3-1**
CHECK	JF	15/11/13	
REVIEW	MM	15/11/13	

14.3.2.2 Regional Study Area

The same 19 ELC map units that occur within the LSA occur within the RSA (Table 14.3-2). The mapped distribution of ELC map units for the RSA is presented in Figure 14.3-2. The primary ELC map unit within the RSA is Recent Burn and accounts for approximately 31.1% (35,993 ha) of the RSA (Table 14.3-2; Figure 14.3-2). Recent Burn areas were affected by fire in 2003, 2006, 2008, and 2010. Regenerating map units represent areas that were historically affected by fire during 1989, 1994, and 1996 and account for approximately 7.5% (8, 656 ha) of the RSA. The most abundant upland map unit is the Jack Pine map unit and accounts for approximately 18.6% (21,492 ha) of the RSA. Wetlands cover approximately 5.4%% (6,213 ha) of the RSA. Existing Disturbances account for approximately 0.8% (889 ha) of the RSA. Approximately 22.7% (26,275 ha) of the RSA is covered with Open Water.

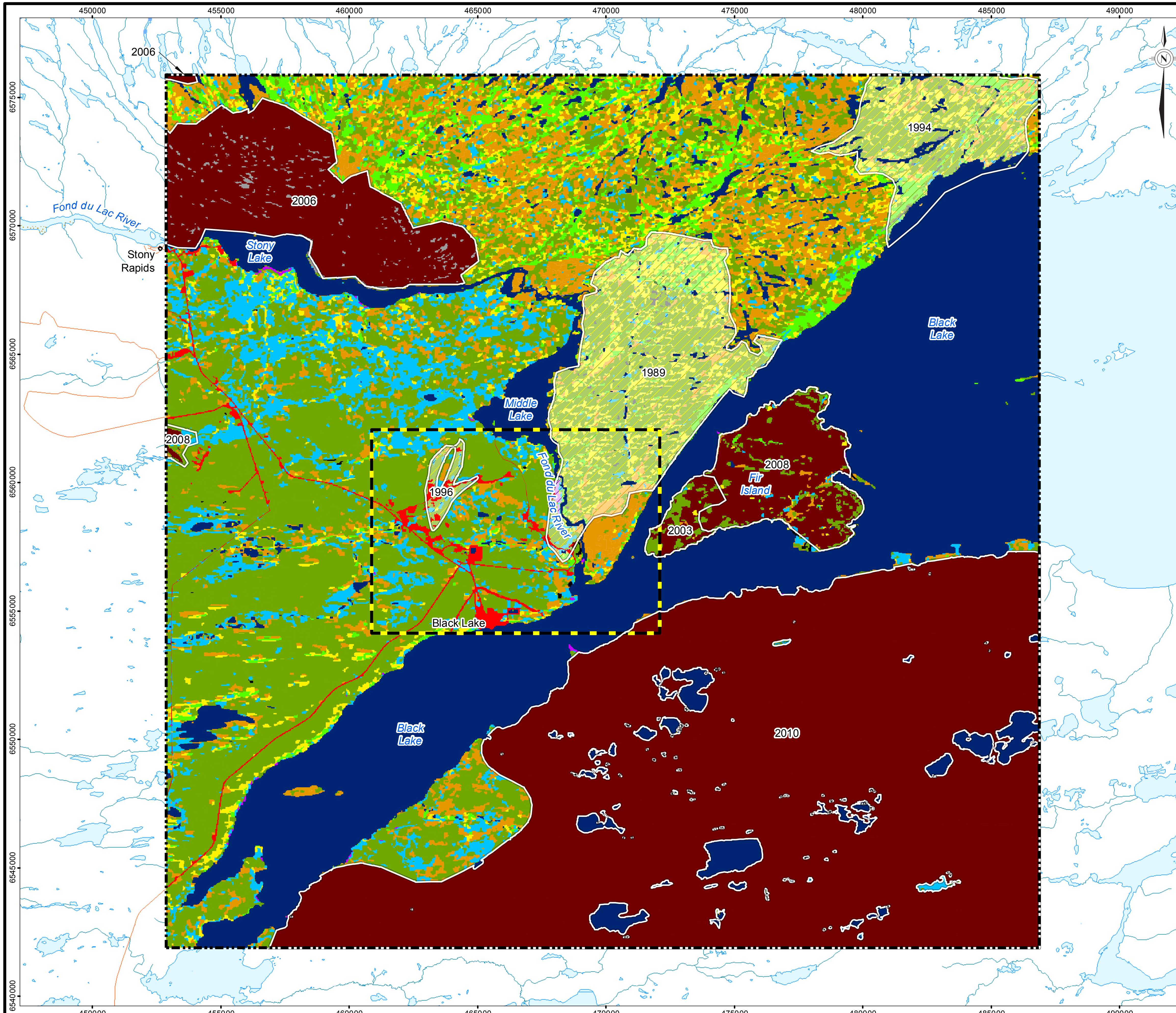
Table 14.3-2: Absolute and Relative Area of Ecological Landscape Classification Map Units within the Regional Study Area

Ecological Landscape Classification Map Unit	Area (ha)	Proportion of RSA (%)
Bedrock	347	0.3
Jack Pine	21,492	18.6
Jack Pine / Black Spruce	117	0.1
Spruce	8,887	7.7
Mixedwood	3,658	3.2
Deciduous	2,971	2.6
Wetland[(a)]	6,213	5.4
Riparian	53	<0.1
Open water	26,275	22.7
Regenerating Jack Pine	4,793	4.1
Regenerating Jack Pine / Black Spruce	48	<0.1
Regenerating Spruce	707	0.6
Regenerating Mixedwood	2,002	1.7
Regenerating Deciduous	854	0.7
Regenerating Wetland[(a)]	229	0.2
Regenerating Riparian	23	<0.1
Recent Burn	35,993	31.1
Existing Disturbance	889	0.8
Unclassified	50	<0.1
Total	**115,600**	**100**

Note: Numbers are rounded for presentation purposes. Therefore, it could appear that the totals do not equal the sum of the individual values.
The Existing Disturbance ELC map unit is the result of existing human related disturbances such as roads, cut lines, and communities. The Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique, did not fit into any of the other ELC map units, and could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified.

(a) Wetland includes bogs, fens, and swamps. Regenerating Wetland includes regenerating bogs, fens, and swamps.

RSA = regional study area; ha = hectares; % = percent; <= less than.



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA
- FOREST FIRES (1989-2010)

ECOLOGICAL LAND CLASSIFICATION

- BEDROCK
- JACK PINE
- JACK PINE / BLACK SPRUCE
- SPRUCE
- MIXEDWOOD
- DECIDUOUS
- WETLAND
- RIPARIAN
- OPEN WATER
- REGENERATING JACK PINE
- REGENERATING JACK PINE / BLACK SPRUCE
- REGENERATING SPRUCE
- REGENERATING MIXEDWOOD
- REGENERATING DECIDUOUS
- REGENERATING WETLAND
- REGENERATING RIPARIAN
- RECENT BURN
- EXISTING DISTURBANCE
- UNCLASSIFIED

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
LANDSAT SCENE WAS ACQUIRED ON JUNE 24, 2010. THE CLASSIFICATION SHOWN HAS BEEN CREATED FROM THIS 30 METRE RESOLUTION LANDSAT SCENE.
SASKATCHEWAN FIRE HISTORY DATA OBTAINED FROM THE GOVERNMENT OF SASKATCHEWAN

5 0 5
SCALE 1:150,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

ECOLOGICAL LANDSCAPE CLASSIFICATION FOR THE REGIONAL STUDY AREA

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	05/11/13	**FIGURE: 14.3-2**
CHECK	JF	15/11/13	
REVIEW	MM	15/11/13	

14.3.2.3 *Ecological Landscape Classification Descriptions*

Characteristic species observed in each vegetation stratum within each of the 19 ELC map units that were found in the RSA and LSA are described in Annex IV (Section 4.3.1.3). The Wetland ELC map unit and regenerating wetland ELC map unit includes bogs, fens, swamps, Regenerating Bog, Regenerating Fen, and Regenerating Swamp. Because these different wetland types could not be separated in the ELC, these are mapped together. However, each wetland type was surveyed during the field programs; therefore, subclasses for the wetland ELC map unit are also described. The Regenerating ELC map units represent areas that were affected by fire in 1989, 1994, and 1996; enough regeneration has occurred in these areas that regenerating areas are considered young forest. The Recent Burn ELC map unit represents areas that have been affected by fire in 2003, 2006, 2008, and 2010. Complete lists of species documented during 2010 and 2012 field programs are presented in Annex IV (Appendix IV.2; Table IV.2-2 and IV.2-3).

14.3.3 Biodiversity

Biodiversity refers to the variety of life forms, especially number of species, and includes the number of ecosystem types. The term biodiversity can be described as the total number of species, the evenness of their distribution, and the differences in their functionality. Biodiversity is often used as a synonym for species richness; however, biodiversity also includes the relative abundance, composition, and presence and absence of key species (Hooper et al. 2005). Species richness is influenced by the number of sites sampled (i.e., a higher sample number could result in higher species richness), but it can nonetheless be an effective comparative measurement, allowing minimum and maximum richness between areas to be compared.

For the purposes of this assessment, biodiversity was evaluated using the number of species within each of the ELC map units in the RSA. Species diversity was determined using DVI and listed plant survey data collected during the field surveys completed in 2010 and 2012. Biodiversity was assessed for each ELC map unit based on the total numbers of species, and the total numbers of vascular, non-vascular, and lichen species. Other biodiversity measures estimated included the number of listed plant species and the number of unique species within each ELC map unit. Minimum and maximum numbers of species by DVI sample plot are also included.

14.3.3.1 *Species Richness by Ecological Landscape Classification Map Unit*

In total, 363 plant species were identified during field programs. This total includes 166 vascular plants (including 7 trees, 36 shrubs and subshrubs, 80 forbs, and 43 graminoids), 86 bryophytes, and 111 ground-dwelling and epiphytic lichens.

The number of vascular, non-vascular, lichen and total species among each ELC map unit was calculated as one measure of biodiversity. The highest number of vascular plant species occurred within the Riparian ELC map unit, Mixedwood ELC map unit, and Wetland map unit – Fen subclass (63, 55, and 54 vascular species, respectively) (Table 14.3-3). The highest number of non-vascular plant species occurred within the Mixedwood ELC map unit, and the highest number of ground-dwelling and epiphytic lichens was observed in the Jack Pine/Black Spruce ELC map unit (Table 14.3-3).

The Mixedwood ELC map unit had the highest total species diversity at 136 species (Table 14.3-3). A total of 102 species occurred in the Fen subclass, and the Deciduous and Riparian ELC map units had 88 species each. The lowest number of vascular plant species occurred within Regenerating Swamp (21 species), Regenerating Jack Pine/Black Spruce (29 species), Regenerating Deciduous (29 species) and Recent Burn (29 species).

Table 14.3-3: Biodiversity Measures by Ecological Landscape Classification Map Unit within the Regional Study Area

Ecological Landscape Classification Map Unit	Number of Sample Sites[(a)]	Number of Vascular Plants	Number of Non-vascular Plants	Number of Lichens	Total Number of Species	Number of Listed Species Occurrences	Number of Species Unique to ELC Type[(b)]
Bedrock	7	39	8	39	86	16	10
Jack Pine	8	31	13	30	74	14	3
Jack Pine / Black Spruce	7	25	8	49	82	18	7
Spruce	7	25	8	15	48	5	2
Mixedwood	20	55	37	44	136	20	28
Deciduous	7	29	19	40	88	10	12
Wetland[(c)]	-	-	-	-	-	-	-
Bog subclass	4	12	15	22	49	10	3
Fen subclass	11	54	23	25	102	9	17
Swamp subclass	5	32	22	13	67	5	14
Riparian	8	63	2	23	88	2	25
Open Water	-	-	-	-	-	1[(d)]	-
Regenerating Jack Pine	6	23	2	7	32	3	0
Regenerating Jack Pine / Black Spruce	3	23	2	4	29	1	3
Regenerating Spruce	0	-	-	-	-	-	-
Regenerating Mixedwood	10	31	11	28	70	11	4
Regenerating Deciduous	4	23	4	2	29	0	1
Regenerating Wetlands[(c)]	-	-	-	-	-	-	-
Regenerating Bog subclass	1	7	3	8	18	9	0
Regenerating Fen subclass	3	36	16	16	68	10	9
Regenerating Swamp subclass	2	17	4	0	21	5	1

Table 14.3-3: Biodiversity Measures by Ecological Landscape Classification Map Unit within the Regional Study Area (continued)

ELC Map Unit	Number of Sample Sites[(a)]	Number of Vascular Plants	Number of Non-vascular Plants	Number of Lichens	Total Number of Species	Number of Listed Species Occurrences	Number of Species Unique to ELC Type[(b)]
Regenerating Riparian	0	-	-	-	-	-	-
Recent Burn	5	25	3	1	29	0	5
Existing Disturbance	0	-	-	-	-	-	-
Unclassified	n/a	-	-	-	-	-	-
Total Number of Species	**118**	**166**	**86**	**111**	**363**	**51[(e)]**	**144**

Note: Numbers presented are total number of species found in that ELC map unit. The same species could occur in more than one ELC map unit.
The Existing Disturbance ELC map unit is the result of existing human related disturbances such as roads, cut lines, and communities.
The Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique, did not fit into any of the other ELC map units, and could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified.

(a) The number of sample sites is based on listed plant surveys completed in 2010 and 2012, and Detailed Vegetation Inventory plots completed in 2012. These numbers do not include ground truth/reconnaissance plots.
(b) Does not include unidentified species.
(c) Totals were not completed for this map unit because the variation of numbers of plant species observed in each of the subclasses.
(d) Alternate-flowered water-milfoil was documented at a riparian plot that included a portion of open water; therefore this observation was placed in the open water map unit and not counted in the riparian map unit.
(e) This includes 6 forbs, 1 graminoid, and 44 lichens documented in 2010 and 2012.

n/a = not applicable; - = not sampled; ELC = Ecological Landscape Classification

14.3.3.2 Total Number of Listed Species

A total of 51 listed plant species occurrences were documented during field surveys and are described in more detail in Annex IV, Section 4.3.3. These species are listed by the SKCDC; however, none of these species is listed under COSEWIC, *SARA* or the *Wildlife Act*. The highest numbers of listed species were found in the Mixedwood ELC map unit with 20 listed species, which were all lichens (Table 14.3-4). Eighteen listed lichen species were found in the Jack Pine/Black Spruce ELC map unit, and 16 (15 lichens and one fern) were found in the Bedrock ELC map unit. No listed species were found in the Recent Burn or Regenerating Deciduous ELC map units (Table 14.3-3).

14.3.3.3 Total Number of Unique Species

Calculating the total number of unique species within ELC types is a way of expressing habitat uniqueness (Table 14.3-3). The Mixedwood and Riparian ELC map units had the highest numbers of unique species with 28 and 25 species, respectively. No unique species were found in Regenerating Jack Pine ELC map unit and the Regenerating Bog subclass.

14.3.3.4 Species Richness by Sample Plot

Species richness for vascular plants, bryophytes (non-vascular), and lichens are shown in Table 14.3-4. Among the highest values for vascular plant species richness are the Regenerating Fen subclass, Swamp subclass, and Mixedwood ELC map units. Mixedwood, Riparian, and Deciduous map units had the highest bryophyte values. Lichen richness was highest in Bedrock, Deciduous, and Jack Pine/Black Spruce ELC map units. Overall species richness was observed to be highest in Regenerating Fen subclass, and Mixedwood and Deciduous ELC map units. The Regenerating Jack Pine ELC map unit was found to have the lowest species richness.

14.3.4 Listed Plant Species and Listed Plant Habitat Potential

14.3.4.1 Listed Plant Species Occurrences

For the purpose of this report, listed species includes all species that are designated as ‘at risk’, ‘rare’, ‘endangered’, ‘threatened’, ‘special concern’, or otherwise tracked by federal and provincial conservation legislation, documents, and databases such as:

- the Saskatchewan Conservation Data Centre (SKCDC 2012d, e, f);
- the Saskatchewan *Wildlife Act* (1998);
- the Committee on the Status of Endangered Wildlife in Canada ([COSEWIC] 2012, 2013);
- the *Species at Risk Act* ([*SARA*] 2012a); and
- the Species at Risk Public Registry (*SARA* 2012b).

Table 14.3-4: Species Richness by Detailed Vegetation Sample Plots in the Regional Study Area

Ecological Landscape Classification Map Unit	Number of Detailed Vegetation Plots Sampled	Vascular Species Richness		Non-vascular Species Richness[a]		Lichen Species Richness		Total Species Richness	
		Min	Max	Min	Max	Min	Max	Min	Max
Bedrock	3	9	17	0	6	7	30	21	42
Jack Pine	2	8	12	3	5	12	16	25	31
Jack Pine / Black Spruce	3	5	12	3	5	17	26	33	37
Spruce	2	7	11	3	4	6	11	16	26
Mixedwood	7	7	21	2	16	2	20	23	46
Deciduous	4	9	16	2	14	1	27	28	46
Wetland[b]	-	-	-	-	-	-	-	-	-
Bog subclass	2	6	11	4	12	0	22	10	43
Fen subclass	4	7	14	5	12	0	14	26	31
Swamp subclass	3	8	25	2	10	0	12	29	30
Riparian	2	11	17	12	15	0	1	27	29
Open water	0	-	-	-	-	-	-	-	-
Regenerating Jack Pine	2	4	10	1	1	2	6	7	17
Regenerating Jack Pine / Black Spruce	0	-	-	-	-	-	-	-	-
Regenerating Spruce	0	-	-	-	-	-	-	-	-
Regenerating Mixedwood	3	5	13	2	7	7	16	18	32
Regenerating Deciduous	0	-	-	-	-	-	-	-	-
Regenerating Wetlands(b)	-	-	-	-	-	-	-	-	-
Regenerating Bog subclass	1	7	-	3	-	8	-	18	-
Regenerating Fen subclass	2	18	29	8	13	7	13	33	55
Regenerating Swamp subclass	0	-	-	-	-	-	-	-	-

Table 14.3-4: Species Richness by Detailed Vegetation Sample Plots in the Regional Study Area (continued)

ELC Map Unit	Number of Detailed Vegetation Plots Sampled	Vascular Species Richness		Non-vascular Species Richness[a]		Lichen Species Richness		Total Species Richness	
		Min	Max	Min	Max	Min	Max	Min	Max
Regenerating Riparian	0	-	-	-	-	-	-	-	-
Recent Burn	1	10	-	1	-	1	-	12	-
Existing Disturbance	0	-	-	-	-	-	-	-	-
Unclassified	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Notes: The Existing Disturbance ELC map unit is the result of existing human related disturbances such as roads, cut lines, and communities.
The Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique, did not fit into any of the other ELC map units, and could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified.

(a) includes bryophytes, which include mosses, liverworts, and hornworts.

(b) Totals were not completed for this map unit because the variation of numbers of plant species observed in each of the subclasses.

min = minimum; max = maximum; - = not completed; n/a = not applicable

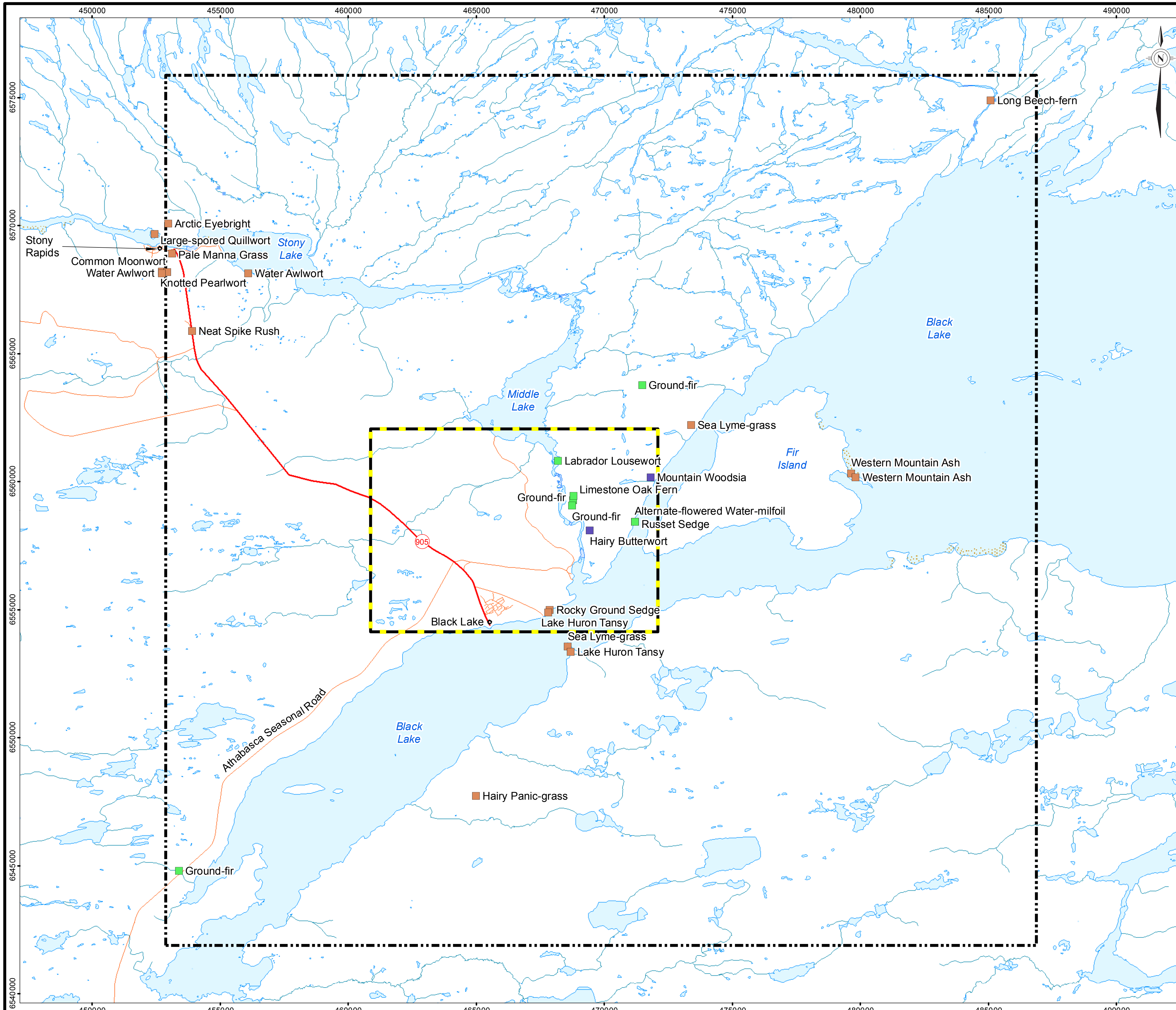
Prior to field programs, an inventory of listed species that are known to occur or have potential to occur within the RSA was compiled using federal and provincial status documents and databases, provincial tracking lists, references/literature, and known distributions. Another search of federal and provincial status databases was completed in 2013 and species statuses were updated if required. Only the COSEWIC (2013) database had been updated in 2013 at the time this report was completed. The habitat requirements of these listed plant species were reviewed and compared to availability of that habitat type in the RSA. Listed plant species with the potential to occur within the RSA and their preferred habitats can be found in Annex IV (Appendix IV.2, Table IV.2-4).

Sampling effort was concentrated in habitats and microsites identified to have a greater potential to support listed plant species. However, listed species surveys were not limited to areas with highest habitat potential, as suitable microhabitats exist across all vegetation types. Listed plant searches were carried out during all field programs to account for early and late flowering species, and were completed within and around all DVI plots.

Listed vascular plant species confirmed to occur within the RSA are presented in Figure 14.3-3 and Table 14.3-5 and listed lichen species are in Figure 14.3-4 and Table 14.3-6. Sixteen provincially listed vascular plant species and 44 provincially listed lichen species have been documented within the RSA. Two historical and seven current listed plant observation locations occur within the LSA (Figure 14.3-3). Lake Huron tansy (*Tanacetum bipinnatum* ssp. *huronense* [(syn. *Tanacetum huronense* var. *floccosum*]), a historical observation within the LSA, is listed as "special concern" under COSEWIC (2013) and under *SARA* (2012a). This species is not identified as a provincial wild species at risk under the *Wildlife Act* (1998) and was not observed during the 2010 and 2012 field programs.

Six provincial listed forbs and one listed graminoid were documented during the 2010 and 2012 field programs (Figure 14.3-3 and Table 14.3-5). For specific locations where these species were observed, see Annex IV (Appendix IV.2, Table IV.2-5). Documented species in 2010 and 2012 included ground-fir (*Diphasiastrum sitchense* [syn. *Lycopodium sitchense*]), limestone oak fern (*Gymnocarpium jessoense* ssp. *parvulum*), alternate-flowered water millfoil (*Myriophyllum alterniflorum*), Labrador lousewort (*Pedicularis labradorica*), hairy butterwort (*Pinguicula villosa*), mountain woodsia (*Woodsia scopulina*), and Russet sedge (*Carex saxatilis* [syn. *Carex saxatilis* var. *rhomalea*]). Ground-fir was observed at four locations, two of which occur within the LSA. These observations were in Regenerating Jack Pine, Regenerating Jack Pine/Black Spruce, Regenerating Mixedwood, and Jack Pine ELC map units. Limestone oak fern was observed on a sparsely vegetation bedrock outcrop in the Jack Pine ELC map unit. Alternate-flowered water milfoil was observed just off the shore in Black Lake. Labrador lousewort was observed in a regenerating poor fen. Hairy butterwort was documented in the Fen subclass – Wetland ELC map unit on the side of a sphagnum hummock along a game trail in a treed poor fen. Mountain woodsia was found in crevices on a bedrock outcrop in the Bedrock ELC map unit. Russet sedge was found in the Riparian ELC map unit along the shore of Black Lake. No COSEWIC or *SARA* listed species were observed within the RSA and LSA during the 2010 and 2012 field surveys.

The 44 provincial listed lichen species observed were widely distributed in the LSA and RSA (Figure 14.3-4 and Table 14.3-6). For specific locations where these species were observed, see Appendix IV.2 (Table IV.2-3). All unburned ELC map units had between 5 and 20 listed lichen species, with the exception of the Riparian map unit, which had 1 listed lichen observation. Regenerating ELC map units had between 0 and 10 listed lichen observations. Recent Burn had no listed lichen species observations.



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA

LISTED PLANT SPECIES OBSERVATION LOCATION

- 2010 OBSERVATION
- 2012 OBSERVATION
- HISTORIC OBSERVATION

REFERENCE

DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
HISTORIC LISTED PLANT OBSERVATION LOCATIONS OBTAINED FROM THE SASKATCHEWAN CONSERVATION DATA CENTRE, 2012.

3 0 3

SCALE 1:150,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATIONS OF LISTED PLANT SPECIES OBSERVATIONS WITHIN THE REGIONAL STUDY AREA

Tazi Twé
Hydroelectric Project

PROJECT	10-1365-0004		FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	LMR/SM	25/07/13	**FIGURE: 14.3-3**	
CHECK	JF	15/11/13		
REVIEW	MM	15/11/13		

Table 14.3-5: Listed Vascular Plant Species Confirmed to Occur Within the Regional and Local Study Areas

Common Name	Scientific Name	Provincial Ranking[a]	Habitat Preference[b], Location, Sighting Circa
Trees and Shrubs			
Western Mountain Ash	*Sorbus scopulina*	S2	Upper beach borders or shore wood and wooded bank slopes. Tobey Point of Fir Island, Black Lake and in mossy rock by lake, 1980 and 1981.
Forbs			
Lake Huron Tansy[c]	*Tanacetum bipinnatum* ssp. *huronense* (syn. *Tanacetum huronense* var. *floccosum*)	S2S3	Broad sandy beaches and beach terraces, moist depressions at the base of sheltered dune slopes. Observed in RSA on a sandy beach, south exposure west shore of Black Lake, 1981, and on a sandy beach, north exposure, east shore of Black Lake, 1980.
Arctic Eyebright	*Euphrasia subarctica*	S1S2	Mesic open woods clearings, rocky shores and drier sedge-fen borders. Observed along paths in coniferous forest in north west of RSA near Stony Rapids, 1961.
Long Beech-fern	*Phegopteris connectilis*	S2	Wet woods and in soil on banks and shores or on moist rocky hillsides and ledges. Observed along Chipman River, Black Lake, 1987.
Ground-fir	*Diphasiastrum sitchense* (syn. *Lycopodium sitchense*)	S2	Dry, sandy coniferous woods. Observed in a regenerating Jack Pine/ Black Spruce habitat, a regenerating Mixedwood habitat, a Regenerating Jack Pine, and Jack Pine habitat, 2012.
Limestone oak fern	*Gymnocarpium jessoense* ssp. *parvulum*	S2S3	Woods, on granitic slopes and outcrops. Observed on a sparsely vegetated bedrock outcrop, 2012.
Alternate-flowered water-milfoil	*Myriophyllum alterniflorum*	S1	Shallow lakes. Aquatic just off shore in Black Lake, 2012.
Labrador lousewort	*Pedicularis labradorica*	S2	Open black spruce woods, treed bogs, regenerating burns, and lichen-tundra. Observed in regenerating poor fen, 2012.
Hairy butterwort	*Pinguicula villosa*	S2S3	On sphagnum hummocks in treed bogs or muskeg. Observed on the side of a Sphagnum hummock on game trail in a treed poor fen, 2010.
Mountain woodsia	*Woodsia scopulina*	S1	Granitic or calcareous cliffs, outcrops, and rocky slopes. In crevices on a bedrock outcrop, 2010.
Graminoids (sedges, grasses, and rushes)			
Knotted pearlwort	*Sagina nodosa* spp. *borealis*	S2	Wet sandy or rocky lake shores. Observed within the northwest portion of the RSA, 1981.
Water awlwort	*Subularia aquatica* var. *americana*	S3	Shallow water at the margins of sandy or gravelly lakes and slow streams. Observed in mud on the margin of a river with shallow water in the northwest of the RSA, 1963, and at the south shore of Stony Rapids, 1980.

Table 14.3-5: Listed Vascular Plant Species Confirmed to Occur Within the Regional and Local Study Areas (continued)

Common Name	Scientific Name	Provincial Ranking[a]	Habitat Preference[b], Location, Sighting Circa
Sea Lyme-grass	*Elymus mollis*	S2	Sandy lake beaches and dunes. Observed on a sandy beach, south exposure west shore of Black Lake and Black Lake "Sandy Point" on the east shore, 1981.
Hairy Panic -grass	*Dichanthelium acuminatum* var. *fasiciculatum*	S2	Dry, sandy open woods and clearings, exposed rock outcrops. Observed on boulder till of large drumlin, regenerating jackpine south facing slope southeast of Stony Rapids, 1982.
Neat spike rush	*Eleocharis nitida*	S2	Open moist shores, pond edges, wet depression clearings, and poor fens. Observed approximately 3.2 km south of Stony Rapids in roadside ditch, in the northwest portion of the RSA, 1961.
Pale manna grass	*Torreyochloa pallida* var. *fernaldii*	S2	Wet sandy beaches and marshy or floating sedge-fen shores. Observed in a swampy area in the north west of the RSA near Stony Rapids, 1960.
Russet sedge	*Carex saxatilis (*syn. *Carex saxatilis* var. *rhomalea)*	S2	Marshy, peaty, sandy, or rocky shores. Observed on a sandy beach, southern exposure west shore of Black Lake, 1980 and 1981. Observed in a riparian habitat next to Black Lake, 2012.

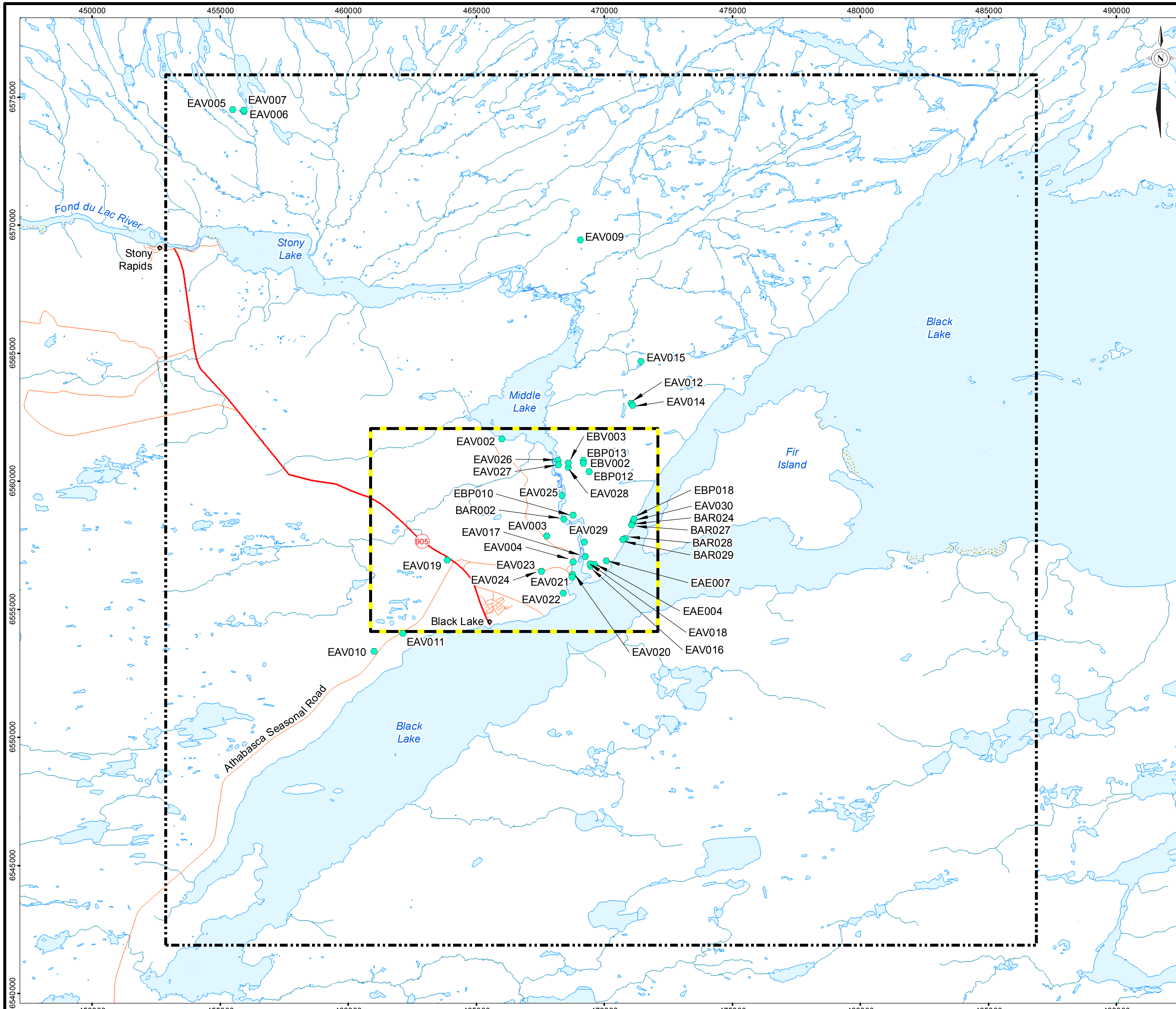
Notes: Common names obtained from SKCDC (2012a, b), Johnson et al. (1995) USDA NRCS (2012), and ACIMS (2012).
No species listed under COSEWIC (2013), *SARA* (2012b), or *Wildlife Act* (1998) were observed during 2010 and 2012 field programs.

(a) Saskatchewan Conservation Data Centre Tracked Species for Vascular Plants (SKCDC 2012d), and Tracked Species for Non-Vascular Plants (SKCDC 2012e), where;
S1 = extremely rare (5 or fewer occurrences in Saskatchewan, or very few remaining individuals);
S2 = rare (6 to 20 occurrences in Saskatchewan or few remaining individuals);
S3 = rare to uncommon (21 to 100 occurrences in Saskatchewan; could be rare and local throughout the province or could occur in a restricted provincial range; could be abundant in places);
S4 = common (more than 100 occurrences in Saskatchewan, generally widespread and abundant, could be rare in part of its range);
S5 = very common (more than 100 occurrences in Saskatchewan, widespread and abundant, could be rare in part of its range);
T = rank for a subspecific taxon (subspecies, variety or population);
SH = Historically known from Saskatchewan, but not verified recently; and
? = Rank Uncertain.

(b) Preferred habitats obtained from Harms et al. (1992), Flora of North America (Brooks and Clements 2012), and SKCDC (2012g).

(c) Listed as 'special concern' under COSEWIC (2013) and under *SARA* (2012b). This species is not identified as a provincial wild species at risk under the *Wildlife Act* (1998).

RSA = regional study area; km = kilometre



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- LOCATION CONTAINING LISTED LICHEN SPECIES
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA

NOTE

FOR THE LICHEN SPECIES OBSERVED AT EACH LOCATION, REFER TO APPENDIX IV, TABLE IV.2-5

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6

5 0 5
SCALE 1:150,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATIONS OF LISTED LICHEN OBSERVATIONS IN THE REGIONAL STUDY AREA

Tazi Twé
Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	06/11/13	FIGURE: 14.3-4	
CHECK	JF	15/11/13		
REVIEW	MM	15/11/13		

Table 14.3-6: Listed Ground-dwelling and Epiphytic Lichen Species Confirmed to Occur Within the Regional and Local Study Areas

Common Name	Scientific Name	Provincial Ranking[(a)]	Ecological Landscape Classification Map Unit(s) Observed
Concentric ring lichen	*Arctoparmelia centrifuga*	S2S3	Bedrock, Jack Pine/Black Spruce, Deciduous, Wetland (Bog)
Rippled ring lichen	*Arctoparmelia separata*	S1S2	Wetland (Bog)
Horsehair	*Bryoria furcellata*	S3	Jack Pine, Spruce, Mixedwood
Speckled horsehair	*Bryoria fuscescens*	S3	Bedrock, Jack Pine, Jack Pine/Black Spruce, Spruce, Mixedwood, Deciduous, Wetland (Bog), Wetland (Fen), Wetland (Swamp), Regenerating Mixedwood
Shiney horsehair lichen	*Bryoria glabra*	S1	Jack Pine/Black Spruce, Mixedwood, Wetland (Fen)
Old man's beard	*Bryoria simplicior*	S3	Jack Pine/Black Spruce, Regenerating Mixedwood
Iceland lichen	*Cetraria ericetorum*	S3S4	Deciduous
Quill lichen	*Cladonia amaurocraea*	S2	Bedrock, Jack Pine, Jack Pine/Black Spruce, Mixedwood, Deciduous, Wetland (Bog), Regenerating Mixedwood
Powdered funnel lichen	*Cladonia cenotea*	S3	Mixedwood
Cup lichen	*Cladonia coniocraea*	S2	Mixedwood
Organ-pipe lichen	*Cladonia crispata*	S3	Bedrock, Jack Pine/Black Spruce, Regenerating Mixedwood, Regenerating Wetland (Fen)
British soldiers	*Cladonia cristatella*	S3	Bedrock, Jack Pine, Jack Pine/Black Spruce, Regenerating Jack Pine, Regenerating Mixedwood, Regenerating Wetland (Bog), Regenerating Wetland (Fen)
Cup lichen	*Cladonia cyanipes*	S3	Jack Pine/Black Spruce, Deciduous
Many-forked cladonia	*Cladonia furcata*	S1	Bedrock
Lipstick powderhorn	*Cladonia macilenta*	S2	Regenerating Mixedwood
Red-fruited pixie-cup	*Cladonia pleurota*	S2	Bedrock, Jack Pine, Mixedwood
Antlered powderhorn	*Cladonia subulata*	S2	Bedrock, Regenerating Jack Pine, Regenerating Mixedwood, Regenerating Wetland (Fen)
Greater sulphur cup	*Cladonia sulphurina*	S2	Jack Pine/Black Spruce, Mixedwood, Regenerating Mixedwood, Regenerating Wetland (Fen)
Salted starburst lichen	*Imshaugia aleurites*	S2	Bedrock, Jack Pine, Mixedwood
American starburst lichen	*Imshaugia placorodia*	S1	Jack Pine, Jack Pine/Black Spruce,
Hagen's rim lichen	*Lecanora hagenii*	S2	Jack Pine/Black Spruce, Wetland (Fen)
Rim lichen	*Lecanora subintricata*	S1	Jack Pine/Black Spruce, Deciduous, Wetland (Fen)

Table 14.3-6: Listed Ground-dwelling and Epiphytic Lichen Species Confirmed to Occur Within the Regional and Local Study Areas (continued)

Common Name	Scientific Name	Provincial Ranking[(a)]	Ecological Landscape Classification Map Unit(s) Observed
Alpine camouflage lichen	*Melanelia stygia*	S1	Bedrock, Wetland (Bog)
Abraded camoflage lichen	*Melanelia subaurifera*	S2S3	Mixedwood
Powdery saucer lichen	*Ochrolechia androgyna*	S1	Wetland (Fen)
Green starburst lichen	*Parmeliopsis ambigua*	S3	Jack Pine, Mixedwood, Wetland (Bog), Wetland (Fen)
Gray starburst lichen	*Parmeliopsis hyperopta*	S3	Jack Pine, Jack Pine/Black Spruce, Mixedwood, Deciduous, Wetland (Fen), Regenerating Mixedwood,
Studded leather lichen	*Peltigera aphthosa*	S2S3	Jack Pine, Jack Pine/Black Spruce, Spruce, Mixedwood, Deciduous, Wetland (Swamp), Riparian, Regenerating Wetland (Fen)
Veinless pelt	*Peltigera malacea*	S3	Mixedwood, Deciduous, Wetland (Fen)
Rough pelt	*Peltigera scabrosa*	S2	Spruce
Star rosette lichen	*Physcia stellaris*	S3S4	Mixedwood
Punctured ramalina	*Ramalina dilacerata*	S3	Mixedwood
Hooded ramalina	*Ramalina obtusata*	S3	Mixedwood
Easter lichen	*Stereocaulon paschale*	S2	Bedrock, Jack Pine, Wetland (Bog)
Strangospora lichen	*Strangospora moriformis*	S1	Deciduous
Fringed wrinkle-lichen	*Tuckermannopsis americana (syn. Cetraria halei or C. ciliaris)*	S3	Bedrock, Jack Pine, Jack Pine/Black Spruce, Spruce, Mixedwood, Deciduous, Wetland (Bog), Wetland (Fen), Wetland (Swamp), Regenerating Mixedwood
Peppered rock tripe	*Umbilicaria deusta*	S2S3	Bedrock
Blistered rock tripe	*Umbilicaria hyperborea*	S2	Bedrock, Wetland (Bog)
Punctured rock tripe	*Umbilicaria torrefacta*	S1	Regenerating Wetland (Fen)
Fishbone beard lichen	*Usnea filipendula*	S2	Jack Pine/Black Spruce
Beard lichen	*Usnea fulvoreagens*	S1	Jack Pine/Black Spruce
Powdered beard lichen	*Usnea lapponica*	S3	Mixedwood, Wetland (Swamp)

Table 14.3-6: Listed Ground-dwelling and Epiphytic Lichen Species Confirmed to Occur Within the Regional and Local Study Areas (continued)

Common Name	Scientific Name	Provincial Ranking[(a)]	Ecological Landscape Classification Map Unit(s) Observed
Straw beard lichen	*Usnea scabrata*	S1	Bedrock, Jack Pine/Black Spruce
Beard lichen	*Usnea subfloridana*	S3S4	Mixedwood, Wetland (Swamp)

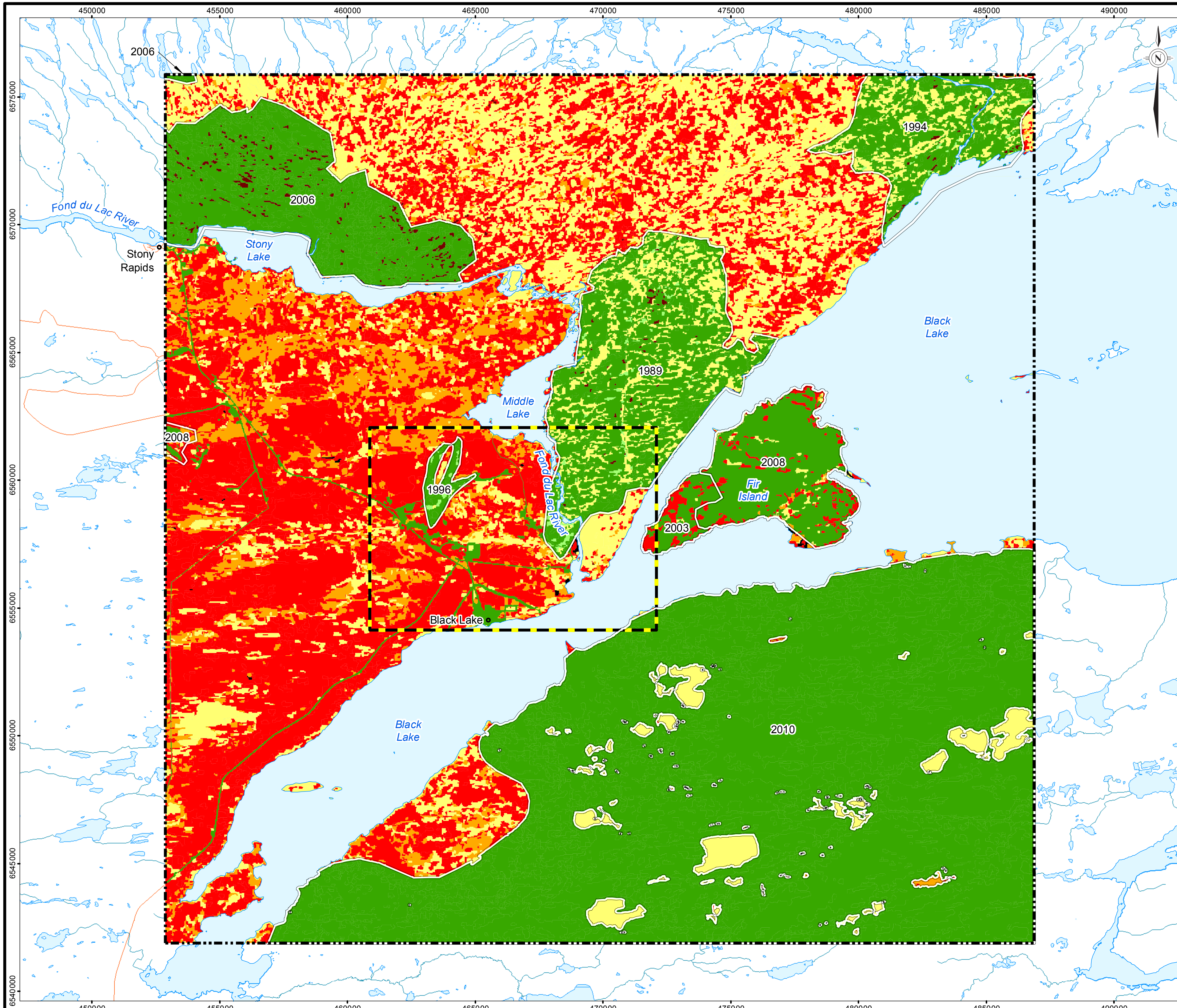
Notes: Common names obtained from SKCDC (2012c), Johnson et al. (1995) USDA NRCS (2012), and ACIMS (2012).
No species listed under COSEWIC (2013), *SARA* (2012b), or *Wildlife Act* (1998) were observed during field programs.
(a) Saskatchewan Conservation Data Centre Tracked Species List for Lichens and Fungi (SKCDC 2012f), where;
S1 = extremely rare (5 or fewer occurrences in Saskatchewan, or very few remaining individuals);
S2 = rare (6 to 20 occurrences in Saskatchewan or few remaining individuals);
S3 = rare to uncommon (21 to 100 occurrences in Saskatchewan; could be rare and local throughout the province or could occur in a restricted provincial range; could be abundant in places);
S4 = common (more than 100 occurrences in Saskatchewan, generally widespread and abundant, could be rare in part of its range);
S5 = very common (more than 100 occurrences in Saskatchewan, widespread and abundant, could be rare in part of its range);
T = rank for a subspecific taxon (subspecies, variety or population);
SH = Historically known from Saskatchewan, but not verified recently; and
? = Rank Uncertain.
ELC = Ecological Landscape Classification

The numbers of provincial and federal listed species observations documented during field programs does not preclude the potential for other listed species to occur within the RSA. Northern areas of the province are not as easily accessed and explored, therefore documented sightings of listed plants are often limited. Listed plant occurrences at a site can be missed due to timing of plant surveys because the species presence can vary annually and locally. In addition, climatic fluctuations might not allow adequate time for plants to mature and produce flowers, making them more difficult to spot and identify. Available microhabitats within larger habitat types can vary over time and space. Therefore, a listed plant survey cannot confirm the absence of listed plants; it can only confirm their presence.

14.3.4.1.1.1 Listed Plant Habitat Potential

Based on the habitat descriptions outlined above and according to listed plant habitat preferences (Harms et al. 1992; Flora of North America 1993+; SKCDC 2012g), the Regenerating ELC map units (except Regenerating Mixedwood), Recent Burn ELC map unit and Existing Disturbance ELC map units would be considered to have low to moderate/low potential to support listed plant species. Spruce, Deciduous, Regenerating Mixedwood, and Wetland ELC map units are considered to have moderate to high/moderate potential for listed plant species. The Jack Pine, Jack Pine/Black Spruce, Mixedwood, and Riparian ELC map units have high potential to support listed plant species. The Bedrock ELC map unit is considered to have a very high potential. Within all map units, where exposed bedrock is present, these microhabitats are considered have higher potential for listed plant species occurrence. Exposed rock provides microhabitats such as moist crevices for plants such as ferns.

The distribution of listed plant species habitat potential within the RSA is shown in Figure 14.3-5 and Table 14.3-7. Very high and high listed plant species habitat potential covers 3,374 ha (38%) of the LSA and 25,667 ha (22.2%) of the RSA. The high/moderate listed habitat potential class is the result of the differences between Bog, Fen, and Swamp subclasses within the Wetland ELC map unit, where the Bog and Fen subclasses were considered to have high habitat potential, and Swamp is considered to have moderate habitat potential. Similarly, the moderate/low listed plant species habitat potential is a result of the differences between the Regenerating Bog, Fen, and Swamp subclasses, where Regenerating Bog and Fen have a moderate listed plant species potential, and the Regenerating Swamp has low potential. Areas of low listed plant species habitat potential represent 1,839 ha (20.7%) of the LSA and 43,307 ha (37.5%) of the RSA.



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA
- FOREST FIRES (1989-2010)

LISTED PLANT HABITAT POTENTIAL

- VERY HIGH
- HIGH
- HIGH/MODERATE
- MODERATE
- MODERATE/LOW
- LOW
- UNCLASSIFIED

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
LANDSAT SCENE WAS ACQUIRED ON JUNE 24, 2010. THE CLASSIFICATION SHOWN HAS BEEN CREATED FROM THIS 30 METRE RESOLUTION LANDSAT SCENE.
SASKATCHEWAN FIRE HISTORY DATA OBTAINED FROM THE GOVERNMENT OF SASKATCHEWAN

5 0 5
SCALE 1:150,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LISTED PLANT HABITAT POTENTIAL WITHIN THE REGIONAL STUDY AREA

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	LMR/SM	06/11/13	FIGURE: 14.3-5	
CHECK	JF	15/11/13		
REVIEW	MM	15/11/13		

LMR

Table 14.3-7: Distribution of Listed Plant Species Habitat Potential within the Local and Regional Study Areas

Listed Plant Habitat Potential	Local Study Area		Regional Study Area	
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
very high	5	0.1	347	0.3
high	3,368	37.9	25,319	21.9
high/moderate	957	10.8	6,213	5.4
moderate	2,597	29.2	40,135	34.7
moderate/low	100	1.1	229	0.2
low	1,839	20.7	43,307	37.5
unclassified	14	0.2	50	<0.1
Total	**8,881**	**100**	**115,600**	**100**

Note: Numbers are rounded for presentation purposes. Therefore, it could appear that the totals do not equal the sum of the individual values.
ha = hectares; % = percent; < = less than

14.3.5 Traditional Use Plants and Habitat Potential

14.3.5.1 Traditional Use Plants

The RSA has been used traditionally by the Aboriginal people of the region for generations (Annex IV). While there has been some decline in active participation in hunting, trapping, fishing, and gathering activities by Aboriginal people over time, these activities continue to hold an important place in the lifestyle of people living in the Athabasca region, including the communities of Black Lake and Stony Rapids (Black Lake and Stony Rapids Key Performance Indicator [KPI] Program 2012).

Traditional uses of forest plant species are numerous. Most traditional plants were used for food, medicine, and tools. At present, gathered goods such as berries, herbs, mushrooms, and medicinal plants are used for local trade, sale, or gifts (Athabasca Land Use Interim Advisory Panel [ALUPIAP] 2003).

Timber production in the Athabasca region is not commercially viable. Some timber permits are issued for small areas for commercial firewood purposes, although most people cut firewood for their own use. Some plants have also been used by community members for specific purposes; for example, mosses were once used by local residents in babies' diapers and for cleaning (Black Lake and Stony Rapids KPI Program 2012).

Current gathering for domestic use is largely for berries, particularly blueberries (*Vaccinium* spp.), bog cranberries (*Vaccinium* spp.), moss berries (*Vaccinium* spp.), and strawberries (*Fragaria virginiana*), as well as other edible vegetation, like mushrooms, when available (Black Lake and Stony Rapids KPI Program 2012). Berries are generally used for jam production and freezing (Black Lake and Stony Rapids KPI Program 2012).

A list of traditional use plants applicable to the RSA is provided in Table 14.3-8. This list is a general list of plant species used and potentially still used as traditional use plants.

Table 14.3-8: Traditional Use Plants of the Northern Boreal Forest

Common Name	Scientific Name	Traditional Use
Trees		
Black spruce	*Picea mariana*	food, medicine, shelter, fuel, tools[a,c]
Jack pine	*Pinus banksiana*	food, medicine, tools, shelter, fuel[b,c]
Paper birch	*Betula papyrifera*	food, medicine, tools, fuel[a,c]
Tamarack	*Larix laricina*	medicine, fuel[a,c]
Trembling aspen	*Populus tremuloides*	food, medicine, tools, fuel[b,c]
White spruce	*Picea glauca*	food, medicine, shelter, fuel, tools[a,c]
Shrubs and Subshrubs		
Kinnikinnick or bearberry	*Arctostaphylos uva-ursi /A. rubra*	food[a]
Blackberry	*Ribes hudsonianum*	food[a]
Blueberry	*Vaccinium myrtilloides/ V. angustifolium*	food, medicine[a,c]
Bog bilberry	*Vaccinium uliginosum/ V. caespitosum*	food, medicine[a,c]
Bog cranberry/ lingonberry	*Vaccinium vitis-ideae*	food, medicine[a,c]
Cloudberry	*Rubus chamaemorus*	food[a]
Crowberry	*Empetrium nigrum*	food, medicine[a]
Gooseberry	*Ribes oxyacanthoides*	food, medicine[b]
Alder	*Alnus* spp.	medicine, fuel[a]
High-bush cranberry	*Viburnum edule*	food, medicine[b]
Juniper	*Juniperus communis*	medicine (berries)[a]
Labrador tea	*Rhododendron groenlandicum*(syn. *Ledum groenlandicum*)	food, medicine[a]
Moss berry	*Vaccinium* spp.	food[c]
Prickly rose	*Rosa acicularis*	food, medicine[a]
Raspberry	*Rubus ideaus*	food[a]
Wild strawberry	*Fragaria virginiana*	food[c]
Willow	*Salix* spp.	fuel, food, tools, medicine[a]
Other Species		
Acerbic bulrush	*Schoenoplectus acutus*	food, medicine, baskets[b]
Lichen	*Cladina* spp., Cetraria spp., *Parmelia* spp., *Actinogyra* spp.	food, medicine[b]
Mushrooms	N/A	food[c]
Sphagnum moss	Sphagnum spp.	medicine, diapers[a]

Note: spp. = multiple species.
[a] Johnson et al. (1995)
[b] Marles et al. (2000)
[c] Black Lake and Stony Rapids KPI Program (2012)
N/A = not applicable; spp. = species; syn. = synonym

14.3.5.2 Traditional Use Plant Habitat Potential

Habitats present within ELC map units were assessed for potential to support traditional use plant species. Field survey results and habitat preference of traditional use plant species were used to determine the potential of each ELC map unit to support traditional use plant species

Many traditional use plants such as black spruce, willow (*Salix* spp.), crowberry (*Empetrum nigrum*), bog cranberry (*Vaccinium vitis-ideae*), Labrador tea (*Ledum groenlandicum*), and prickly rose (*Rosa acicularis*) are common in a number of different ELC map units. However, there are a few traditional use species such as acerbic bulrush (*Schoenoplectus acutus*) and tamarack (*Larix laricina*) that are more restricted in their distribution and tend to only be associated with a few ELC map units. Within an ELC map unit, these species could be locally abundant.

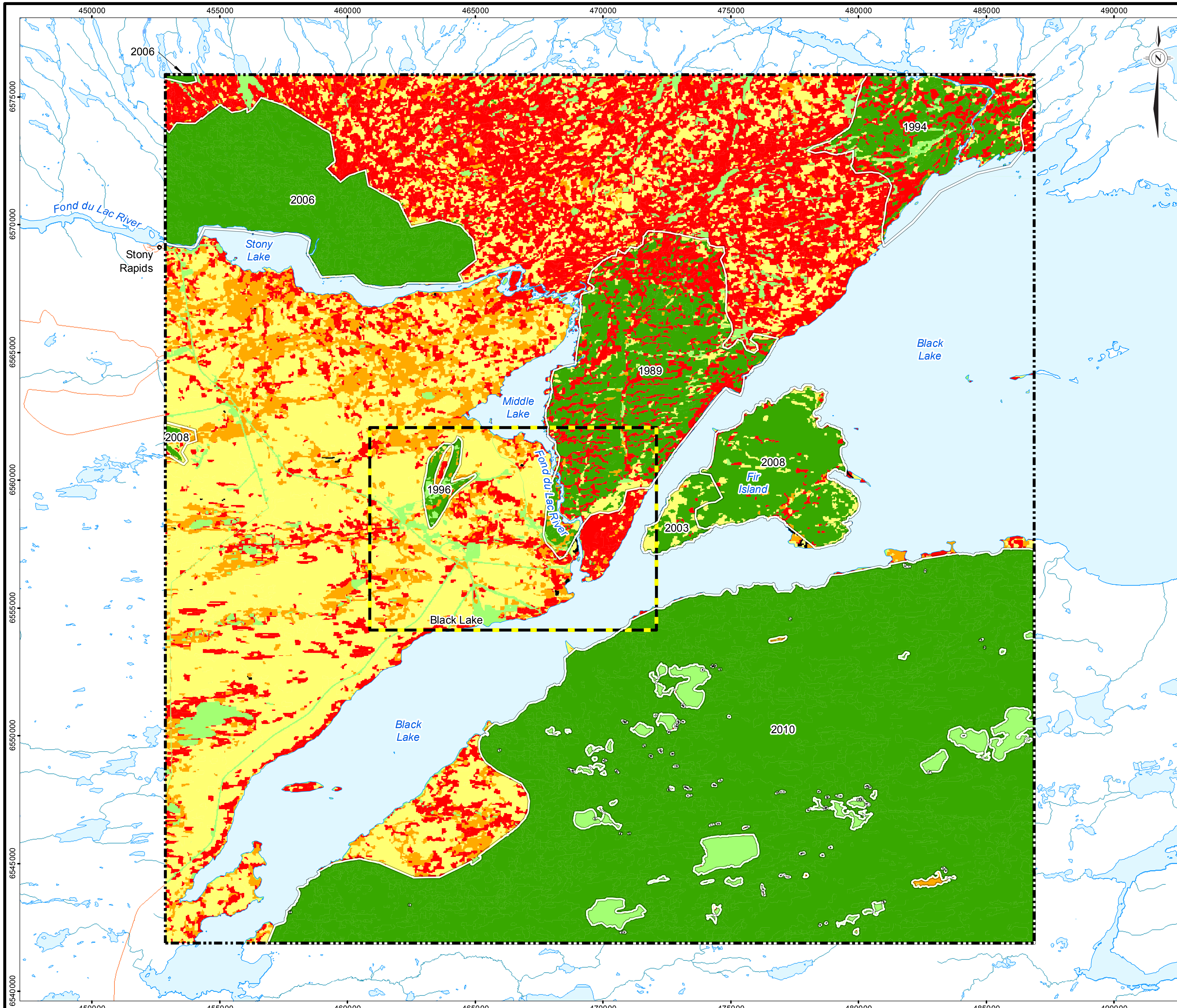
Based on the habitat requirements of traditional use species, the Bedrock, Regenerating Jack Pine, Regenerating Riparian, and Recent Burn ELC map units would be considered to have low potential to support traditional use plant species. Jack Pine/Black Spruce, Spruce, Mixedwood, Deciduous, Regenerating Mixedwood, and Regenerating Deciduous ELC map units are considered to have high potential for traditional use plant species. Wetland and Regenerating Wetland were classed as moderate/high because of the differences in habitat potentials of each of the subclasses present in the wetland ELC map unit. Swamp and Regenerating Swamp were rated as high, whereas Bog, Fen, Regenerating Bog, and Regenerating Fen were rated as having a moderate potential to support traditional use species

The distribution of traditional use plant habitat potential within the LSA and RSA is shown in Table 14.3-9 and Figure 14.3-6. High and moderate/high traditional use plant species habitat potential covers 2,493 ha (28.1%) of the LSA and 24,931 ha (21.6%) of the RSA. Areas of low and very low traditional use plant species habitat potential represent 3,013 ha (33.9%) of the LSA and 68,320 ha (59.1%) of the RSA.

Table 14.3-9: Distribution of Traditional Use Plant Species Habitat Potential within the Local and Regional Study Areas

Traditional Use Plant Habitat Potential	Local Study Area		Regional Study Area	
	Area (ha)	Proportion of LSA (%)	Area (ha)	Proportion of RSA (%)
high	1,436	16.2	18,488	16.0
moderate/high	1,057	11.9	6,442	5.6
moderate	3,360	37.8	22,299	19.3
low	1,074	12.1	41,156	35.6
very low	1,939	21.8	27,164	23.5
unclassified	14	0.2	50	<0.1
Total	**8,881**	**100**	**115,600**	**100**

Note: Numbers are rounded for presentation purposes. Therefore, it could appear that the totals do not equal the sum of the individual values.
ha = hectares; % = percent; LSA = local study area; RSA = regional study area



LEGEND

HAMLET OR COMMUNITY	TERRESTRIAL REGIONAL STUDY AREA
HIGHWAY	TERRESTRIAL LOCAL STUDY AREA
ROAD	FOREST FIRES (1989-2010)
RIVER	
WATERBODY	

TRADITIONAL USE PLANT HABITAT POTENTIAL
- HIGH
- MODERATE/HIGH
- MODERATE
- LOW
- VERY LOW
- UNCLASSIFIED

REFERENCE

DATUM: NAD83 PROJECTION: UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
LANDSAT SCENE WAS ACQUIRED ON JUNE 24, 2010. THE CLASSIFICATION SHOWN HAS BEEN CREATED FROM THIS 30 METRE RESOLUTION LANDSAT SCENE.
SASKATCHEWAN FIRE HISTORY DATA OBTAINED FROM THE GOVERNMENT OF SASKATCHEWAN

5 0 5
SCALE 1:150,000 KILOMETRES

PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE
TRADITIONAL USE PLANT HABITAT POTENTIAL WITHIN THE REGIONAL STUDY AREA

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	LMR/SM	06/11/13	FIGURE: 14.3-6	
CHECK	JF	15/11/13		
REVIEW	MM	15/11/13		

14.4 Screening of Project Interactions and Mitigation

This section identifies and evaluates the interactions between Project components or activities, and the correspondent potential effects on the maintenance of self-sustaining plant populations and communities (i.e., the assessment endpoint). The process begins with the identification of all potential interactions for the Project. To provide a robust assessment of potential effects, each interaction is initially considered to have a linkage to a change in the terrestrial environment and associated potential effects on vegetation.

Each potential interaction is evaluated to determine if mitigation can be developed and incorporated to remove the interaction or limit the potential effects on vegetation. Mitigation includes Project design elements, environmental best practices, and management policies and procedures, and is developed through an iterative process between the Project's engineering and environmental teams. Knowledge of the terrestrial environment and mitigation is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for a residual effect on vegetation.

Interactions are determined to be primary, secondary, or as having no linkage using scientific knowledge, professional judgment of technical specialists, experience with similar developments, and mitigation (Table 14.4-1). Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by environmental design features and mitigation so that the Project results in no detectable (measurable) change and no residual effects on vegetation relative to baseline or guideline values;
- secondary – interaction could result in a minor change, but would have a negligible residual effect on vegetation relative to baseline or guideline values and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary – interaction is likely to result in a measurable change that could contribute to significant residual effects on vegetation relative to baseline or guideline values.

Primary interactions are anticipated to result in a residual effect on the maintenance of self-sustaining plant populations and communities and require further analysis to determine the significance of the residual effect. Interactions with no linkage to a change or changes that are considered minor (secondary) will not be analyzed further or classified in the Environmental Impact Statement (EIS) because mitigation and environmental design features will remove the interaction (no linkage) or residual effects can be determined to be negligible through a simple qualitative or quantitative evaluation. Project interactions determined to have no linkage or those that are considered secondary are not predicted to result in significant effects on the maintenance of self-sustaining plant populations and communities.

Project components/activities and the associated mitigation implemented during the various Project phases, including accidents and malfunctions are summarized in Table 14.4-1. Potential effects on vegetation from each Project interaction and its associated classification are summarized in Table 14.4-1, with more detailed descriptions provided in the subsequent sections.

Table 14.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Vegetation

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Vegetation	Environmental Design Features and Mitigation	Interaction Classification
■ Infrastructure Footprints ▪ Temporary infrastructure – construction camp – overburden and waste rock disposal areas – construction area and materials laydown area ▪ Operational infrastructure – power generation station – water intake structure – power tunnel – tailrace channel – submerged weir – bridge – transmission line – waste rock disposal areas – water diversion structures around the Project footprint – potable water and wastewater intake and discharge structures – site access roads (including source material)	Construction Operations Closure	Loss or alteration of permafrost can change terrain and affect vegetation.	■ Organic and upper soil horizons will not be stripped in areas containing ice-rich permafrost to reduce potential for an increase in thaw depth and related thaw subsidence.	No Linkage
	Construction Operations Closure	Direct loss or alteration, and fragmentation of vegetation from the Project footprint.	■ Clearing of vegetation will be limited to the extent possible and will only be removed in areas that could pose a hazard or interfere with construction activities. ■ Siting and construction of the Project will be planned to avoid environmentally sensitive areas (e.g., critical wildlife habitat, listed plants species, and wetlands) as much as possible. ■ Location of the settling ponds will be based on topography (i.e., a low area) that is not in a sensitive feature such as a wetland or floodplain. ■ If avoidance of sensitive areas is not feasible, consultation with MOE will be completed to determine the significance of the area and identify feasible mitigation strategies. ■ The Project will avoid listed plants as much as possible, however, if avoidance of listed plants is not feasible, consultation with MOE will be completed to determine the significance of the area and identify feasible mitigation strategies. ■ If a listed plant species is encountered that was not expected, appropriate mitigation will be applied prior to further construction activities. ■ Upper soil horizons will be salvaged (i.e., seed bank) and replaced on areas to be reclaimed to enhance regeneration of vegetation. ■ Matting (e.g., timber or rig mats) will be placed in sensitive areas to avoid rutting. ■ A Reclamation Plan will be developed for the Project to be reviewed and approved by agencies. ■ Progressive reclamation is expected to occur following construction and during operations. ■ Access roads will be removed and recontoured and engagement with local communities will be completed to determine the timing for the removal of access roads. ■ If merchantable timber is cleared, it will be made available to the local community for use.	Primary
■ General Construction, Operations, and Closure Activities	Construction Closure	Introduction of weed species can affect plant community composition, and listed and traditional use plant species.	■ Native species seed mixtures (i.e., locally harvested or certified) will be applied to reclaimed areas as soon as practical following construction, which can reduce the potential for the establishment and spread of invasive plant and weed species. ■ Equipment and Project vehicles will be cleaned so they are free of weed seeds and plant propagules before arriving on-site. ■ A detailed Weed Management Plan will be developed prior to construction and for licensing. ■ Weed and invasive species will be controlled if identified during construction. ■ Site-specific predisturbance surveys will be completed to identify current locations of weed or invasive species and the extent of the distribution will be delineated. ■ Any construction machinery or vehicles working in an area containing weed or invasive species will be thoroughly cleaned before leaving the work area.	Secondary

Table 14.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Vegetation (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Vegetation	Environmental Design Features and Mitigation	Interaction Classification
■ Blasting Activities	Construction	Use of explosives can cause changes to soil quality, and affect vegetation.	■ A detailed Blasting Plan will be developed for the Project. ■ Best practices, as outlined in the Blasting Plan for the Project, will be applied to blasting activities to reduce any potential for enhanced nitrogen loading in the environment due to the placement and use of ammonium nitrate/fuel oil (ANFO) during construction. ■ A Site Water Management Plan will be developed for the project. ■ Construction and monitoring of settling ponds or water treatment areas will be part of Site Water Management Plan.	Secondary
■ Air Emissions ▪ emission of dust from blasting activities and hauling waste rock to waste rock disposal areas. ▪ emission of standard pollutants from vehicles and heavy equipment operation	Construction Operations Closure	Deposition of criteria air contaminants can change the surface water, sediment, and soil chemistry, which can affect vegetation.	■ Equipment will be regularly maintained for compliance with provincial and federal air emission standards. ■ The equipment used for hauling and mucking operations will operate using diesel fuel with an ultra-low sulfur diesel content (less than 15 parts per million [ppm]. ■ The heavy-duty stationary and mobile diesel-fueled equipment fleet will meet or exceed EPA Tier 2/3 air quality emissions standards. ■ The gasoline-fueled equipment fleet will meet or exceed EPA Tier 2 Bin 6 air quality emissions standards. ■ An Environmental Protection Plan (EnvPP) will describe material handling protocols including dust management. ■ Soil salvage stockpiles or exposed soils will be seeded with non-aggressive annual species appropriate for the area. ■ All unpaved roads will be watered on a regular basis to prevent wind driven fugitive dust. ■ A speed limit will be enforced on unpaved roads on site.	Secondary
		Dust deposition can change vegetation quality and quantity.		Secondary
■ Power Generation Activities ▪ water withdrawal for power generation ▪ diversion of water through the power tunnel to the powerhouse ▪ discharge of tailrace channel flows	Operations	Withdrawal, diversion, and discharge of water for power generation could change hydrology, which can affect vegetation.	■ A submerged weir will be constructed on the Fond du Lac River at the outlet of Black Lake and will be designed to maintain the range of water levels in Black Lake and in the uppermost section of the Fond du Lac River within the historical range, for all powerhouse operating flow conditions. ■ Project site runoff resulting from rainfall, snowmelt, and groundwater releases will be managed by directing runoff around work site infrastructure by using appropriately sized ditches, channels, and culverts.	No Linkage
		Diversion of water through the power tunnel could change groundwater quantity, which can change hydrology, and affect vegetation.		No Linkage
■ Site Water Management ▪ collection and treatment of surface runoff within the project footprint ▪ discharge of wastewater ▪ collection and treatment of groundwater in the power tunnel	Construction Operations	Collection and disposal of wastewater from the site can cause changes to hydrology, which could affect vegetation.	■ A Site Water Management Plan will be developed for the Project. ■ The site will be properly graded and be surrounded by ditches and berms to capture runoff from the waste rock disposal areas. ■ Surface runoff will be diverted around and away from waste rock disposal areas as much as possible. ■ Runoff water in contact with the waste rock disposal areas will be sent to settling ponds. ■ The waste rock disposal areas will be placed in locations that are easily modified to be controllable in terms of run-on and run-off. ■ Runoff and drainage from within and around Project roadways and structures will be managed through the incorporation of erosion control methods (e.g., ditch blocks, silt fences). ■ Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns. ■ Ditch capacities will be sized to accommodate an extreme daily rainfall event. ■ Rock material energy dissipaters and ditch lining will be installed in areas where predicted runoff velocities are deemed excessive to reduce soil erosion. ■ Groundwater originating from construction of the power tunnel will be collected, treated if required, and monitored to confirm discharge criteria are met prior to release into the receiving environment. ■ Implementation of a Water Quality Monitoring Program. ■ Contingency plans for off-site disposal of dewatered settling pond sludge will be included in an EnvPP.	No Linkage
		Collection and disposal of wastewater can change surface water quality and soils, which can affect vegetation.		No Linkage

Table 14.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Vegetation (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Vegetation	Environmental Design Features and Mitigation	Interaction Classification
■ Waste rock disposal areas	Construction Operations	Seepage from waste rock disposal areas can change soil quality, and affect vegetation.	■ A Waste Rock Management Plan will be prepared and will include a Project Site Drainage Plan. ■ Excavated rock and aggregate materials will be tested to confirm that this material will not have negative effects on the surrounding environment. Specific mitigation measures will be applied if the material is identified to be acid generating or to contain unacceptable levels of metals or radionuclides. ■ Additional site investigation and laboratory testing will be completed upon completion of the final Project design and during construction of the Project.	No Linkage
■ Accidents and Malfunctions ▪ emergency shutdowns of power turbines ▪ hazardous materials spills ▪ failure of embankment dykes	Operations	Emergency shutdowns of power generation activities can change surface hydrology, which can affect vegetation.	■ During unplanned emergency shutdowns, downstream flows will be maintained by bypassing water around the powerhouse turbine generator units using a bypass conduit.	No Linkage
	Construction Operations Closure	Release or spills of hazardous substances (e.g., fuel, oil) can change soil quality, which can affect vegetation.	■ Individuals working on-site and handling hazardous materials will be trained in Workplace Hazardous Materials Information Systems (WHMIS) and Transportation of Dangerous Goods (TDG). ■ Controlled products will not be allowed on-site unless accompanied by approved labels and Material Safety Data Sheets (MSDS). ■ All fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard; a lined and dyked containment area around these tanks will be provided to contain any potential fuel spills. The design of the containment area will be based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. ■ The storage containers will be regularly inspected for leaks or damage, and replaced when necessary. ■ Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled, and located in lined and bermed containment areas. ■ Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers. ■ Regular maintenance of construction equipment. ■ Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. ■ Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills of fuel would flow to the sump, which would be pumped out to a container for shipment off-site. ■ An Emergency Response Plan will be developed. ■ Spill response material (e.g., sorbent pads) will be stored on-site in designated areas and in vehicles. ■ Contaminated (impacted) soils will be removed and disposed of in an approved landfill or waste management facility.	No Linkage
	Construction Operations	Failure of the embankment dykes around the settling ponds can change surface water and soil quality, which can affect vegetation.	■ Fill material used for constructing the embankment dykes around the settling pond will be clean mineral soil with sufficient moisture to allow for proper compaction. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap as soon as practical following construction. ■ The settling ponds will be engineered to provide adequate storage of wastewater streams under normal and extreme operating conditions (e.g., settling ponds will be designed to contain the 1:100 year storm event). In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling ponds would be provided by the inclusion of an overflow spillway in the embankment. ■ The settling ponds will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. ■ During the detailed design stage, additional mitigation could be identified and included as part of the Environmental Protection Plan and the Emergency Response Plan.	No Linkage

Table 14.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Vegetation (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Vegetation	Environmental Design Features and Mitigation	Interaction Classification
Accidents, Malfunctions, or Unplanned Events	Construction, Operations, and Closure	Fire	■ The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail. ■ Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. ■ Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute).Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. ■ Personnel will be trained in fire prevention and response procedures. ■ Firefighting equipment will be available on site.	Secondary

MOE = Ministry of Environment; CCME = Canadian Council of Minister of the Environment; Project = Tazi Twé Hydroelectric Project; DFO = Fisheries and Oceans Canada; EnvPP = Environmental Protection Plan; mm = millimetres; % = percent

14.4.1 Interactions with No Linkage to Effects

An interaction might have no linkage to effects if the activity does not occur (e.g., site runoff is not released), or if the interaction is removed by mitigation and environmental design features so that the Project results in no detectable change in measurement endpoints. Subsequently, no residual effect on the maintenance of self-sustaining plant populations and communities (including listed species) is expected. The following interactions are anticipated to have no linkage to effects on vegetation, and will not be carried through the residual effects assessment.

- **Loss or alteration of permafrost can change terrain and affect vegetation.**

The LSA is within the sporadic discontinuous permafrost zone, where permafrost could occupy approximately 10% to 50% of the area (Natural Resources Canada 1995). The distribution and occurrence of permafrost is highly variable in the sporadic discontinuous permafrost discontinuous zone. The permafrost in this area is characterized by having low ice content, indicating the ground ice content in the upper 10 to 20 m of the ground has less than 10% ice content by volume of visible ice (Natural Resources Canada 1995).

Clearing of an area and subsequent construction activities can cause permafrost to degrade slowly due to ground thermal changes resulting from removal and disturbance of vegetation. Once permafrost degrades, it can change surface relief and subsequently influence the surface drainage of an area (Lawson 1986).

The amount of ground ice present in permafrost is important for assessing the response of permafrost to clearing, construction, and subsequent recovery of ice conditions following disturbance (Jorgenson et al. 2010). The magnitude of changes to permafrost thermal regimes and potential thaw settlement is directly related to the nature and abundance of ground ice and the type and severity of disturbance at the surface (Lawson 1986; Pullman et al. 2007). Freeze induced displacement of soil (i.e., frost jacking) and thaw induced displacement of soil (i.e., subsidence) are the main issues related to permafrost degradation (i.e., loss and alteration). Changes to thaw penetration and thickness of the active layer can influence surface stability through thaw settlement, frost heave, and bearing capacity, as well as slope stability (Tarnoicai et al. 2004). Changes to the permafrost active layer can also affect vegetation by altering local hydrology, soil moisture, and nutrient availability conditions.

Areas with high ground ice content (i.e., terrain with abundant ice wedges) should be avoided where possible. These areas are more sensitive to thaw-settlement and can result in longer-term changes in terrain and surface hydrology (Jorgenson et al. 2010). Conversely, areas with small volumes of ground ice are not as sensitive to thaw settlement (Lawson 1986).

If permafrost were present in areas to be disturbed, the following mitigation would be applied:

- the access road will be as narrow as possible, while maintaining safe construction and operation practices; and
- organic and upper soil horizons will not be stripped in areas containing ice-rich permafrost to reduce potential for an increase in thaw depth and related thaw subsidence.

Soil present in the LSA ranged from having Very Low potential for permafrost (moderate to rapidly drained Brunisolic soils) to Moderate (imperfect to poorly drained Organic soils). Within the LSA, permafrost, if present, likely occurs in localized areas within treed bogs with poorly drained Organic soils and would likely have low ground ice content. Because of the relatively low likelihood of permafrost occurring in the LSA and the use of mitigation if permafrost is identified, changes to soil quality are not expected to be measurable. As such this interaction was determined to have no linkage to effects on vegetation.

- **Withdrawal, diversion, and discharge of water for power generation could change hydrology, which can affect vegetation.**
- **Diversion of water through the power tunnel could change groundwater quantity, which can change hydrology, and affect vegetation.**

Power generation activities such as water withdrawal, diversion of water through the power tunnel to the powerhouse, and discharge of tailrace channel flows can cause changes to water levels in Black Lake, the Fond du Lac River, Middle Lake, and a small lake (Lake A). Changes in water levels beyond the natural range of variability could lead to alterations in shoreline erosion, thereby affecting vegetation. In addition to changes in lake water levels, changes in downstream flows (e.g., altered drainage patterns, flow velocities) from water drawdown or re-direction of Black Lake could affect vegetation downstream.

Alterations to natural water level fluctuations have the potential to influence riparian vegetation by changing soil moisture (Nilsson and Svedmark 2002; Leyer 2005). Although riparian vegetation is adapted to thrive at the aquatic/terrestrial boundary, riparian vegetation is sensitive to changes in soil moisture (Leyer 2005; Nilsson and Svedmark 2002). If water levels change permanently, aquatic and terrestrial vegetation in the riparian area would change in relation to the changes in soil moisture (Shafroth et al. 2002). As soil moisture levels change because of reduction of water level fluctuations, plant species that thrive in more stable soil moisture regimes will out-compete riparian vegetation that relies on these fluctuations (Shafroth et al. 2002; Leyer 2005).

The long-term average annual flow for the Fond du Lac River is 304 m^3/s. Water will be diverted from the water intake at Black Lake through a power tunnel at a flow of up to 190 m^3/s to produce 50 megawatt (MW) of power and discharged into the Fond du Lac River from the tailrace channel upstream of Middle Lake. The remaining 114 m^3/s (on average) will pass through the natural Black Lake outlet into the Fond du Lac River. Simulation of natural conditions over the period of record indicated that Black Lake water levels typically fluctuate approximately 0.865 m over the course of an average year. Over the 40-year record, the maximum annual water level fluctuation was approximately 1.787 m.

During operations, the diversion of water through the power tunnel could interact with local groundwater, which could subsequently affect surface water locally or regionally. During operation of the tunnel, groundwater is predicted to flow into the tunnel at a maximum estimated rate of 680 m^3/d (Section 9.0, Appendix 9.2). This rate is less than 0.0001% of the tunnel and minimum downstream flow rate (up to 190 m^3/s) and is not expected to result in detectable changes to hydrology.

To maintain historical water levels in Black Lake, a submerged weir will be constructed on the Fond du Lac River at the outlet of Black Lake and will be designed to maintain the historical range of water levels in Black Lake and in the uppermost section of the Fond du Lac River, for all powerhouse operating flow conditions. A Site Water Management Plan will be implemented to meet minimum target seasonal riparian flows in the Fond du Lac River and maintain streamflow quantity along natural flow pathways. Downstream of the tailrace channel outlet where water flowing through the Project rejoins the Fond du Lac River, river flows would remain unchanged from baseline conditions.

Overall, the withdrawal, diversion, and discharge of water for power generation are not expected to result in detectable changes to groundwater quantity and hydrology. Therefore, these interactions were determined to have no linkage to effects on vegetation.

- **Collection and disposal of wastewater from the site can cause changes to hydrology, which can affect vegetation.**
- **Collection and disposal of wastewater from the site can change surface water quality and soils, which can affect vegetation.**

Collection and disposal of wastewater from the Project site could potentially affect vegetation within and adjacent to the Project footprint, through increased soil erosion and changes in soil quality. Increased levels of soil erosion can also lead to increased sediment loads in wetlands and waterbodies, thus reducing plant abundance and diversity (Forman and Alexander 1998). In addition, discharge of wastewater into the Fond du Lac River could cause changes to flow velocities, surface water levels, and surface water quality, which could affect riparian vegetation. Changes in water level fluctuations to waterways can alter soil moisture regimes resulting in stress to plant species in riparian habitat (Leyer 2005, Nilsson and Svedmark 2002).

Three settling ponds have been included in the construction plan for the Project for the treatment and management of the Project's wastewater (other than site runoff and sewage and grey water). One settling pond will be located near the water intake to collect the intake construction water along with a portion of the power tunnel dewatering flows and waste rock runoff from the waste rock disposal area south of the intake (Figure 5.1-1). A second settling pond will be located near the powerhouse excavation to collect the remainder of the tunnel and powerhouse dewatering. A third settling pond, beside the downstream end of the tailrace channel, will collect the tailrace channel dewatering and any runoff directed from the main waste rock disposal areas to the northeast of the tailrace channel (Figure 5.1-1). Water collected in disturbed areas located away from the settling ponds will be pumped to these locations. Surface water diversions could also be constructed to maintain natural drainage characteristics, whereas other structures could be designed to actively divert water away from its natural flow path to prevent the interaction with site infrastructure, potentially contaminated water, or areas sensitive to erosion.

Retention of runoff in the settling ponds will allow suspended sediments and associated parameters (e.g., some metals) to settle out. This water will eventually be discharged downstream to its natural receiving waterbody (the Fond du Lac River through the tailrace channel). Water quality in the settling ponds will be tested and will meet appropriate discharge criteria (if required) prior to release into the environment. A Water Quality Monitoring Program will be implemented to determine the nature of potential changes to the water quality of the Fond du Lac River receiving discharge from the settling ponds. Waste water in the settling ponds will be discharged in the Fond du Lac River (at one of the potential discharge locations identified in Figure 5.3-3) after the water has been tested and treated (if necessary) to meet appropriate discharge criteria. Contingency plans for off-site disposal of dewatered settling pond sludge will be included in an Environmental Protection Plan (EnvPP).

The results of the water quality modelling indicate that only minor, short-term changes would occur to the water chemistry of the Fond du Lac River during the construction phase because of discharge from the settling pond (Section 11.0, Appendix 11.1). For example, predicted concentrations of various parameters are within the range of baseline concentrations measured in 2010 and 2011. As well, these changes would not involve exceedences of applicable water quality guidelines under fully mixed conditions, or at the edge of the applicable mixing zone in the river. Therefore, changes to riparian vegetation are not anticipated to be measureable.

Access roads within the site will be kept to a minimum (i.e., limit the number of roads) to reduce effects on the environment. Surface water will be directed into natural flows by means of swales, culverts, and ditches where necessary to maintain local drainage patterns. Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns and ditch capacities will be sized to accommodate an extreme daily rainfall event. Riprap energy dissipaters and ditch lining will be used in areas where the predicted runoff velocities are deemed excessive to reduce soil erosion.

Overall, surface water runoff and wastewater within the Project footprint are not expected to result in detectable changes to hydrology, surface water quality, and soils. Therefore, these interactions were determined to have no linkage to effects on vegetation.

- **Seepage from waste rock disposal areas can change soil quality, and affect vegetation.**

Construction of the power tunnel and tailrace channel from Black lake to Middle Lake will be constructed and will Construction of the powerhouse, water intake, power tunnel, and tailrace channel will produce approximately 1,074,000 m^3 of waste rock and 118,000 m^3 of overburden that will need to be stored on-site. The waste rock disposal areas will be placed in locations that are easily modified to control seepage and a Waste Rock Management Plan will be prepared for the Project. Excavated material will be stored near the Project construction areas, and located away from watercourses or lakes. Site grading, ditches, and berms will be used to capture runoff from the waste rock disposal areas, which will be sent to settling ponds. Surface water will be diverted around and away from waste rock disposal areas as much as possible. This runoff will be collected and will be tested and treated, if necessary, before release to the environment.

Some portion of the waste rock excavated from the power tunnel could be acid-generating, have elevated concentrations of various metals, or contain uranium mineralization, particularly waste rock from the section of the power tunnel within, or near, the Black Lake Shear Zone. The power tunnel waste will be tested for susceptibility to generate ARD and potential for metal leaching (ML) prior to being placed in waste rock disposal areas. Previous geological testing has confirmed that radioactive waste rock is not likely to be encountered in the LSA (Hatch 2005, 2012). However, waste rock will be tested for radioactivity as construction progresses. Any rock waste that is found to be radioactive will be disposed of according to provincial and federal guidelines.

If bedrock materials are ARD-generating or susceptible to ML, the rock will be segregated for special management. In this case, environmental design features will be required to limit seepage from the waste rock disposal areas. A containment system will be designed to control seepage from the waste rock disposal areas to groundwater or underlying aquifers. The design will control shallow horizontal migration. Potentially contaminated wastewater from waste rock disposal areas run-off will be collected in on-site settling ponds. Once wastewater is collected, it will be tested and treated, if necessary, prior to discharge. Wastewater will meet applicable water quality guidelines (e.g., CCME) prior to being released into a nearby waterbody (i.e., Black Lake, Fond du Lac River, or Middle Lake).

If no adverse characteristics are identified in the waste rock, this material can be used as aggregate for road construction and concrete production. It can be used as riprap to armour the walls of the tailrace channel or to construct the submerged weir across the Fond du Lac River at Grayling Island. Re-use of “clean” waste rock at the Project site will reduce the overall volume stored in the waste rock disposal areas.

Ongoing monitoring requirements outside of those specified within the Project license would default to terms outlined within the relevant federal and provincial acts, regulations, and standards applicable at the time. Effects on soil quality from seepage and long-term contaminant transport from the waste rock disposal areas are expected to be limited using mitigation and environmental design features. Therefore, these interactions are not expected to result in detectable changes in soil quality and were determined to have no linkage to effects on vegetation.

14.4.2 Interactions with Secondary Linkages

In some cases, both a source and an interaction exist, but because the change caused by the Project is anticipated to be minor, it is expected to have a negligible residual effect on vegetation relative to baseline values. The following interactions are expected to be minor and will not be carried through the residual effects assessment.

- **Introduction of weed species can affect plant community composition, and listed and traditional use plant species.**

The construction and closure of the Project have potential to introduce prohibited, noxious, and nuisance weed species listed under the *Weed Control Act* (2010). There is also potential to introduce invasive plant species into new areas, which can disrupt plant communities and decrease habitat quality (Mack et al. 2000; Carlson and Shepherd 2007; Truscott et al. 2008). Weed species introduced into natural areas have the potential to affect plant community structure and species diversity directly through competition and indirectly through alterations to soil microorganisms, nutrients, and soil moisture (Mack et al. 2000; Truscott et al. 2008).

The majority of weed species introductions arise from human transport (Mack et al. 2000; Reichard and White 2001), and roads act as dispersal route and habitat for weed establishment (Parendes and Jones 2000). Transportation corridors to and from construction areas provide a means of ingress for prohibited, noxious, nuisance, and invasive weed species through direct dispersion of plant propagules (seeds and/or vegetative parts) from vehicles and machinery, and indirectly through the formation of suitable sites for weeds, in the form of disturbed road edges. Many weed species are able to spread more easily in landscapes that have been fragmented, often become established along edge habitats, such as disturbed road edges associated with transportation corridors (Lafortezza et al. 2010).

Construction of a submerged weir, bridge, and power tunnel provide the potential to introduce weed species into watercourses in the RSA. Changes in water level fluctuations to waterways can alter soil moisture regimes resulting in stress to plant species in riparian habitat (Leyer 2005, Nilsson and Svedmark 2002). Stressed vegetation is less competitive, thereby allowing other species to become established. In addition, waterways can act as dispersal corridors for weed species (Richardson et al. 2007) resulting in riparian habitats being susceptible to the introduction of weed species.

No noxious, nuisance, prohibited, or invasive weed species were recorded during vegetation surveys within the RSA. Preventing weed species from entering an area is often more efficient and cost effective than dealing with their removal once established (Clark 2003; Polster 2005; Carlson and Shephard 2007). To mitigate the transport and introduction of prohibited, noxious, nuisance, and invasive plant species into new areas, construction equipment will be regularly cleaned on site. Equipment used for construction will be locally sourced, if possible. A detailed Weed Plant Management Plan will be designed and implemented to prevent, detect, control (remove), and monitor areas with weed species, particularly those species listed as prohibited, noxious, and nuisance under the *Weed Control Act* (2010). To increase confidence in baseline data, site-specific predisturbance surveys will be completed to identify current locations of weed or invasive species and the distribution will be delineated. Native species seed mixtures (i.e., locally harvested or certified) will be applied to reclaimed areas as soon as practical following construction, which can reduce the potential for the establishment and spread of invasive plant and weed species.

The implementation of these mitigation practices will reduce the potential for introduction of weed species during construction and closure activities. The localized introduction of weed and invasive species would result in minor changes to the abundance and distribution of plant populations and communities relative to baseline conditions. Therefore, this interaction was determined to have a negligible residual effect on vegetation.

- **Use of explosives can change surface water quality, and soil quality, which may affect vegetation**

Use of explosives during the construction phase of the Project could cause changes in surface water quality and soil quality, which has potential to affect vegetation. At the present time, ANFO is expected to be used for the tunnel excavation. This type of explosive has the potential to release nitrogen residual substances (e.g., ammonia and nitrate). Blasting activities and the removal of waste rock could increase dust deposition, as well the waste rock is expected to be contain trace metal (e.g., aluminum, cadmium, chromium, copper, iron, mercury, and silver) concentrations and nitrogen residual substances.

A Blasting Plan is expected to be developed for the Project and will describe the type of explosives used and the method of detonation. As part of this plan, best practices will be applied to blasting activities to reduce the potential for enhanced nitrogen loading of groundwater inflows, and nearby soils. Waste rock produced from blasting activities is expected to contain trace amounts of residual substances from use of the ANFO explosives; therefore, surface water runoff from the waste rock disposal areas may also contain residual substances. Surface water runoff from the waste rock disposal areas will be collected and pumped to the settling ponds. Water in settling ponds will be routinely tested prior to release, as part of the Site Water Management Plan that will be developed for the Project. The amount of residue in the waste rock is anticipated to diminish over time.

The water quality modelling indicates that loads of ammonia and nitrate from the use of explosives would result in only minor increases in the concentrations of these parameters in the Fond du Lac River. This would not result in an exceedance of applicable water quality guidelines for the protection of aquatic life at the edge of the mixing zone (Section 11.5.2). Consequently, changes to surface water quality and soil quality from the use of ANFO explosives was determined to have a negligible residual effect on vegetation.

- **Deposition of criteria air contaminants can change surface water, sediment, and soil chemistry, which can affect vegetation.**
- **Dust deposition can change vegetation quality.**

Construction and operation of the Project will generate air emissions such as carbon monoxide (CO), oxides of sulphur (SO_x), includes sulphur dioxide [SO_2]), oxides of nitrogen (NO_x), particulate matter ($PM_{2.5}$, PM_{10}), and total suspended particulates (TSP). Air quality modelling was completed to predict the spatial extent of air and dust emissions and deposition from the Project (Section 8.5). Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates.

Air emissions (i.e., SO_2 and NO_2) can result from the use of fossil fuels in generators, vehicles, and machinery during construction and operation of the Project. The deposition of SO_2 and NO_2 can alter soil pH, nutrient content, and cause acidification of the soils, which can lead to changes in soil fauna composition (Rusek and Marshall 2000). Changes in soil fauna can lead to changes in vegetation, as there could be alterations in organic matter decomposition rates and nutrient cycling. Deposition of SO_2 and NO_2 can also lead to acidification of wetlands, which can cause changes in plant communities (Bobbink et al. 1998). However, changes from soil acidification to vegetation depend on the buffering capacity of the soil (Bobbink et al. 1998; Barton et al. 2002). Brunisolic soils in the RSA were rated as having a High sensitivity to acidification (Annex IV, Section 3.3.3.2). Gleysolic soils were rated as having a Low to High sensitivity; however, this is dependent on proximity to wetlands. Organic soils that occur in moderate and rich fens are least susceptible to acidification and therefore have a Low sensitivity rating. Organic soils that occur in bogs and in poor fens have a Medium sensitivity rating.

Results of the air quality modelling indicate that the maximum ground-level concentrations of CO, SO_2, and NO_x are all below the Saskatchewan Ambient Air Quality Standards (SAAQS 1996) and the Canada Wide Standard (CCME 2000; Section 8.5.1), and are limited to the immediate vicinity of the Project. The related changes to soil pH is determined by several complex geochemical factors, which include nutrient uptake by plants, decomposition of vegetation, cation and anion exchange in soil, soil sensitivity to acidification, and atmospheric inputs (Turchenek et al. 1998). When NO_x is oxidized, it can produce NO_3^-, which is typically limited in poor fens and bogs, therefore taken up by vegetation. Biological uptake can reduce the effects of nitrogen deposition. Nitrogen is retained in the plant biomass and therefore can result in a neutralizing effect. Sulphur transformations are affected by redox and pH interactions, and are biologically mediated. When SO_2 is oxidized, it can produce sulphate (SO_4^{2-}). Higher plants normally take up sulphur as SO_4^{2-}. The results indicate that deposition of SO_2 and NO_x will not likely result in changes to soil pH. Overall, it is expected there will be no changes to soil quality from SO_2 and NO_x therefore, no effects on vegetation are expected.

Dust deposition can also cause chemical loading in soils as dust emissions can include metal particles. Metal particle deposition can result in increased metal concentrations in plant leaves (Grantz et al. 2003; Peachey et al. 2009). Metal particle deposition can also affect soil biota composition (Grantz et al. 2003), which could indirectly affect vegetation. Although metal deposition can change vegetation chemistry, a study by Peachy et al. (2009) found that vegetation that received some metals from dust deposition did not cause direct toxicity to plants.

In addition to metals, dust can contain cations and anions. When cations (e.g., ammonium [NH_4^+], sodium [Na^+], potassium [K^+] calcium [Ca^{2+}], magnesium [Mg^{2+}]) are deposited into an ecosystem, the vegetation present can take up the cation; however, other cations, usually hydrogen [H^+], are released into the environment, and can decrease soil pH (Turchenek et al. 1998). When anions (e.g., chloride [Cl^-], nitrite [NO_2^-], bromide [Br^-]) are deposited into an ecosystem, anions such as hydroxide [OH^-] can be released. Although OH^- increases pH, cation and anion uptake have generally shown to result in a net production of acidity. The net effect is acidification because the cations are generally retained in the plant biomass and are therefore not mineralized. Ultimately, the concentration and duration of air and dust emissions and the sensitivity of the ecosystems determine the overall influence that emission deposition will have on vegetation (Bobbink et al. 1998).

Modelling results indicate that the Project's maximum annual emissions rate is 0.020 tonnes of H+ per day (t/d) and the average for the 2014 to 2017 construction period is 0.014 t/d. These values are well below the

Saskatchewan Ministry of Environment's threshold of 0.175 t/d. The Project's potential for acid deposition is low, and therefore, it is expected there will be no change to soils from acidification, and subsequently no effects on vegetation.

Transportation routes, particularly unpaved roads that are used to access the Project are the main source of dust due to the re-suspension of soil particles (Farmer 1993; Harrison et al. 2003; Peachey et al. 2009). In addition to potential changes to chemistry from air and dust deposition, dust covering vegetation can have a physical or physiological effect on plants. Larger dust particles can cause visible injuries and abrasions (Farmer 1993; Grantz et al. 2003), while smaller dust particles landing on leaves can affect photosynthesis by blocking sunlight and reduce respiration and transpiration by clogging stomata (Farmer 1993; Grantz et al. 2003). Dust on vegetation can also result in a reduction of plant growth and biomass, and can alter species composition (Grantz et al. 2003). Walker and Everett (1987) and Everett (1980) reported that few vascular plant species showed physiological effects from dust, except where vegetation was subject to very high dust loading.

Most studies indicate that potential effects from dust are localized to within 50 m of the source and typically do not extend to the regional area (Grantz et al. 2003). Watson et al. (1996) found that most dust generated from transportation corridors were deposited within a 50 m of the source and concentrations of dust decrease by greater than 90% within that 50 m. Meininger and Spatt (1988) found that most of environmental effects of dust occurred within 5 to 50 m of a road, with less obvious environmental effects observed between 50 and 500 m from a road. Walker and Everett (1987) and Everett (1980) reported that effects of dust were confined to a 50 m buffer on either side of a road.

Most of the traffic to the Project will occur during construction. All unpaved roads will be watered regularly to prevent wind driven fugitive dust. Speed limits will be enforced to reduce dust generation from roads. Once construction is complete, the numbers of vehicles travelling to and from the Project are expected to decrease (Section 5.5.1). Modelling results indicate that the maximum predicted TSP and $PM_{2.5}$ concentrations are 114.4 $\mu g/m^3$ and 22.8 $\mu g/m^3$, respectively, which do not exceed the SAAQS and Canada-Wide Standard (Section 8.5.1.2.3). Because PM and TSP predictions are below applicable criteria, it is expected there will be no changes to soil quality. Dust emissions from access roads and subsequent deposition are expected to be localized and residual effects on vegetation are expected to be negligible.

Overall, air and dust emissions and subsequent deposition are expected to result in minor changes soil and vegetation quality. Therefore, these interactions were determined to have a negligible residual effect on vegetation.

14.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events occurring on-site have the potential to affect vegetation. The following events were identified as having a potential interaction with vegetation.

- **Emergency shutdowns of power generation activities can change surface hydrology, which can affect vegetation.**

It is estimated that the power plant will undergo between 10 and 50 emergency shutdowns per year, with most of these occurring during the summer months (i.e., weather-related). The power plant will be shut down without advance notice if there is a load rejection in the transmission system due to transmission line failure. These unplanned shutdowns are expected to be relatively brief, typically from a few minutes to four or five hours. On occasions during the spring fish spawning and rearing period (May 15 to July 15), when the unplanned shutdown exceeds 15 minutes, the bypass conduit at the powerhouse will begin releasing flow to reduce drawdown effects on the Fond du Lac River below the tailrace channel outlet and upstream of Middle Lake. During these periods, flows through the natural outlet would slowly increase as water levels in Black Lake respond to reduced power tunnel outflows.

The turbine generator units for the proposed station will be equipped with turbine inlet valves (TIV) to start and stop flows. The TIVs will be designed to close at a rate that will avoid undesirable increases in water pressure in the power tunnel.

During average flow conditions, a 60 minute emergency shutdown would result in an increase in Black Lake water level of less than one millimetre (mm). During a prolonged emergency shutdown and average natural flow conditions (300 m^3/s), inflow to Middle Lake would be reduced by about 190 m^3/s, which would result in a decrease in Middle Lake water level of approximately 8.67 cm/hour and a maximum drawdown of 0.91 m. If the bypass facility is activated at 50% during a prolonged emergency shutdown, this drawdown rate in Middle Lake would be reduced to 4.35 cm/hour with a maximum total drawdown of 0.41 m (Appendix 10.3).

Overall, changes to surface flows during an emergency shutdown are predicted to have no detectable change to hydrology; therefore, this interaction was determined to have no linkage to effects on vegetation.

- **Release or spills of hazardous substances (e.g., fuel, oil) can change soil quality, which can affect vegetation.**

Spills during construction, operations, or decommissioning and reclamation activities following closure have the potential to change surface water, sediment, and soil quality, which can adversely affect vegetation. Spills that occur in high enough concentrations could contaminate surface water and soils and cause direct toxicity to aquatic organisms, soil organisms, and vegetation. Spills are generally preventable and local in nature.

The powerhouse will be equipped with an oil containment and separation system to prevent the release of petroleum based wastes into waterways. The turbine governor pumping systems will be surrounded by trenches or curbs to allow drainage via the trench or sumps to catch and transfer wastes to the oil separation system. Any room with the potential to produce an oil spill will also be equipped with containment curbs and door ramps. Additionally, the governor hydraulic power units will be high-pressure systems to reduce the potential for spills by maintaining the total volume of hydraulic oil in the system. The main transformers will be removed from the main tailrace deck and surrounded by oil spill containment walls to reduce the potential for spills to interact with the waterways. Double walled heat exchangers will be used for the turbine and generator cooling systems to reduce the risk that cooling coil failure will discharge oil into the water. Self-lubricated bushings will be used throughout the design to eliminate sources of water pollution typical of greased bushings.

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks to limit the effects of spills and leaks to the environment. Spill containment supplies will be available in designated areas and within Project vehicles. An Emergency Response Plan will be developed and will include instruction for the rapid response control, and management of spills or release of hazardous substances occurring on site. All spills will be isolated and immediately cleaned up. Spills will be reported to the appropriate agency if the spill exceeds reportable volumes for the material spilled as outlined in the provincial *Environmental Spill Control Regulations*. In the unlikely event of a spill, disposal of all contaminated soil will be handled by a licensed contractor and will be hauled off-site to an approved facility. Alternative approaches for in-situ treatment of contaminated soils could be considered (e.g., phyto- or bio- remediation), depending on the substance spilled and capacity to treat the volume of material affected. Mitigation identified in the Environmental Protection Plan (EnvPP) will also be implemented to reduce the likelihood and extent of spills associated with the Project.

Storage facilities for hazardous wastes will meet regulatory requirements. All fuel storage tanks will be designed and constructed based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. The storage containers will be regularly inspected for leaks or damage, and replaced when necessary. Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled, and located in lined and bermed containment areas. Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers.

Vehicles will be regularly maintained and cleaned and will carry fire extinguishers and standard emergency clean-up kits. Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills on the fueling stations would flow to the sump, which would be pumped out to a container for shipment off-site.

Implementation of the above environmental design features are expected to reduce the likelihood and extent of the release or spills of hazardous materials occurring on-site. No detectable changes to soil quality are expected. Therefore, these interactions are determined to have no linkage to effects on vegetation.

- **Failure of the embankment dykes around the settling ponds can change surface water, sediment, and soil quality, which can affect vegetation.**

Failure of embankment dykes around the settling ponds could result in the release of sediment laden water and potential contaminants to the surface water and terrestrial environments. Environmental controls will be in place to limit the potential for embankment dyke failure. For example, water from the waste rock disposal areas will be diverted to the settling ponds by gravity. The settling pond will be engineered to provide adequate storage of process streams under normal and extreme operating conditions. Maximum operating levels will be developed to provide adequate storage volumes for the design storm event. In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling pond would be provided by the inclusion of an overflow spillway in the embankment.

The embankment dyke will be constructed around the settling ponds to contain wastewater from site and from the waste rock disposal areas. Embankment dykes will be stripped of vegetation, topsoil, and roots to expose the mineral soil subgrade as necessary to accommodate the size of the settling pond. Fill material used for constructing the dyke will be clean mineral soil with sufficient moisture to allow for proper compaction and will be placed in lifts not exceeding 150 mm in compacted thickness and compacted to a minimum of 95% standard proctor maximum dry density. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap as soon as practical following construction.

The settling ponds will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. During the detailed design stage, additional mitigation will be identified and included as part of the EnvPP and the Emergency Response Plan. Consequently, embankment dyke failure was determined to have no linkage to effects on vegetation.

- **Fire**

Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. Fire safety measures and response will be reviewed with the communities of Black Lake and Stony Rapids. On-site personnel will be trained in established fire prevention and response procedures and appropriate firefighting equipment will be available on-site so that trained personnel will be able to respond promptly. The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail.

Each pump will be sized to meet the full demand of the largest component of the system with the addition of 31.5 litres per second (L/s) for hose demand. Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute).

Although a fire is likely to result in loss of some vegetation, the implementation of the abovementioned mitigation is anticipated to result in negligible effects to vegetation.

14.4.4 Primary Interactions

The following interaction was determined to be primary for effects on the maintenance of self-sustaining plant populations and communities and is carried forward to the residual effects analysis (Section 14.5).

- **Direct loss, alteration, and fragmentation of vegetation from the Project footprint.**

14.5 Residual Effects Analysis

The residual effects analysis considered all primary Project interactions that likely result in measureable environmental changes and effects on vegetation after implementing environmental design features and mitigation. The residual effects assessment is completed by calculating and estimating changes to measurement endpoints associated with the primary Project interactions. These measurement endpoints include:

- habitat loss and fragmentation; and
- relative abundance and distribution of plant species, including plant community diversity.

Assessment cases are defined for the effects analysis and include the baseline case, application case (Project case, which includes construction, operation, and closure), and future case (if applicable). The baseline case considers the current conditions in the RSA, such as natural disturbances (e.g., fire) and previous and existing human developments and activities. The regional area surrounding the Project has experienced little industrial human development and activity. Previous activity includes exploration work for the Nisto uranium deposit (mineral property #1621), which is located on the west shore of Black Lake, approximately 23 km east of Stony

Rapids (Government of Saskatchewan 2013). In 1950, two adits were driven and lateral work was completed. Ore was mined from the shoots accessible from the northeast adit in 1959. Only exploration work has been completed in the area since 1959. Existing human-related disturbance includes trails, roads, cabins, the Black Lake lagoon, and the communities of Black Lake and Stony Rapids. Populations and communities in aquatic and terrestrial ecosystems have likely adapted to the low level of human industrial activity over the last 50 to 60 years. Therefore, current (baseline) conditions in the RSA are expected to reflect the cumulative influence of previous and existing human industrial activities on aquatic and terrestrial ecosystems relative to reference conditions. Reference conditions represent no to little human development, except for First Nation communities, which are assumed part of the historical natural ecosystems.

The application case occurs during the start of construction of the Project through closure and the associated duration of predicted effects (i.e., until effects are reversed or are deemed irreversible). The magnitudes of effects from the Project are expected to be strongest during construction and the initial period of operation. For example, the magnitude of some effects, such as the changes from blasting activities to existing noise levels and dust deposition are expected to stop at the end of construction, and the duration of these effects will likely end within the initial period of operation. Physical disturbance to the terrestrial environment is expected to only occur at the beginning of construction and the majority of the area disturbed will be reclaimed immediately following construction; therefore, the construction phase and the operations phase were considered separately in the vegetation residual effect analysis. Reclamation activities following construction will include the removal of portions of the temporary construction infrastructure not required during operation. Temporary infrastructure includes the construction camp, contractor's work areas, material laydown areas, and overburden disposal areas.

The duration of some effects from the Project have the potential to last over the 90-year operation period. The presence of the main access road and powerhouse for the 90-year period represent Project components that will affect vegetation long-term, but the magnitude and geographic extent of these effects should be much smaller than similar effects during construction because the majority of the area expected to be disturbed will be reclaimed immediately following construction. Because the differences in the magnitude and geographic extent of effects are expected to be measurable between construction and closure, the analysis examined both phases. Analyses were quantitative where possible and qualitative where necessary.

There is potential for this Project to operate beyond the expected 90-year operational period; however increasing the duration of the operation phase of the Project would have little influence on effects predictions. Most of the physical changes to vegetation from the operations footprint and the effects on the environment from these changes are considered permanent because of the length of operations (i.e., the duration of the change will be well beyond the temporal boundary of the assessment). The outcome of reclamation activities with respect to the operation footprint is highly uncertain, particularly in an environment where natural succession processes are slow, and trajectories can be altered by a number of factors (e.g., climate changes, fire, and unforeseeable human development).

Closure is when power production operations end, and decommissioning and reclamation of the final infrastructure (i.e., powerhouse, water intake, power tunnel, tailrace channel, switchyard, access roads, distribution line, and waste rock disposal areas) is completed.

Both the Project specific (incremental) and cumulative effects from the Project and previous and existing human developments and activities are analyzed in this section. Both Project-specific (incremental) and cumulative effects from the Project and existing human developments and activities are analyzed in this section. The future case includes baseline and the Project, plus reasonably foreseeable developments or designated projects. The geographic extent (zone of influence) of residual effects from the Project on vegetation is expected to be limited to the RSA. No other major developments in the region are located within the RSA. Therefore, the zones of influence associated with the Project and existing developments are not expected to overlap and generate cumulative effects on vegetation. Currently, there are no reasonably foreseeable developments that could have an overlapping temporal boundary with the Project and potential to generate cumulative effects on vegetation.

14.5.1 Loss, Alteration, and Fragmentation of Vegetation from the Project Footprint

Development of the Project is expected to change the relative abundance and distribution of plant populations and communities. Communities or plants that are common (high relative abundance) or widely distributed are likely to be more resilient than those with low abundance and limited distribution. Changes to the relative abundance and distribution of plant populations and communities generally occur at a local scale, but because of potential indirect effects on vegetation, changes to the abundance and distribution of vegetation were examined at the local and regional scales.

Fragmentation refers to the division of a landscape into smaller habitat patches that can be more isolated from each other and is generally thought to have a negative effect on biodiversity (Turner 1996; Swift and Hannon 2010). Fragmentation influences population resilience, and species richness by increasing edge effects, and altering the relative abundance of habitat, landscape connectivity, and patch size and distribution (Debinski and Holt 2000; Fahrig 2003; Fletcher et al. 2007).

The changes from loss and fragmentation of plant populations and communities are expressed by changes to ELC map units. Locally, direct loss of ELC map units from Project can affect biodiversity, including species richness, population abundance, habitat distribution, and genetic diversity. To understand the range and sustainability of vegetation, these environmental changes need to be examined at a regional scale. Habitat loss includes the direct removal or alteration of a landcover type (ELC map unit). Habitat loss has negative environmental effects on biodiversity (Fahrig 2003; Fletcher et al. 2007); as specific habitat decreases, species that rely on that habitat also decrease (Andrén 1994).

Within each ELC map unit, listed and unique species were counted as part of assessing biodiversity (Section 14.3.4; Table 14.3.3). To provide additional context to support the assessment of effects on changes to plant populations and community distribution, including potential effects on listed plants, the number and types of listed and unique species documented within the RSA during the 2010 and 2012 baseline studies is presented in Table 14.5-1.

Mean distance to nearest neighbour (MDNN) was calculated using the program FRAGSTATS (Version 3.0; McGarigal et al. 2002) in a Geographic Information System (GIS) platform. Direct loss of ELC map units caused by the Project footprint were also quantified in a GIS platform to calculate the areas and predicted changes of ELC map units within the LSA and RSA. To be conservative, a disturbance assessment area was defined for the Project.

Table 14.5-1: Number of Listed and Unique Species by Ecological Landscape Classification Map Unit within the Regional Study Area

Ecological Landscape Classification Map Unit	Number of Listed Species Occurrences	Number of Species Unique to ELC Map Unit[a]
Bedrock	16 (1 forb, 15 lichen)	10 (5 forbs, 2 graminoids, 3 lichen)
Jack pine	14 (2 forbs, 14 lichen)	3 (1 forb, 1 bryophyte, 1 lichen)
Jack pine/Black spruce	18 (all lichen)	7 (1 forb, 6 lichen)
Spruce	5 (all lichen)	2 (lichen)
Mixedwood	20 (all lichen)	28 (2 forbs,13 bryophytes, 12 lichen)
Deciduous	10 (all lichen)	12 (1 graminoid, 1 bryophyte, 10 lichen)
Wetland[b]	-	-
Bog subclass	10 (all lichen)	3 (2 bryophytes, 1 lichen)
Fen subclass	9 (1 forb, 8 lichen)	17 (2 shrubs, 3 forbs, 4 graminoids, 6 bryophytes, 2 lichen)
Swamp subclass	5 (all lichen)	14 (1 tall shrub, 1 shrub, 3 graminoids, 4 bryophytes, 1 lichen)
Riparian	2 (1 forb, 1 lichen)	25 (1 shrub, 12 forbs, 6 graminoids, 6 bryophytes)
Open water	1[c] (forb)	-
Regenerating Jack pine	3 (1 forb, 2 lichen)	0
Regenerating Jack pine/Black spruce	1 (forb)	3 (1 shrub, 2 forbs)
Regenerating Spruce	-	-
Regenerating Mixedwood	11 (1 forb, 10 lichen)	4 (1 graminoid, 1 bryophyte, 2 lichen)
Regenerating Deciduous	0	1 (forb)
Regenerating Wetlands[b]	-	-
Regenerating Bog subclass	9 (all lichen)	0
Regenerating Fen subclass	10 (1 forb, 9 lichen)	9 (1 tall shrub, 1 forb, 4 bryophytes, 3 lichen)
Regenerating Swamp subclass	5 (all lichen)	1 (graminoid)
Regenerating Riparian	-	-
Recent Burn	0	5 (1 shrub, 1 forb, 3 graminoids)
Existing Disturbance	-	-
Total	**51[d]**	**144**

Note: Totals presented are numbers of species found in that ELC type. The same species can occur in more than one ELC type. The total number of species observed is 347. The total number of listed species observed is 51.

(a) Does not include unidentified species.

(b) Totals were not completed for this map unit because the variation of numbers of plant species observed in each of the subclasses.

(c) alternate-flowered water-milfoil was documented at a riparian plot that included a portion of open water; therefore, this observation was placed in the open water map unit and not counted in the riparian map unit.

(d) This includes 6 forbs, 1 graminoid, and 44 lichens documented during the 2010 and 2012 surveys.

ELC = Ecological Landscape Classification; - = not sampled

The maximum possible extent of disturbance during construction (disturbance assessment area) is estimated to be 1,620 ha (16.1% of the LSA; 1.4% of the RSA). The predicted Project footprint is estimated to be 869 ha, and represents approximately 54% of the disturbance assessment area (9.8% of the LSA; 0.8% of the RSA). Most of the reclamation activities are expected to be concentrated during the period immediately following construction. Reclamation activities following construction will include the removal of portions of the temporary construction infrastructure not required during operation (589 ha; 6.6% of the LSA; 0.5% of the RSA). The remaining infrastructure required for operations is estimated to cover 280 ha (3.2% of the LSA; 0.2% of the RSA). Following closure of the Project, the entire area will be reclaimed.

The incremental residual effects on vegetation are assessed using predicted changes to habitat fragmentation, ELC map units, listed plant species habitat potential, and traditional use plant habitat potential. The changes to vegetation from habitat fragmentation only considered the maximum predicted point of development of the Project footprint (disturbance assessment area). This area was used in the fragmentation analysis because wildlife might or might not use the vegetation islands interspersed among the Project footprint that will be created during construction. Thus, the fragmentation analysis overestimates the changes to fragmentation from the Project.

Changes to the relative abundance and distribution of plant populations and communities, including listed plant species and traditional use plant species, are also assessed for the maximum possible extent of disturbance during construction; however, the change following construction was also considered because it is not expected that the entire area will actually be disturbed during construction. Although wildlife might not use the vegetation islands remaining after construction, habitat for individual plant species will likely be maintained. Reclamation of temporary infrastructure is expected to occur immediately following construction and is anticipated to limit incremental residual effects. The environmental effects analysis results represent a conservative estimate of residual effects on vegetation. Incremental changes are assessed at the local and regional scales. The changes to vegetation were estimated by calculating the relative difference or net change in that map unit between the baseline and application (i.e., construction and closure phases) cases using the following equations. The change in relation to the LSA and RSA are also considered.

- (construction phase value – baseline case value)/baseline case value x 100%.
- (closure phase value – baseline case value)/baseline case value x 100%.

The resulting value is the percent change in habitat area for each comparison, and provides both direction and magnitude of the residual effect. For example, a high negative value would indicate a substantial loss of that that ELC map unit or habitat type, while a low positive value would indicate a slight increase in the ELC map unit. Following reclamation activities during operation and after final decommissioning and reclamation of the Project following closure, it was assumed that there will be a net change to these ELC map units or habitat types, relative to the LSA and RSA, but it is unknown what ELC map units these areas will become in the future. As such, the change following reclamation is classified as “Reclaimed Vegetation”.

14.5.1.1 Changes to Plant Populations and Communities from Fragmentation

Habitat fragmentation, patch size, and isolation are generally accepted as a key determinant of species diversity in fragmented ecosystems; however, many studies have shown that there is a poor correlation between patch size and plant species diversity (Donaldson et al. 2002). This poor correlation implies that plants could be more resilient to habitat fragmentation than other taxa, such as insects or wildlife (i.e., plant pollinators).

Plant species respond to fragmentation and edge habitats in a variety of ways. Many plant species can increase and become more common in edge habitats as compared to interior habitats, resulting in a positive effect on species diversity (Lin and Coa 2009). Plant communities characteristic of edge habitats tend to be more dense and diverse, when compared to those plant communities within the interior of a closed-canopy, late successional forest (Landenberger and McGraw 2004). Disturbed forest edges can also provide suitable habitat for the colonization of early-successional species soon after disturbance (Landenberger and McGraw 2004). This can be viewed as a positive effect on vegetation; however, the effect of an increase in edge can have negative effects on wildlife that use these areas (Section 15.5). Although there can be a positive response by some plant species to edge habitats, negative ecological consequences, such as the introduction of weedy species can result in deleterious effects on a plant community (Lin and Coa 2009).

Another factor that can influence plant reproduction in fragmented habitats is plant population size, which is not always correlated with patch size (Donaldson et al. 2002). For some species, fragmentation can promote seed germination because the disturbance creates microsites suitable for some species (i.e., shade-intolerant species), while in other plant species, rates of germination can decrease (e.g., shade-tolerant species) (Saunders et al. 1991; Donaldson et al. 2002). The natural abundance of a species can influence the effects of fragmentation on specific groups of plant species (Hobbs and Yates 2003). For example, fragmentation can have more pronounced effects on uncommon and rare species where a small patch can contain a population and distance to another area containing the same species has increased (Donaldson et al. 2002). The effect of fragmentation can be enhanced simply because the natural abundance of rare or uncommon species is restricted prior to fragmentation (Donaldson et al. 2002; Hobbs and Yates 2003).

Habitat fragmentation results in changes to the functional interactions within an ecosystem, such as the ability of pollinators to pollinate plants or a plant reliance on seed dispersers (Donaldson et al. 2002; Hobbs and Yates 2003; Newman et al. 2013), which has a direct effect on some plant species reproductive success and spread, and thus population persistence. For example, an increase in the spatial distance between plant populations and pollinator habitat can result in a decrease in pollinator visitation and an increase in genetic isolation of a plant population (Newman et al. 2013). Additionally, an increase in spatial distance between patches can affect wildlife foraging behaviour (Mahan and Yahner 1999; Section 15.5.1), thus potentially decreasing pollinator visitation. Although a decrease in pollinator visitation can occur from fragmentation, the magnitude of the effects of fragmentation is a function of the reliance of a plant species' reproductive dependence on specific pollinators. For example, a plant species that relies on a single species of pollinator can be at a greater risk of decreasing in abundance than a generalist pollinated plant species. A decline in specific pollinators can have a negative effect on the success of plant reproduction in some species (Donaldson et al. 2002). Not all consequences of fragmentation are negative with respect to pollinators-plant relationships. For example, plant species that are a generalist pollinated species are more resilient to fragmented habitats than those that have specific pollinator requirements.

The MDNN for the Recent Burn and Regenerating Jack Pine/Black Spruce map units are expected to decrease by approximately 84 m and 7 m respectively, relative to baseline conditions (Table 14.5-2). Deciduous, Regenerating Spruce, Mixedwood, and Spruce, map units are expected to decrease by less than 1 m relative to baseline conditions. No change is expected in the Riparian map unit. The MDNN for the Bedrock and Regenerating Wetland (includes regenerating bogs, fens, and swamps) map units are expected to increase by approximately 12 m and 11 m, respectively. Regenerating Deciduous and Regenerating Jack Pine are expected to increase by approximately 8 m and 5 m, respectively, with development of the Project. The MDNN for

Regenerating Mixedwood, Wetland (includes bogs, fens, and swamps), Jack Pine/Black Spruce, and Open Water are expected to increase by 3 m to less than 1 m, relative to baseline conditions.

Changes to vegetation in the RSA from fragmentation are predicted to be within or slightly exceed baseline values. The majority of plant communities (ELC map units) that are expected to be affected by the Project are not unique to areas to be disturbed. Those ELC map unit that are not abundant within the LSA at baseline are Bedrock, Jack Pine/Black Spruce, Riparian, Regenerating Jack Pine/Black Spruce, and Regenerating Riparian; however, the majority of these ELC map units are present elsewhere within the RSA. Bedrock and Riparian map units were among those map units that contained the highest numbers of unique species (Table 14.5-1). The MDNN in the Bedrock ELC map unit is predicted to increase by 5% (12 m), relative to baseline values (Table 14.5-2), which can increase the isolation of this habitat type. Although there is a potential increase in isolation, the Bedrock ELC map unit is currently present in patches in the RSA. This map unit was documented to contain 10 plant species that are unique to this map unit; however, small areas of exposed bedrock were characteristic of all upland map units, therefore bedrock microsites are present in all upland map units (Annex IV; Section 4.3.1). In addition, it is likely that the plant species present in the Bedrock map unit are already adapted to the existing patchy nature of this habitat type within the RSA (e.g., fern species). The Riparian map unit was predicted to not be affected by fragmentation (Table 14.5-2).

14.5.1.2 Changes to Plant Population and Community Abundance

The assumed (conservative) maximum area of ELC map units to be disturbed by the Project footprint during construction is 1,620 ha. The ELC map units that will likely experience the greatest change during construction are Regenerating Jack Pine, Spruce, and Jack Pine (Table 14.5-3, Table 14.5-4; Figure 14.5-1). A total of 534 ha of Regenerating Jack Pine will be disturbed, representing a decrease of 6.0% relative to the LSA (0.5% relative to the RSA). A total of 313 ha of Spruce will be disturbed, representing a decrease of 3.5% relative to the LSA (0.3% relative to the RSA). A total of 235 ha of Jack Pine will be disturbed, representing a decrease of 2.6% relative to the LSA (0.2% relative to the RSA).

Approximately 4 ha of the Bedrock ELC map unit will be disturbed by the Project; however, this map unit is uncommon within the LSA (less than 0.1% of the LSA), which translates into approximately 72% of its current abundance within the LSA being disturbed (Table 14.5-3). This map unit is more common outside of the LSA, and less than 1% of its current abundance within the RSA will be disturbed (Table 14.5-4). As discussed above, Bedrock contains 10 plant species that are unique to this map unit; however, bedrock microsites exist within all upland map units, and therefore all map units have potential to contain some of these unique species. Similar to the Bedrock ELC map unit, Regenerating Riparian is also restricted in abundance (less than 0.1% of the LSA and RSA; Table 14.5-3 and Table 14.5-4). Approximately 70% of this map unit's current abundance within the LSA and RSA will be disturbed. Between 46% and 73% of the current abundance of the other Regenerating map units within the LSA will be disturbed by the Project; however this represents 4% and 22% of the current abundance with the RSA. In addition, all Regenerating habitats contain only a few unique species (less than 4 species) with the exception of Regenerating Fen subclass (9 species; Table 14.5-1).

Table 14.5-2: Change in Mean Distance to Nearest Neighbour of Ecological Landscape Classification Map Units from Development of the Project in the Regional Study Area

Ecological Landscape Classification Map Unit	Baseline	Construction to Closure (Application)[a]		
	Mean Distance to Nearest Neighbour (m)	Mean Distance to Nearest Neighbour (m)	Net Change between Baseline and Construction (m)	Net Change between Baseline and Construction (% unit)
Bedrock	255.5	268.0	12.4	4.9
Jack Pine	118.21	118.1	0.2	0.2
Jack Pine/Black Spruce	411.5	412.6	-2.4	-0.6
Spruce	171.1	170.9	-0.1	-0.1
Mixedwood	166.9	166.6	-0.3	-0.2
Deciduous	205.3	204.6	-0.6	-0.3
Wetland	186.2	188.0	1.9	1.0
Riparian	850.6	850.6	0	0
Open Water	274.1	274.2	0.1	<0.1
Regenerating Jack Pine	96.0	100.8	4.7	4.9
Regenerating Jack Pine/Black Spruce	404.8	393.9	-6.8	-1.7
Regenerating Spruce	159.0	158.5	-0.3	-0.2
Regenerating Mixedwood	105.7	108.5	3.3	3.1
Regenerating Deciduous	160.9	167.6	7.9	4.9
Regenerating Wetland	307.4	317.8	10.5	3.4
Regenerating Riparian	86.6	n/a	n/a	n/a
Recent Burn	214.9	130.8	-84.1	-39.1

Notes: A value <0.1 or <-0.1 approaches zero.
Negative numbers indicate a reduction or change in that ELC map unit. Positive numbers indicate an increase or gain in that ELC map unit.
Changes in the MDNN for Regenerating Riparian habitat is not applicable (n/a) because the Project is expected to remove all but one patch of Regenerating Riparian habitat.
[a] based on disturbance assessment area
ha = hectares; % = percent; <= less than; n/a = not applicable

During operations, those areas not disturbed during construction are assumed to remain the same as baseline conditions. Areas of temporary construction infrastructure not required during operation will be reclaimed immediately following construction. It is expected that of the maximum area that might be disturbed by the Project during construction, that 869 ha will actually be required for the Project footprint (i.e., 54% of the disturbance assessment area). Of this 869 ha, 589 ha will be reclaimed immediately following construction (6.6% of the LSA; 0.5% of the RSA) and 280 ha will be required for operation (3.2% of the LSA; 0.2% of the RSA; Table 14.5-3, Table 14.5-4). Following closure of the Project, the entire area will be reclaimed (Table 14.5-3, Table 14.5-4; Figure 14.5-2).

Table 14.5-3: Net Change in Ecological Landscape Classification Map Units in the Local Study Area during the Project

Ecological Landscape Classification Map Unit	Baseline		End of Construction[a]				Closure[b]	
	Area (ha)	Proportion of LSA (%)	Area following Construction (ha)	Net Change from Baseline (ha)	Net Change from Baseline (% unit)	Net Change from Baseline (% LSA)	Area following Closure (ha)	Net Change from Baseline (% LSA)
Bedrock	5	0.1	1	-4	-71.9	<-0.1	5	<-0.1
Jack Pine	3,165	35.6	2,930	-235	-7.4	-2.6	2,975	-2.1
Jack Pine/Black Spruce	7	0.1	6	-1	-13.3	<-0.1	7	<-0.1
Spruce	809	9.1	497	-313	-38.6	-3.5	676	-1.5
Mixedwood	188	2.1	172	-16	-8.4	-0.2	176	-0.1
Deciduous	104	1.2	86	-18	-17.0	-0.2	96	-0.1
Wetland	957	10.8	909	-49	-5.1	-0.5	916	-0.5
Riparian	8	0.1	7	<-1	-6.1	<-0.1	8	0
Open Water	1,423	16.0	1,411	-12	-0.9	-0.1	1,419	<-0.1
Regenerating Jack Pine	963	10.8	429	-534	-55.5	-6.0	704	-2.9
Regenerating Jack Pine/Black Spruce	4	0.0	2	-2	-45.8	<-0.1	4	<-0.1
Regenerating Spruce	183	2.1	80	-103	-56.2	-1.2	138	-0.5
Regenerating Mixedwood	261	2.9	103	-158	-60.5	-1.8	176	-1.0
Regenerating Deciduous	67	0.8	18	-48	-72.7	-0.5	30	-0.4
Regenerating Wetland	100	1.1	50	-50	-50.2	-0.6	88	-0.1
Regenerating Riparian	23	0.3	7	-16	-69.8	-0.2	19	<-0.1
Recent Burn	83	0.9	80	-3	-3.9	<-0.1	80	<-0.1
Existing Disturbance	516	5.8	465	-51	-9.9	-0.6	485	-0.4
Unclassified	14	0.2	7	-7	-50.2	-0.1	10	<-0.1
Project Footprint	n/a	n/a	1,620	1,620	n/a	18	0	0
Reclaimed Vegetation	n/a	n/a	0	0	n/a	0	869	9.8

Note: the total area of the local study area is 8,881 ha

Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique and did not fit into any of the other ELC map units. In addition, these areas could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified.

Existing Disturbance ELC map unit is the result of existing human related disturbances such as roads, cut lines, and communities.

A value <0.1 or <-0.1 approaches zero.

Negative numbers indicate a reduction or change in that ELC map unit. Positive numbers indicate an increase or gain in that ELC map unit.

[a] based on disturbance assessment area

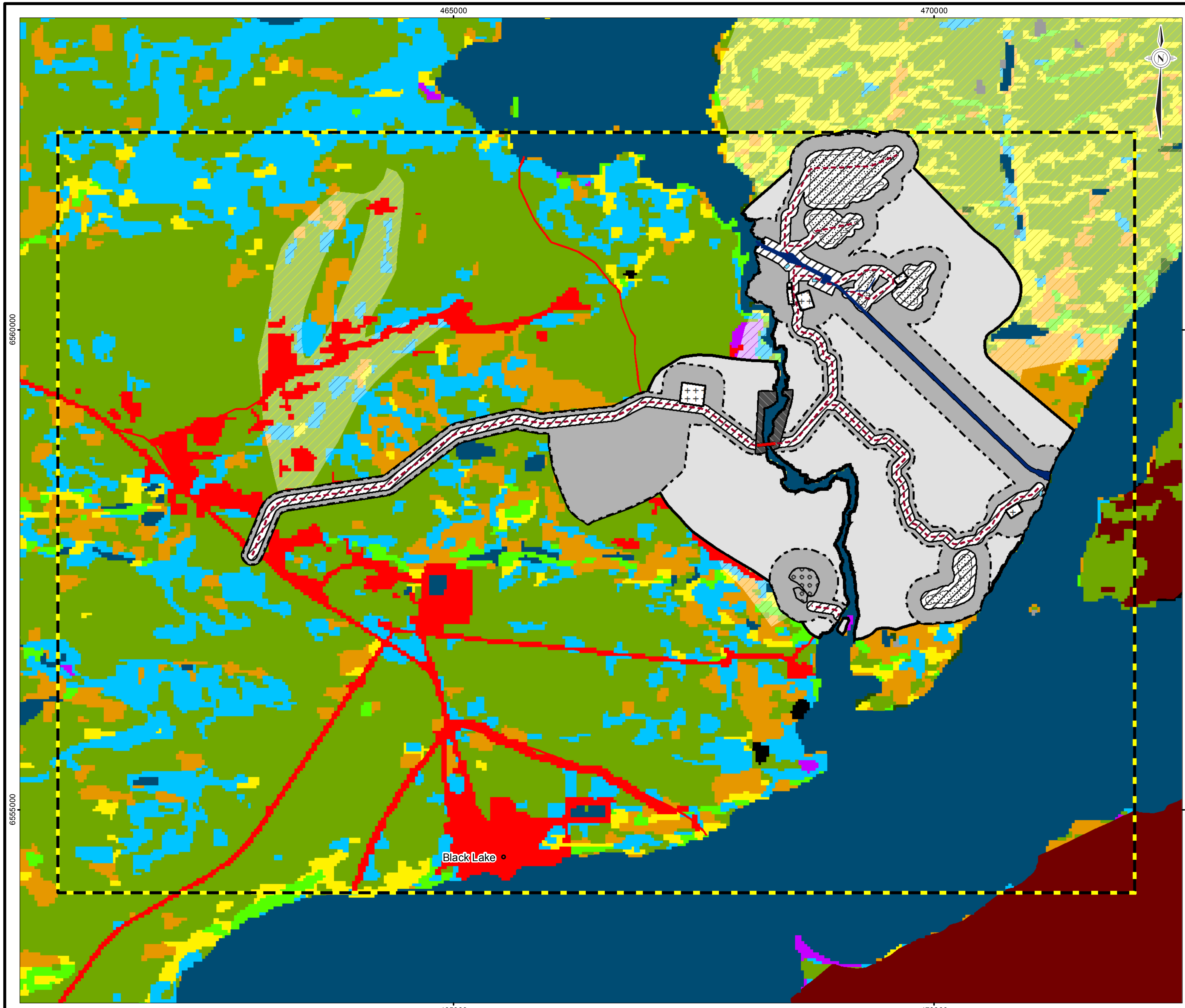
[b] based on actual predicted Project footprint

ha = hectares; % = percent; <= less than; LSA = local study area; n/a = not applicable

Table 14.5-4: Net Change in Ecological Landscape Classification Map Units in the Regional Study Area during the Project

Ecological Landscape Classification Map Unit	Baseline		End of Construction[a]				Closure[b]	
	Area (ha)	Proportion of RSA (%)	Area following Construction (ha)	Net Change from Baseline (ha)	Net Change from Baseline (% unit)	Net Change from Baseline (% RSA)	Area following Closure (ha)	Net Change from Baseline (% RSA)
Bedrock	347	0.3	343	-4	-1.1	<-0.1	347	<-0.1
Jack Pine	21,492	18.6	21,257	-235	-1.1	-0.2	21,302	-0.2
Jack Pine/Black Spruce	117	0.1	116	-1	-0.8	<-0.1	117	<-0.1
Spruce	8,887	7.7	8,574	-313	-3.5	-0.3	8,753	-0.1
Mixedwood	3,658	3.2	3,642	-16	-0.4	<-0.1	3,646	<-0.1
Deciduous	2,971	2.6	2,953	-18	-0.6	<-0.1	2,962	<-0.1
Wetland	6,213	5.4	6,165	-49	-0.8	<-0.1	6,172	<-0.1
Riparian	53	<0.1	52	<-1	-0.9	<-0.1	53	0
Open Water	26,275	22.7	26,262	-12	<-0.1	<-0.1	26,270	<-0.1
Regenerating Jack Pine	4,793	4.1	4,259	-534	-11.1	-0.5	4,534	-0.2
Regenerating Jack Pine/Black Spruce	48	0.0	46	-2	-4.2	<-0.1	48	<-0.1
Regenerating Spruce	707	0.6	604	-103	-14.6	-0.1	662	<-0.1
Regenerating Mixedwood	2,002	1.7	1,845	-158	-7.9	-0.1	1,918	-0.1
Regenerating Deciduous	854	0.7	805	-48	-5.7	<-0.1	817	<-0.1
Regenerating Wetland	229	0.2	179	-50	-21.9	<-0.1	217	<-0.1
Regenerating Riparian	23	<0.1	7	-16	-69.8	<-0.1	19	<-0.1
Recent Burn	35,993	31.1	35,990	-3	<-0.1	<-0.1	35,991	<-0.1
Existing Disturbance	889	0.8	838	-51	-5.7	<-0.1	858	<-0.1
Unclassified	50	<0.1	43	-7	-14.3	<-0.1	46	<-0.1
Project Footprint	n/a	n/a	1,620	1,620	n/a	1.4	0	0
Reclaimed Vegetation	n/a	n/a	0	0	n/a	0	869	0.8

Note: the total area of the Regional Study Area is 115,600 ha.
Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique and did not fit into any of the other ELC map units. In addition, these areas could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified
Existing Disturbance ELC map unit is the result of existing human related disturbances such as roads, cut lines, and communities.
A value <0.1 or <-0.1 approaches zero.
Negative numbers indicate a reduction or change in that ELC map unit. Positive numbers indicate an increase or gain in that ELC map unit.
(a) based on disturbance assessment area
(b) based on actual predicted Project footprint
ha = hectares; % = percent; <= less than; RSA = regional study area; n/a = not applicable



LEGEND

- HAMLET OR COMMUNITY
- TERRESTRIAL LOCAL STUDY AREA
- DISTURBANCE ASSESSMENT AREA
- PREDICTED PROJECT FOOTPRINT
- OPERATIONS FOOTPRINT

SPECIFIC CONSTRUCTION SITES

- POTENTIAL BRIDGE ALIGNMENT
- PERMANENT ROAD
- CONTRACTOR CAMP / LAYDOWN AREA
- BORROW AREA
- SETTLING POND
- SPOIL DISPOSAL AREA
- POTENTIAL BRIDGE ALIGNMENT AREA
- TUNNEL AND TAILRACE ALIGNMENT

ECOLOGICAL LAND CLASSIFICATION

- BEDROCK
- JACK PINE
- JACK PINE / BLACK SPRUCE
- SPRUCE
- MIXEDWOOD
- DECIDUOUS
- WETLAND
- RIPARIAN
- OPEN WATER
- REGENERATING JACK PINE
- REGENERATING JACK PINE / BLACK SPRUCE
- REGENERATING SPRUCE
- REGENERATING MIXEDWOOD
- REGENERATING DECIDUOUS
- REGENERATING WETLAND
- REGENERATING RIPARIAN
- RECENT BURN
- EXISTING DISTURBANCE
- UNCLASSIFIED

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
LANDSAT SCENE WAS ACQUIRED ON JUNE 24, 2010. THE CLASSIFICATION SHOWN HAS BEEN CREATED FROM THIS 30 METRE RESOLUTION LANDSAT SCENE.
SASKATCHEWAN FIRE HISTORY DATA OBTAINED FROM THE GOVERNMENT OF SASKATCHEWAN

1 0 1
SCALE 1:40,000 KILOMETRES

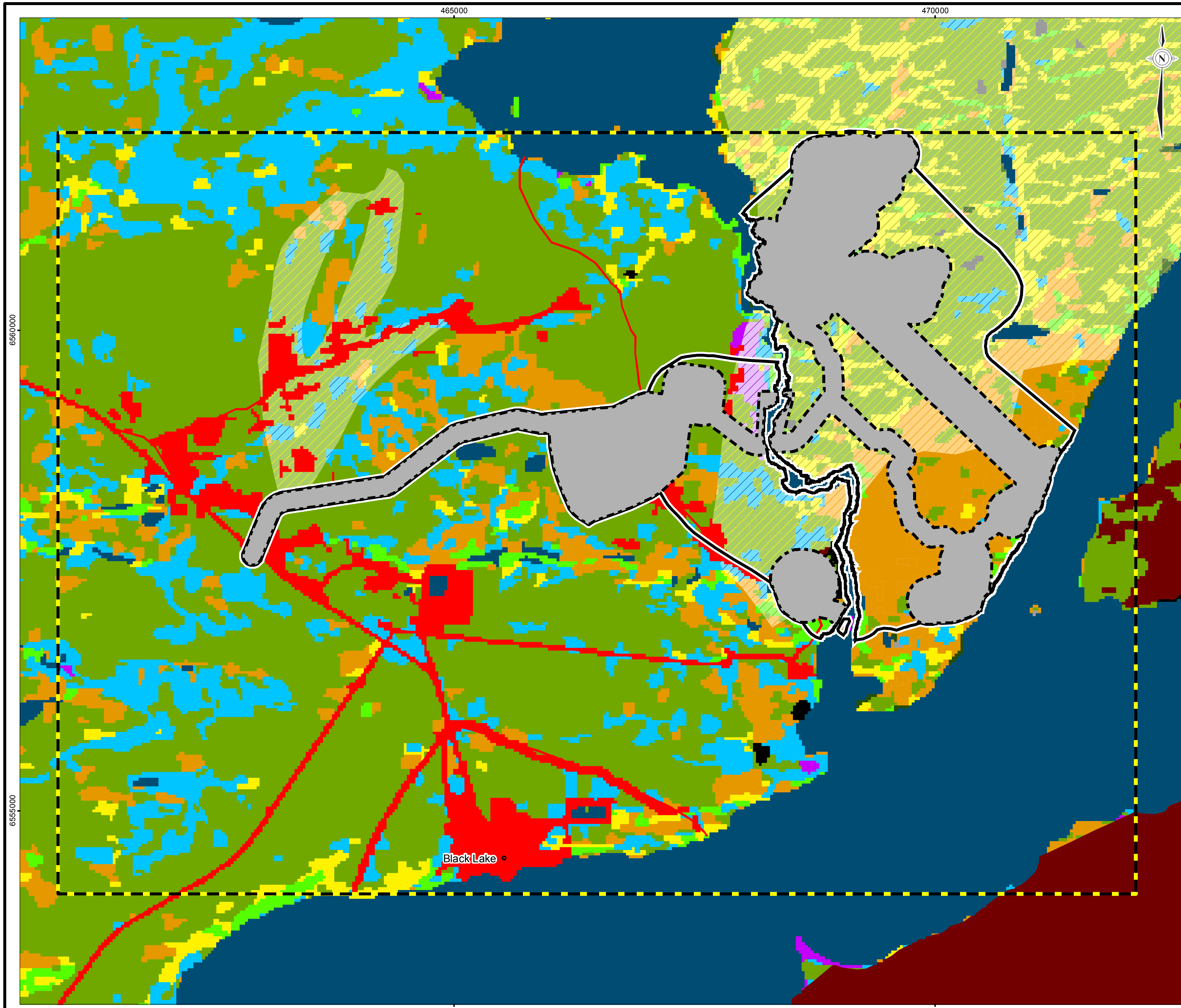
PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

ECOLOGICAL LANDSCAPE CLASSIFICATION DURING CONSTRUCTION

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM/LMR	12/07/13	FIGURE: 14.5-1	
CHECK	JF	15/11/13		
REVIEW	MM	15/11/13		



LEGEND

- HAMLET OR COMMUNITY
- TERRESTRIAL LOCAL STUDY AREA
- RECLAIMED
- DISTURBANCE ASSESSMENT AREA

ECOLOGICAL LAND CLASSIFICATION

- BEDROCK
- JACK PINE
- JACK PINE / BLACK SPRUCE
- SPRUCE
- MIXEDWOOD
- DECIDUOUS
- WETLAND
- RIPARIAN
- OPEN WATER
- REGENERATING JACK PINE
- REGENERATING JACK PINE / BLACK SPRUCE
- REGENERATING SPRUCE
- REGENERATING MIXEDWOOD
- REGENERATING DECIDUOUS
- REGENERATING WETLAND
- REGENERATING RIPARIAN
- RECENT BURN
- EXISTING DISTURBANCE
- UNCLASSIFIED

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
LANDSAT SCENE WAS ACQUIRED ON JUNE 24, 2010. THE CLASSIFICATION SHOWN HAS BEEN CREATED FROM THIS 30 METRE RESOLUTION LANDSAT SCENE.
SASKATCHEWAN FIRE HISTORY DATA OBTAINED FROM THE GOVERNMENT OF SASKATCHEWAN

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

ECOLOGICAL LANDSCAPE CLASSIFICATION FOLLOWING CLOSURE

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM/LMR	31/07/13	FIGURE: 14.5-2	
CHECK	JF	15/11/13		
REVIEW	MM	15/11/13		

14.5.1.3 Changes to Listed Plant Species and Listed Plant Species Habitat Potential

Listed plant species are considered rare either federally or provincially because of low numbers or limited range within the province or country (Robson 1998). Plants can be rare for many reasons; preferred habitat can be uncommon, or the location could be near the edge of that species range. Rare plants are important to humans and ecosystems because they are an irreplaceable part of our natural heritage, can have scientific value (e.g., medicinal uses), contribute to the full diversity of life on earth, can be indicators of good stewardship and ecosystem health, and contribute to the aesthetics of the natural landscape (Neely et al. 2009).

To evaluate the residual effects from the Project on federal and provincial listed plant species two approaches were used. The first approach was to map the locations of known or historically observed listed plants. These locations were used to determine the direct residual effects of the Project on known individuals or communities of listed plants. Because field surveys cannot confirm the absence of listed plants and can only confirm their presence, the second approach included ranking ELC map units present in the LSA and RSA for potential to contain these species. Field survey results and habitat preference of listed species were used to determine the potential of each ELC map unit to support listed plant species (Annex IV; Section 4.3.3.2).

The listed plant potential for each ELC map unit is shown in Table 14.5-5. Wetland and Regenerating Wetlands included bogs, fens, and swamps or regenerating bogs, fens, and swamps, but could not be mapped separately in the ELC. Therefore, wetland was classed as high/moderate and regenerating wetland as moderate/low to capture the range of listed plant habitat potentials in these ELC map units. Net change in habitat for listed plants in the LSA and RSA was estimated by calculating the differences between baseline and construction, and baseline and closure.

Table 14.5-5: Potential of Ecological Landscape Classification Map Units in the Local and Regional Study Areas to Support Listed Plant Species

Ecological Landscape Classification Map Unit	Listed Plant Habitat Potential
Bedrock	very high
Jack pine, Jack pine/Black spruce, Mixedwood, Riparian	high
Wetland	high/moderate
Spruce, Deciduous, Open water[a], Regenerating Mixedwood	moderate
Regenerating Wetland	moderate/low
Regenerating Jack pine, Regenerating Jack pine/Black spruce, Regenerating Spruce, Regenerating Deciduous, Regenerating Riparian, Recent Burn, Existing Disturbance	low
Unclassified	unclassified

Note: Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique and did not fit into any of the other ELC map units. In addition, these areas could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified.
Existing Disturbance ELC map unit is the result of existing human related disturbances such as roads, cut lines, and communities
[a] Water generally represents deep water, which has a low rare plant habitat potential. However, it is classed with a moderate rare plant habitat potential as it is also associated with shallow water (e.g., littoral zones) where a relatively high number of rare plants can be found.

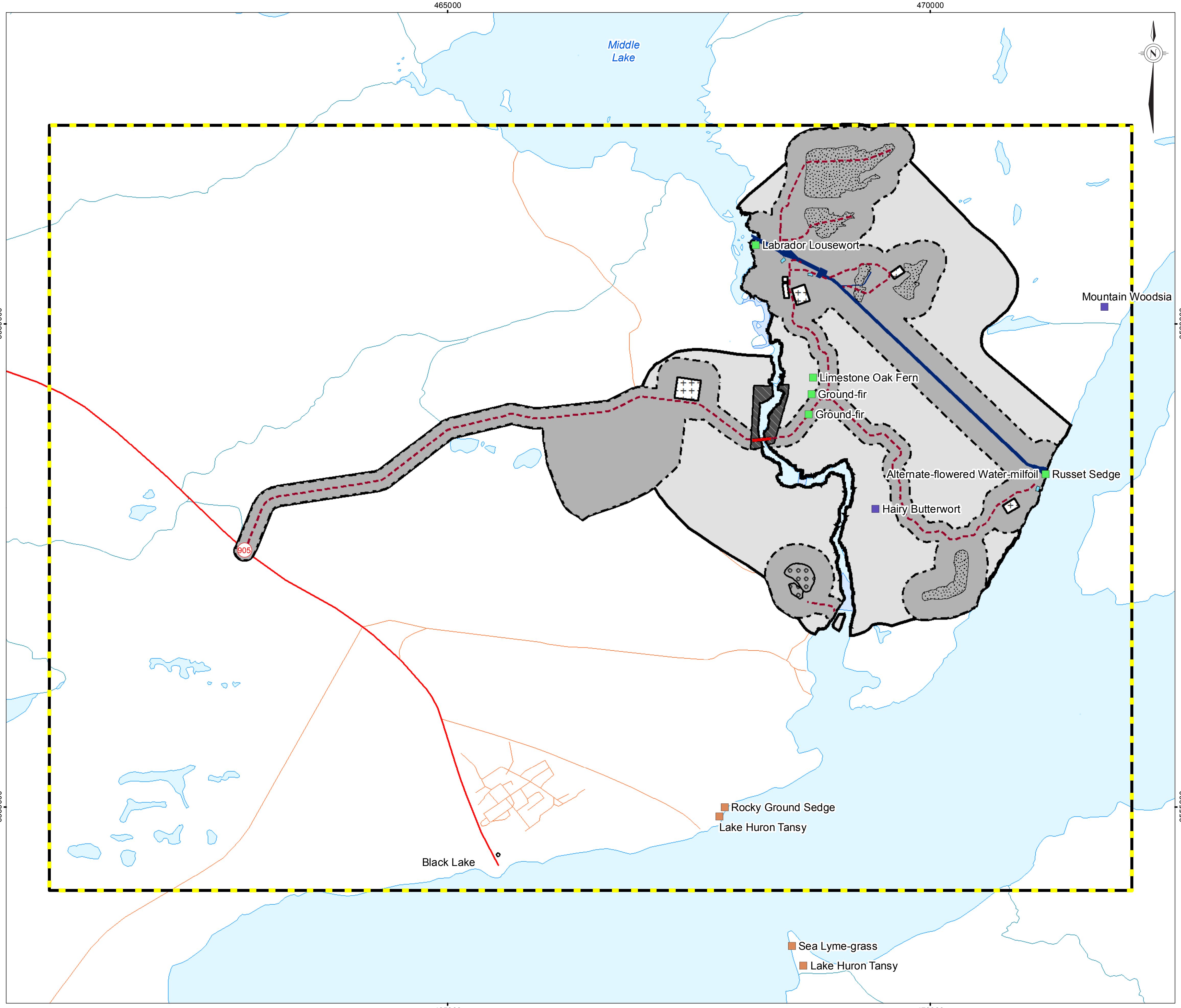
Provincial listed vascular plant species were identified as occurring at a six locations within the areas expected to be disturbed by the Project (Figure 14.5-3). Russet sedge was observed at the water intake location and Labrador lousewort was observed at the tailrace channel outlet. Limestone oak fern, ground fir (2 locations), and hairy butterwort were observed at locations along the temporary access road alignments. None of these species were observed outside of the LSA except ground fir. One historical observation of Lake Huron tansy (federally listed) was documented in the LSA approximately 2.6 km outside of the Project footprint and this species was not observed during the 2010 and 2012 field programs.

The 44 listed lichen species observed were widely distributed in the LSA and RSA and were present across all ELC map units except Recent Burn. The lichens observed were not unique to any of the areas to be disturbed by the Project. In addition, relatively little has been published on the distribution of lichens across Saskatchewan and the majority of published lichen surveys are focused on the southern half of the province (de Vries and Wright 2011); therefore, there might not be a good inventory of lichen species in northern Saskatchewan. In addition, lichens are identified using morphology, anatomy, and chemistry, which make field identification difficult. In most cases, proper identification of lichen requires collection and subsequent identification in a laboratory by a lichen specialist.

Although additional listed plant and lichen species were not observed within areas expected to be disturbed by the Project, this does not preclude the potential for other listed species to be present in areas expected to be disturbed. The following mitigation will be used to reduce effects on listed plant populations:

- A pre-disturbance survey will be completed prior to construction of the Project.
- Clearing of vegetation will be limited to the minimum extent possible and will only be removed in areas that might pose a hazard or interfere with construction activities.
- The Project will avoid the listed plants as much as possible.
- The listed plants will be delineated with fencing or flagging for the duration of construction so that these areas are avoided.
- If avoidance is not feasible, consultation with the Ministry of Environment (MOE) will be completed to determine the significance of the population and identify feasible mitigation strategies.
- If a listed plant species is encountered that was not expected, appropriate mitigation will be applied prior to further construction activities.

A total of 1,082 ha of low listed plant species habitat potential areas will be disturbed during construction, resulting in a decrease of 8.5% and 0.7% in the LSA and RSA, respectively (Table 14.5-6, Table 14.5-7, Figure 14.5-4). Moderate/low and moderate listed plant species habitat potential will decrease by approximately 551 ha (6.2% of the LSA and 0.4% of the RSA). High listed plant species habitat potential will decrease by 252 ha (2.8% of the LSA and 0.2% of the RSA). Very high listed plant species habitat potential will decrease by 4 ha (<0.1% of the LSA and RSA).



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- TERRESTRIAL LOCAL STUDY AREA
- PREDICTED PROJECT FOOTPRINT
- DISTURBANCE ASSESSMENT AREA

LISTED PLANT SPECIES OBSERVATION LOCATION

- 2010 OBSERVATION
- 2012 OBSERVATION
- HISTORIC OBSERVATION

SPECIFIC CONSTRUCTION SITES

- POTENTIAL BRIDGE ALIGNMENT
- PERMANENT ROAD
- CONTRACTOR CAMP / LAYDOWN AREA
- BORROW AREA
- SETTLING POND
- SPOIL DISPOSAL AREA
- POTENTIAL BRIDGE ALIGNMENT AREA
- TUNNEL AND TAILRACE ALIGNMENT

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
HISTORIC LISTED PLANT OBSERVATION LOCATIONS OBTAINED FROM THE SASKATCHEWAN CONSERVATION DATA CENTRE, 2012.

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATIONS OF LISTED PLANT SPECIES OBSERVATIONS DURING CONSTRUCTION

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	06/11/13	**FIGURE: 14.5-3**	
CHECK	JF	15/11/13		
REVIEW	MM	15/11/13		

Table 14.5-6: Net Change in Listed Plant Habitat Potential in the Local Study Area during the Project

Listed Plant Habitat Potential	Baseline		End of Construction[a]				Closure[b]	
	Area (ha)	Proportion of LSA (%)	Area Following Construction (ha)	Net Change from Baseline (ha)	Net Change from Baseline (% unit)	Net Change from Baseline (% LSA)	Area Following Closure (ha)	Net Change from Baseline (% LSA)
very high	5	0.1	1	-4	-71.9	<-0.1	5	<-0.1
high	3,368	37.9	3,116	-252	-7.5	-2.8	3,166	-2.3
high/moderate	957	10.8	909	-49	-5.1	-0.5	916	-0.5
moderate	2,597	29.2	2,096	-500	-19.3	-5.6	2,366	-2.6
moderate/low	100	1.1	50	-50	-50.2	-0.6	88	-0.1
low	1,839	20.7	1,082	-758	-41.2	-8.5	1,460	-4.3
unclassified	14	0.2	7	-7	-50.2	-0.1	10	<-0.1
Project Footprint	n/a	n/a	1,620	1,620	n/a	18.2	0	0
Reclaimed Vegetation	n/a	n/a	0	0	n/a	0	869	9.8

Note: the total area of the local study area is 8,881 ha

Unclassified is the result of the Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique and did not fit into any of the other ELC map units. In addition, these areas could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified

A value <0.1 or <-0.1 approaches zero.

Negative numbers indicate a reduction or change in that listed plant species habitat potential. Positive numbers indicate an increase or gain in that listed plant species habitat potential

[a] based on disturbance assessment area

[b] based on actual predicted Project footprint

ha = hectares; % = percent; <= less than; LSA = local study area; n/a = not applicable

Table 14.5-7: Net Change in Listed Plant Habitat Potential in the Regional Study Area during the Project

Listed Plant Habitat Potential	Baseline		End of Construction[a]				Closure[b]	
	Area (ha)	Proportion of RSA (%)	Area Following Construction (ha)	Net Change from Baseline (ha)	Net Change from Baseline (% unit)	Net Change from Baseline (% RSA)	Area Following Closure (ha)	Net Change from Baseline (% RSA)
very high	347	0.3	343	-4	-1.1	<-0.1	347	<-0.1
high	25,319	21.9	25,067	-252	-1.0	-0.2	25,117	-0.2
high/moderate	6,213	5.4	6,165	-49	-0.8	<-0.1	6,172	<-0.1
moderate	40,135	34.7	39,634	-500	-1.2	-0.4	39,904	-0.2
moderate/low	229	0.2	179	-50	-21.9	<-0.1	217	<-0.1
low	43,307	37.5	42,549	-758	-1.7	-0.7	42,928	-0.3
unclassified	50	0.0	43	-7	-14.3	<-0.1	46	<-0.1
Project Footprint	n/a	n/a	1,620	1,620	n/a	1.4	0	0
Reclaimed Vegetation	n/a	n/a	0	0	n/a	0	869	0.8

Note: the total area of the Regional Study Area is 115,600 ha

Unclassified is the result of the Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique and did not fit into any of the other ELC map units. In addition, these areas could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified

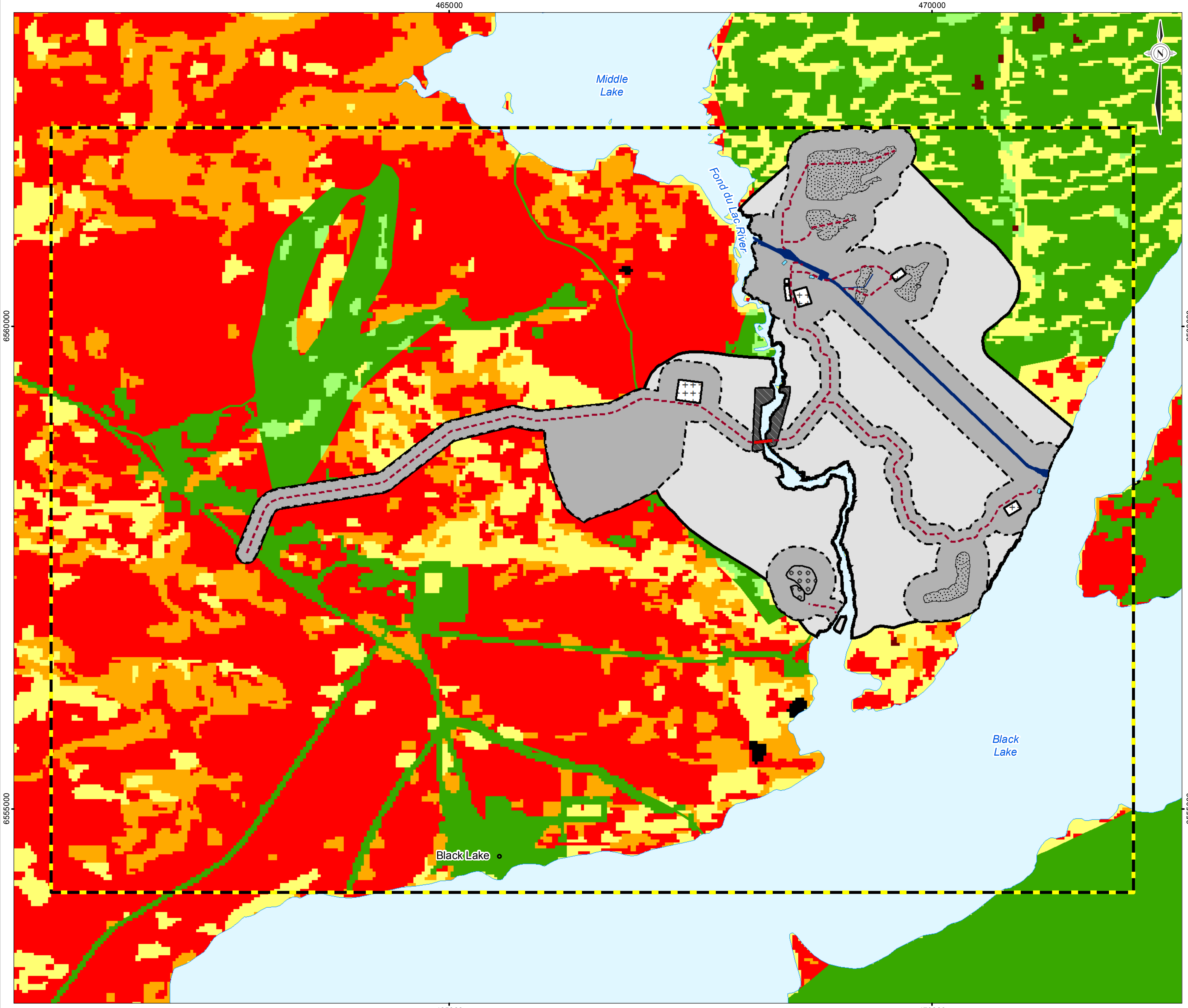
A value <0.1 or <-0.1 approaches zero.

Negative numbers indicate a reduction or change in that listed plant species habitat potential. Positive numbers indicate an increase or gain in that listed plant species habitat potential

[a] based on disturbance assessment area

[b] based on actual predicted Project footprint

ha = hectares; % = percent; <= less than; RSA = regional study area; n/a = not applicable



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- TERRESTRIAL LOCAL STUDY AREA
- PREDICTED PROJECT FOOTPRINT
- DISTURBANCE ASSESSMENT AREA

SPECIFIC CONSTRUCTION SITES

- POTENTIAL BRIDGE ALIGNMENT
- PERMANENT ROAD
- CONTRACTOR CAMP / LAYDOWN AREA
- BORROW AREA
- SETTLING POND
- SPOIL DISPOSAL AREA
- POTENTIAL BRIDGE ALIGNMENT AREA
- TUNNEL AND TAILRACE ALIGNMENT

LISTED PLANT HABITAT POTENTIAL

- VERY HIGH
- HIGH
- HIGH/MODERATE
- MODERATE
- MODERATE/LOW
- LOW
- UNCLASSIFIED

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
LANDSAT SCENE WAS ACQUIRED ON JUNE 24, 2010. THE CLASSIFICATION SHOWN HAS BEEN CREATED FROM THIS 30 METRE RESOLUTION LANDSAT SCENE.
SASKATCHEWAN FIRE HISTORY DATA OBTAINED FROM THE GOVERNMENT OF SASKATCHEWAN

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE
LISTED PLANT HABITAT POTENTIAL FOLLOWING CONSTRUCTION

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	06/11/13	**FIGURE: 14.5-4**
CHECK	JF	15/11/13	
REVIEW	MM	15/11/13	

The 4 ha of very high listed plant potential is associated with the Bedrock ELC map unit (Table 14.5-6; Table 14.5-7). The Bedrock map unit was documented to contain 15 listed lichen species and 1 listed forb species (Table 14.5-1); however bedrock microsites exist within all upland map units, and therefore all map units have potential to contain some of these species. For example, limestone oak fern was observed on a bedrock outcrop within the Jack Pine ELC map unit. In addition, the majority of the listed species occurrences were provincial listed lichen, and these species were not unique to any of the habitats present across the RSA. High potential habitat current abundance is expected to decrease by approximately 7.5% relative to the LSA, and 1% relative to the RSA.

Following closure of the Project, the entire area will be reclaimed and represents 9.8% of the LSA (0.8% of the RSA; Table 14.5-6, Table 14.5-7; Figure 14.5-5). These reclaimed areas were not assigned a listed plant species habitat potential because it is not known what the reclaimed landscape will look like in the future and if it will have the same capacity to support listed plant species.

14.5.1.4 Changes to Traditional Use Plants and Traditional Use Plant Habitat Potential

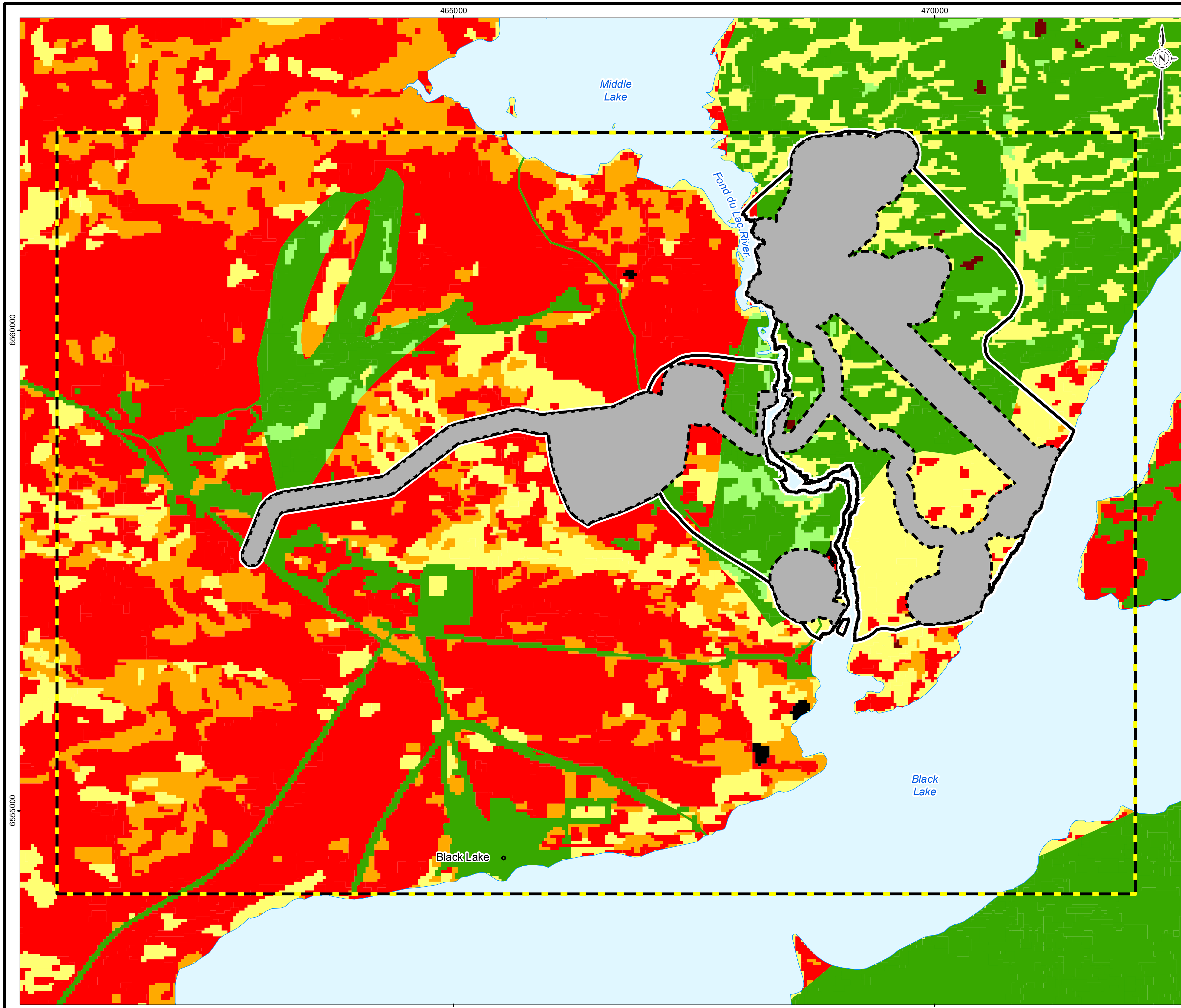
The habitat requirements of traditional use plant species were used to rank ELC map units according to their ability to support traditional use plant species. Professional judgment was used to assign a traditional use plant potential rank to each ELC map unit after reviewing the traditional use species-habitat relationships documented from the baseline studies and available literature.

The traditional use plant potential for each ELC map unit is shown in Table 14.5-8. Wetland and Regenerating Wetlands included bogs, fens, and swamps or regenerating bogs, fens, and swamps, but could not be mapped separately in the ELC. Therefore, Wetland and Regenerating Wetland were rated as moderate/high to capture the range of traditional use plant habitat potentials in these ELC map units. Net change in habitat for traditional use plants in the LSA and RSA was estimated by calculating the differences between baseline, construction operations, and closure.

Table 14.5-8: Potential of Ecological Landscape Classification Map Units in the Local and Regional Study Areas to Support Traditional Use Plants

Ecological Landscape Classification Map Unit	Traditional Use Plant Habitat Potential
Jack pine / Black spruce, Spruce, Mixedwood, Deciduous, Regenerating Mixedwood, Regenerating Deciduous	high
Wetland, Regenerating Wetland, Regenerating Jack pine/Black spruce, Regenerating Spruce	moderate/high
Jack pine, Riparian	moderate
Bedrock, Regenerating Jack pine, Regenerating Riparian, Recent Burn	low
Open water, Existing Disturbance	very low
Unclassified	unclassified

Notes: Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique and did not fit into any of the other ELC map units. In addition, these areas could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified.
Existing Disturbance ELC map unit is the result of existing human related disturbances such as roads, cut lines, and communities.



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- TERRESTRIAL LOCAL STUDY AREA
- DISTURBANCE ASSESSMENT AREA
- RECLAIMED

LISTED PLANT HABITAT POTENTIAL

- VERY HIGH
- HIGH
- HIGH/MODERATE
- MODERATE
- MODERATE/LOW
- LOW
- UNCLASSIFIED

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
LANDSAT SCENE WAS ACQUIRED ON JUNE 24, 2010. THE CLASSIFICATION SHOWN HAS BEEN CREATED FROM THIS 30 METRE RESOLUTION LANDSAT SCENE.
SASKATCHEWAN FIRE HISTORY DATA OBTAINED FROM THE GOVERNMENT OF SASKATCHEWAN

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LISTED PLANT HABITAT POTENTIAL FOLLOWING CLOSURE

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	06/11/13	**FIGURE: 14.5-5**	
CHECK	JF	15/11/13		
REVIEW	MM	15/11/13		

A total of 403 ha of very low and low traditional use plant species habitat potential areas will be disturbed during construction, resulting in a decrease of 4.5% and 0.4% in the LSA and RSA, respectively (Table 14.5-9, Table 14.5-10, Figure 14.5-6). Moderate traditional use plant species habitat potential will decrease by approximately 557 ha (6.3% of the LSA and 0.5% of the RSA). High traditional use plant species habitat potential will decrease by 553 ha (6.2% of the LSA and 0.5% of the RSA); approximately 39% relative to the LSA and 3% relative to the RSA of the current abundance of this habitat potential will be disturbed.

Following closure of the Project, the entire area will be reclaimed and represents 9.8% of the LSA (0.8% of the RSA; Table 14.5-9, Table 14.5-10; Figure 14.5-7). These reclaimed areas were not assigned a traditional use plant species habitat potential because it is not known what the reclaimed landscape will look like in the future and if it will have the same capacity to support traditional use plant species.

14.5.2 Management of Uncertainty

Ecosystems are complex and interactions among abiotic and biotic components of the ecosystem occur across multiple scales and are typically nonlinear (Boyce 1992; Holling 1992; Levin 1998; Wu and Marceau 2002). These characteristics can confound our understanding of ecosystem processes and limit our capacity to make predictions. Like all scientific results and inference, residual effects predictions will have uncertainty associated with the data and current knowledge of the system. The confidence in residual effect predictions is related to the following:

- adequacy of baseline data for understanding current conditions and future changes unrelated to the Project (e.g., climate change, catastrophic events);
- accuracy of the ELC;
- the understanding of Project-related effects on complex ecosystems that contain interactions across different scales of time and space (e.g., exactly how the Project will influence plant species); and
- knowledge of the effectiveness of the environmental design features (mitigation) for limiting effects on vegetation (e.g., revegetation of disturbed areas).

One source of uncertainty for the Project is the degree to which residual effects could occur (e.g., magnitude and duration). There is a high degree of confidence in that the Project will disturb plant populations and communities; however, it is not known what the rate of recovery or final plant community composition will be in the reclaimed areas. There are also uncertainties in the direction, magnitude, and spatial extent of future natural fluctuations in plant populations and communities, independent of residual effects from the Project. The identified sources of uncertainty affect the magnitude and duration components of predictions.

There is uncertainty associated with the ELC, because it was developed using satellite imagery. Uncertainty in the ELC was reduced using field ground-truthing and professional experience and judgement in the creation of the ELC. In general, the ELC represents an accurate interpretation of the landscape. The ELC map units were used to assess plant community abundance and distribution on the landscape and fragmentation, and were assigned listed plant species and traditional use plant potentials to approximate the residual effects on listed and traditional use plant species. Listed plant species habitat potential and traditional use plant potential were developed using field data and professional judgement, however uncertainty remains because each listed plant species or traditional use plant will have different habitat preferences and vulnerability.

Table 14.5-9: Net Change in Traditional Use Plant Habitat Potential in the Local Study Area during the Project

Traditional Use Plant Potential	Baseline		End of Construction[a]				Closure[b]	
	Area (ha)	Proportion of LSA (%)	Area following Construction (ha)	Net Change from Baseline (ha)	Net Change from Baseline (% unit)	Net Change from Baseline (% LSA)	Area following Closure (ha)	Net Change from Baseline (% LSA)
high	1,436	16.2	883	-553	-38.5	-6.2	1,161	-3.1
moderate/high	1,057	11.9	958	-99	-9.3	-1.1	1,004	-0.6
moderate	3,360	37.8	2,803	-557	-16.6	-6.3	3,094	-3.0
low	1,074	12.1	734	-340	-31.7	-3.8	839	-2.6
very low	1,939	21.8	1,876	-63	-3.3	-0.7	1,903	-0.4
unclassified	14	0.2	7	-7	-50.2	-0.1	10	<-0.1
Project Footprint	n/a	n/a	1,620	1,620	n/a	18.2	0	0
Reclaimed Vegetation	n/a	n/a	0	0	n/a	0	869	9.8

Note: the total area of the local study area is 8,881 ha
Unclassified is the result of Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique and did not fit into any of the other ELC map units. In addition, these areas could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified
A value <0.1 or <-0.1 approaches zero.
Negative numbers indicate a reduction or change in that traditional use plant species habitat potential. Positive numbers indicate an increase or gain in that traditional use plant species habitat potential
(a) based on disturbance assessment area
(b) based on actual predicted Project footprint
ha = hectares; % = percent; <= less than; LSA = local study area

Table 14.5-10: Net Change in Traditional Use Plant Habitat Potential in the Regional Study Area during the Project

Traditional Use Plant Potential	Baseline		End of Construction[a]				Closure[b]	
	Area (ha)	Proportion of RSA (%)	Area following Construction (ha)	Net Change from Baseline (ha)	Net Change from Baseline (% unit)	Net Change from Baseline (% RSA)	Area following Closure (ha)	Net Change from Baseline (% RSA)
high	18,488	16.0	17,935	-553	-3.0	-0.5	18,213	-0.2
moderate/high	6,442	5.6	6,344	-99	-1.5	-0.1	6,389	<-0.1
moderate	22,299	19.3	21,742	-557	-2.5	-0.5	22,033	-0.2
low	41,156	35.6	40,816	-340	-0.8	-0.3	40,921	-0.2
very low	27,164	23.5	27,101	-63	-0.2	-0.1	27,128	<-0.1
unclassified	50	0.0	43	-7	-14.3	<-0.1	46	<-0.1
Project Footprint	n/a	n/a	1,620	1,620	n/a	1.4	0	0
Reclaimed Vegetation	n/a	n/a	0	0	n/a	0.0	869	0.8

Note: the total area of the Regional Study Area is 115,600 ha

Unclassified is the result of Unclassified ELC map unit is the result of areas in the imagery where the spectral characteristics were unique and did not fit into any of the other ELC map units. In addition, these areas could not be placed in one of the above classes because no ground truth data were collected in these locations, therefore they remain unclassified

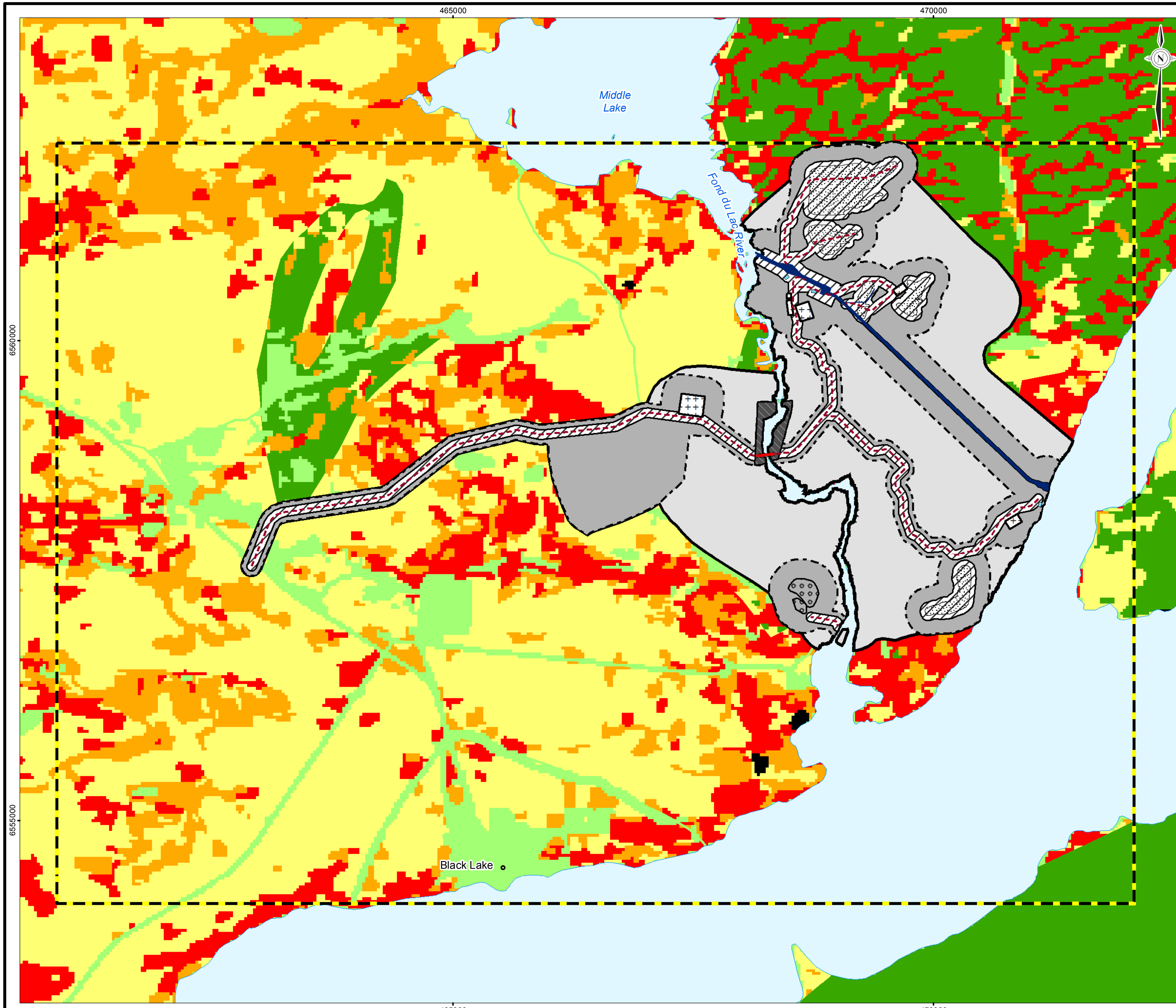
A value <0.1 or <-0.1 approaches zero.

Negative numbers indicate a reduction or change in that traditional use plant species habitat potential. Positive numbers indicate an increase or gain in that traditional use plant species habitat potential

[a] based on disturbance assessment area

[b] based on actual predicted Project footprint

ha = hectares; % = percent; <= less than; RSA = regional study area; n/a = not applicable



LEGEND

- HAMLET OR COMMUNITY
- WATERBODY
- TERRESTRIAL LOCAL STUDY AREA
- OPERATIONS FOOTPRINT
- PREDICTED PROJECT FOOTPRINT
- DISTURBANCE ASSESSMENT AREA

SPECIFIC CONSTRUCTION SITES

- POTENTIAL BRIDGE ALIGNMENT
- PERMANENT ROAD
- CONTRACTOR CAMP / LAYDOWN AREA
- BORROW AREA
- SETTLING POND
- SPOIL DISPOSAL AREA
- POTENTIAL BRIDGE ALIGNMENT AREA
- TUNNEL AND TAILRACE ALIGNMENT

TRADITIONAL USE PLANT HABITAT POTENTIAL

- HIGH
- MODERATE/HIGH
- MODERATE
- LOW
- VERY LOW
- UNCLASSIFIED

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
LANDSAT SCENE WAS ACQUIRED ON JUNE 24, 2010. THE CLASSIFICATION SHOWN HAS BEEN CREATED FROM THIS 30 METRE RESOLUTION LANDSAT SCENE.
SASKATCHEWAN FIRE HISTORY DATA OBTAINED FROM THE GOVERNMENT OF SASKATCHEWAN

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT

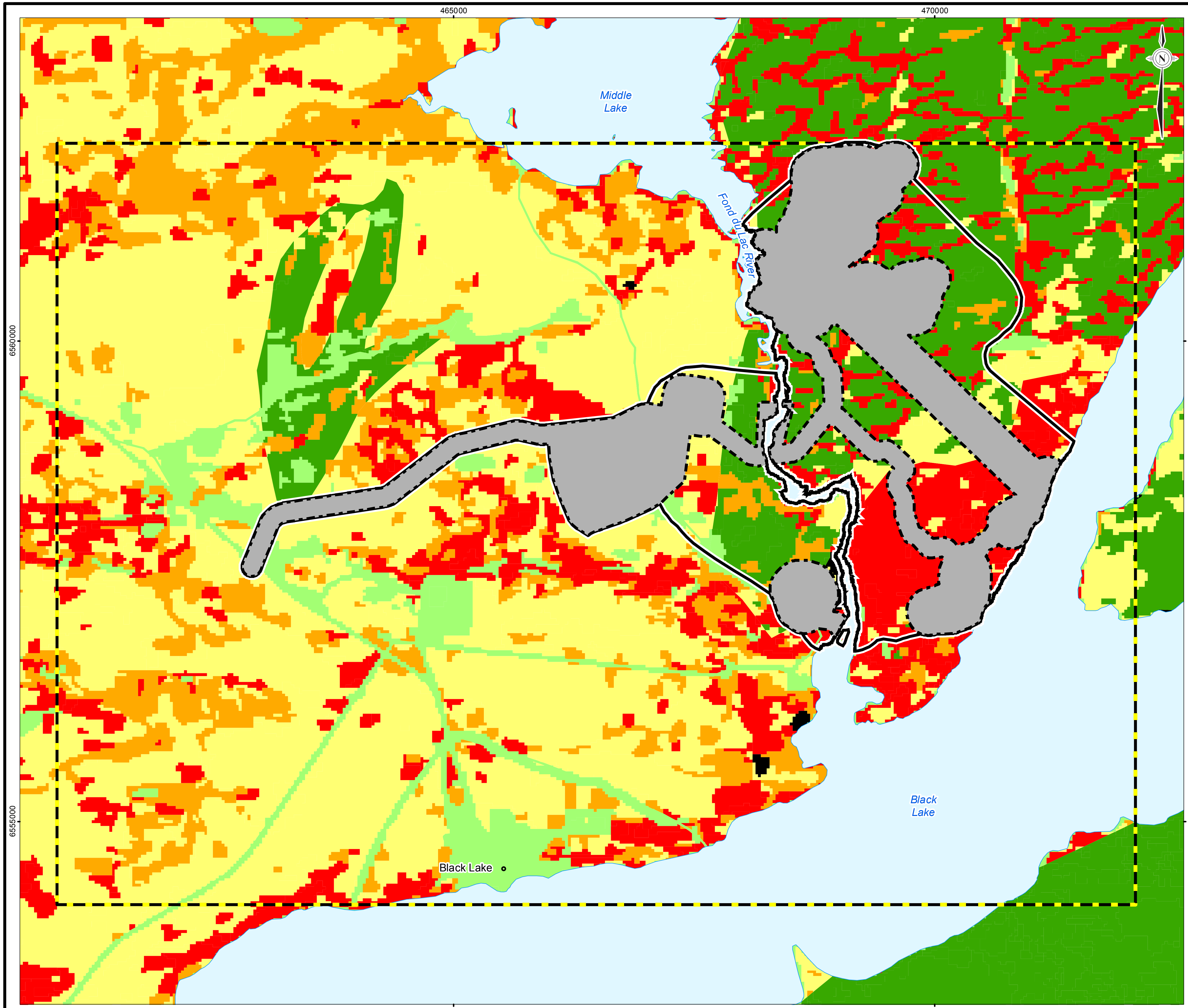
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

TRADITIONAL USE PLANT HABITAT POTENTIAL DURING CONSTRUCTION

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	06/11/13	FIGURE: 14.5-6
CHECK	JF	15/11/13	
REVIEW	MM	15/11/13	



LEGEND

- VILLAGE
- WATERBODY
- TERRESTRIAL LOCAL STUDY AREA
- DISTURBANCE ASSESSMENT AREA
- RECLAIMED

TRADITIONAL USE PLANT HABITAT POTENTIAL

- HIGH
- MODERATE/HIGH
- MODERATE
- LOW
- VERY LOW
- UNCLASSIFIED

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6
LANDSAT SCENE WAS ACQUIRED ON JUNE 24, 2010. THE CLASSIFICATION SHOWN HAS BEEN CREATED FROM THIS 30 METRE RESOLUTION LANDSAT SCENE.
SASKATCHEWAN FIRE HISTORY DATA OBTAINED FROM THE GOVERNMENT OF SASKATCHEWAN

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

TRADITIONAL USE PLANT HABITAT POTENTIAL FOLLOWING CLOSURE

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	06/11/13	**FIGURE: 14.5-7**	
CHECK	JF	15/11/13		
REVIEW	MM	15/11/13		

Tazi Twé Hydroelectric Project

Uncertainty was addressed in the assessment by incorporating information from available and applicable literature, and using past experience in similar areas. Conservative estimates were used so that residual effects were not underestimated. A conservative estimate of the Project footprint (1,620 ha) was used to assess changes to vegetation. The Project footprint that was used in the vegetation assessment is larger than the actual area expected to be disturbed during construction (approximately 869 ha) and larger than the anticipated Project footprint that will remain for the 90-year life of the Project (approximately 280 ha). In addition, conservative assumptions were used to rank the listed plant species and traditional use plant potential. Best management practices during construction, operations, and reclamation activities will be implemented to mitigate residual effects on vegetation.

14.6 Determination of Significance

The determination of significance considers all primary Project interactions that are expected to result in residual effects on plant populations and communities, after implementing environmental design features and mitigation. The classification of residual effects from primary interactions provides the foundation for determining environmental significance from the Project and other developments on self-sustaining plant populations and communities (including listed species). The main sources of residual effects are related to construction of the Project. Although, the changes to traditional use plants and traditional use plant habitat potential are presented in Section 14.5.1.4, the significance of the effects on traditional use species is discussed in Section 17.0 Land Use.

14.6.1 Residual Effects Criteria

The purpose of the residual effects classification is to describe the incremental and cumulative effects from the Project and other developments on VCs using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment. The following criteria are used to classify the residual effects from the Project in the EIS:

- direction;
- magnitude;
- geographic extent;
- duration;
- reversibility;
- frequency; and
- likelihood.

Definitions for each of the criteria for the determination of the significance of residual effects on vegetation used in this assessment are provided below and summarized in Table 14.6-1.

Direction: Direction indicates whether the residual effect on vegetation is negative (i.e., less favourable), positive (i.e., improvement), or neutral (i.e., no change). While the main focus of the residual effects assessment is to predict whether the development is likely to cause significant residual effects on vegetation or cause public concern, the positive changes associated with the Project also are reported. Neutral changes are not assessed.

Table 14.6-1: Effects Criteria Used in the Determination of Significance for Vegetation

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood
Negative: There is a less favourable change relative to baseline values or conditions **Positive:** There is an improvement over baseline values or conditions	**Negligible to Low:** There is no measurable residual effect on vegetation **Moderate:** The residual effect on vegetation is measurable, but is not predicted to alter the state of a self-sustaining plant population or community **High:** The residual effect is near or predicted to alter the state of a self-sustaining plant population or community	**Local:** Predicted maximum spatial extent of direct and indirect effects from the Project **Regional:** Project-specific effects exceed the local scale and can include cumulative effects from other developments in the RSA **Beyond Regional:** Effects from the Project and other developments extend beyond the RSA	**Short-term:** The residual effect is reversible at end of construction **Medium-term:** The residual effect is reversible at a defined length of time beyond construction following initial decommissioning and reclamation activities **Long-term:** The residual effect is reversible within a defined length of time beyond closure and final decommissioning and reclamation activities **Permanent:** The residual effect is irreversible	**Reversible:** The residual effect is reversible within a time period that can be identified when the Project no longer influences plant population or community processes (e.g., forest succession) and properties, stability and resilience) **Irreversible:** The residual effect is predicted to affect plant populations and communities indefinitely (duration is permanent or unknown)	**Isolated:** The residual effect is confined to a specific discrete period (i.e., construction) or Project activity **Periodic:** The residual effect occurs intermittently, but repeatedly over the temporal boundary of the assessment (95 years) **Continuous:** The residual effect will occur continually over the temporal boundary of the assessment (95 years)	**Unlikely:** The residual effect is possible but unlikely within the temporal boundary of the assessment (95 years; <10% chance of occurring) **Possible:** the residual effect is possible within a year, or a chance of occurring within the temporal boundary of the assessment (95 years) **Likely:** The residual effect is probable within a year, or at least a change of occurring in the next 10 years (>80% chance of occurring) **Highly Likely:** The residual effect is certain

RSA = regional study area; < = less than; > = greater than

Magnitude - Magnitude is a measure of the intensity of a residual effect, or the degree of change caused by the Project relative to baseline conditions. It is classified into three scales: negligible to low, moderate, and high. Because effects threshold levels on the abundance and distribution of plant populations and communities have not been estimated for the RSA, the magnitude of residual effects is assessed qualitatively for vegetation. Evaluating magnitude considers the residual effects on alter the state of a self-sustaining plant population and community and incorporated conservatism. For example, in cases where species life history traits, such as reproduction, seed production, and dispersal, and resiliency information was available, a qualitative evaluation was completed to determine if the response of the species and community to disturbance is large enough to cause a change in state of plant populations and communities from baseline conditions. Alterations in the physical environment (e.g., landscape connectivity), population processes (e.g., reproduction, dispersal), or population and community properties (e.g., resilience) can occur without a change in state of self-sustaining plant populations and communities.

For a change of state from baseline conditions to occur, the magnitude of alterations in the physical environment, population and community processes, and properties must be large enough so that there is a significant residual effect on self-sustaining plant populations and communities (including listed plants). The ecological characteristics of a particular plant population could provide it with the defences and adaptive capacity to withstand stresses associated with landscape change, which could include physical damage, changes in lighting levels and temperature, and increased competition. Alternately, species that are sensitive to change could respond by declining in abundance gradually or immediately. Where biological information was lacking for a species, general ecological principles are discussed in context of the magnitude of the residual effects from changes to the physical environment on vegetation. Quantitative measures (vegetation loss and fragmentation) of the change in the physical environment were determined to aid in assessing the magnitude of change.

Geographic Extent - Geographic extent refers to the spatial extent of the effect, and is different from the spatial boundary for the effects analysis (i.e., effects study area). The geographic extent of effects can occur on a number of scales within the effects study area. Geographic extent refers to the area affected, and is categorized into three scales of local, regional, and beyond regional. Effects at the local scale are largely associated with the predicted maximum spatial extent of combined direct and indirect effects from the Project (i.e., zone of influence). Effects at the regional scale are associated with incremental and cumulative changes from the Project and other developments. The beyond regional scale includes cumulative residual effects from the Project and other developments that extend beyond the RSA. The principle applied when using geographic extent to understand magnitude is that local effects from the Project are less severe than effects that extend to the regional or beyond regional scales.

Duration – Duration is defined as the amount of time (usually in years) from the beginning of a residual effect to when the effect on vegetation is reversed, and is expressed relative to Project phases. Duration has two components. It is the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases), plus the time required for the effect to be reversible. Essentially, duration is a function of the length of time that VCs are exposed to Project activities and reversibility.

Both the duration of individual events and the overall time frame during which the residual effect could occur are considered. Some residual effects could be reversible soon after the effect has ceased, while other residual effects could take longer to be reversed. By definition, residual effects that are short-term, medium-term, or long-term in duration are reversible.

In some cases, available scientific information and professional judgment could predict that the residual effect is irreversible. Alternately, the duration of the residual effect could not be known, except that it is expected to be extremely long and well beyond the temporal boundary of the assessment (95 years). As such, any number of factors could cause vegetation to never return to a state that is unaffected by the Project. In other words, science and logic predict that the likelihood of reversibility is so low that the residual effect is irreversible.

Reversibility - After removal of the Project activity or stressor, reversibility is the likelihood that the Project will no longer influence vegetation at a future predicted period in time. This term usually has only one alternative: reversible or irreversible. The period is provided for reversibility (i.e., duration) if a residual effect is reversible. Permanent residual effects are considered irreversible.

Frequency - Frequency refers to how often a residual effect will occur and is expressed as isolated (confined to a discrete period), periodic (occurs intermittently, but repeatedly over the temporal boundary of the assessment), or continuous (occurs continuously over the temporal boundary of the assessment). Frequency is explained more fully by identifying when the residual effect occurs (e.g., once at the beginning of the Project). If the frequency is periodic, then the length of time between occurrences, and the seasonality of occurrences (if present) is discussed.

Likelihood - Likelihood is the probability of an effect occurring and is described in parallel with uncertainty. Four categories are used: unlikely (residual effect is possible, but unlikely to occur within the temporal boundary of the assessment [95 years; less than 10% chance of occurring]), possible (residual effect is possible within a year, or a chance of occurring within the temporal boundary of the assessment [95 years], but is not certain), likely (residual effect is likely to occur or probable within a year, or at least a change of occurring in the next 10 years, and greater than 80% chance of occurring), and highly likely (the residual effect is certain).

14.6.2 Classification of Residual Effects

The residual effects were classified for the maximum possible spatial extent of disturbance at construction (disturbance assessment area) for conservatism. The classification of residual effects from the Project and previous and existing developments on vegetation is reported in Table 14.6-2.

Table 14.6-2: Summary of the Classification of Residual Effects on Vegetation

Residual Effect	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood
Direct loss, alteration, and fragmentation of vegetation from the Project footprint	Negative	Negligible to low for plant communities Moderate for listed plant populations	Local and Regional	Short-term (majority of construction footprint) Long-term (operations footprint)	Reversible (majority of construction footprint) Permanent (operations footprint)	Isolated (majority of construction footprint) Continuous (operations footprint)	Highly Likely

The LSA does not support isolated plant populations and communities that are endemic to the region. Effects from direct loss, alteration, and fragmentation of vegetation from the Project and previous and existing developments are expected to be of negligible to low magnitude (effects are anticipated to be not measurable or within baseline values) and highly likely to occur (Table 14.6-2). Overall, the Project was conservatively estimated to disturb 1.4% of the RSA during construction. Previous and existing developments (Existing Disturbance) have resulted in the loss and alteration of approximately 1% of vegetation in the RSA.

It is expected there will be a decrease of 0.1% to 39% in MDNN, relative to baseline conditions, with Recent Burn experiencing the greatest decrease in MDNN. A decrease in MDNN can be viewed as a positive effect as the distance between patches is becoming smaller. For example, an increase in the spatial distance between plant populations and pollinator habitat can result in a decrease in pollinator visitation and an increase genetic isolation of a plant population (Newman et al. 2013). Where this spatial distance is decreasing, it would have the opposite effect. It is expected there will be an increase in MDNN of less than 0.1% to 5%, with Regenerating Bedrock experiencing the largest change in MDNN.

The changes within each ELC map unit in the RSA are predicted to be less than 0.6%, with Regenerating Jack Pine, Spruce, and Jack Pine habitats experiencing the largest change (0.5%, 0.3%, and 0.2%, respectively). For those map units that have a limited abundance in the RSA, including Bedrock and Riparian, it was estimated that approximately 1% or less of the current abundance of these habitats will be lost. Bedrock was predicted to decrease in abundance by approximately 72% relative to baseline in the LSA (1% relative to the RSA). Regenerating Riparian was predicted to decrease in abundance by approximately 70%, relative to baseline in the LSA and RSA.

Less than 0.3% of habitats with high and very high listed plant potential area expected to be affected by the Project, and high and very high potential habitat is not unique to the areas expected to be disturbed by the Project (2% decrease in the current abundance). Approximately 0.5% of high traditional use habitat potential is expected to be affected, and high potential habitat is not unique to the areas expected to be disturbed by the Project (3% decrease in current abundance). Therefore, the magnitude of residual effects on plant communities is predicted to be negligible to low.

Existing S2 and S3 provincial listed vascular plant species are expected to be disturbed by the Project. An S2 designation indicates that this species is rare (6 to 20 occurrences in Saskatchewan or few remaining individuals). An S3 designation indicates that this species is rare to uncommon (21 to 100 occurrences in Saskatchewan; could be rare and local throughout the province or could occur in a restricted provincial range; could be abundant in places). Russet sedge was observed at the water intake location and Labrador lousewort was observed at the tailrace channel outlet. Limestone oak fern, ground fir, and hairy butterwort were observed at locations along the temporary access road alignments. One historical observation of Lake Huron tansy was documented in the LSA approximately 2.6 km outside of the Project footprint (listed as 'special concern' under COSEWIC [2013] and under *SARA* [2012a]); however, this species was not observed during the 2010 and 2012 field programs. In addition, listed lichen species are expected to be disturbed by the Project; however, these were not isolated to areas to be disturbed. The Project could affect the local listed plant species populations, but other suitable habitat is present in the RSA for these species. In addition, ground fir and the listed lichens were not isolated to the areas to be disturbed. With appropriate mitigation, it is expected that the residual effects of the Project to these populations will be moderate in magnitude (Table 14.6-2).

Not all areas within the disturbance assessment area will be disturbed during construction; therefore, these areas will remain the same as baseline. In addition, revegetation to a self-sustaining vegetation cover will be completed for the Project (Reclamation and Closure Plan; Section 5.5). The residual effect of the footprint required for operation (280 ha; less than 0.1% of the RSA) will be continuous over the life of the Project and permanent. The operations footprint and the effects on the environment from these changes are considered permanent because of the length of operations. The expected 90-year time period and likelihood that effects will be reversed is uncertain, particularly in an environment where natural succession processes are slow, and trajectories can be altered by a number of factors (e.g., climate change, fire, or unknown human development).

14.6.3 Significance of Residual Effects

The classification of residual effects from the primary interactions provides the foundation for determining environmental significance from the Project and other developments on self-sustaining plant populations and communities (including listed species). Magnitude, geographic extent, and duration (which include reversibility) are the principal criteria used to predict significance (FEARO 1994). Other criteria, such as frequency and likelihood are used as modifiers (where applicable) in the determination of significance. Significance is determined for the residual effect of the Project overall, as well as for the cumulative effects from the Project and previous and existing developments (there a currently no known reasonably foreseeable developments that overlap the spatial and temporal boundaries of the assessment [Section 14.5]).

Environmental significance is used to identify predicted effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to the abundance, distribution, and state of plant populations and communities. A number of high magnitude and long-term or irreversible effects at the population and community levels (beyond local scale) would likely be significant. Non-significant effects are strong enough to be detectable at the population and community levels, but are not likely to decrease resilience or alter the state and increase the risk to self-sustaining plant populations and communities.

In summary, the following information is used in the evaluation of the significance of residual effects from the Project on vegetation:

- results from the residual effects classification;
- magnitude, geographic extent, and duration of the effect as principal criteria, with frequency and likelihood as modifiers; and
- application of professional judgment and ecological principles, such as resilience, to predict the duration and associated reversibility of residual effects.

The residual effects from the Project and previous and existing developments are not predicted to be large enough to alter the state of plant communities and significantly influence self-sustaining plant populations and communities. The scale of residual effects from the Project interactions, independently or combined, should not be large enough to cause irreversible changes at the population level and decrease the resilience of plant populations and communities. Overall, the residual effects from the Project and previous and existing developments on vegetation VCs are predicted to be not significant.

14.7 Environmental Management, Monitoring, and Follow-up

Construction of the Project will lead to the direct loss and alteration of vegetation and other natural features. This includes changes to various types of forest cover and wetlands. These changes will predominantly occur during construction. Following construction and reclamation of temporary Project infrastructure, the footprint will be at a much smaller spatial extent. It is anticipated that monitoring of re-vegetation techniques and success will be required during the Project, but the objectives and methods of re-vegetation will need to be determined with input from regulators and the communities. Analyzing and assessing the success of re-vegetation techniques would provide input into the Reclamation Plan. Environmental monitoring would include surveys for weed species during construction and operation and the implementation of a Weed Management Plan if required.

Environmental monitoring data reporting will be undertaken as part of a comprehensive Monitoring and Follow-up Plan. The plan will provide flexibility for SaskPower and MOE to effectively identify and respond to unanticipated changes to habitat quality and quantity, to adapt to new regulatory frameworks such as the Saskatchewan Environmental Code, and to provide appropriate feedback required to improve future environmental assessments. It is anticipated that data reporting will occur yearly, with data analysis being undertaken every five years and communicated in the form of Status of the Environment Reports.

Follow-up programs are typically implemented when the accuracy of the determination of significance needs to be verified or the resulting residual effects cause sufficient public concern to warrant an increased effort to determine the accuracy of the predictions or test the effectiveness of the mitigation/compensation. There is no follow-up program anticipated for vegetation.

14.8 References

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14.9 Glossary

Term	Description
Acidification	The process of becoming acid or being converted into an acid.
Baseline	A surveyed or predicted condition that serves as a reference point to which later surveys are coordinated or correlated.
Bedrock	The body of rock that underlies gravel, soil or other material.
Biodiversity	The level of variety, or diversity, that exists in a natural system, especially the number of species. Biodiversity includes the number of ecosystem types and genetic variation, within species.
Bog	A peatland with weakly to moderately decomposed Sphagnum and forest peat material formed in oligotrophic environments. The bog surface is acidic and low in nutrients due to the slightly raised peat surfaces disassociating it from underlying and surrounding mineral rich soil waters.
Boreal forest	The northern hemisphere, circumpolar, tundra forest type consisting primarily of black spruce and white spruce with balsam fir, birch and aspen.
Bryophyte	Small herbaceous plants that lack the internal structure for transporting water and nutrients, which is characteristic of vascular plants. Includes mosses, liverworts, and hornworts.
Buffering capacity	The ability of a soil to resist changes in pH.
Calcareous	Soil containing sufficient calcium carbonate, often with magnesium carbonate, to effervesce visibly when treated with cold 0.1N hydrochloric acid.
Cation	An ion carrying a positive charge of electricity. The common soil cations are calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and hydrogen (H).
CCME guidelines	Canadian Council of Ministers of the Environment; body of Environment Canada that sets ambient guidelines for air, water, soil, and contaminants.
Climate	The prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, cloudiness, and winds, throughout the year, averaged over a series of years.
Disturbed land	Land that has experienced a significant change, usually as a result of human activity or natural processes such as erosion or fire.
Ecological landscape classification (ELC)	An ecological mapping process that involves the integration of site, soil, and vegetation information.
Ecoregion	Relatively homogeneous subdivisions of an ecozone, which are characterized by distinctive climatic zones or regional landforms.
Ecosystem	A relatively homogeneous area of organisms interacting with their environment.
Environmental Impact Statement (EIS)	A report that documents the information required to evaluate the environmental effect of a project.
Erosion	(i) The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. (ii) Detachment and movement of soil or rock by water, wind, ice, or gravity.
Fen	A fen is a peat-covered or peat-filled wetland with a high water table which is not hydrologically isolated and receives water from streams or groundwater.
Fen, Poor	And ecosite that is transitional between the fen and bog. A poor fen is intermediate in nutrient regime and similar floristic composition to fen and bog. Sedges and peat moss, golden and brown mosses composed the majority of the organic matter content.
Fen, Rich	A peatland with moderate to well-decomposed sedge, grass, and reed peat material from in eutrophic environments. Mineral-rich waters are at or are just above the fen surface.

Term	Description
Forb	An herbaceous vascular plant which is not a grass, sedge, or rush.
Forest, young seral	Forest containing early seral communities that are characterized by young and even-aged stands.
Forest, young climax	Forest with a stand composition that is typical of the climax forest expected for the location, but community structure has not yet developed and characterized by a young, even-aged stand with a uniform canopy height.
Forest, disclimax	Forest where the species composition of the area differs from that expected for the location.
Geographical information system (GIS)	A computer-based tool for analyzing, displaying and manipulating digital spatial data.
Graminoid	Grass-like in form.
Habitat	The physical location or type of environment in which an organism or biological population lives or occurs.
Herb	Any flowering plant except those developing persistent woody bases and stems.
Landform	A particular type of land formation.
Landscape	A heterogeneous land area with interacting ecosystems that are repeated in similar form throughout. From a wildlife perspective, a landscape is an area of land containing a mosaic of habitat patches within which a particular “focal” or “target” habitat patch is embedded.
Lichen	Composite organisms consisting of a fungus and a photosynthetic partner (e.g., green algae or cyanobacterium) growing together in a symbiotic relationship.
Local study area (LSA)	The area where direct effects and small-scale indirect effects from the Project are expected to occur. Occurs within the regional study area.
Lowlands	Areas with ground slopes of less than 0.5% and typically poorly drained.
Map unit	A combination of kinds of soil, terrain, or other feature that can be shown at a specified scale of mapping for the defined purpose and objectives of a particular survey.
Marsh	A mineral or a peat-filled wetland which is periodically inundated by standing or slowly moving water.
Microclimate	(i) The climate of a small area resulting from the modification of the general climate by local differences in elevation or exposure. (ii) The sequence of atmospheric changes within a very small region.
Microhabitat	The small-scale physical requirements of a particular organism or population.
Moisture regime	The relative moisture supply at a site available for plant growth.
Non-vascular plant	A general term for plants with no internal structure for transporting water and nutrients, and lack roots, stems, or leaves. Includes the bryophytes and algae.
Nutrients	Environmental substances (elements or compounds) such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.
Nutrient regime	The relative supply of nutrients available for plant growth at a given site.
Organic matter	Plant and animal materials that are in various stages of decomposition.
Parameter	A particular physical, chemical, or biological property that is being measured in a waterbody; whatever it is you measure in a waterbody.
Permafrost	Permanently frozen soil or rock and incorporated ice and organic material that remain at or below 0°C for a minimum of two years due to natural climatic factors (van Everdingen 1998). The occurrence of permafrost increases with latitude (i.e., more northern areas permafrost is continuous, and more southern areas patches of permafrost alternate with unfrozen ground).
Pioneer species	Plant species that are the first to establish in an area after a disturbance, such as fire or vegetation clearing. These species are typically fast growing and short lived.

Term	Description
Plant community	A collection of plants that live together on a relatively uniform area of land with a floristic composition and structure that is distinct from surrounding vegetation.
Polygon	A map delineation that represents a tract of land with certain landform, soil, hydrologic and vegetation features. The smallest polygon on a 1:50,000 scale map is about 0.5 cm^2 and represents a tract of about 12.5 ha.
Reclamation	The process of reconverting disturbed land to its former or other productive uses.
Regional study area (RSA)	A broad area defined for the description of vegetation conditions generally centred on the Project and surroundings, and including areas where indirect effects of the Project might be expected to occur. Includes the local study area.
Relative abundance	The number of organisms of a particular species as a proportion of the total number of organisms of a given habitat or defined area.
Riparian	(i) The interface between an upland area and a river or stream. (ii) the floodplain portion of a river or stream corridor.
Shrub	A woody perennial plant differing from a tree by its low stature and by generally producing several basal shoots instead of a single trunk.
Sediment	Solid particles of material that have been derived from rock weathering. They are transported and deposited from water, ice or air as layers at the earth's surface.
Soil	The naturally occurring, unconsolidated mineral or organic material at least 10 cm thick that occurs at the earth's surface and is capable of supporting plant growth. Soil extends from the earth's surface through the genetic horizons, if present, into the underlying material to the depth of the control section (normally about 1 to 2 m). Soil development involves climatic factors and organisms, conditioned by relief and water regime, acting through time on geological materials, and thus modifying the properties of the parent material (Agriculture Canada Expert Committee on Soil Survey 1987).
Soil macroorganisms	Invertebrates that live in the soil, and are generally visible to the naked eye. Many benefits of macroorganisms include helping to break down minerals, soil particles and nutrients. Examples include beetles, earthworms, and some nematodes.
Soil microorganisms	Any organism in soil which requires a microscope to observe. These organisms include bacteria, fungi, algae, and protozoa. Soil microorganisms are responsible for the breakdown of organic matter, conversion of inorganic compounds from one form to another, and the production of humus.
Species	(i) A group of organisms that actually or potentially interbreed and are reproductively isolated from all other such groups; (ii) a taxonomic grouping of genetically and morphologically similar individuals; (iii) the category below genus.
Species richness	The number of different species in a given area.
Swamp	Wooded mineral wetland or a peatland with standing water or water gently flowing through pools or channels that persist for long periods.
Taiga	A moist, circumpolar, subarctic biome dominated by coniferous species. The taiga is bound to the north by the tundra.
Terrain	The landscape or lay of the land. This term is considered to comprise specific aspects of the landscape, namely genetic material, material composition, landform (or surface expression), active and inactive processes that modify material and form, slope, aspect, and drainage conditions. Terrain analysis is the identification of the above land surface features, to a more or less defined depth and determining their areal extent. The identification of special features such as permafrost, erosion, and landforms indicating subsurface structures are included in such analyses.
Thermal regime, soil	Refers to the amount of heat available for plant growth and development during the growing period. Thermal regime also influences the presence or absence of permafrost.
Topography	The surface features of a region, such as hills, valleys, or rivers.

Term	Description
Topsoil	Uppermost layer of soil, usually the top 5 to 20 cm. It has the highest concentration of organic matter and microorganisms and is where most of the biological activity occurs. Plants generally concentrate their roots in and obtain most of their nutrients from this layer.
Traditional use plants	Plant species that were or are currently used for food, medicinal, spiritual, or technical/trade (i.e., tools or products for use or trade) purposes by First Nations and Métis people.
Tundra	An area between the polar icecap and taiga that is characterized by a lack of trees and permanently frozen subsoil.
Upland	Areas that have typical ground slopes of 1 to 3% and are better-drainage.
Vascular plant	Higher-order plants that have internal structure for transporting water and nutrients. Includes flowering plants, conifers, fern, clubmosses, horsetail. Does not include mosses or algae.
Vegetation	A term to describe all of the plants or plant life of a place.
Weed	A plant that is undesirable in its current location. For example, weedy species in an agricultural field could include native plants, while crop and forage plants are considered weeds in native habitat.
Weed, Invasive	Invasive weeds are typically introduced plants that have the capacity to markedly alter plant communities or displace native plants, reduce biodiversity, and can cause economic damage to private and public lands. These species are aggressive competitors for moisture, nutrients and light, and typically do not have predators or pathogens.
Weed, Prohibited	Any plant, as defined by the *Weed Control Act* 2010, that is designated by order of the minister as a prohibited weed, and includes the seeds or any other part of that plant that could grow to produce another plant.
Weed, Noxious	Any plant, as defined by the *Weed Control Act* 2010, that is designated by order of the minister as a noxious weed, and includes the seeds or any other part of that plant that could grow to produce another plant.
Weed, Nuisance	Any plant, as defined by the *Weed Control Act* 2010, that is designated by order of the minister as a nuisance weed, and includes the seeds or any other part of that plant that could grow to produce another plant.
Wildlife	A term to describe all undomesticated animals living in the wild.
Zone of influence	The defined area affected by alterations or disturbances from sensory disturbance that could have an effect on wildlife abundance and distribution.

14.10 List of Acronyms

Acronym	Definition
ALUPIAP	Athabasca Land Use Interim Advisory Panel
ARD	acid rock drainage
CCME	Canadian Council of Ministers of the Environment
DFO	Fisheries and Oceans Canada
DVI	detailed vegetation inventory
EIS	Environmental Impact Statement
ELC	ecological landscape classification
EnvPP	Environmental Protection Plan
GIS	Geographic Information System
KPI	Key Performance Indicator
LSA	local study area
MDNN	mean distance to nearest neighbour
ML	metals leaching
MSDS	Material Safety Data Sheets
NRCS	Natural Conservation Service
Project	Tazi Twé Hydroelectric Project
RSA	regional study area
SDCDC	Saskatchewan Conservations Data Centre
TDG	Transportation of Dangerous Goods
TIV	turbine inlet valves
USDA	United States Department of Agriculture
VC	valued components
WHMIS	Workplace Hazardous Material Information System

14.11 List of Units

Term	Definition
%	percent
ha	hectares
km	kilometre
km^2	square kilometre
L/day	litres per day
m	metre
m^2	square metres
m^3	cubic metres
m^3/s	cubic metres per second

15.0 WILDLIFE

15.1 Introduction

The purpose of the wildlife section is to describe the terrestrial environment that could be affected by the Tazi Twé Hydroelectric Project (Project) and to assess the effects on wildlife. The scope of the wildlife section includes an analysis of Project-related changes during construction, operations, and closure, and considers accidents, malfunctions, and unplanned events. The overall residual effects from the Project and potential for cumulative residual effects from the Project and previous, existing, and reasonably foreseeable developments on wildlife are also assessed.

Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples, and the public. The value of a component relates to its role in the ecosystem and to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development, and therefore, are used to predict the effects of the Project on all environmental components. Rationale for selection of wildlife as a VC is discussed below.

Given the large number of species that could potentially interact with the Project, it is neither possible, nor necessary to attempt to measure effects on all possible receptors. Thus, VCs are identified as surrogates to focus or structure the environmental effects assessment, with the understanding that effects on other components of the environment would be similar. For example, assessing the effects from the Project on increases in harvest pressure on furbearer populations using American marten is expected to provide similar results for black bear, wolverine, and lynx occupying the study area. Valued components can include an aspect of the biophysical environment (e.g., air or water quality), specific animals or plants (e.g., American marten), or specific habitat types (e.g., wetlands). Eight terrestrial wildlife VCs were identified and used in assessing the effects of the Project on wildlife (Table 15.1-1).

The assessment endpoint is the key property that should be protected for use by future human generations and for wildlife considers the maintenance of self-sustaining wildlife populations (including listed species). The measurement endpoints are quantifiable and qualitative expressions of change to the assessment point, and for wildlife include the relative abundance and distribution of wildlife species, habitat quantity and fragmentation, habitat quality, and survival and reproduction.

15.2 Spatial Boundaries

To quantify baseline conditions and assess Project-related effects on the terrestrial environment, a regional study area (RSA) and a local study area (LSA) were defined for all terrestrial components (soil and terrain, vegetation, and wildlife).

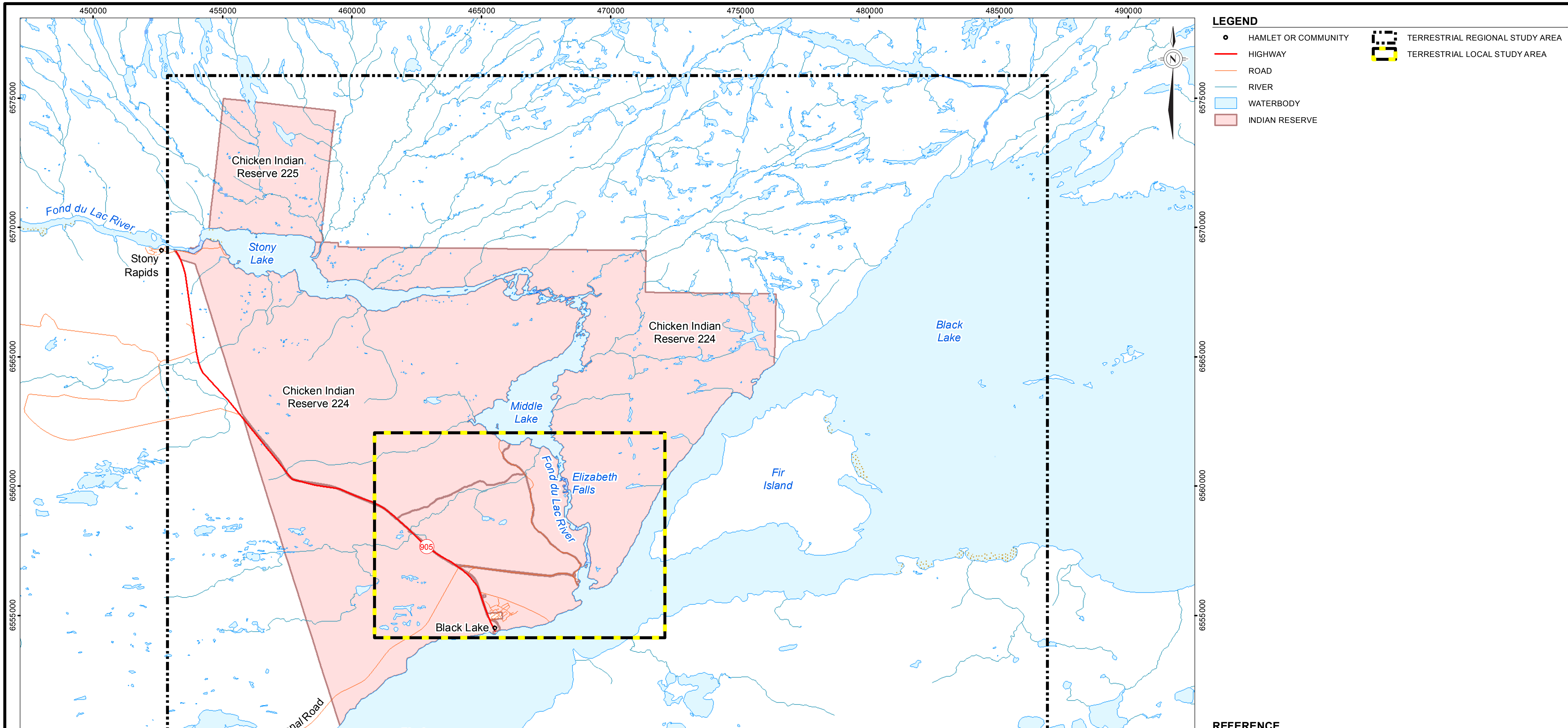
The LSA is approximately 89 square kilometres (km^2) (8,881 hectares [ha]), and includes the Project infrastructure and the main access road (Figure 15.2-1). The LSA was based on the predicted direct and small-scale indirect effects from the Project on the terrestrial environment. Direct effects on wildlife include removal of wildlife habitat from the Project footprint. Small-scale indirect effects include changes to wildlife habitat from dust deposition, air emissions, and surface water levels and flows. For species with small home ranges, such as upland breeding birds, the LSA could contain habitat that is capable of supporting all requirements necessary for the survival and reproduction of individuals, including forage, cover, and breeding habitat.

The Project is located in an area with a relatively low level of human-related disturbance. The area north of the main body of Black Lake and the Fond du Lac River currently has no human-related disturbances, except for isolated fishing camps and cabins. The community of Black Lake is located approximately 7 kilometres (km) southwest of the Project and the Northern Hamlet of Stony Rapids is located about 25 km northwest. Camp Grayling is a fishing camp located approximately 2.5 km south of the Project. Other human-related disturbances near the Project include small developments (less than 8 ha), such as old gravel and borrow pits, cabins, and linear features such as all-terrain vehicle and snowmobile trails. Highway 905, an all-season road, connects the communities of Black Lake and Stony Rapids.

Table 15.1-1: Rationale for Selection of Wildlife Valued Components

Group	Valued Component	Rationale
Ungulates	Woodland caribou	■ Extensive range requirements. ■ May be affected by disturbance. ■ Prey species for large carnivores in boreal forest environments. ■ Important cultural species. ■ Considered "rare to uncommon" in Saskatchewan, and ranked as "threatened" by COSEWIC and *SARA*.
	Barren-ground caribou	■ Extensive range requirements. ■ May be affected by disturbance. ■ Prey species for large carnivores in boreal forest environments. ■ Important cultural species.
	Moose	■ Large home range size. ■ Important subsidence and cultural species. ■ Prey species for large carnivores.
Furbearers	Beaver	■ Valued economic species. ■ Important prey species for large and medium-sized carnivores. ■ Tolerant of human activities but could be affected by habitat loss. ■ May be affected by changes to water levels.
	American marten	■ Valued economic species. ■ Mid-trophic predator in boreal ecosystems.
Migratory Birds	Upland breeding birds	■ Small territory size means large numbers of upland birds could be affected by habitat loss. ■ Migratory birds are susceptible to population declines because of changing environmental conditions on breeding and overwintering habitats. ■ Some species are tracked in Saskatchewan, and listed as "special concern" and "threatened" federally.
	Waterbirds	■ May be affected by loss of shoreline habitat for breeding. ■ Important staging habitat could also be lost. ■ Can be sensitive to noise disturbance and human activity. ■ Some species are important for subsistence. ■ Some species are tracked in Saskatchewan, and are listed as "special concern" federally.
	Bald eagle	■ Breeding habitat is limited. ■ Can be sensitive to noise disturbance and human activity during nesting. ■ May be affected by changes to water levels, as species is piscivorous. ■ Tracked species in Saskatchewan.

COSEWIC = Committee on the Status of Endangered Species in Canada; *SARA = Species at Risk Act*



PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATION OF THE LOCAL AND REGIONAL STUDY AREAS FOR WILDLIFE

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	06/11/13	FIGURE: 15.2-1	
CHECK	LD	15/11/13		
REVIEW	ME	15/11/13		

The RSA selected for wildlife consisted of a 1,156 km^2 (115,600 ha) area centered on the Project (Figure 15.2-1). The RSA was selected based on the predicted spatial extent of the combined direct and indirect effects on wildlife from the Project.

Direct effects from the Project include mortality to individuals from physical hazards (e.g., infrastructure and vehicle collisions) and physical changes to terrain and soils, vegetation and surface water (i.e., wildlife habitat) from the Project footprint, which occur mostly at the local scale. Indirect effects from the Project could extend beyond the immediate Project footprint (i.e., sensory disturbances such as noise, lights, and smells, and other factors that can indirectly influence the environment at a distance). Most wildlife VCs are highly mobile and can interact with other human activities near the Project. Effects from human-related sensory disturbance on bird and mammal populations can extend over 1 km and 5 km, respectively (Benitez-Lopez et al. 2010). The RSA boundary is at least 8 km from the Project and should encompasses unaffected (i.e., reference) areas and areas influenced by the Project and other human activities.

The RSA is predicted to be large enough to assess the ecologically relevant effects on wildlife populations from the Project, coupled with previous, existing, and reasonably foreseeable developments. Here, a population (or population area) is defined by a group of individuals of the same species occupying an area of sufficient size so that changes in abundance and distribution are largely determined by reproduction and survival (Berryman 2002). For wildlife VCs with small to moderate breeding ranges (e.g., beaver, marten, upland breeding birds, and raptors), the population should be primarily affected by natural and human-related factors that change reproduction and survival of individuals in the RSA. For VCs with large ranges, such as caribou and moose, the RSA could be occupied seasonally or annually by a number of individuals from the population or metapopulation. Analysis of incremental and cumulative effects from the Project and other developments to caribou and moose that could use the RSA is expected to be sufficient to determine effects on the larger population.

15.3 Existing Environment

The purpose of this section is to describe the existing population status and distribution of wildlife VCs species within the RSA, with a focus on the LSA, as a basis to assess the potential Project-specific effects on wildlife. The detailed methods and results for the baseline surveys are located in Section 5.0 of Annex IV.

15.3.1 Provincial and Federal Listed Species

For the purpose of this report, listed species includes all species that are designated as ”at risk”, ”rare”, ”endangered”, ”threatened”, ”special concern”, or otherwise tracked by federal and provincial conservation legislation, documents, and databases such as:

- the Saskatchewan Conservation Data Centre (SKCDC 2012a);
- the Saskatchewan *Wildlife Act* (1998);
- the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2012, 2013);
- the *Species at Risk Act* (*SARA* 2012a); and
- the Species at Risk Public Registry (*SARA* 2012b).

Prior to field programs, an inventory of listed species that are known to occur or have potential to occur within the RSA was compiled using federal and provincial status documents and databases, and provincial tracking lists. Another search of federal and provincial status databases was completed in 2013 and species statuses were updated if required. Only the COSEWIC (2013) database had been updated in 2013 at the time this report was completed.

There are 28 provincial and federal listed species that have the potential to occur in the RSA. A total of three provincially tracked, two COSEWIC-recommended, and one *SARA*-listed species were observed during wildlife baseline surveys in 2012 (Appendix IV.3, Table IV.3-2). In addition, some swan individuals that could not be identified to species were recorded as unknown swan species. Both trumpeter swan (*Cygnus buccinator*) and tundra swan (*C. columbianus*) are tracked by the province of Saskatchewan (SKCDC 2012a).

15.3.2 Woodland Caribou

15.3.2.1 Population Status and Distribution

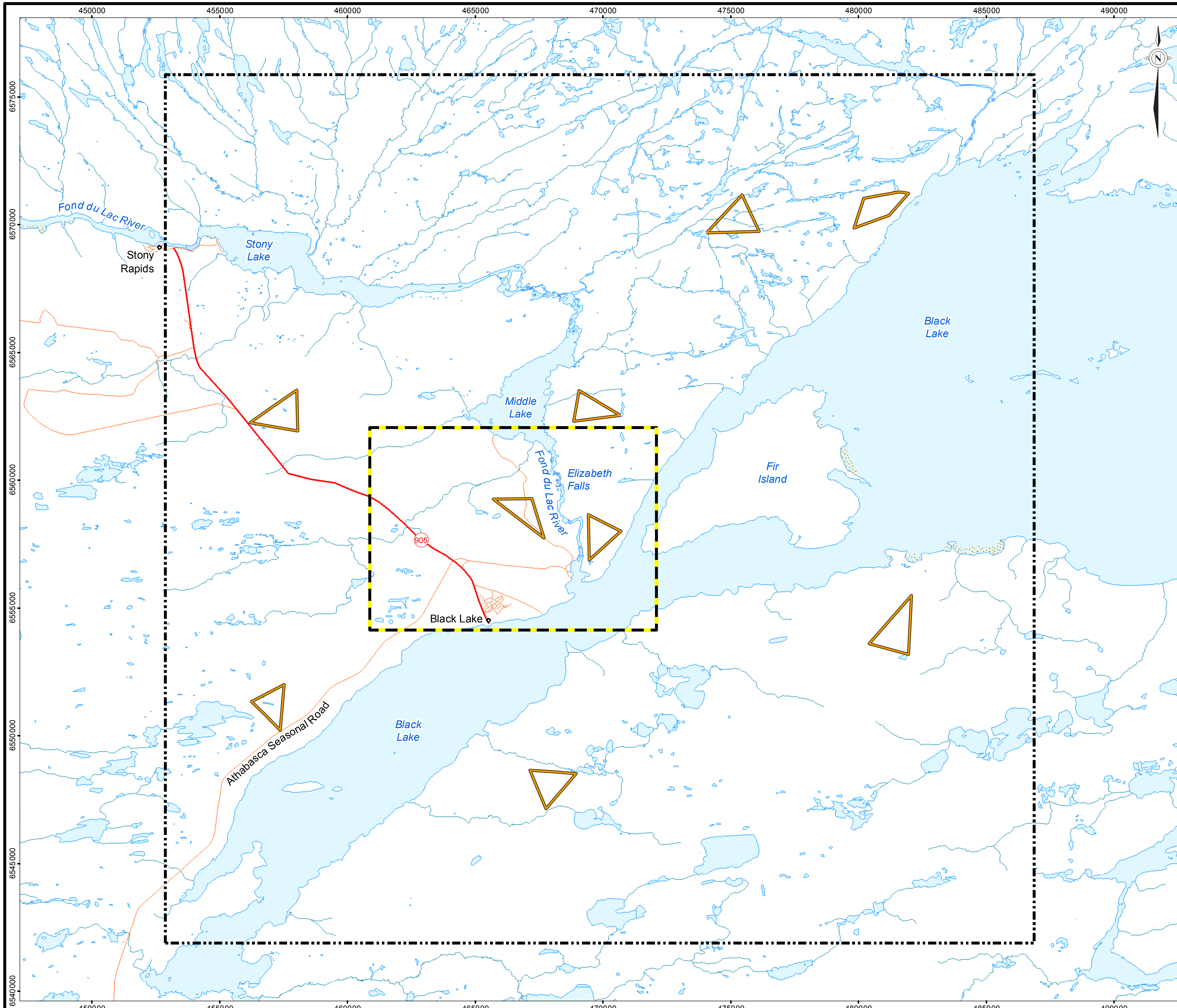
Estimates of woodland caribou (*Rangifer tarandus caribou*) occurrence, abundance, and distribution in the RSA were determined from winter track count (WTC) surveys and ungulate aerial surveys. Nine transects (5.1 to 7.3 km in length) were established in the RSA. Each transect was surveyed twice, once between January 7 and 17, 2012 and once between February 16 and 19, 2012 (Figure 15.3-1). The length of WTC surveys equalled 48 km over eight habitat types.

Habitats surveyed during the WTC surveys were combined when appropriate to increase sample sizes within habitat types; thereby, creating a more robust statistical analysis. This resulted in eight habitat types (Ecological Landscape Classification [ELC] map units) used for analysis, including Wetland, Recent Burn, Deciduous, Jack Pine, Jack Pine/Black Spruce, Regenerating, Spruce, and Open Water (Ice). These habitat types deviated from the ELC classification by the grouping of Regenerating habitat into one category for this analysis, because of insufficient sample sizes within the individual regenerating habitat types.

Ungulate aerial surveys were completed on January 15, 2012 and again on February 20, 2012. Transects were 30 km in length and were spaced 3.7 km apart (Figure 15.3-2). Transect specific density (number of individuals/km^2) for ungulates was estimated by dividing the total number of individuals of a species observed on a transect by the transect area. This process was repeated for each transect (n = 8) to approximate mean density and standard error of ungulates observed during the survey. The estimated number of ungulates within the RSA was calculated by dividing the number of individuals observed by the proportion of the RSA surveyed.

No woodland caribou were observed in the RSA during any wildlife surveys. The nearest known woodland caribou conservation unit is located approximately 30 km south of the Project (SKCDC 2013). The only sign of caribou that was found during terrestrial baseline surveys was decades-old caribou antlers (disintegrating and encrusted with lichen). Woodland caribou are considered highly unlikely to be present in the RSA based on local knowledge, provincial information, and baseline surveys.

Most woodland caribou populations have declined in recent years (COSEWIC 2002). The boreal ecotype of woodland caribou is listed as ”rare/uncommon” in Saskatchewan (SKCDC 2012a) and “threatened” by COSEWIC (2013) and *SARA* (2012b). Woodland caribou are distributed across the forested and mountainous regions of Canada, reaching the northern limit of their range in the Northwest Territories (NWT; COSEWIC 2002). Woodland caribou do not have definitive calving grounds similar to barren-ground caribou, although individual females often show fidelity to previous calving sites (Edmonds and Smith 1991; Dzus 2001). Instead, pregnant females separate themselves from other caribou for calving.



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- WINTER TRACK COUNT TRANSECT
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6

5 0 5
SCALE 1:150,000 KILOMETRES

PROJECT

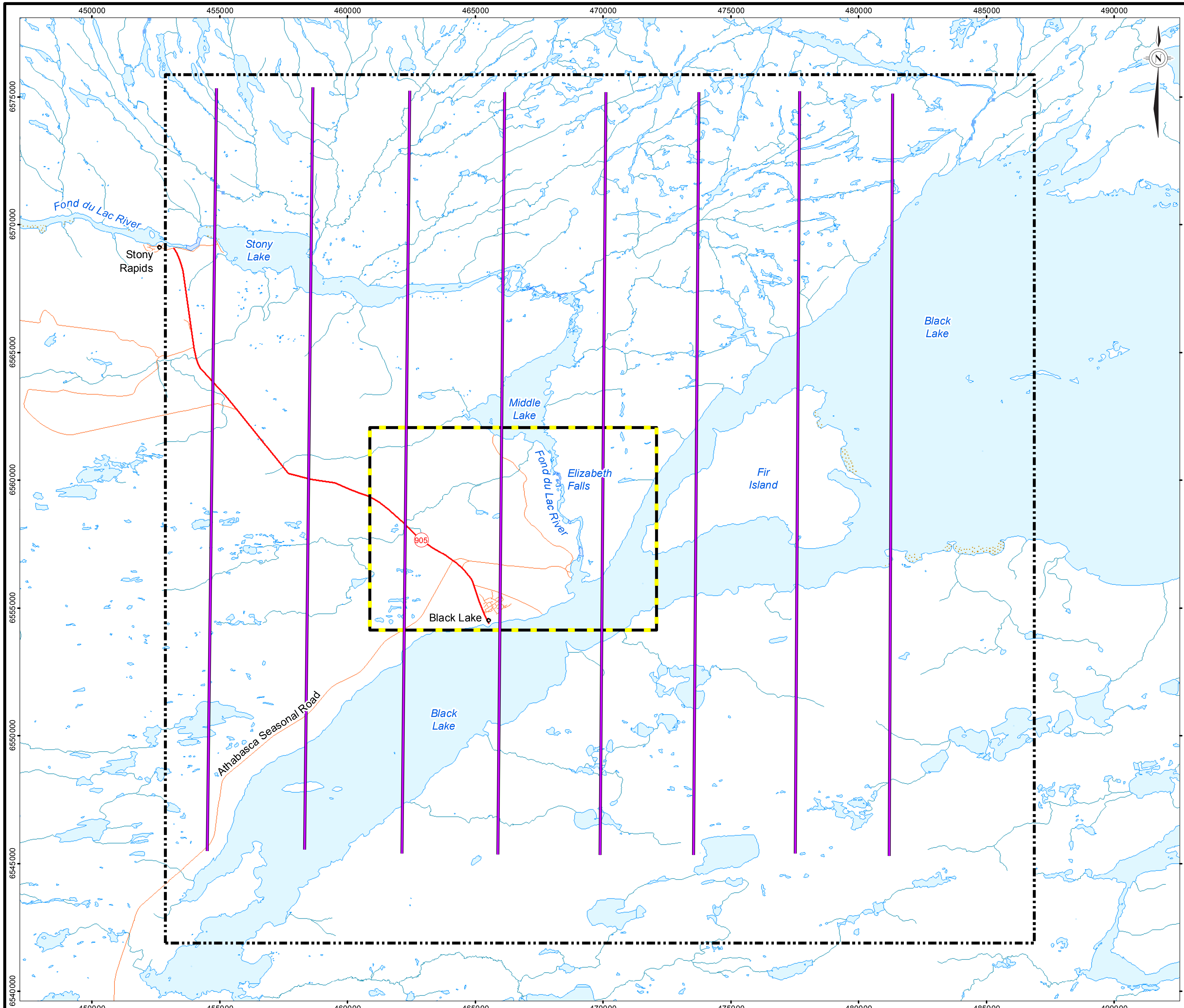
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATION OF WINTER TRACK COUNT SURVEY TRANSECTS, 2012

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	06/11/13	**FIGURE: 15.3-1**
CHECK	LD	15/11/13	
REVIEW	ME	15/11/13	



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- UNGULATE AERIAL SURVEY TRANSECT
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6

5 0 5

SCALE 1:150,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATION OF UNGULATE AERIAL SURVEY TRANSECTS, 2012

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004	FILE No.
DESIGN		SCALE AS SHOWN REV. 0
GIS	SM 06/11/13	
CHECK	LD 15/11/13	
REVIEW	ME 15/11/13	

FIGURE: 15.3-2

The woodland caribou boreal population was estimated to be 34,000 in the boreal region of Canada in 2000 to 2002 (COSEWIC 2002) and 32,000 in 2011 (Environment Canada 2012b). However, population numbers and trends for woodland caribou in Canada are poorly known; low densities, large land area, and multiple jurisdictions inhibit accurate population estimates. The life history of boreal woodland caribou gives insight into their population declines because of their solitary occurrence (i.e., low densities to reduce predation) and low fecundity (i.e., cows typically do not reproduce until three years of age and have only one calf per year; COSEWIC 2002; Environment Canada 2012b). Their need for large tracts of mature to old-growth coniferous forests (COSEWIC 2002) is a limiting factor for population growth. There are two populations of boreal woodland caribou in Saskatchewan; the northern population in the boreal shield is considered to be of unknown size and sustainable while the southern boreal plains population is ranked as not sustainable (Environment Canada 2012b). There are an estimated 5,000 boreal woodland caribou in Saskatchewan with approximate densities of 3.0 to 3.5 caribou/100 km^2 in preferred habitat (COSEWIC 2002). Range sizes for female tracked caribou in Saskatchewan's boreal plains ranged from 208 to 1,240 km^2 among five populations studied from 1993 to 1996 (Rettie and Messier 2001).

15.3.2.2 Habitat Selection and Foraging

The sedentary ecotype of woodland caribou is not migratory and remains in forested habitats year round (Dzus 2001). The woodland caribou rut occurs in early- to mid-October (Edmonds and Bloomfield 1984). In November, woodland caribou disperse into smaller groups throughout their annual home range (Dzus 2001). When snow depth increases, caribou tend to move into areas of higher tree cover since movement and feeding are easier in these areas (Fuller and Keith 1981).

Foraging behaviour, energetics, survival, and reproduction of woodland caribou populations can be influenced by many environmental factors. Deep, crusted snow can affect energy expenditure and food accessibility for caribou (Stuart-Smith et al. 1997). Extreme winter conditions can influence access to food and result in lower calf weights, delayed parturition, or starvation, which influences calf survival (Skogland 1984; Adamczewski et al. 1987; Cameron et al. 1993; Dzus 2001). Female nutrition status from summer to winter also affects pregnancy rate and parturition rate (Dzus 2001). Caribou recruitment (Environment Canada 2008), distribution (Schaefer and Pruitt 1991; Dunford 2003; Joly et al. 2003; Vors et al. 2007; Courtois et al. 2007; Schaefer and Mahoney 2007; Dalerum et al. 2007), and persistence (Schaefer and Mahoney 2007; Vors et al. 2007; Wittmer et al. 2007; Sorenson et al. 2008) are negatively affected by the level of disturbance (anthropogenic and burned) within caribou ranges.

15.3.3 Barren-ground Caribou

15.3.3.1 Population Status and Distribution

Estimates of barren-ground caribou (*Rangifer tarandus groenlandicus*) occurrence, abundance, and distribution in the RSA were determined from WTC surveys and an ungulate aerial surveys (Section 15.3.2). The only sign of caribou found during terrestrial baseline surveys was decades-old caribou antlers (disintegrating and encrusted with lichen).

Barren-ground caribou are primarily distributed throughout Arctic areas in North America, where they spend the summers on the tundra but enter the boreal forest during the winter. During the preceding 15 years, seven of the eight Arctic caribou herds present in the NWT have declined (Porcupine, Cape Bathurst, Bluenose East, Bluenose West, Bathurst, Beverly, and Qamanirjuaq) (Fisher et al. 2009; BQCMB 2008, 2009). Of the eight barren-ground caribou herds that inhabit the NWT, four herds have the potential to occur in northern Saskatchewan (i.e., Beverly, Qamanirjuaq, Bathurst, and Ahiak herds) (Gunn et al. 2011). Barren-ground caribou are tracked in Saskatchewan (SKCDC 2012a) but are not listed under COSEWIC (2013) or *SARA* (*2012*a).

Recent surveys indicate that the Bathurst herd has decreased by approximately 93% between 1986 and 2009 (from approximately 472,000 individuals to 31,900 individuals) (Adamczewski et al. 2009; Fisher et al. 2009). This herd appears to be stabilizing based on the survey completed in 2010 (ENR 2011).

Beverly herd size was estimated at 276,000 in 1994 but has demonstrated a large decline in recent years. Surveys indicated that the number of breeding cows on the calving grounds declined from 5,737 in 2004 to 93 in 2008 (BQCMB 2008). This decline has been attributed to the herd shifting its calving distribution from the traditional grounds to the Queen Maud Gulf area (Nagy et al. 2011). Some cows could have joined the Ahiak herd. Surveys of the Beverly herd calving grounds in 2008 found that for every 100 cows there was estimated to be only 15 calves (BQCMB 2008). This is far below the usual 80 calves per 100 cows.

The Ahiak herd has not been well studied or managed in the past due to its calving ground location and range overlap with the Bathurst and Beverly herds (Gunn et al. 2011). In 1986, the herd was estimated to be 11,265 increasing to 83,164 in 1996 and 123,226 in 2006. There was a 60% decline in the size of the herd found on the calving grounds from 2006 to 2009; however, there was an increase in numbers on the calving ground in 2010 (ENR 2011).

The size of the Qamanirjuaq herd was considered low in the 1980s but increased to 496,000 caribou in 1994 (Gunn et al. 2011). Since then there has been a slight decrease to 348,000 in 2008 although the calf to cow ratio decreased from 42 calves to 100 cows in 1996 to less than 20 calves for 100 cows between 2006 and 2008 (BQCMB 2011).

The number of animals in barren-ground caribou herds cycles at relatively regular intervals, for example, 30 to 60 years (Zalatan et al. 2006). Although these natural fluctuations in herd size appear to be linked to changes in climatic patterns and winter range quality (Gunn 2009, Vors and Boyce 2009, Ferguson and Messier 2000; Weladji and Holand 2003), the exact mechanisms responsible for generating these population cycles are unknown.

Although there were no observations of barren-ground caribou in the RSA during the 2012 wildlife baseline surveys, reports from tracking of satellite-collared caribou from the four herds have indicated their proximity to the RSA in the past. In 2001, caribou from the Bathurst herd were recorded approximately 17 km north of the RSA (Stimson 2009). Satellite tracking data from 2004 and 2006 indicate that some of the Ahiak herd was recorded 89 km north of the RSA and some of the Beverly herd was recorded 62 km north of the RSA. In the winter of 1979, the Beverly herd overwintered in northern Saskatchewan (Thomas et al. 1998). In the winter of 2004 to 2005, the Qamanirjuaq herd was radio–tracked into northeastern Saskatchewan near Wollaston Lake (BQCMB 2005).

The Beverly and Qamanirjuaq herds' ranges include part of northern Saskatchewan (BQCMB 2011). The recent increase in surveys of the Ahiak herd has indicated that its range extends into northern Saskatchewan (Gunn et al. 2011). However, these herds have recently decreased their winter migration into northern Saskatchewan and southern NWT (BQCMB 2011). Barren-ground caribou hunting is managed in northern Saskatchewan, but only within wildlife Management Zone (WMZ) 76, which borders the NWT (Saskatchewan Ministry of Environment [MOE] 2009). Caribou from the Qamanirjuaq and Beverly herds are often hunted near Wollaston Lake in northeastern Saskatchewan and near Selwyn Lake on the Saskatchewan NWT border (MOE 2009).

15.3.3.2 Habitat Selection and Foraging

A number of natural large-scale environmental factors can influence the foraging behaviour, energetics, survival, and reproduction of caribou populations. Food abundance and quality on summer and winter ranges are important elements in barren-ground caribou population dynamics (Reimers 1983; Skogland 1990; Post and Klein 1999). Snow conditions, such as depth and hardness, also affect the movement rate and food accessibility for caribou (Stuart-Smith et al. 1997). Extreme weather events, such as late spring snowfall or late snowmelt, can influence access to food and result in lower calf weights or delayed parturition (i.e., births), which influences survival of young (Skogland 1984; Adamczewski et al. 1987; Cameron et al. 1993). High insect abundance can also decrease forage intake, milk production, calf growth, and calf survival (Helle and Tarvainen 1984; Russell et al. 1998). Factors that influence adult female food intake from summer through winter also determine pregnancy rate and parturition rate. A complex interaction exists between habitat, caribou foraging, and movement patterns that is not well understood for caribou herds. For example, studies of caribou have shown that the historical cumulative effect of overgrazing on calving, summer, or winter ranges can result in periodic range shifts and large population fluctuations (Messier et al. 1988; Ferguson and Messier 2000).

Variation in barren-ground caribou movement and distribution occurs within and among years, and for different populations. Caribou population numbers naturally fluctuate, and caribou expand their range when populations increase and limit their distribution when populations decrease (Banfield and Jakimchuk 1980; Bergerud et al. 1984; Heard and Calef 1986). Although the precise timing and location of barren-ground caribou movements between winter ranges and calving grounds are unpredictable, general corridors and the broad timing of movements are known.

Barren-ground caribou migrate from wintering grounds in the boreal forest, north to calving grounds in the tundra. Pregnant cows lead the northern migration in late winter/early spring, followed by juveniles and bulls (Miller 1992). After calving, cows and calves begin to migrate back to the winter range. As spring turns into summer, the cows meet up with the bulls that have continued to travel north (ENR 2013). In August and September, the caribou move across the tundra towards the treeline. The rut occurs in October, and can last for two to three weeks. The distribution of barren-ground caribou changes constantly during the winter as they search for places where the food is abundant and the snow is the shallowest (ENR 2013). When spring arrives, the caribou once again begin their migration to the calving grounds.

15.3.4 Moose

15.3.4.1 Population Status and Distribution

Estimates of the occurrence, abundance, and distribution of moose in the RSA were determined from WTC surveys and an ungulate aerial survey (Section 15.3.2). Moose tracks were highest in deciduous habitat during the WTC surveys (Table 15.3-1; Appendix IV.3, Table IV.3-7). Single tracks accounted for 100% winter track observations of moose. Two moose (i.e., one adult and one calf) were incidentally observed during waterbird breeding surveys in June 2012 (Appendix IV.3, Table IV.3-5).

Moose density (± 1SE) during the aerial surveys was estimated to be similar in January (0.06 ± 0.04/km^2) and February (0.07 ± 0.02/km^2). Calf density was similar between the two survey periods (0.01/km^2 in January and 0.02 ± 0.01/km^2 in February). Adult density was similar between survey periods (0.05 ± 0.03/km^2 in January and 0.05 ± 0.02/km^2 in February). Moose were observed 17 times during aerial surveys (11 groups consisting of 1 to 3 individuals) (Appendix IV.3, Table IV.3-8).

Table 15.3-1: Moose Snow Track Density among Habitats within the Regional Study Area, 2012

Habitat Type	Sample Size	Mean TKD (± 1SE)	Total TKD	Distance Sampled (km)
Wetland	19	0	0	2.26
Recent Burn	7	0	0	1.74
Deciduous	8	0.42 ± 0.30	3.33	21.70
Jack Pine	50	0.17 ± 0.16	8.30	6.74
Jack Pine/Black Spruce	20	0.28 ± 0.27	5.65	0.50
Regenerating	5	0	0	4.09
Spruce	19	0.21 ± 0.12	3.90	1.09
Open Water (Ice)	3	0	0	9.70
Total	**131**	**N/A**	**21.18**	**47.81**

TKD = Number of tracks per kilometre surveyed per days since last snow fall/wind event; km = kilometre; N/A = not applicable; SE = standard error

Moose populations in Saskatchewan are ranked as common (SKCDC 2013) and moose are not listed federally (*SARA* 2012b; COSEWIC 2013). Moose range across all of Saskatchewan from the Boreal Shield and Boreal Forest in the north to the Aspen Parkland and prairies of the south (MOE 2009). There are an estimated 50,000 moose in Saskatchewan (MOE 2009). The area with the highest density of moose is the mixedwood section of the Boreal Forest; however, densities in the Aspen Parkland and prairies to the south have been increasing (MOE 2009). Moose density in similar habitat in Ontario from 1990 to 1995 was estimated to be 0.209 moose/km^2 (McKenney et al. 1998).

Moose cows usually select areas near small ponds and marshes for calving. Stenhouse et al. (1994) found that mean annual home range for cows in the Mackenzie Valley, NWT was 174 km^2 (± 31 km^2, n = 29). This home range estimate was larger than those reported for adult moose in other parts of North America (Stenhouse et al. 1994), which might indicate that forage abundance was lower (Mace et al. 1984; Risenhoover 1986).

Moose are primarily threatened by direct and indirect habitat loss, altered predator/prey relationships, and hunting. Their primary predators are wolves and bears, which most often kill calves, although adults can become prey (Ballard and Van Ballenberghe 1997). Predation and snow conditions are interrelated factors that can affect moose survival and recruitment (Telfer and Kelsall 1984, Dussault et al. 2005). When snow is deep, moose gather in areas of shallow snow, which increases predation risk from wolves. In addition, snow depth of over 80 centimetres (cm) greatly hinders their movements and reduces the availability of suitable browse species above the snowpack (Hundertmark et al. 1990).

15.3.4.2 Habitat Selection and Foraging

Optimal moose habitat consists of deciduous shrub and ground layers within deciduous, mixed, and conifer forests that offer edge or disturbed areas of early successional vegetation (Poole and Stuart-Smith 2003; Osko et al. 2004). Deciduous browse is a primary food source, varying from twigs and bark in the winter, to leaves in the spring and summer (URSUS Ecosystem Management Ltd. and Komex International Ltd [URSUS and Komex] 1997). During the spring, moose tend to seek out low elevation areas, usually wetlands, muskeg lowlands, and river floodplains, as this is typically where the first green-up occurs (Stelfox 1993). Moose obtain most of their annual salt requirements from pond lilies and aquatic vegetation (Stelfox 1993). They tend to continue to use these areas in the summer periods when they will also feed in adjacent forest stands.

Moose are positively influenced by wildfire because fire increases the availability of deciduous browse species that moose depend on throughout the winter (MacCracken and Viereck 1990; Collins and Helm 1997). Moose densities were found to be greatest in 10- to 26-year old burned areas (Maier et al. 2005). Moose occupation of burned areas will vary with fire intensity, as severely burned areas will have scarce vegetation growth for up to five years (Gasaway et al. 1989).

During summer, moose use upland forests and eat fresh shoots and leaves from deciduous shrubs and young deciduous trees (mainly trembling aspen and balsam poplar). However, they are known to browse on young coniferous trees, such as balsam fir (*Abies balsamea*), in the summer, if available. Moose diet in summer is typically made up of 74 percent (%) shrubs and trees, 25% forbs, and 1% graminoids (Rednecker 1987). During the fall and winter, moose typically prefer habitats where adequate browse is available. Preferred fall and winter browse includes red-osier dogwood (*Cornus sericea*), dwarf birch (*Betula pumila*), alder (*Alnus* spp.), beaked hazelnut (*Corylus cornuta*), willow species, trembling aspen, and balsam poplar, among others (Stelfox 1993). To access this forage, habitats with high cover of shrub species, such as shrubby fens and bogs and riparian habitats with open canopies, are preferred, particularly in late winter. Shrub height is important during winter conditions, as forage shrub species must be higher than the snowpack to be accessed by moose and other ungulates.

15.3.5 Beaver

15.3.5.1 Population Status and Distribution

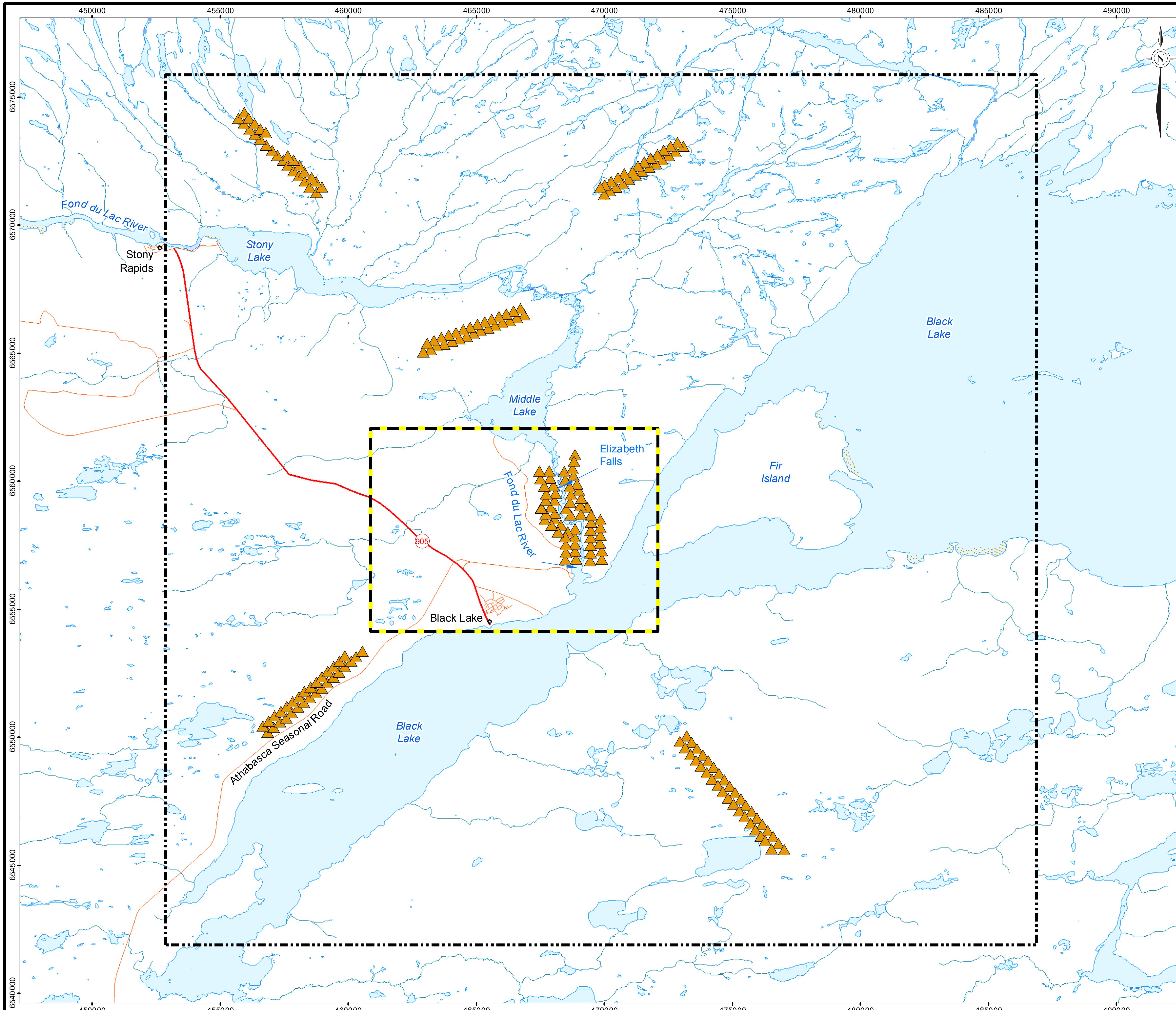
Beaver (*Castor canadensis*) observations were recorded in the LSA and RSA in conjunction with waterbird breeding and productivity surveys. While observers were flying waterbird transects, they recorded beaver sightings, as well as evidence of beaver activity (e.g., lodges and dams) for all wetlands located within 200 metres (m) of observers. Incidental observations of beavers and beaver activity were recorded during other baseline surveys in 2012. Two beavers and ten lodges and dams were observed during the waterbird breeding surveys on June 1, 2012 (Figure 15.3-3; Appendix IV.3, Table IV.3-5).

Beavers are commonly found in forested and non-forested areas throughout North America (Jenkins and Busher 1979). Beaver populations are currently stable, and are considered to be widespread, abundant, and secure across North America. Beaver are not listed by COSEWIC (2013) or *SARA* (2012a) and are "very common" in Saskatchewan (SKCDC 2012b).

In the 2008-2009 and 2009-2010 trapping seasons, beaver were the second most harvested animal in the Northern Fur Conservation Area (NFCA), by total value and number of pelts marketed (MOE 2010, 2011). Beavers were ranked as 'abundant' in the NFCA in both the 2008-2009 and 2009-2010 seasons, according to trapper questionnaire surveys. The Project is located in the N-80 Fur Management Zone (FMZ) in the NFCA of Saskatchewan. No beaver pelts were sold in the N-80 FMZ in the 2008-2009 season; however, nine beaver pelts were sold in the N-80 FMZ in the 2009-2010 season.

15.3.5.2 Habitat Selection and Foraging

Beavers require deep water to prevent their lodge entrances from freezing during the winter. In areas where water levels are low, beavers build dams to provide a constant water depth. In areas where water is naturally deep, lodges are built on lake or river margins (Allen 1983). Reductions of water flows in stream or rivers can expose lodge entrances and food caches, which can leave beavers vulnerable to predation (Boyle and Owens 2007). Increased flows could flood lodges or wash away lodges, dams, and food caches.



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- UPLAND BREEDING BIRD POINT COUNT STATION
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6

5 0 5
SCALE 1:150,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATION OF UPLAND BREEDING BIRD POINT COUNT SURVEYS, 2012

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	06/11/13	**FIGURE: 15.3-3**	
CHECK	LD	15/11/13		
REVIEW	ME	15/11/13		

Beavers are herbivores and can forage up to 100 m from riparian areas (Boyle and Owens 2007). Beavers eat the leaves, twigs, and bark of woody plants, as well as many species of aquatic and terrestrial herbaceous vegetation (Allen 1983). Diet will vary seasonally. Trembling aspen (*Populus tremuloides*), willow (*Salix* spp.), balsam poplar (*Populus balsamifera*), and alder (*Alnus* spp.) are preferred in the summer, while conifers and the rhizomes and roots of aquatic vegetation are important food sources during the winter. Beavers cache food to sustain them through the winter months.

15.3.6 American Marten

15.3.6.1 Population Status and Distribution

The presence and relative abundance of American marten (*Martes americana*) were determined from WTC surveys in the RSA (Section 15.3.2). Fisher (*Martes pennanti*) and American marten tracks are difficult to distinguish, as there is size overlap between male marten and female fisher; therefore, tracks for these species were combined in the analysis. The number of tracks was standardized by the number of days since last snowfall, as snowfall influences the visibility of snow tracks. The adjusted track density (TKD) was the number of tracks per km sampled per number of days since last snowfall to the nearest half-day. Mean adjusted track densities (with associated standard error) are presented for each habitat type. These calculations were completed to determine the relative activity level of American marten within habitats in the RSA.

One marten was incidentally observed during the breeding bird survey (BBS) in May 2012. Fisher and marten tracks were recorded in all of the eight habitat types during WTC surveys in 2012 (Table 15.3-2; Appendix IV.3, Table IV.3-6). Open Water (Ice) and Regenerating habitats had the highest track densities; however, these densities have a high variance due to the small sample size associated with these habitat types. Jack Pine habitat had the next highest track density. Single tracks accounted for 100% of winter track observations.

Table 15.3-2: Fisher and American Marten Snow Track Density among Habitats within the Regional Study Area, 2012

Habitat Type	Sample Size	Mean TKD (± 1SE)	Total TKD	Distance Sampled (km)
Wetland	19	0.37[(a)]	7.08	2.26
Recent Burn	7	0.84 ± 0.55	5.91	1.74
Deciduous	8	0.38 ± 0.29	3.04	21.70
Jack Pine	50	1.56 ± 0.50	78.08	6.74
Jack Pine/Black Spruce	20	1.16 ± 0.39	23.27	0.50
Regenerating	5	1.86 ± 1.12	9.31	4.09
Spruce	19	1.49 ± 0.66	28.28	1.09
Open Water (Ice)	3	4.63 ± 3.48	13.88	9.70
Total	**131**	**N/A**	**168.86**	**47.81**

(a) Only mean reported because species was only observed once in habitat type.
TKD = number of tracks per kilometre surveyed per days since last snow fall/wind event; km = kilometre; N/A = not applicable; SE = standard error

Historically, marten have been trapped for fur in North America, and populations have declined since European contact (Buskirk and Ruggiero 1994). Marten are not a provincial (SKCDC 2012a) or federal (*SARA* 2012a, b; COSEWIC 2013) listed species. Marten are the most important fur-bearing species in the RSA; 78 and 122 pelts were sold in the N-80 FMZ during the 2008-2009 and 2009-2010 seasons, respectively (MOE 2010, 2011). A total of 3,739 and 3,186 marten pelts were sold in the NFCA in the 2008-2009 and 2009-2010 season, respectively. The monetary value of these pelts comprised 43% and 40% of the total monetary value in this area for the 2008-2009 and 2009-2010 seasons, respectively.

Martens breed between July and August and the young are born in March or April of the following year (Strickland et al. 1982). Marten occupy larger home ranges than would be expected for a mammal of their size (Buskirk and Ruggiero 1994). Adult males occupy ranges of 0.8 to 45 km^2, and adult females occupy ranges of 0.42 to 27 km^2 (Mech and Rogers 1977; Burnett 1981; Latour et al. 1994; Smith and Schaefer 2002). Marten home ranges vary as a function of geographic area, habitat type, and prey density (Soutiere 1979; Thompson and Colgan 1987). Marten movements have not been rigorously studied, and reports on the dispersal period ranges from August to October (Buskirk and Ruggiero 1994). There is no information on the dispersal distance in juveniles or adults.

15.3.6.2 Habitat Selection and Foraging

Marten have been classified as requiring late succession forests and are intolerant of habitat types with sparse canopy cover (Buskirk and Ruggiero 1994; Chapin et al. 1997; Smith and Schaefer 2002). Some studies suggest that marten are closely associated with late-succession mesic conifer forests that have complex physical structure near the ground (Buskirk and Ruggiero 1994). However, other studies suggest that requirements of canopy cover and structure near the ground can be met in a variety of habitat types (Chapin et al. 1997).

Fire can provide a mosaic of habitats for marten to use throughout various life stages (Nelson et al. 2008). Marten do use burned areas, but burned habitat is avoided relative to its availability on the landscape (Latour 1994). Non-breeding individuals were found in higher densities in six- to nine-year old burn versus mature sites; however, breeding individuals were only found in low densities in recently burned areas (Paragi et al. 1996; Fisher and Wilkinson 2005). Non-breeding individuals could be responding to the high density of microtine prey species that can be found in burned areas (Nelson et al. 2008).

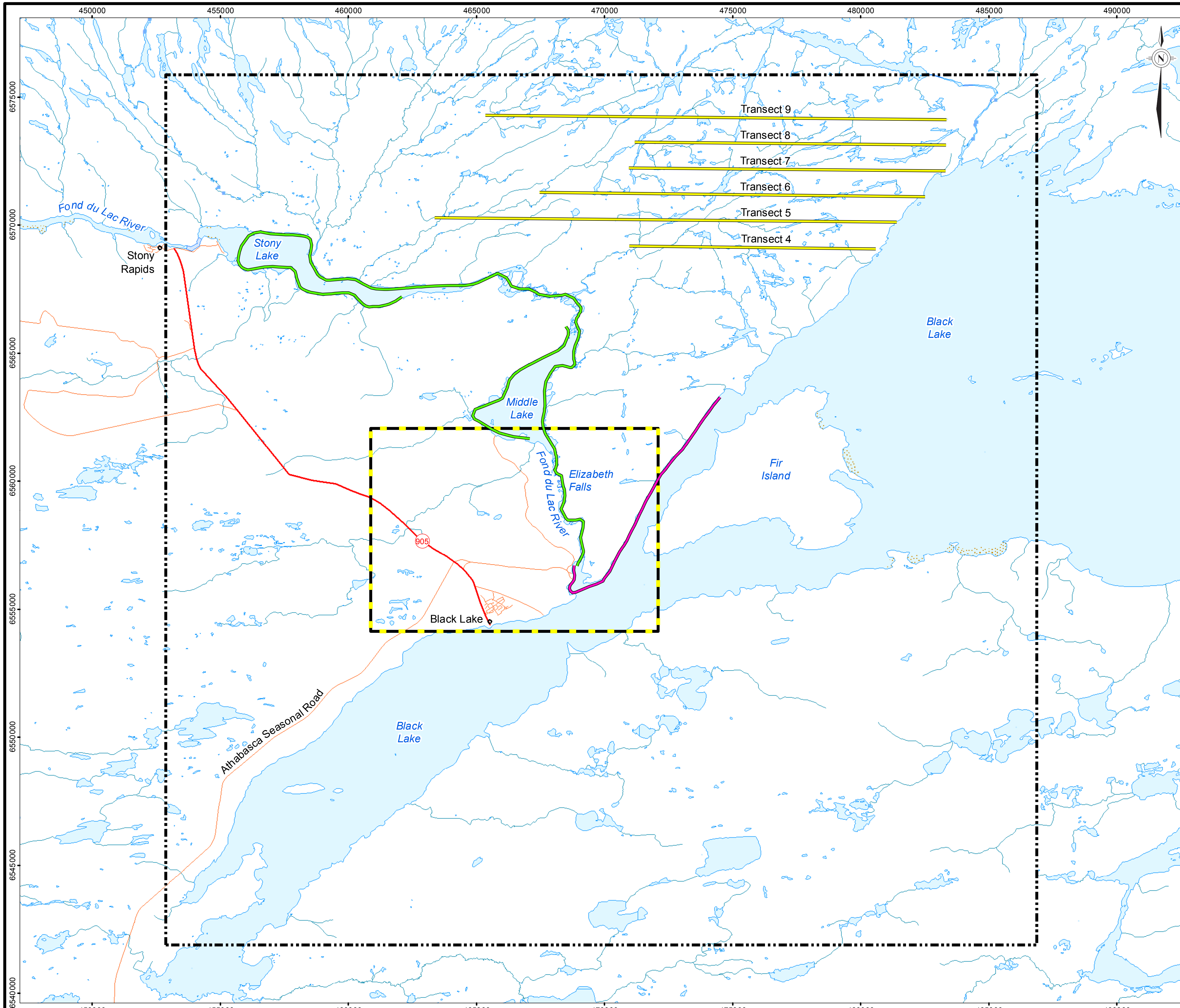
Although there is little information available on denning sites that are preferred by marten, especially in western and northern North America, studies have reported marten to be highly selective of sites used for denning. Marten have separate denning sites for parturition and raising their young with both den types found only in old-growth forest (Ruggiero et al. 1998). Burns might not provide adequate denning habitat for marten.

Marten diet varies seasonally. In summer, marten eat bird eggs and nestlings, insects, fish, and small mammals. Their winter diet is more restricted and is comprised of small to medium-sized mammals. Snowshoe hare is an important prey species for marten and can consist of 3% to 64% of marten diet by biomass (Poole and Graf 1996). Marten diet, body fat, ovulation rates, and juvenile recruitment vary with snowshoe hare density.

15.3.7 Upland Breeding Birds

15.3.7.1 Population Status and Distribution

Upland breeding birds include ptarmigan, grouse, shorebirds, woodpeckers, nighthawks, and songbirds (Order Passeriformes excluding common raven [*Corvus corax*]). A point-count upland BBS was used to determine local occurrence, relative abundance, and richness of bird species within habitat types found in the RSA. A total of 211 point count plots were surveyed across eight terrestrial habitat types between May 30 and June 9, 2012 (Figure 15.3-4). Community density and individual species densities were determined using the effective detection radius (Buckland et al. 2001). Community species richness was determined from bird species recorded within 50 m of the observer.



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA

SURVEY TRANSECT

- BLACK LAKE
- FOND du LAC RIVER
- NORTHEASTERN RSA

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6

5 0 5

SCALE 1:150,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

LOCATIONS OF WATERBIRD BREEDING AND PRODUCTIVITY AERIAL SURVEY TRANSECTS, 2012

Tazi Twé
Hydroelectric Project

PROJECT		10-1365-0004	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM	06/11/13	**FIGURE: 15.3-4**
CHECK	LD	15/11/13	
REVIEW	ME	15/11/13	

Ptarmigan and grouse tracks were also recorded during WTC surveys (Section 15.3.3.1). Rock ptarmigan (*Lagopus muta*) and willow ptarmigan (*Lagopus lagopus*) tracks were combined for analysis, as were sharp-tailed grouse (*Tympanuchus phasianellus*), spruce grouse (*Falcipennis canadensis*), and ruffed grouse (*Bonasa umbellus*) tracks because of the difficulty in distinguishing among species.

Species Level Results

A total of 48 bird species were observed in 211 survey plots across eight different habitat types (Appendix IV.3, Table IV.3-1). This included incidental upland bird observations (i.e., birds recorded as outside of 50 m from the plot center).

One olive-sided flycatcher (federal listed species) was incidentally observed outside the 50 m point count area in Recent Burn habitat during the BBS. No other listed upland breeding bird species were recorded during wildlife surveys.

Thirty-six upland bird species were identified within 50 m of the observers. Densities for these upland bird species were calculated individually for each habitat. American redstart (*Setophaga ruticilla*) was only detected in Wetland habitat, while Nashville warbler (*Oreothlypis ruficapilla*) was only recorded in Jack Pine habitat. Yellow-bellied sapsucker (*Sphyrapicus varius*) and Wilson's warbler (*Wilsonia pusilla*) were only observed in deciduous habitat. Northern flicker (*Colaptes auratus*), tree swallow (*Tachycineta bicolor*), cedar waxwing (*Bombycilla cedrorum*), red crossbill (*Loxia curvirostra*), winter wren (*Troglodytes troglodytes*), and white-crowned sparrow (*Zonotrichia leucophrys*) were observed only in Recent Burn habitat. No bird species were determined to be unique to Regenerating, Mixedwood Forest, Jack Pine/Black Spruce, or Spruce habitats. Hermit thrush (*Catharus guttatus*), palm warbler (*Setophaga palmarum*), yellow-rumped warbler (*Setophaga coronata*), dark-eyed junco (*Junco hyemalis*), and chipping sparrow (*Spizella passerina*) were observed in all habitat types. Yellow-rumped warbler was the most abundant species in Deciduous, Jack Pine, Regenerating, Mixedwood Forest, Jack Pine/Black Spruce, and Spruce habitats, while dark-eyed junco was the most abundant species in Recent Burn habitat. Dark-eyed junco and palm warbler were the most abundant species in Wetland habitat.

Grouse showed a preference for coniferous habitats in the RSA. Track density was highest in Jack Pine/Black Spruce and second highest in the Wetland habitat type. Single tracks accounted for 100% of the winter track observations. Ptarmigan tracks and were recorded in all eight habitat types. Track density was highest in Deciduous habitat type; however, there was a high variance associated with this estimate due to a small sample size. Track densities were second highest in Jack Pine/Black Spruce habitat type. Single tracks accounted for 97% of the winter track observations, while trails and networks accounted for 1%, and 2%, respectively.

Community Level Results

Relative abundance of bird species (birds per hectare) was calculated for each habitat type. Jack Pine habitat had the highest mean density of birds (Table 15.3-3). Species richness was highest in Regenerating Jack Pine and Spruce habitat. Recent Burn and Jack Pine/Black Spruce habitats had the lowest species abundance and richness of the surveyed habitats.

Mean abundance of birds in Jack Pine and Recent Burn habitats were significantly different from each other ($F_{7,203}$ = 3.42, P <0.01; Tukey-Kramer Honestly Significant Difference [HSD] P ≤0.05). No statistical difference was detected between Wetland, Deciduous Forest, Mixedwood Forest, Jack Pine/Black Spruce, Regenerating Jack Pine, and Spruce habitats types based on bird density.

Table 15.3-3: Density (birds/hectare) and Observed Species Richness of Upland Birds for Habitats in the Regional Study Area, 2012

Habitat Type	Number of Plots	Density		Species Richness	
		Mean ± 1SE	Min – Max	Mean ± 1SE	Min – Max
Wetland	28	1.98 ± 0.26	0 - 5.42	2.50 ± 0.30	0 - 6
Recent Burn	46	1.27 ± 0.13	0 - 4.06	1.78 ± 0.16	0 - 4
Deciduous Forest	31	1.51 ± 0.16	0 - 3.39	2.10 ± 0.22	0 - 5
Jack Pine	32	2.24 ± 0.24	0 - 5.42	2.44 ± 0.21	0 - 5
Mixedwood Forest	15	2.03 ± 0.30	0 - 4.06	2.47 ± 0.35	0 - 5
Jack Pine/Black Spruce	23	1.44 ± 0.20	0 - 4.06	1.83 ± 0.24	0 - 5
Regenerating Jack Pine	15	2.12 ± 0.22	0.68 - 3.39	2.60 ± 0.25	1 - 5
Spruce	21	1.97 ± 0.27	0 - 4.74	2.57 ± 0.31	0 - 5

SE = standard error; Min = minimum; Max = maximum

15.3.7.2 Habitat Selection and Foraging

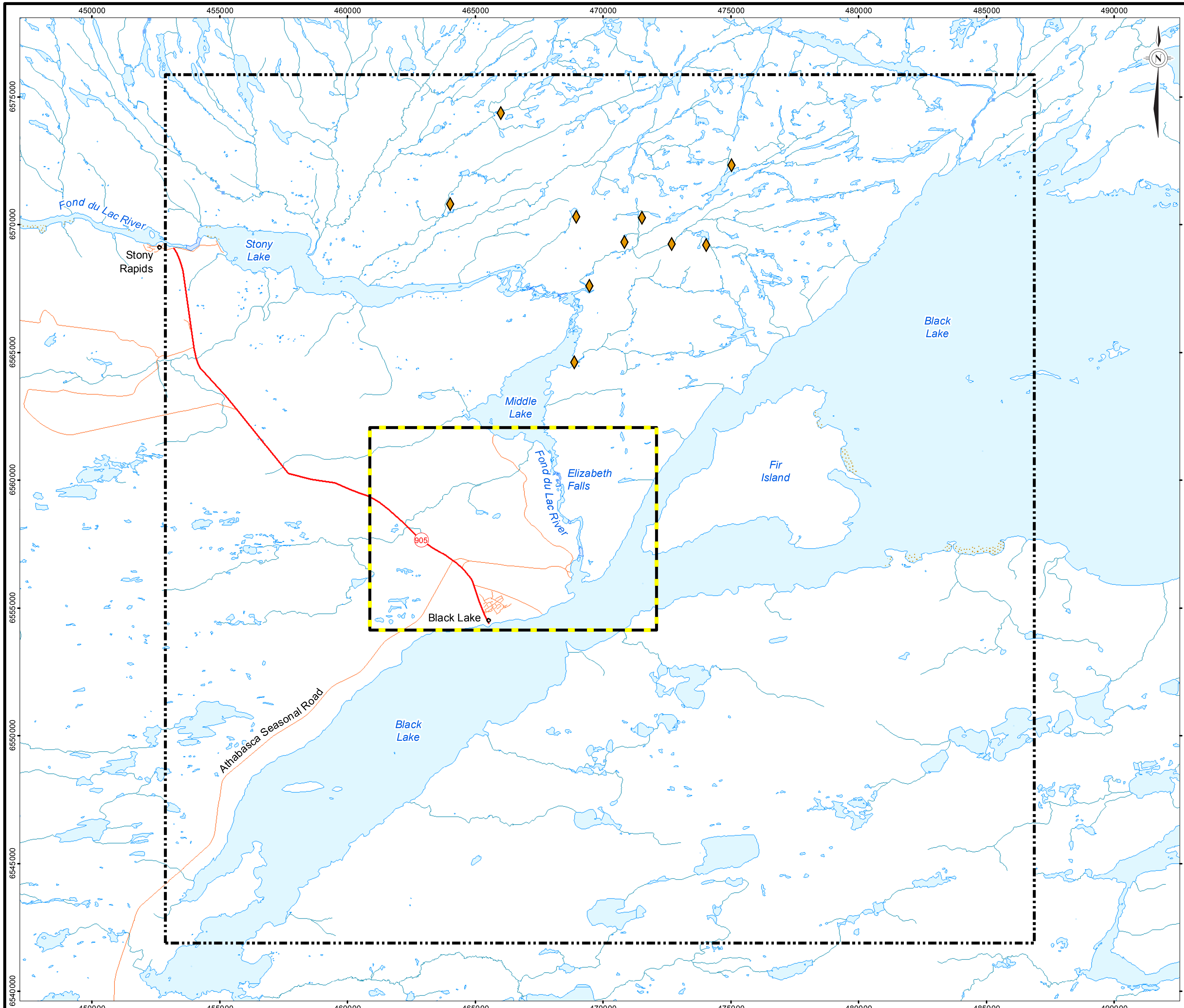
Nest requirements (e.g., tree cavities) designate where certain bird species will nest and breed and indicate habitat preferences specific to each species. Habitat preferences were assigned by accessing species information from Birds of North American Online (BNA 2013), and Boreal Avian Modeling Project (2012). Deciduous forest breeding birds were the most numerous species observed during the BBS within the RSA and accounted for 36% of the 36 upland species recorded within 50 m of the observer. Coniferous forest birds accounted for 19%, while open area/shrubland, recent burn, and Mixedwood forest species accounted for 17%, 14%, and 14%, respectively.

Most upland breeding birds observed within the RSA are insectivorous, although they will also occasionally eat seeds, fruit, and other arthropods (BNA 2013). Some exceptions to this are American crow, which is omnivorous, and cedar waxwing, which is primarily fructivorous. Spruce grouse, sharp-tailed grouse, ruffed grouse, willow ptarmigan, and rock ptarmigan are all primarily herbivores but will occasionally consume invertebrates.

15.3.8 Waterbirds

15.3.8.1 Population Status and Distribution

Waterbirds include loons, grebes, swans, geese, ducks, scoters, mergansers, American coot (*Fulica americana*), sandhill crane (*Grus canadensis*), gulls, and terns. Aerial survey transects to determine waterbird breeding adult density in the RSA were flown on June 1 and July 19, 2012. Transects (8 to 47 km in length) were flown along the shore of Black Lake, along the Fond du Lac River (including Stony Lake and Middle Lake) and in the northeastern RSA (6 linear transects) (Figure 15.3-5). The Black Lake and Fond du Lac River transects were divided into 1 km segments, which were used for calculating waterbird densities (mean ± 1 Standard Error [SE]) (i.e., densities were calculated based on 0.4 km^2). For the Northeastern portion of the RSA, transect density was determined by calculating the total open water area for each transect (Table 15.3-4) and dividing the quantity of waterbirds observed on each transect by the total open water area.



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- INDIDENTAL BEAVER DAM AND LODGE OBSERVATION
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6

5 0 5
SCALE 1:150,000 KILOMETRES

PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE
LOCATIONS OF BEAVER DAM AND LODGE OBSERVATIONS IN THE REGIONAL STUDY AREA, 2012

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	06/11/13	FIGURE: 15.3-5	
CHECK	LD	15/11/13		
REVIEW	ME	15/11/13		

Table 15.3-4: Total Area Sampled per Transect in the Northeastern Regional Study Area during Waterbird Breeding and Productivity Surveys, 2012

Transect Number	Open Water Area (ha)	Transect Area (ha)	% Open Water
4	8	397	2.0%
5	36	734	4.9%
6	74	614	12.0%
7	24	508	4.7%
8	48	499	9.3%
9	43	733	5.9%

ha = hectares, % = percent

Nine species and three unidentified species groups (merganser species, duck species, and gull species) were recorded in the RSA during waterbird breeding surveys in 2012 (Appendix IV.3, Table IV.3-13). Densities for these 12 waterbird species and species groups were calculated individually for the three surveyed areas (i.e., Black Lake, Fond du Lac River, and Northeastern RSA) (Table 15.3-5). Black Lake had the lowest number of waterbird species present with only mallard (*Anas platyrhynchos*) and an unidentified merganser species (*Merginae* spp). The Fond du Lac River surveys had the highest species diversity with seven species and three unidentified species groups. American wigeon (*Anas americana*), northern shoveler (*Anas clypeata*), surf scoter (*Melanitta perspicillata*), and white-winged scoter (*Melanitta fusca*) were only observed in the Fond du Lac River survey area. Waterbodies in the Northeastern RSA had five waterbird species and three unidentified species groups. Canada goose (*Branta canadensis*) and bufflehead (*Bucephala albeola*) were only observed in the Northeastern RSA transects. In total, mallard and unknown merganser species were the most abundant waterbirds observed during the breeding surveys.

Table15.3-5: Adult Density (birds/hectare) (± 1SE) during Waterbird Breeding Surveys within the Regional Study Area, 2012

Common Name	Scientific Name	Black Lake (n = 11)	Fond du Lac River (n = 45)	Northeastern RSA (n = 6)	Total (n = 90)
Canada Goose	*Branta canadensis*	0	0	0.053 ± 0.040	0.004 ± 0.003
Mallard	*Anas platyrhynchos*	0.009 ± 0.006	0.081 ± 0.027	0.081 ± 0.051	0.047 ± 0.014
American Wigeon	*Anas americana*	0	0.004 ± 0.003	0	0.002 ± 0.001
Northern Shoveler	*Anas clypeata*	0	0.001[a]	0	0.001[a]
Blue-winged Teal	*Anas discors*	0	0.001[a]	0.009[a]	0.001[a]
Bufflehead	*Bucephala albeola*	0	0	0.042 ± 0.021	0.003 ± 0.002
Surf scoter	*Melanitta perspicillata*	0	0.009[a]	0	0.005[a]
White-winged scoter	*Melanitta fusca*	0	0.011[a]	0	0.006[a]
Unidentified Merganser Species	*Merginae* species	0.009[a]	0.060 ± 0.018	0.237 ± 0.064	0.047 ± 0.010
Unidentified Duck Species	*Anatidae* species	0	0.010 ± 0.004	0.034 ± 0.016	0.007 ± 0.002
Sandhill Crane	*Grus canadensis*	0	0.001[a]	0.024 ± 0.016	0.002 ± 0.001
Unidentified Gull Species	*Laridae* species	0	0.008 ± 0.004	0.029 ± 0.010	0.006 ± 0.002

[a] Only the mean is reported as the species was only recorded on one transect segment.
RSA = regional study area; n = number of transects segments; SE = standard error

Eight species and four unidentified species groups (scoter species, duck species, gull species, and tern species) were recorded in the RSA during waterbird productivity surveys in 2012 (Appendix IV.3, Table IV.3-13). Densities for these 12 adult waterbird species and species groups were calculated individually for the three surveyed areas (Table 15.3-6). Black Lake had the lowest number of waterbird species present with only an unidentified gull species observed. The Fond du Lac River surveys had the highest species diversity with seven species and four unidentified species groups. Mallard, common merganser, scaup species (*Aythya marila* or *A. affinis*), unidentified scoter species, and unidentified tern species were only observed in the Fond du Lac River survey area. The Northeastern RSA surveys had five waterbird species and one unidentified species group. Horned grebe (*Podiceps auritus*) was only observed in the Northeastern RSA transects. In total, common merganser (*Mergus merganser*) was the most abundant waterbird observed during the productivity surveys.

Table 15.3-6: Adult Density (birds/hectare) (± 1SE) during Waterbird Productivity Surveys within the Regional Study Area, 2012

Common Name	Scientific Name	Black Lake (n = 11)	Fond du Lac River (n = 45)	Northeastern RSA (n = 6)	Total (n = 62)
Horned Grebe	*Podiceps auritus*	0	0	0.007[(a)]	0.001[(a)]
Mallard	*Anas platyrhynchos*	0	0.009 ± 0.004	0	0.006 ± 0.003
American Wigeon	*Anas americana*	0	0.007 ± 0.003	0.06[(a)]	0.011 ± 0.006
Green-winged Teal	*Anas crecca*	0	0.003 ± 0.002	0.041 ± 0.041	0.006 ± 0.004
Scaup species	*Aythya marila* or *A. affinis*	0	0.017 ± 0.008	0	0.012 ± 0.006
Common Goldeneye	*Bucephala clangula*	0	0.004 ± 0.003	0.023[(a)]	0.005 ± 0.003
Bufflehead	*Bucephala albeola*	0	0.004 ± 0.003	0.062[(a)]	0.009 ± 0.006
Unidentified Scoter species	*Melanitta* species	0	0.003 ± 0.002	0	0.002[(a)]
Common Merganser	*Mergus merganser*	0	0.033 ± 0.015	0	0.024 ± 0.011
Unidentified Duck species	Anatidae species	0	0.006 ± 0.003	0.144 ± 0.073	0.018 ± 0.009
Unidentified Gull species	Laridae species	0.007 ± 0.004	0.006 ± 0.002	0	0.005 ± 0.002
Unidentified Tern species	Sternidae species	0	0.013[(a)]	0	0.01[(a)]

[(a)] Only the mean is reported as the species was only recorded on one transect segment.
RSA = Regional study area
n = number of transect segments; SE = standard error

Seven juvenile waterbird species and juveniles of one unidentified species group (duck species) were recorded in the RSA during waterbird productivity surveys in 2012 (Appendix IV.3, Table IV.3-13). Densities for these eight juvenile waterbird species and species groups were calculated individually for the three surveyed areas (Table 15.3-7). The Northeastern RSA transect had the highest species diversity with five waterbird species and one unidentified species group observed. Horned grebe, green-winged teal (*Anas crecca*), bufflehead, and unidentified duck species were observed only in the Northeastern RSA transects. Four waterbird species were observed in the Fond du Lac River area. Mallard and scaup species were observed only in the Fond du Lac river area. In total, scaup species were the most abundant juvenile waterbird species observed during the productivity surveys.

Table 15.3-7: Juvenile Density (birds/ha) (± 1SE) during Waterbird Productivity Surveys within the Regional Study Area, 2012

Common Name	Scientific Name	Black Lake (n = 11)	Fond du Lac River (n = 45)	Northeastern RSA (n = 6)	Total (n = 62)
Horned Grebe	*Podiceps auritus*	0	0	0.005[(a)]	0
Mallard	*Anas platyrhynchos*	0	0.002[(a)]	0	0.002[(a)]
American Wigeon	*Anas americana*	0	0.002[(a)]	0.051[(a)]	0.006 ± 0.005
Green-winged Teal	*Anas crecca*	0	0	0.028[(a)]	0.003[(a)]
Scaup species	*Aythya marila or A. affinis*	0	0.011 ± 0.006	0	0.008 ± 0.005
Common Goldeneye	*Bucephala clangula*	0	0.002[(a)]	0.018[(a)]	0.003 ± 0.002
Bufflehead	*Bucephala albeola*	0	0	0.041[(a)]	0.004[(a)]
Unidentified Duck species	Anatidae species	0	0	0.031 ± 0.024	0.003 ± 0.002

(a) Only the mean is reported as the species was only recorded on one transect segment.
RSA = Regional study area
n = number of transect segments; SE = standard error

15.3.8.2 Habitat Selection and Foraging

The Western Boreal Forest is ranked third out of the 25 most important and threatened waterfowl habitats in North America (Ducks Unlimited Canada 2005). These waterfowl areas act both as a staging area for waterbird migration and as a valuable breeding area for many species of waterbirds including scoters, mallards, scaup species, American wigeons, green-winged teals, buffleheads, mergansers, common goldeneye and loons. The boreal forest is particularly important to waterfowl when the prairies are dry, as waterfowl will migrate to this area in search of more permanent water.

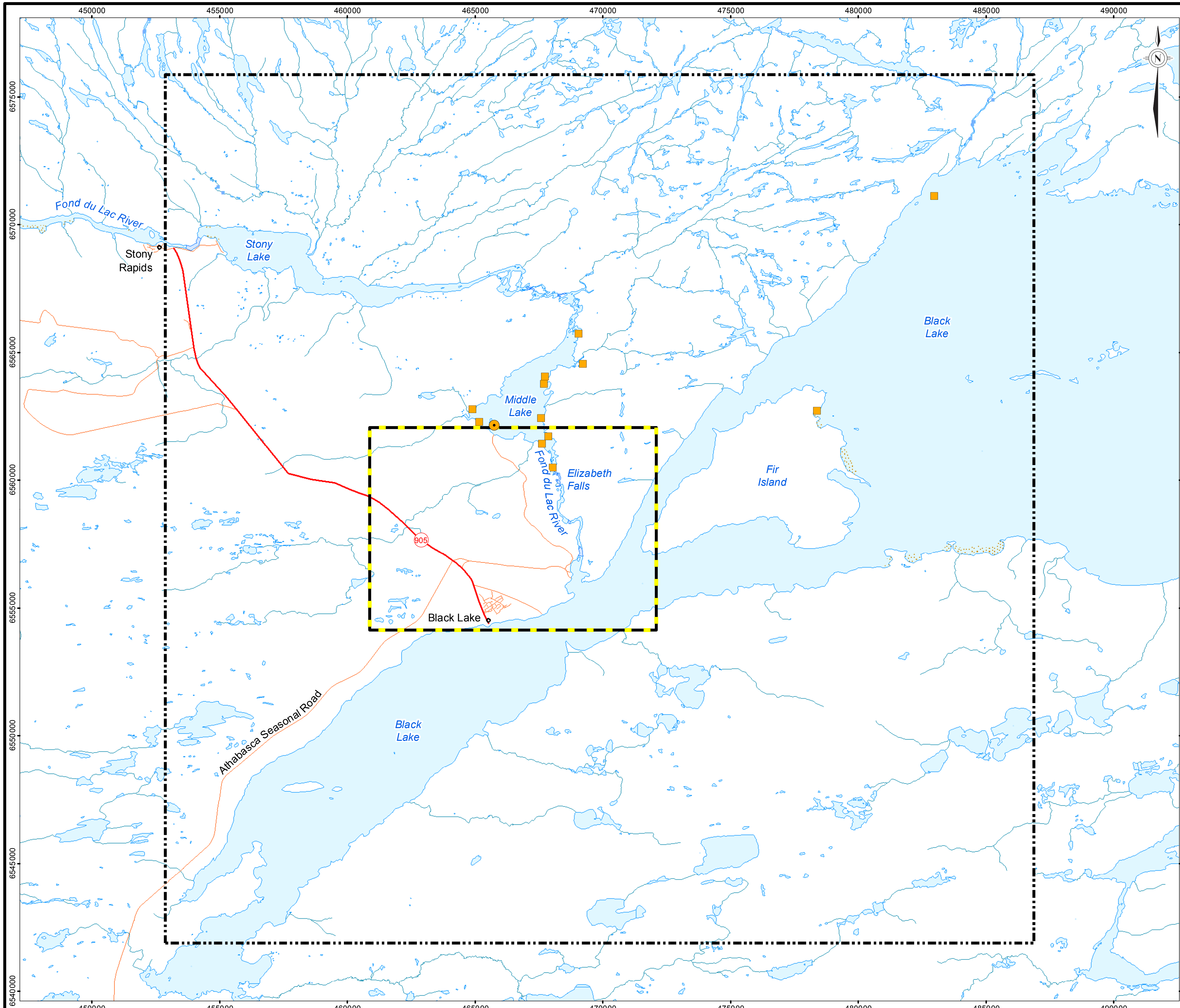
Dabbling ducks (e.g., mallards, American wigeon, and scoters) nest in upland areas while diving ducks (e.g., scaup species) mostly nest over water in emergent vegetation or on structures such as beaver lodges. Mergansers, goldeneyes, and buffleheads nest in tree cavities. The variety of aquatic habitats in the boreal forest provides food items such as aquatic vegetation, invertebrates, and fish supporting many species of waterbirds. Waterfowl young are dependent on invertebrates during their first four weeks of life because invertebrates satisfy protein requirements for feather development (Hornung 2005).

15.3.9 Bald Eagle

15.3.9.1 Population Status and Distribution

Surveys to locate bald eagle (*Haliaeetus leucocephalus*) nests were completed in the RSA in conjunction with the waterbird breeding and productivity surveys (Section 15.3.8.1). Nests that were found during the waterbird breeding survey were revisited during the waterbird productivity survey to determine nest success. Incidental observations of bald eagles also were recorded during other wildlife baseline surveys in 2012.

One individual bald eagle and one bald eagle nest were observed during spring fish spawning surveys in 2010 (Figure 15.3-6). One bald eagle was observed during amphibian calling surveys. Nine bald eagles and one bald eagle nest were observed during waterbird breeding surveys, while three bald eagles were observed during waterbird productivity surveys in 2012.



LEGEND

- HAMLET OR COMMUNITY
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- BALD EAGLE
- BALD EAGLE NEST
- TERRESTRIAL REGIONAL STUDY AREA
- TERRESTRIAL LOCAL STUDY AREA

REFERENCE

NAD83 UTM ZONE 13
NTS MAPSHEETS: 73P/3,4,5,6

5 0 5

SCALE 1:150,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

BALD EAGLE OBSERVATIONS IN THE REGIONAL STUDY AREA, 2012

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	06/11/13	**FIGURE: 15.3-6**	
CHECK	LD	15/11/13		
REVIEW	ME	15/11/13		

Bald eagle populations have increased dramatically since DDT was banned in 1972 (Buehler 2000). Between 1982 and 1997, bald eagle populations have increased an average of 8.6% per year in the United States. The population estimate for North America in 1999 was 100,000 individuals.

15.3.9.2 Habitat Selection and Foraging

Bald eagles commonly nest in forested areas adjacent to large, fish-bearing waterbodies; however, they will nest on cliffs, large rocks, and the ground if suitable trees are not available (Buehler 2000). Bald eagles prefer to eat fish but will consume carrion, muskrats (*Ondatra zibethicus*), snowshoe hares (*Lepus americanus*), and waterfowl if available.

15.3.10 Traditional Use of Wildlife

The area surrounding the Project has been used traditionally by the Aboriginal people of the region for generations (Annex IV). While there has been some decline in active participation in hunting, trapping, fishing, and gathering activities by Aboriginal people over time, these activities continue to hold an important place in the lifestyle of people living in the Athabasca region, including the communities of Black Lake and Stony Rapids (Black Lake and Stony Rapids Key Performance Indicator [KPI] Program 2012).

Traditional use of wildlife was determined by reviewing information presented in Annex VI – Cultural Environment Baseline Report. Traditional use of species in the RSA includes hunting of wolf, black bear, and moose and trapping of smaller mammals such as American marten, snowshoe, and red squirrel (*Tamiasciurus hudsonicus*) (Annex VI, Section 4.1.5). Most hunting for caribou by residents of BLFN takes place outside of the RSA in the northern reaches of Saskatchewan and into the NWT (Annex VI, Section 4.1).

15.4 Screening of Project Interactions and Mitigation

This section identifies and evaluates the interactions between Project components or activities, and the correspondent potential effects on the maintenance of self-sustaining wildlife populations, including listed species (i.e., the assessment endpoint). The process begins with the identification of all potential interactions for the Project. To provide a robust assessment of potential effects, each interaction is initially considered to have a linkage to a change in the terrestrial environment and associated potential effects on wildlife.

Each potential interaction is evaluated to determine if mitigation can be developed and incorporated to remove the interaction or limit the potential effects on wildlife. Mitigation includes Project design elements, environmental best practices, and management policies and procedures. Mitigation is developed through an iterative process between the Project's engineering and environmental teams. Knowledge of the terrestrial environment and mitigation is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for a residual effect on wildlife.

Interactions are determined to be primary, secondary, or as having no linkage using scientific knowledge, professional judgment of technical specialists, logic, experience with similar developments, and mitigation (Table 15.4-1). Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by environmental design features and mitigation so that the Project results in no detectable (measureable) change and no residual effects on wildlife relative to baseline values;
- secondary – interaction could result in a minor change, but would have a negligible residual effect on wildlife relative to baseline values and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or

- primary – interaction is likely to result in a measurable change that could contribute to a significant residual effect on wildlife relative to baseline values.

Primary interactions are anticipated to result in residual effects on the maintenance of self-sustaining wildlife populations (including listed species) and require further analysis to determine the significance of the residual effect. Interactions with no linkage to a change or changes that are considered minor (secondary) will not be analyzed further or classified in the EIS because environmental design features and mitigation will remove the interaction (no linkage) or residual effects can be determined to be negligible through a simple qualitative or quantitative evaluation. Project interactions determined to have no linkage or those that are considered secondary are not predicted to result in significant effects on the maintenance of self-sustaining wildlife populations (including listed species).

Project components and activities, and the associated mitigation implemented during the various Project phases, including accidents, malfunctions, and unplanned events are summarized in Table 15.4-1. Potential effects on wildlife from each Project interaction and its associated classification are summarized in Table 15.4-1, with more detailed descriptions are provided in the subsequent sections.

Table 15.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Wildlife

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Wildlife	Environmental Design Features and Mitigation	Interaction Classification
■ Infrastructure Footprints ▪ Temporary infrastructure – construction camp – overburden and waste rock disposal areas – construction area and materials laydown area ▪ Operational infrastructure – power generation station – water intake structure – power tunnel – tailrace channel – submerged weir – bridge – transmission line – waste rock disposal areas – water diversion structures around the Project footprint – potable water and wastewater intake and discharge structures – site access roads (including source material)	Construction Operations Closure	Loss or alteration of permafrost can change terrain and affect wildlife habitat.	■ Organic and upper soil horizons will not be stripped in areas containing ice-rich permafrost to reduce potential for an increase in thaw depth and related thaw subsidence.	No Linkage
	Construction Operations Closure	Direct loss and fragmentation of habitat from the Project footprint can affect wildlife abundance.	■ Clearing of vegetation will be limited to the minimum extent possible and will only be removed in areas that could pose a hazard or interfere with construction activities. ■ Vegetation clearing will not be completed during the period of migratory breeding bird and nesting activity (approximately May 1 through July 31). If clearing is to occur during this time, a qualified environmental monitor will be on-site to identify any bird nests that could be present prior to vegetation clearing. ■ Siting and construction of the Project will be planned to avoid environmentally sensitive areas (e.g., critical wildlife habitat, listed wildlife species, and wetlands) as much as possible. ■ Location of the settling ponds will be based on topography (i.e., a low area) that is not in a sensitive feature such as a wetland or floodplain. ■ If avoidance of sensitive areas is not feasible, consultation with MOE will be completed to determine the significance of the area and identify feasible mitigation strategies. ■ If a listed wildlife species is encountered that was not expected, appropriate mitigation will be applied prior to further construction activities. ■ Upper soil horizons will be salvaged (i.e., seed bank) and replaced it on areas to be reclaimed to enhance regeneration of vegetation. ■ Matting (e.g., timber or rig mats) will be placed in sensitive areas to avoid rutting. ■ A Reclamation Plan will be developed for the Project to be reviewed and approved by agencies. ■ Progressive reclamation is expected to occur following construction and during operations. ■ Access roads will be removed and terrain contoured, to blend with the surrounding terrain. A discussion will be held with the local community about the ongoing use and maintenance of the access roads at the time of Project closure.	Primary
	Construction	Destruction of migratory bird nests can affect bird populations.	■ Site-specific pre-construction surveys of all areas to be disturbed, including adjacent buffers as applicable, will be completed. ■ Vegetation clearing will not be completed during the period of migratory breeding bird and nesting activity (from approximately May 1 to July 31). If clearing is to occur during this time, a qualified environmental monitor will be on-site to identify any bird nests that could be present prior to vegetation clearing. ■ If an active nest is encountered, appropriate mitigation will be applied prior to further construction activities. ■ The occurrence of potentially re-used nest sites (e.g., cavity or stick nests) and active nest sites will be documented. ■ Activity restriction guidelines and setback distance recommendations for wildlife species will be followed.	No Linkage
	Construction	Dewatering of the power tunnel during construction could cause drawdown in nearby lakes, which can affect wildlife habitat.	■ Not applicable	Secondary
■ Site Access	Construction Operations Closure	Sensory effects (e.g., presence of buildings, lights, smells, noise, blasting activity, and vehicles) can affect wildlife.	■ If construction occurs during sensitive nesting, breeding, and rearing periods for wildlife species, then an appropriate pre-construction survey should be completed and provincial activity setback guidelines will be applied. ■ The powerhouse will be located in the bedrock and insulated, which will reduce noise emissions from the building. ■ Lighting will be covered and will face downwards to illuminate the ground, not the sky. ■ Low-glare fixtures or lighting with motion sensors will be used, where possible. ■ Lighting will be high cut-off fixtures that will limit light emissions beyond work areas. ■ A detailed Blasting Plan is expected to be developed for the Project.	Primary

Table 15.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Wildlife (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Wildlife	Environmental Design Features and Mitigation	Interaction Classification
■ Site Access (continued)	Construction Operations Closure	Access to the site and areas on the east side of the Fond du Lac River can increase risk of mortality from hunting of wildlife.	■ A shuttle will be used to transfer incoming and outgoing workers between the Northern Hamlet of Stony Rapids and the site to reduce the use of personal vehicles. ■ No firearms will be allowed on the Project site. ■ A "no hunting" zone will be imposed, and will include a 500 m buffer extending beyond the Project footprint, and within access road rights-of-way. The no hunting zone will be developed in consultation with BLFN. ■ A "no hunting, trapping, harvesting, or fishing policy" will be developed and enforced for Project employees. ■ All public access to the construction, laydown, and camp areas will be restricted until Project construction is completed. ■ An Access Management Plan will be developed for the construction camp and worksite. ■ The use of recreational all-terrain vehicles will be prohibited at the site.	Secondary
		Access to the site and areas on the east side of the Fond du Lac River will be controlled, which can affect the movement and behaviour of wildlife.		Secondary
■ Site Infrastructure	Construction Operations Closure	Site infrastructure (e.g., tailrace channel) could restrict wildlife movement and increase risk of mortality from predation, which can affect wildlife.	■ The tailrace channel will be fenced to prevent wildlife from entering this area and falling into the tailrace channel. ■ Open trenches or pits will be fenced to exclude wildlife, or one of the ends or sides will be sloped to allow escape. ■ During winter construction periods, gaps will be left in some windrows along access roads and around the site to allow escape routes for mid to large sized wildlife.	Secondary
		Physical hazards (e.g., blasting activities, tailrace channel, buildings, and waste rock disposal areas) from the Project can cause injury or mortality to wildlife and affect wildlife populations.	■ Open trenches or pits will be fenced to exclude wildlife, or one of the ends/sides will be sloped to allow escape. ■ The tailrace channel, water intake, and powerhouse structures will be fenced to prevent wildlife from entering these areas and falling into the tailrace channel. ■ During winter construction periods, gaps will be left in some windrows along access roads and around the site to allow escape routes for mid to large-sized wildlife. ■ Good housekeeping will be practiced to prevent wildlife from becoming entangled with or injured by on-site material. ■ Surface blasting will be suspended temporarily if large mammals are observed within the danger zone identified by the blast supervisor.	Secondary
■ Blasting Activities	Construction	Use of explosives near can change surface water and soil quality, and wildlife habitat.	■ A Blasting Plan will be developed for the Project and set-back distances during blasting of the water intake foundation and tailrace channel will be included as part of this plan. ■ Best practices, as outlined in the Blasting Plan for the Project, will be applied to blasting activities to limit any potential for enhanced nitrogen loading of groundwater inflows due to the placement and use of ammonium nitrate/fuel oil (ANFO) during construction. ■ A Site Water Management Plan will be developed for the Project. ■ Construction and monitoring of settling ponds or water treatment areas will be part of Site Water Management Plan.	Secondary
■ Air Emissions and Noise Levels ▪ Emission of dust from blasting activities and hauling waste rock to disposal areas. ▪ emission of standard pollutants from vehicles and heavy equipment operation	Construction Operations Closure	Deposition of criteria air contaminants can change surface water, soil, and vegetation quality, which can affect wildlife habitat.	■ Equipment will be regularly maintained for compliance with provincial and federal air emission standards. ■ The equipment used for hauling and mucking operations will operate using diesel fuel with an ultra-low sulphur diesel content (less than 15 ppm). ■ The heavy-duty stationary and mobile diesel-fueled equipment fleet will meet or exceed EPA Tier 2/3 air quality emissions standards. ■ The gasoline-fueled equipment fleet will meet or exceed EPA Tier 2 Bin 6 air quality emissions standards. ■ An EnvPP will describe material handling protocols including dust management. ■ Soil salvage stockpiles or exposed soils will be seeded with non-aggressive annual species as appropriate for the area. ■ All unpaved roads will be watered on a regular basis to prevent wind-driven to limit fugitive dust. ■ A speed limit will reduce fugitive dust from site roads.	Secondary
		Dust deposition can change surface water, soil, and vegetation quality, which can affect wildlife habitat.		Secondary

Table 15.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Wildlife (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Wildlife	Environmental Design Features and Mitigation	Interaction Classification
■ Power Generation Activities ▪ water withdrawal for power generation ▪ diversion of water through the power tunnel to the powerhouse ▪ discharge of tailrace channel flows	Operations	Withdrawal, diversion, and discharge of water for power generation could change hydrology, which can affect wildlife habitat.	■ A submerged weir will be constructed on the Fond du Lac River at the outlet of Black Lake and will be designed to maintain the range of water levels in Black Lake and in the uppermost section of the Fond du Lac River within the historical range, for all powerhouse operating flow conditions. ■ Project site runoff resulting from rainfall, snowmelt, and groundwater releases will be managed by directing runoff around work site infrastructure by using appropriately sized ditches, channels, and culverts.	No Linkage
		Diversion of water through the power tunnel could alter groundwater quantity and cause changes to hydrology, which affect wildlife habitat.		No Linkage
		Discharge of water for power generation could change groundwater and surface water quality, which could affect the health of wildlife.	■ The Project has been designed to incorporate a subsurface intake as part of the tunnel diversion, which is anticipated to reduce the amount of air entrained in the system by the intake and reduce the plunging of air and water to depth at the tailrace channel outlet. ■ Rock material used to construct the submerged weir will consist of un-weathered rock with low potential for acid generation or radioactive materials.	No Linkage
		Withdrawal and discharge for power generation could change the temperature of the water, which can affect wildlife habitat.	■ A wide, shallow intake approach is expected to withdraw water from the surface of the lake to reduce temperature differences between the water entering the river at the tailrace channel outlet and what naturally enters the Fond du Lac River via the Black Lake outlet.	Secondary
		Withdrawal and discharge for power generation could change the temperature of the water and therefore ice thickness in Black Lake and Middle Lake, which can affect wildlife.		Secondary
■ Domestic and Industrial Waste Management	Construction Operations Closure	Attraction to the Project (e.g., food waste or oil products) could increase human-wildlife interactions and mortality risk to individual animals, which can affect wildlife populations.	■ Garbage and human wastes will be collected and stored in secure containers to avoid attracting wildlife. ■ Individuals working on site and handling hazardous materials will be trained in the TDG. ■ Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers. ■ Domestic and recyclable waste dangerous goods will be stored on site in appropriate containers to prevent exposure until they are shipped off site to an approved facility. ■ A WMP will be developed for the Project. ■ Bins and receptacles will be allocated around the site in appropriate areas. ■ Disposal of food wastes in suitable, covered containers to reduce wildlife attraction. ■ Domestic wastes will be collected and transferred to appropriate off-site disposal facilities by a licensed contractor. ■ A recycling program for wastes will reduce the amount of material that will be transported to an off-site landfill. Recyclable materials can be sorted and collected in appropriate containers, and transferred to appropriate recycling facilities, if available. ■ Hazardous waste will be collected in appropriate containers for storage prior to shipment off-site to appropriate recycle or disposal facilities via a licensed contractor. Where suppliers will accept them, empty containers used to ship hazardous materials to site can be returned to the supplier. Those that cannot be returned will be shipped to appropriate recycle or disposal facilities. ■ Sewage and grey water will be hauled off-site and disposed of at the Black Lake lagoon.	Secondary
		Attraction to the Project (e.g., food waste, oil products) could increase predator numbers and predation risk, which can affect prey populations.		Secondary

Table 15.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Wildlife (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Wildlife	Environmental Design Features and Mitigation	Interaction Classification
■ Site Water Management ▪ collection and treatment of surface runoff within the Project footprint ▪ discharge of wastewater ▪ collection and treatment of groundwater in the power tunnel	Construction Operations	Collection and disposal of wastewater from the site can cause changes to hydrology, which could affect vegetation, and therefore, wildlife habitat.	■ A Site Water Management Plan will be developed for the Project. ■ The site will be properly graded and be surrounded by ditches and berms to capture runoff from the waste rock disposal areas. ■ Surface runoff will be diverted around and away from waste rock disposal areas as much as possible. ■ Runoff water in contact with the waste rock disposal areas will be sent to settling ponds.	No Linkage
		Collection and disposal of wastewater can change surface water quality and soils, which can affect vegetation, and thus wildlife habitat.	■ The waste rock disposal areas will be placed in locations that are easily modified to be controllable in terms of run-on and run-off. ■ Runoff and drainage from within and around Project roadways and structures will be managed through the incorporation of erosion control methods (e.g., ditch blocks or silt fences). ■ Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns. ■ Ditch capacities will be sized to accommodate an extreme daily rainfall event. ■ Riprap energy dissipaters and ditch lining will be installed in areas where predicted runoff velocities are deemed excessive to reduce soil erosion. ■ Groundwater originating from construction of the power tunnel will be collected, treated if necessary, and monitored to confirm discharge criteria are met prior to release into the receiving environment. ■ Implementation of a Water Quality Monitoring Program. ■ Contingency plans for off-site disposal of dewatered settling pond sludge will be included in a Construction Environmental Management Plan.	No Linkage
■ Waste Rock Disposal Areas	Construction Operations Closure	Seepage from waste rock disposal areas can change surface water, soil, and vegetation quality, which can affect wildlife habitat.	■ A Waste Rock Management Plan will be prepared and will include a Project Site Drainage Plan. ■ Excavated rock and aggregate materials will be tested to confirm that this material will not have negative effects on the surrounding environment. Specific mitigation measures will be applied if the material is identified to be acid generating or to contain unacceptable levels of metals or radionuclides. ■ Additional site investigation and laboratory testing will be completed upon completion of the final Project design and during construction of the Project.	No Linkage
■ Closure Activities	Closure	Cessation of power generation activities, including the withdrawal, diversion, and discharge of water, can change hydrology, which can affect wildlife habitat.	■ A Decommissioning and Reclamation Plan will be developed for the Project. ■ A series of concrete bulkheads will be placed in the tunnel, if necessary, to isolate mineralized bedrock zones and reduce potential for mineralized groundwater to discharge through the power tunnel. ■ Quality of groundwater discharging through the tunnel may be monitored and sampled during the decommissioning phase, if required.	No Linkage
■ Accidents, Malfunctions, and Unplanned Events ▪ emergency shutdowns of power turbines ■ hazardous materials spills	Operations	Emergency shutdowns of power generation activities can change surface hydrology, which can affect wildlife and wildlife habitat.	■ During unplanned emergency shutdowns, downstream flows will be maintained by bypassing water around the powerhouse turbine generator units using a bypass conduit.	No Linkage

Table 15.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Wildlife (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Wildlife	Environmental Design Features and Mitigation	Interaction Classification
■ Accidents, Malfunctions, and Unplanned Events ▪ emergency shutdowns of power turbines ▪ hazardous materials spills	Construction Operations Closure	Release or spills of hazardous substances (e.g., fuel or oil) can change surface water, sediment, and soil quality, which can affect wildlife habitat.	■ Individuals working on-site and handling hazardous materials will be trained in WHMIS and TDG. ■ Controlled products will not be allowed on-site unless accompanied by approved labels and MSDS. ■ All fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard; a lined and dyked containment area around these tanks will be provided to contain any potential fuel spills. The design of the containment area will be based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. ■ The storage containers will be regularly inspected for leaks or damage, and replaced when necessary. ■ Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled, and located in lined and bermed containment areas. ■ Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers. ■ Regular maintenance of construction equipment. ■ Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. ■ Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills of fuel would flow to the sump, which would be pumped out to a container for shipment off-site. ■ An Emergency Response Plan will be developed. ■ Spill response material (e.g., sorbent pads) will be stored on-site in designated areas and in vehicles. ■ Contaminated (impacted) soils will be removed and disposed of in an approved landfill or waste management facility.	■ No Linkage
	Construction Operations Closure	Increased traffic can increase the potential for vehicle-wildlife collisions, which can cause injury or mortality to wildlife.	■ Speed limits will be clearly posted on construction roads and enforced to militate against potential road mortalities during construction. ■ Vegetation along the roadside will be mowed and cut to increase visibility of wildlife passing through or using the roadsides or ditches. ■ Unpaved roads within the limits of the Project will be regularly graded and maintained to avoid washboarding and rutting. ■ Safety policies will be developed by SaskPower and the general contractor will address safe driving practices for all construction personnel on public roads. SaskPower and the general contractor will monitor all reported incidents of speed violations and provide appropriate disciplinary measures, where necessary. ■ Shuttle vehicles will be used by the contractor to transport workers between the construction site and the Stony Rapids airport to reduce the use of personal vehicles.	Secondary
■ Accidents, Malfunctions, and Unplanned Events	Construction Operations Closure	Failure of the embankment dykes around the settling ponds can change surface water, soil, and vegetation quality, which can affect wildlife habitat.	■ Fill material used for constructing the embankment dykes around the settling pond will be clean mineral soil with sufficient moisture to allow for proper compaction. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap as soon as practical following construction. ■ The settling ponds will be engineered to provide adequate storage of wastewater streams under normal and extreme operating conditions (e.g., settling ponds will be designed to contain the 1:100 year storm event). In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling ponds would be provided by the inclusion of an overflow spillway in the embankment. ■ The settling ponds will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. ■ During the detailed design stage, additional mitigation could be identified and included as part of the Environmental Protection Plan and the Emergency Response Plan.	No Linkage

Table 15.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Wildlife (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Wildlife	Environmental Design Features and Mitigation	Interaction Classification
■ Accidents, Malfunctions, or Unplanned Events	Construction, Operations, and Closure	Fire	■ The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail. ■ Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. ■ Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute).Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. ■ Personnel will be trained in fire prevention and response procedures. ■ Firefighting equipment will be available on site.	Secondary

MOE = Saskatchewan Ministry of Environment; BLFN = Black Lake First Nation; EnvPP = Environmental Protection Plan; WMP = Waste Management Plan; WHMIS = Workplace Hazardous Materials Information Sheet; TDG = Transportation of Dangerous Goods; MSDS = Material Safety Data Sheets; CCME = Canadian Council of Ministers for the Environment; ppm = parts per million

15.4.1 Interactions with No Linkage to Effects

An interaction might have no linkage to effects if the activity does not occur (e.g., site runoff is not released), or if the interaction is removed by mitigation or environmental design features so that the Project results in no detectable change in measurement endpoints. Subsequently, no residual effect on the maintenance of self-sustaining wildlife populations (including listed species) is expected. The following interactions are anticipated to have no linkage to effects on wildlife and will not be carried through the residual effects assessment.

- **Loss or alteration of permafrost can change terrain and affect wildlife habitat.**

The LSA is within the sporadic discontinuous permafrost zone, where permafrost could occupy approximately 10% to 50% of the area (Natural Resources Canada 1995). The distribution and occurrence of permafrost is highly variable in the sporadic discontinuous permafrost discontinuous zone. The permafrost in this area is characterized by having low ice content, indicating the ground ice content in the upper 10 to 20 m of the ground has less than 10% ice content by volume of visible ice (Natural Resources Canada 1995).

Clearing of an area and subsequent construction activities can cause permafrost to degrade slowly due to ground thermal changes resulting from removal and disturbance of vegetation. Once permafrost degrades, it can change surface relief and subsequently influence the surface drainage of an area (Lawson 1986).

The amount of ground ice present in permafrost is important for assessing the response of permafrost to clearing, construction, and subsequent recovery of ice conditions following disturbance (Jorgenson et al. 2010). The magnitude of changes to permafrost thermal regimes and potential thaw settlement is directly related to the nature and abundance of ground ice and the type and severity of disturbance at the surface (Lawson 1986; Pullman et al. 2007). Freeze induced displacement of soil (i.e., frost jacking) and thaw induced displacement of soil (i.e., subsidence) are the main issues related to permafrost degradation (i.e., loss and alteration). Changes to thaw penetration and thickness of the active layer can influence surface stability through thaw settlement, frost heave, and bearing capacity, as well as slope stability (Tarnocai et al. 2004). Changes to the permafrost active layer can affect vegetation and wildlife habitat by altering local hydrology, soil moisture, and nutrient availability conditions.

Areas with high ground ice content (i.e., terrain with abundant ice wedges) should be avoided where possible. These areas are more sensitive to thaw-settlement and can result in longer-term changes in terrain, soils, and surface hydrology (Jorgenson et al. 2010). Conversely, areas with small volumes of ground ice are not as sensitive to thaw settlement (Lawson 1986).

If permafrost were present in areas to be disturbed, the following mitigation would be applied:

- the access road will be as narrow as possible, while maintaining safe construction and operation practices; and
- organic and upper soil horizons will not be stripped in areas containing ice-rich permafrost to reduce potential for an increase in thaw depth and related thaw subsidence.

Soil present in the LSA ranged from having Very Low potential for permafrost (moderate to rapidly drained Brunisolic soils) to Moderate (imperfect to poorly drained Organic soils). Within the LSA, permafrost, if present, likely occurs in localized areas within treed bogs with poorly drained Organic soils and would likely have low ground ice content. Because of the relatively low likelihood of permafrost occurring in the LSA and the use of mitigation if permafrost is identified changes to wildlife habitat are not expected to be measurable. As such these interactions were determined to have no linkage to effects on wildlife habitat.

- **Destruction of migratory bird nests can affect wildlife populations.**

The *Migratory Birds Convention Act* (*MBCA* 1994) prohibits the destruction of migratory bird nests (passerine, waterfowl, and raptor) during the breeding season. In northern Saskatchewan, the migratory bird breeding season extends from approximately April 20 to August 25, although some individuals can nest outside of these dates (Gregoire 2013, pers. comm.). As much as possible, vegetation clearing for the Project would take place outside of the migratory bird nesting season. If construction activities must be completed during the migratory bird breeding season, then vegetation and top soil will be removed from potentially affected upland areas prior to the nesting season or nest searches will be completed prior to the clearing of vegetation. These mitigation practices are anticipated to limit changes to the nest success of birds from the Project relative to baseline conditions. Therefore, this pathway was determined to have no linkage to effects on birds.

- **Withdrawal, diversion, and discharge of water for power generation could change hydrology, which can affect wildlife habitat.**
- **Diversion of water through the power tunnel could alter groundwater quantity and cause changes to hydrology, which affect wildlife habitat.**

Power generation activities such as water withdrawal, diversion of water through the power tunnel to the powerhouse, and discharge of tailrace channel flows can change water levels in Black Lake, the Fond du Lac River, Middle Lake, and a small lake (Lake A). Changes in water levels beyond the natural range of variability could lead to alterations in habitat availability, shoreline erosion, re-suspension of sediments and sedimentation, thereby affecting wildlife habitat. In addition to changes to lake water levels, changes to downstream flows (e.g., altered drainage patterns, flow velocities) from water drawdown or re-direction of Black Lake could affect wildlife habitat downstream.

Alterations to natural water level fluctuations have the potential to influence riparian vegetation by changing soil moisture (Nilsson and Svedmark 2002, Leyer 2005). Although riparian vegetation is adapted to thrive at the aquatic/terrestrial boundary, riparian vegetation is sensitive to changes in soil moisture (Leyer 2005; Nilsson and Svedmark 2002). If water levels change permanently, aquatic and terrestrial vegetation in the riparian area would change in relation to the changes in soil moisture (Shafroth et al. 2002). As soil moisture levels change because of reduction of water level fluctuations, plant species that thrive in more stable soil moisture regimes will out-compete riparian vegetation that relies on these fluctuations (Shafroth et al. 2002; Leyer 2005). Alterations to the vegetation in riparian areas can lead to changes in use by wildlife.

The long-term average annual flow for the Fond du Lac River is 304 m^3/s. Water will be diverted from the intake at Black Lake through a power tunnel at a flow of up to 190 m^3/s to produce 50 megawatt (MW) of power and discharged into the Fond du Lac River from the tailrace channel upstream of Middle Lake. The remaining 114 m^3/s (on average) will pass through the natural Black Lake outlet into the Fond du Lac River. Simulation of natural conditions over the period of record indicated that Black Lake water levels typically fluctuate approximately 0.865 m over the course of an average year. Over the 40-year record, the maximum annual water level fluctuation was approximately 1.787 m.

During operations, the diversion of water through the power tunnel could interact with local groundwater, which could subsequently affect surface water locally or regionally. During operation of the tunnel, groundwater is predicted to flow into the tunnel at a maximum estimated rate of 680 m^3/d (Section 9.0, Appendix 9.2). This rate is less than 0.0001% of the tunnel and minimum downstream flow rate (190 m^3/s) and is not expected to result in detectable changes to hydrology.

To maintain historical water levels in Black Lake, a submerged weir will be constructed on the Fond du Lac River at the outlet of Black Lake and will be designed to maintain the historical range of water levels in Black Lake and in the uppermost section of the Fond du Lac River, for all powerhouse operating flow conditions. A Site Water Management Plan will be implemented to meet minimum target seasonal riparian flows in the Fond du Lac River and maintain streamflow quantity along natural flow pathways. Downstream of the tailrace channel outlet where water flowing through the Project rejoins the Fond du Lac River, river flows would remain unchanged from baseline conditions.

Overall, the withdrawal, diversion, and discharge of water for power generation are not expected to result in detectable changes to groundwater quantity and hydrology. Therefore, these interactions were determined to have no linkage to effects on wildlife.

- **Discharge of water for power generation could change groundwater and surface water quality, which could affect the health of wildlife.**

Withdrawal of water from Black Lake, diversion of water into the power tunnel, and subsequent discharge of water to the Fond du Lac River for power generation during operation could change surface water quality in Black Lake, the Fond du Lac River, or Middle Lake. As water passes through a hydroelectric facility, it could become super-saturated with dissolved gases (Becker et al. 2003). The proposed Project has been designed to incorporate a subsurface intake as part of the tunnel diversion, which is anticipated to reduce the amount of air entrained in the system by the intake and reduce the plunging of air and water to depth at the tailrace channel outlet (CEA 2001). Characteristics (e.g., depth, turbulence) of the receiving waters immediately downstream of the power plant discharge determine the rate of degassing for water released from the power generating facility. Gases in super-saturated waters dissipate rapidly in shallow, well-mixed areas of rivers; degassing potential is much lower in river reaches or lakes that are deep or calm (Parametrix Inc. [Parametrix] 2005). The proposed tailrace channel design has a length of approximately 800 m, a width of 25 m, and a depth of 5.5 m (the final design is subject to optimization). Because air entrainment within the tailrace flows is expected to be minimal, it is anticipated that mixing of Project and riparian flows below the tailrace channel outlet will limit the potential for super-saturated conditions downstream in Middle Lake.

The proportion of groundwater inflows within the power tunnel flows is expected to be minimal during operation of the Project (e.g., 680 m^3/d; Section 9.0, Appendix 9.2). These groundwater inflows will represent a very small fraction of the total operational flows through the tunnel (i.e., 0.004% of the flow through the tunnel, approximately up to 190 m^3/s for a 50 MW facility). Therefore, release of mineralized groundwater to the surface water environment from the power tunnel during operations is anticipated to have only a negligible effect on surface water quality in Middle Lake.

The Project will require the construction of a submerged weir. Rock used to construct the weir will consist of un-weathered rock with low potential for acid generation or radioactive materials. Therefore, the quality of water flowing to the Fond du Lac River during operations is not expected to be altered by the presence of the weir.

Overall, the withdrawal, diversion, and discharge of water for power generation are not expected to result in detectable changes to groundwater and surface water quality. Therefore, this interaction was determined to have no linkage to effects on wildlife.

- **Collection and disposal of wastewater from the site can cause changes to hydrology, which could affect vegetation, and therefore, wildlife habitat.**
- **Collection and disposal of wastewater can change surface water quality and soils, which can affect vegetation, and thus wildlife habitat.**

Collection and disposal of wastewater from the Project site could potentially affect vegetation within and adjacent to the Project footprint, through increased soil erosion and changes in soil quality. Increased levels of soil erosion can also lead to increased sediment loads in wetlands and waterbodies, thus reducing plant abundance and diversity (Forman and Alexander 1998). In addition, discharge of wastewater into the Fond du Lac River could cause changes to flow velocities, surface water levels, and surface water quality, which could affect riparian vegetation. Changes in water level fluctuations to waterways can alter soil moisture regimes resulting in stress to plant species in riparian habitat (Leyer 2005, Nilsson and Svedmark 2002).

Three settling ponds have been included in the construction plan for the Project for the treatment and management of the Project's wastewater (other than site runoff and sewage and grey water). One settling pond will be located near the water intake to collect the intake construction water along with a portion of the power tunnel dewatering flows and waste rock runoff from the waste rock disposal area south of the intake (Figure 5.1-1). A second settling pond will be located near the powerhouse excavation to collect the remainder of the tunnel and powerhouse dewatering. A third settling pond, beside the downstream end of the tailrace channel, will collect the tailrace channel dewatering and any runoff directed from the main waste rock disposal areas to the northeast of the tailrace channel (Figure 5.1-1). Water collected in disturbed areas located away from the settling ponds will be pumped to these locations. Surface water diversions could also be constructed to maintain natural drainage characteristics, whereas other structures could be designed to actively divert water away from its natural flow path to prevent the interaction with site infrastructure, potentially contaminated water, or areas sensitive to erosion.

Retention of runoff in the settling ponds will allow suspended sediments and associated parameters (e.g., some metals) to settle out. This water will eventually be discharged downstream to its natural receiving waterbody (the Fond du Lac River through the tailrace channel). The Water Quality Monitoring Program will be developed during the permitting process to determine the nature of potential changes to the water quality of the Fond du Lac River receiving discharge from the settling ponds. Waste water in the settling ponds will be discharged in the Fond du Lac River (at one of the potential discharge locations identified in Figure 5.3-3) after the water has been tested and treated (if necessary) to meet appropriate discharge criteria. Contingency plans for off-site disposal of dewatered settling pond sludge will be included in a Construction Environmental Management Plan.

The results of the water quality modelling indicate that only minor, short-term changes would occur to the water chemistry of the Fond du Lac River during the construction phase because of discharge from the settling pond (Section 11.0, Appendix 11.1). For example, predicted concentrations of various parameters are within the range of baseline concentrations measured in 2010 and 2011. As well, these changes would not involve exceedences of applicable water quality guidelines under fully mixed conditions, or at the edge of the applicable mixing zone in the river. Therefore, changes to riparian vegetation (wildlife habitat) are not anticipated to be measureable.

Access roads within the site will be kept to a minimum (i.e., limit the number of roads) to reduce effects on the environment. Surface water will be directed into natural flows by means of swales, culverts, and ditches where necessary to maintain local drainage patterns. Appropriately sized culverts will be incorporated into the Project design to maintain local drainage patterns and ditch capacities will be sized to accommodate an extreme daily rainfall event. Riprap energy dissipaters and ditch lining will be used in areas where the predicted runoff velocities are deemed excessive to reduce soil erosion.

Overall, surface water runoff and wastewater within the Project footprint are not expected to result in detectable changes to hydrology, surface water quality, and vegetation (wildlife habitat). Therefore, these interactions were determined to have no linkage to effects to wildlife.

- **Seepage from waste rock disposal areas can change surface water, soil, and vegetation quality, which can affect wildlife habitat.**

Construction of the powerhouse, roads, water intake, power tunnel, and tailrace channel will produce approximately 1,074,000 m^3 of waste rock and 118,000 m^3 of overburden that will need to be stored on-site. The waste rock disposal areas will be placed in locations that are easily modified to control seepage and a Waste Rock Management Plan will be prepared for the Project. Excavated material will be stored near the Project construction areas and located away from watercourses or lakes. Site grading, ditches, and berms will be used to capture runoff from the waste rock disposal areas, which will be sent to settling ponds. Surface water will be diverted around and away from waste rock disposal areas as much as possible. This runoff will be collected, tested, and treated, if necessary, before release to the environment.

Some portion of the waste rock excavated from the power tunnel could be acid-generating, have elevated concentrations of various metals, or contain uranium mineralization, particularly waste rock from the section of the power tunnel within, or near, the Black Lake Shear Zone. The power tunnel waste will be tested for susceptibility to generate ARD and potential for metal leaching (ML) prior to being placed in waste rock disposal areas. Previous geological testing has confirmed that radioactive waste rock is not likely to be encountered in the LSA (Hatch 2005, 2012). However, waste rock will be tested for radioactivity as construction progresses. Any rock waste that is found to be radioactive will be disposed of according to provincial and federal guidelines.

If bedrock materials are ARD-generating or susceptible to ML, the rock will be segregated for special management. In this case, environmental design features will be required to limit seepage from the waste rock disposal areas. A containment system will be designed to control seepage from the waste rock disposal areas to groundwater or underlying aquifers. The design will control shallow horizontal migration. Potentially contaminated wastewater from waste rock disposal areas run-off will be collected in on-site settling ponds. Once wastewater is collected, it will be tested and treated, if necessary, prior to discharge. Wastewater will meet applicable water quality guidelines (e.g. CCME) prior to being released into a nearby waterbody (i.e., Black Lake, Fond du Lac River, and Middle Lake).

If no adverse characteristics are identified in the waste rock, this material can be used as aggregate for road construction and concrete production. It can be used as riprap to armour the walls of the tailrace channel or to construct the weir across the Fond du Lac River at Grayling Island. Re-use of “clean” waste rock at the Project site will reduce the overall volume stored in the waste rock disposal areas.

Ongoing monitoring requirements outside of those specified within the Project license would default to terms outlined within the relevant federal and provincial acts, regulations, and standards applicable at the time. Effects to soil quality from seepage and long-term contaminant transport from the waste rock disposal area are expected to be limited using mitigation and environmental design features. Therefore, these interactions are not expected to result in detectable changes in surface water, soil, and vegetation quality and were determined to have no linkage to effects on wildlife and wildlife habitat.

- **Cessation of power generation activities, including the withdrawal, diversion, and discharge of water, can change hydrology, which can affect wildlife habitat.**

The cessation of power generating activities will be completed in compliance with all federal and provincial acts, regulations, and standards applicable at the time, and in consultation with the BLFN. Closure activities will be designed to minimize changes to hydrology and the effectiveness of mitigation and reclamation techniques will be monitored.

The cessation of diverted water flow through the power tunnel will be completed at the same time as the decommissioning of the submerged weir at the outflow of Black Lake to maintain hydrologic characteristics in Black Lake, the Fond du Lac River, and downstream environments. Cessation of power generating activities will be completed according to a Decommissioning and Reclamation (D&R) Plan that will include details on the rate at which the diverted water is reduced to zero and the rate at which the weir is removed. Water management strategies during this time will be important to effectively and efficiently return local hydrology to its natural condition.

Overall, the cessation of power activities is not expected to result in measurable changes to hydrology and, subsequently wildlife habitat, relative to baseline conditions. Therefore, this interaction was determined to have no linkage to effects on wildlife**.**

15.4.2 Interactions with Secondary Linkages

In some cases, both a source and an interaction exist, but because the change caused by the Project is anticipated to be minor, it is expected to have a negligible residual effect on wildlife relative to baseline values. The following interactions are expected to be minor and will not be carried through the residual effects assessment.

- **Dewatering of the power tunnel during construction can cause drawdown in nearby lakes, which can affect wildlife habitat.**

During the construction of the power tunnel and tailrace channel, work will be completed in the dry and potential seepage into these areas will require dewatering. Dewatering activities could alter groundwater flows thereby affecting surface waterbodies within the zone of influence. The period of dewatering may last throughout construction (three years), but it is not expected to reach maximum drawdown rates until the latter stages of construction.

The only surface waterbody located within the zone of influence and potentially affected by dewatering activities is Lake A, which is a non-fish bearing lake located approximately 1.5 km north of the proposed water intake structure. Although this lake is relatively small, it may provide habitat to wildlife, in particular waterbirds.

Under worst-case scenario groundwater modeling results (i.e., the scenario resulting in greatest change to Lake A), this lake is predicted to lose 35 cubic metres per day (m^3/d) to groundwater during baseline conditions. During dewatering of the power tunnel, this loss to groundwater is predicted to increase up to 100 m^3/d (Section 9.0, Appendix 9.2). This drawdown rate is approximately 3% of the average annual flow though rate, indicating that the outflow channel should remain active for the majority of its flow season and that any drawdown that occurs during low inflow periods will be replenished annually. Additionally, this rate of drawdown is predicted only during a short period in the latter stages of construction and could be of lower magnitude if less conservative fault, overburden, and bedrock hydraulic conductivities and recharge through the overburden exist. Overall, dewatering of the power tunnel during construction is expected to result in minor and temporary changes to surface water levels in Lake A. Therefore, this interaction was determined to have negligible effects on wildlife habitat.

- **Withdrawal and discharge for power generation could change the temperature of the water, which can affect wildlife habitat.**
- **Withdrawal and discharge for power generation could change the temperature of the water and therefore ice thickness in Black Lake and Middle Lake, which can affect wildlife.**

The construction and operation of the Project has the potential to change the temperature of the water in Black Lake, which can affect wildlife and wildlife habitat. Changes to water temperatures at the water intake site and in waterbodies downstream of the discharge location are often among the most prevalent water quality issues encountered at hydropower facilities (Oak Ridge National Laboratory [ORNL] et al. 2010). Water diverted for power generation is often withdrawn from near the reservoir bottom; in temperate regions where lakes and reservoirs tend to be thermally stratified, this can lead to withdrawal of cooler water in the summer and relatively warm water in the winter (ORNL et al. 2010). Withdrawal and discharge of cooler bottom water in the summer, for example, may cause water temperatures at the water intake site to increase and water temperatures downstream of the power generation facility to decrease (Department of Electricity Development [DOED] 2002). These changing temperatures may result in changes to wildlife habitat, which could result in alterations in wildlife abundance and distribution. The opposing phenomenon would be expected during winter, when inverse stratification is likely to occur in lakes and reservoirs. This change in water temperature may result in decreased ice thickness, which can be a hazard to wildlife.

The water intake approach channel will be designed and constructed so that diverted water is withdrawn from near the surface of the lake, thereby reducing temperature differences between Project water and water entering the river through the natural Black Lake outlet (Appendix 12.3). Because Black Lake will not be impounded, the volumes and temperatures of water flowing out of the lake during operation (i.e., through the natural outflow and the water intake) will be similar to current values (i.e., volumes and temperatures of water flowing out the natural outflow) throughout much of the year. However, it is possible that during winter, water withdrawn from greater depths (i.e., closer to 5 m deep) in Black Lake could be slightly warmer than water draining naturally at the outlet to the Fond du Lac River.

Water withdrawn from Black Lake will pass through a 2.95 km long power tunnel to the powerhouse and then discharge into an open tailrace channel, which flows into the Fond du Lac River at a location upstream of Middle Lake. The preferred tailrace channel design has a length of approximately 800 m long (the final design is subject to optimization). It is anticipated that water passing through the Project facility will not have the same opportunity to cool (winter) or warm (summer) as water passing down the Fond du Lac River under open channel flow conditions. During winter, water entering the Fond du Lac River from the tailrace channel may cool slightly when exposed to cold air, but is expected to be slightly warmer than the natural flow in the Fond du Lac River where the two flows converge, upstream of Middle Lake.

Because flows in the bypassed river reaches will be reduced, it is anticipated the rate of heat exchange between the water remaining in the river channel and ambient air will increase, thereby potentially altering water temperatures. The most extreme temperature effects of the Project would be expected to occur during the periods of lowest riparian flow and extreme cold (i.e., winter), as well as periods of extreme heat (summer). The hydrology modelling results indicate that riparian flow temperatures could fall as low as 0.0°C when the Project is operating during winter and riparian flows in the Fond du Lac River are reduced below approximately 50 m^3/s.

Water temperatures downstream of the tailrace channel outlet in the Fond du Lac River will be governed by mixing of water that has passed through Project infrastructure (i.e., water intake, power tunnel, and tailrace channel) and water that has flowed through the bypassed river reaches. The maximum difference between the river temperature upstream of the tailrace channel outlet in the Fond du Lac River and the mixed river temperature downstream of the tailrace channel discharge is expected to be approximately 0.5°C, assuming an extreme low winter riparian flow of 30 m^3/s. Based on this riparian flow rate, the temperature of water entering Middle Lake in the winter months is expected to be approximately 0.3°C warmer than under current conditions.

In winter, cooler ambient air temperatures and reduced riparian flow volumes resulting from Project operation can reduce water temperatures and increase the potential for ice formation (Stantec 2010) in the bypassed section of the Fond du Lac River. Formation of anchor ice (i.e., submerged ice that is anchored to the bottom) is not reported to occur in Black Lake, Middle Lake, or the connecting section of the Fond du Lac River under current temperature and flow conditions. Formation of frazil ice and anchor ice is not expected to be an issue downstream of the tailrace channel outlet when the Project is operating because the mixed water is expected to be slightly warmer during winter. Because the water entering Middle Lake during winter may be slightly warmer than under current conditions, it is anticipated that the period and spatial extent of ice cover on Middle Lake may be somewhat reduced.

A wide, shallow water intake approach is expected to withdraw water from the surface of the lake to limit temperature differences between the water entering the river at the tailrace channel outlet and what naturally enters the Fond du Lac River through the Black Lake outlet. Overall, the withdrawal and discharge of water for power generation is expected to result in minor changes in the temperature of water in Black Lake and Middle Lake. However, these interactions were determined to have a negligible effect on wildlife.

- **Access to the site and areas on the east side of the Fond du Lac River can increase risk of mortality from hunting of wildlife.**

An all season gravel road will be constructed from Highway 905 to the Project. Highway 905 connects the communities of Black Lake and Stony Rapids. The new access road will increase access to the east side of the Fond du Lac River. Hunting and trapping currently occurs within the LSA and RSA and hunting and trapping areas have been identified by interview participants from the BLFN (Annex V – Heritage Baseline Report). Animals in the LSA and RSA are generally harvested for fur and meat. Animals currently hunted or trapped in the RSA include wolf, black bear, moose, American marten, snowshoe hare, and red squirrel. Most hunting for caribou by the BLFN takes place outside of the RSA in the northern reaches of Saskatchewan and into the NWT.

Currently, access to the east side of the Fond du Lac River during the spring, summer, and autumn is limited to watercraft. During the winter, vehicles such as snowmobiles could access this area using frozen waterbodies and existing trails. The new access road will allow year-round vehicle access to the east side of the Fond du Lac River for hunters and trappers, which has the potential to increase harvesting pressure on wildlife.

An Access Management Plan will be developed for the construction camp and worksite and will include the development of a "no hunting, trapping, harvesting, or fishing policy" for Project employees. No firearms will be allowed on the Project site. A "no hunting" zone will be imposed for the Project, and will include a 500 m buffer around the Project footprint and access road right-of-ways. The no hunting zone will be developed in consultation with the BLFN. Unauthorized public visits to the construction camp and associated facilities will be restricted. All public access to the construction, laydown, and camp areas will be restricted to the public until Project construction is completed. The use of recreational all-terrain vehicles will be prohibited at the site.

In summary, the implementation of environmental design features and wildlife protection practices are expected to result in minor changes in mortality from hunting of wildlife relative to baseline conditions. Therefore, this interaction was predicted to have a negligible residual effect on wildlife.

- **Physical hazards (e.g., blasting activities, tailrace channel, buildings, and waste rock disposal areas) from the Project can cause injury or mortality to wildlife and affect wildlife populations.**

Project infrastructure can be hazardous to wildlife. Birds are vulnerable to collisions with man-made structures and commonly are victims of electrocution by power lines (Bevanger 1998; Erickson et al. 2005; Drewitt and Langston 2008). Mammals could become tangled in fencing or wire that is lying on the ground and fall into open pits, trenches, or the tailrace channel.

The preferred tailrace channel design has a length of approximately 800 m.. This is an open-air channel proposed to be located in a broad flat valley that gently slopes to the northwest. The installation of a 50 MW generator will result in a full plant discharge of up to 190 m^3/s requiring a tailrace channel 25 m wide with a flow channel depth of 5.5 m. In areas composed of bedrock, sidewalls for the tailrace channel are expected to be sloped at one horizontal to ten vertical (1H: 10V). Sidewalls will be sloped at three horizontal to ten vertical (3H: 1V) for areas composed of glaciofluvial material and rock riprap will be installed in these areas to increase stability. The tailrace channel, water intake, and powerhouse structures will be fenced to prevent wildlife from entering these areas and falling into the tailrace channel.

The tailrace channel will be decommissioned by contouring it so it is safe for wildlife. If there are concerns about leaving the tailrace channel open once the plant is decommissioned, the waste rock and overburden could be used to fill in the channel.

Many factors affect the potential for bird collisions with buildings, including weather, lighting of infrastructure, infrastructure size, and infrastructure orientation in relation to migratory flyways or local flight paths between roosting and foraging areas (Klem 1990; Drewitt and Langston 2008). Collisions can increase during spring and fall migration periods due to flocking behaviour of migrating birds and the increased number of young and inexperienced birds (Drewitt and Langston 2008).

Blasting activities can also cause physical injury or mortality to wildlife. A detailed Blasting Plan will be developed. Surface blasting will be temporarily suspended if animals are observed within the danger zone identified by the blast supervisor.

In addition to the above-mentioned environmental design features, the following mitigation will also be implemented:

- open trenches or pits will be fenced to exclude wildlife or one of the ends or sides will be sloped to allow escape;

- during winter construction periods, gaps will be left in some windrows along access roads and around the site to allow escape routes for mid to large sized wildlife; and
- good housekeeping will be practiced to prevent wildlife from becoming entangled with or injured by on-site material.

These environmental design features and the implementation of mitigation practices are expected to result in minor changes in the mortality or injury rate of wildlife from physical hazards associated with the Project, relative to baseline conditions. Therefore, this interaction was determined to have a negligible residual effect on wildlife.

- **Access to the site and areas on the east side of the Fond du Lac River will be controlled, which can affect the movement and behaviour of wildlife.**
- **Site infrastructure (e.g., tailrace channel and roads) could restrict wildlife movement and increase risk of mortality from predation, which can affect wildlife.**

The access roads, buildings, fenced tailrace channel, and additional infrastructure will present physical barriers to the movements of some wildlife species through the LSA. These physical barriers to wildlife can result in local changes to wildlife behaviour and the abundance and distribution of wildlife populations.

Roads can act as barriers or conduits to wildlife species (Dyer et al. 2002). Roads also contribute to fragmentation of habitats, which in itself creates barriers to wildlife movement (Carthew et al. 2009). A species with very specific habitat requirements and low dispersal ability (or ability to move) is more likely to be negatively affected by barriers and habitat fragmentation than a generalist or highly mobile species. For example, small mammals, insects, and amphibians commonly show a reduction in the likelihood to cross a road, seismic line, or utility corridor, even in clearings as narrow as 2.5 m wide (Forman and Alexander 1998; Carthew et al. 2009). In contrast, some larger species are unaffected by clearings or road corridors (Carthew et al. 2009).

The main access road right-of-way will be approximately 40 m, with additional clearing as required to maintain sight lines and distances. The access road could affect marten population connectivity as marten might avoid crossing gaps wider than 72 to 100 m (Marklevitz 2003; Cushman et al. 2011; Caryl et al. 2012). Marten could also avoid the Project access roads because of sensory disturbance associated with roads (Robitaille and Aubry 2000; Alexander et al. 2005).

Caribou cross roads less frequently during most of the year (Dyer et al. 2002). Caribou might cross roads less frequently for several reasons, including the aversion for the physical barrier presented by the road, vehicle traffic, or predation by humans (Dyer et al. 2002). Areas of reduced use were demonstrated by caribou of up to 500 m away from developments, but the area of reduced use is influenced by associated sensory disturbance from traffic, not just the physical barrier alone (Dyer et al. 2002). No woodland or barren-ground caribou were observed in the RSA during any wildlife surveys. The nearest known woodland caribou conservation unit is located approximately 30 km south of the Project (SKCDC 2013). The only sign of caribou that was found during terrestrial baseline surveys was decades-old caribou antlers (disintegrating and encrusted with lichen). Barrier effects from the Project access roads could influence the ability of moose to travel across the land (Stewart and Komers 2012) and access important habitats (e.g., winter refuge habitat, mineral licks, and aquatic feeding areas) (Naylor 2005).

Species that can move effectively (i.e., most birds) might consider habitat patches to be connected even when covering only 35% to 40% of the landscape (With and Crist 1995). In other studies, effects from habitat fragmentation on populations are small until habitat amounts decrease below a threshold level (approximately 60% to 90% habitat loss) (Flather and Bevers 2002; Swift and Hannon 2010). Gaps in forest cover of 50 to 200 m have been reported to effectively isolate songbirds in forested landscapes (Desrochers and Hannon 1997; Schmiegelow et al. 1997; St. Clair et al. 1998). The ability and willingness of a bird to cross a matrix (i.e., less preferred habitat portions of the landscape) also could be influenced by the quality of the matrix. For example, a matrix could decrease the survival probability of an individual because of increased risk of predation or collision with a vehicle (Swift and Hannon 2010).

Wolves have a positive correlation with road density in areas with low road and human density (Thurber et al. 1994; Houle et al. 2010; Bowman et al. 2010). Roads with high traffic volumes might be a partial barrier to wolf movement, but other linear developments (e.g., roads with low traffic, power line corridors) could be preferred travel corridors for wolves, especially when snow is deep (Paquet and Callaghan 1996; Gurarie et al. 2011).

The Fond du Lac River is an existing natural barrier that traverses the LSA. Wildlife species will typically go around a small body of water or cross a river at the narrowest or shallowest section, although crossings could be more frequent when waterbodies are frozen. However, wildlife species currently using the area likely do not frequently cross the Fond du Lac River, but use the frozen lakes during the winter to move around. With respect to the Fond du Lac River corridor, wildlife species currently in the area are more likely to travel along the river corridor than through the Project site, especially because of sensory disturbance from the Project.

The Project footprint will be limited to reduce effects on the environment. Clearing of vegetation will be limited to the extent possible and will only be removed in areas that could pose a hazard or interfere with construction activities. Siting and construction of the Project will be planned to avoid environmentally sensitive areas (e.g., critical wildlife habitat, rare wildlife species, and wetlands) as much as possible. During winter construction periods, gaps will be left in some windrows along access roads and around the site to allow escape routes for mid to large sized wildlife. The Project infrastructure and tailrace channel will be fenced to prevent wildlife from entering this area. Although the Project infrastructure will be fenced, the temporary Project infrastructure (i.e., construction camp and contractor’s work areas) will be removed and reclaimed following construction.

Based on this information, physical barriers to wildlife are expected to result in minor changes in the movement and behavior of wildlife relative to baseline conditions. Therefore, these interactions were determined to have a negligible residual effect on wildlife.

- **Use of explosives near surface waterbodies can change surface water and soil quality and affect wildlife habitat.**

Use of explosives during the construction phase of the Project could cause changes in surface water and soil quality, which has potential to affect wildlife habitat. At the present time, ammonium nitrate fuel oil (ANFO) is expected to be used for the tunnel excavation. This type of explosive has the potential to release nitrogen residual substances (e.g., ammonia and nitrate). Blasting activities and the removal of waste rock could increase dust deposition and could increase trace metal (e.g., aluminum, cadmium, chromium, copper, iron, mercury, and silver) concentrations and nitrogen residual substances.

A Blasting Plan is expected to be developed for the Project and will describe the type of explosives used and the method of detonation. As part of this plan, best practices will be applied to blasting activities to reduce the potential for enhanced nitrogen loading of nearby soils. Waste rock produced from blasting activities is expected to contain trace amounts of residual substances from use of the explosives; therefore, surface water runoff from the waste rock disposal areas may also contain residual substances. Surface water runoff from the waste rock disposal areas will be collected and pumped to the settling ponds. Water in settling ponds will be routinely tested prior to release, as part of the Site Water Management Plan that will be developed for the Project. The amount of residue in the waste rock is anticipated to diminish over time.

The approved Blasting Plan will follow Fisheries and Oceans Canada (DFO's) Guidelines for the Use of Explosives in or Near Canadian Waters (Wright and Hopky 1998) to limit the potential for residual blasting interactions with downstream water quality. The Blasting Plan will also provide mitigation to limit the potential for effects on surface water quality from fugitive dust generation through excavation and material transport. The water quality modelling indicates that loads of ammonia and nitrate from the use of explosives would result in only minor increases in the concentrations of these parameters in the Fond du Lac River. This would not result in an exceedance of applicable water quality guidelines for the protection of aquatic life at the edge of the mixing zone (Section 11.5.2). Consequently, changes to surface water quality and soil quality from the use of explosives was determined to have a negligible residual effect on wildlife.

- **Deposition of criteria air contaminants can change surface water, soil, and vegetation quality chemistry, which can affect wildlife.**
- **Dust deposition can change surface water, soil, and vegetation quality, which can affect wildlife.**

Construction and operation of the Project will generate air emissions such as carbon monoxide (CO), oxides of sulphur (SO_x), includes sulphur dioxide [SO_2]), oxides of nitrogen (NO_x), particulate matter ($PM_{2.5}$, PM_{10}), and total suspended particulates (TSP). Air quality modelling was completed to predict the spatial extent of air and dust emissions and deposition from the Project (Section 8.5). Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates (Section 8.5).

Air emissions (i.e., SO_2 and NO_2) can result from the use of fossil fuels in generators, vehicles, and machinery during construction and operation of the Project. The deposition of SO_2 and NO_2 can alter soil pH, nutrient content, and cause acidification of the soils, which can lead to changes in soil fauna composition (Rusek and Marshall 2000). Changes in soil fauna can lead to changes in vegetation (i.e., wildlife habitat), as there could be alterations in organic matter decomposition rates and nutrient cycling. Deposition of SO_2 and NO_2 can also lead to acidification of wetlands, which can cause changes in plant and wildlife communities (Bobbink et al. 1998). Inputs of SO_2 and NO_2 and the acidification of wetlands can affect amphibian species by increasing primary production (e.g., algae) and triggering toxicological responses (Smith et al. 2006). However, changes from soil acidification to vegetation and wildlife habitat depend on the buffering capacity of the soil (Bobbink et al. 1998; Barton et al. 2002). Brunisolic soils in the RSA were rated as having a High sensitivity to acidification (Annex IV, Section 3.3.3.2). Gleysolic soils were rated as having a Low to High sensitivity; however, this is dependent on proximity to wetlands. Organic soils that occur in moderate and rich fens are least susceptible to acidification and therefore have a Low sensitivity rating. Organic soils that occur in bogs and in poor fens have a Medium sensitivity rating.

Results of the air quality modelling indicate that the maximum ground-level concentrations of CO, SO_2, and NO_x are all below the Saskatchewan Ambient Air Quality Standards (SAAQS 1996) and the Canada Wide Standard (CCME 2000; Section 8.5.1), and are limited to the immediate vicinity of the Project. The related changes to soil pH is determined by several complex geochemical factors, which include nutrient uptake by plants, decomposition of vegetation, cation and anion exchange in soil, soil sensitivity to acidification, and atmospheric inputs (Turchenek et al. 1998). When NO_x is oxidized, it can produce NO_3^-, which is typically limited in poor fens and bogs, therefore taken up by vegetation. Biological uptake can minimize the effects of nitrogen deposition. Nitrogen is retained in the plant biomass and therefore can result in a neutralizing effect. Sulphur transformations are affected by redox and pH interactions, and are biologically mediated. When SO_2 is oxidized, it can produce sulphate (SO_4^{2-}). Higher plants normally take up sulphur as SO_4^{2-}. The results indicate that deposition of SO_2 and NO_x will not likely result in changes to soil pH. Overall, it is expected there will be no changes to soil quality from SO_2 and NO_x therefore, no effects on wildlife habitat are expected.

Dust deposition can cause chemical loading in soils as dust emissions can include metal particles. Metal particle deposition can result in increased metal concentrations in plant leaves (Grantz et al. 2003; Peachey et al. 2009). Metal particle deposition can also affect soil biota composition (Grantz et al. 2003), which could indirectly affect vegetation. Although metal deposition can change vegetation chemistry, a study by Peachy et al. (2009) found that vegetation that received some metals from dust deposition did not cause direct toxicity to plants.

In addition to metals, dust can contain cations and anions. When cations (e.g., ammonium [NH_4^+], sodium [Na^+], potassium [K^+] calcium [Ca^{2+}], magnesium [Mg^{2+}]) are deposited into an ecosystem, the vegetation present can take up the cation; however, other cations, usually hydrogen [H^+], are released into the environment, and can decrease soil pH (Turchenek et al. 1998). When anions (e.g., chloride [Cl^-], nitrite [NO_2^-], bromide [Br^-]) are deposited into an ecosystem, anions such as hydroxide [OH^-] can be released. Although OH^- increases pH, cation and anion uptake have generally shown to result in a net production of acidity. The net effect is acidification because the cations are generally retained in the plant biomass and are therefore not mineralized. Ultimately, the concentration and duration of air and dust emissions and the sensitivity of the ecosystems determine the overall influence that emission deposition will have on wildlife habitat (Bobbink et al. 1998).

Modelling results indicate that the Project's maximum annual emissions rate is 0.020 tonnes of H+ per day (t/d) and the average for the 2014 to 2017 construction period is 0.014 t/d. These values are well below the MOE's threshold of 0.175 t/d. The Project's potential for acid deposition is low, and therefore, it is expected there will be no change to surface water quality and soils from acidification, and, subsequently, no effects to wildlife habitat.

Transportation routes, particularly unpaved roads that are used to access the Project are the main source of dust due to the re-suspension of soil particles (Farmer 1993; Harrison et al. 2003; Peachey et al. 2009). In addition to potential changes to chemistry from air and dust deposition, dust covering vegetation can have a physical or physiological effect on plants (Farmer 1993; Grantz et al. 2003). Dust on vegetation can also result in a reduction of plant growth and biomass, and can alter species composition (Grantz et al. 2003). Walker and Everett (1987) and Everett (1980) reported that few vascular plant species showed physiological effects from dust, except where vegetation was subject to very high dust loading.

Most studies indicate that potential effects from dust are localized to within 50 m of the source and typically do not extend to the regional area (Grantz et al. 2003). Watson et al. (1996) found that most dust generated from transportation corridors are deposited within a 50 m of the source. Meininger and Spatt (1988) found that most of environmental effects of dust occurred within 5 to 50 m of a road, with less obvious environmental effects observed between 50 and 500 m from a road. Walker and Everett (1987) and Everett (1980) reported that effects of dust were confined to a 50 m buffer on either side of a road.

Most of the traffic to the Project will occur during construction. All unpaved roads will be watered regularly to prevent wind driven fugitive dust. Speed limits will be enforced to reduce dust generation from roads. Once construction is complete, the numbers of vehicles travelling to and from the Project are expected to decrease (Section 5.5.1). Modelling results indicate that the maximum predicted TSP and $PM_{2.5}$ concentrations are 114.4 µg/m^3 and 22.8 µg/m^3, respectively, which do not exceed the SAAQS and Canada-Wide Standard (Section 8.5.1.2.3). Minor Project-related increases in TSS could occur in association with the spring freshet, when accumulated dust deposited over winter migrates with melted snow; however, this increase would be very short in duration (i.e., over the duration of the freshet) and would likely only occur during the three year construction phase when dust deposition is expected to be greatest.

Overall, air and dust emissions and subsequent deposition are expected to result in minor changes to surface water, soil, and vegetation quality. Therefore, these interactions were determined to have a negligible residual effect on wildlife.

- **Attraction to the Project (e.g., food waste, oil products) could increase human-wildlife interactions and mortality risk to individual animals, which can affect wildlife populations.**
- **Attraction to the Project (e.g., food waste, oil products) could increase predator numbers and predation risk, which can affect prey populations.**

Attraction of wildlife to the Project might result in increased mortality, risk of predation, and human-wildlife interactions. Wastes generated by human activities during construction and operation can be attractive to wildlife, which can result in human-wildlife interactions and the intentional removal of problem wildlife (Knight and Cole 1991). Carnivores can be attracted to food smells and other aromatic compounds such as petroleum-based chemicals, grey water, and sewage. In addition, infrastructure could attract carnivores as it can serve as a temporary refuge to escape extreme heat or cold. Corvids and raptors could also be attracted to infrastructure and anthropogenic food sources (Restani et al. 2001; Marzluff and Netherland 2006; CWS 2007; Kristan and Boarman 2007; Baxter and Allan 2008). The attraction of carnivores, raptors, corvids, and gulls can increase predation pressure on prey species (e.g., moose, passerines, and waterfowl) (CWS 2007; Liebezeit et al. 2009). This increase in predation could have the potential to cause local and regional population declines of these prey species (Monda et al. 1994; CWS 2007; Liebezeit et al. 2009).

Ungulates require the intake of salts as part of seasonal changes in diet (Atwood and Weeks 2003; Ayotte et al. 2006). Salt build-up near roads might attract ungulates searching for salts (Laurian et al. 2008a, b). Birds and bats could be attracted to the abundance of insects around Project lights at night.

Environmental design features and management plans will be implemented to limit wildlife attraction to the Project site. A Waste Management Plan will be developed for the Project. Non-hazardous domestic waste (e.g., kitchen waste and office waste) and construction material waste (plastics, wood, metal, and other inert materials) will be stored on site in appropriate containers to prevent exposure until they are hauled to the Black Lake landfill for disposal. Food waste, which has the highest probability of attracting wildlife, will be managed with wildlife-proof storage containers and will be hauled off-site to the local landfill.

Non-consumable organic waste material such as wood and paper can be burned on-site. Storage facilities for hazardous wastes and explosives will meet the appropriate regulatory requirements and site personnel will be properly trained. Disposal of hazardous wastes will be handled by a licensed contractor and hauled to an approved facility.

In addition to the above-mentioned mitigation, the following procedures will also be implemented:

- individuals working on site and handling hazardous materials will be trained in the Transportation of Dangerous Goods;
- hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers; and
- sanitary sewage will be collected from washroom and toilet areas and treated and disposed of at the Black Lake lagoon according to Saskatchewan regulatory requirements.

Environmental design features and mitigation are expected to limit wildlife attraction to the Project and result in a minor change to the mortality of wildlife relative to baseline conditions. Therefore, these interactions are expected to have a negligible residual effect on wildlife.

15.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events occurring on-site have the potential to affect wildlife. The following events were identified as having a potential interaction with wildlife.

- **Emergency shutdowns of power generation activities can change surface hydrology, which can affect wildlife habitat**.

It is estimated that the power plant will undergo between 10 and 50 emergency shutdowns per year, with most of these occurring during the summer months (i.e., weather-related). The power plant will be shut down without advance notice if there is a load rejection in the transmission system due to transmission line failure. These unplanned shutdowns are expected to be relatively brief, typically from a few minutes to four or five hours. On occasions during the spring fish spawning and rearing period (May 15 to July 15), when the unplanned shutdown exceeds 15 minutes, the bypass conduit at the powerhouse will begin releasing flow to reduce drawdown effects on the Fond du Lac River below the tailrace channel outlet and upstream of Middle Lake. During these periods, flows through the natural outlet would slowly increase as water levels in Black Lake respond to reduced power tunnel outflows.

The powerhouse will be shut down without advance notice if there is a load rejection in the transmission system due to transmission line failure. These unplanned shutdowns are expected to be infrequent and relatively brief, typically ranging from a few minutes to four or five hours. On occasions, when the unplanned shutdown exceeds two hours, the bypass conduit at the powerhouse would begin releasing flow to reduce drawdown effects on the Fond du Lac River below the tailrace outlet and upstream of Middle Lake. During these periods, flows through the natural outlet would slowly increase as water levels in Black Lake respond to reduced outflows.

The turbine generator units for the proposed station will be equipped with turbine inlet valves (TIV) to start and stop flows. These will be designed to close at a rate that will avoid undesirable increases in water pressure in the power tunnel.

During average flow conditions, a 60 minute emergency shutdown would result in an increase in Black Lake water level of less than one millimetre (mm). During a prolonged emergency shutdown and average natural flow conditions (300 m^3/s), inflow to Middle Lake would be reduced by 190 m^3/s, which would result in a decrease in Middle Lake water level of approximately 8.67 cm/hour and a maximum drawdown of 0.91 m. If the bypass conduit is activated at 50% during a prolonged emergency shutdown, this drawdown rate in Middle Lake would be reduced to 4.35 cm/hour with a maximum total drawdown of 0.41 m (Appendix 10.3).

Overall, changes to surface flows during an emergency shutdown are predicted to have no detectable change to hydrology; therefore, this interaction was determined to have no linkage to effects on wildlife.

- **Release or spills of hazardous substances (e.g., fuel or oil) can change surface water, sediment, and soil quality, which can affect wildlife habitat.**

Spills during construction, operations, or decommissioning and reclamation activities following closure have the potential to change surface water, sediment, and soil quality, which can adversely affect wildlife, and wildlife habitat. Spills that occur in high enough concentrations could contaminate surface water and soils and cause direct toxicity to aquatic organisms, soil organisms, and vegetation. Spills are generally preventable and local in nature.

The powerhouse will be equipped with an oil containment and separation system to prevent the release of petroleum based wastes into waterways. The turbine governor pumping systems will be surrounded by trenches or curbs to allow drainage via the trench or sumps to catch and transfer wastes to the oil separation system. Any room with the potential to produce an oil spill will also be equipped with containment curbs and door ramps. Additionally, the governor hydraulic power units will be high-pressure systems to reduce the potential for spills by maintaining the total volume of hydraulic oil in the system. The main transformers will be removed from the main tailrace channel deck and surrounded by oil spill containment walls to reduce the potential for spills to interact with the waterways. Double walled heat exchangers will be used for the turbine and generator-cooling systems to reduce the risk that cooling coil failure will discharge oil into the water. Self-lubricated bushings will be used throughout the design to eliminate sources of water pollution typical of greased bushings.

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks to the environment. Spill containment supplies will be available in designated areas and within Project vehicles. An Emergency Response Plan will be developed and will include instruction for the rapid response control, and management of spills or release of hazardous substances occurring on site. All spills will be isolated and immediately cleaned up. Spills will be reported to the appropriate agency if the spill exceeds reportable volumes for the material spilled as outlined in the provincial *Environmental Spill Control Regulations*. In the unlikely event of a spill, disposal of all contaminated soil will be handled by a licensed contractor and will be hauled off-site to an approved facility. Alternative approaches for in-situ treatment of contaminated soils could also be considered (e.g., phyto- or bio- remediation), depending on the substance spilled and capacity to treat the volume of material affected. Mitigation identified in the EnvPP will also be implemented to reduce the likelihood and extent of spills associated with the Project.

Storage facilities for hazardous wastes will meet regulatory requirements. All fuel storage tanks will be designed and constructed based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. The storage containers will be regularly inspected for leaks or damage, and replaced when necessary. Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double-walled and located in lined and bermed containment areas. Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers.

Vehicles will be regularly maintained and will carry fire extinguishers and standard emergency clean-up kits. Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills on the fueling stations would flow to the sump, which would be pumped out to a container for shipment off-site.

Implementation of the above environmental design features are expected to reduce the likelihood and extent of the release or spills of hazardous materials occurring on-site. No detectable changes to surface water and soil quality are expected. Therefore, these interactions are determined to have no linkage to effects on wildlife.

- **Increased traffic can increase the potential for vehicle to wildlife collisions, which can cause injury or mortality to wildlife.**

The Project will increase vehicle traffic during construction, which could result in increased injury and mortality to wildlife. Wildlife (primarily mammals, reptiles, and amphibians) are often attracted to roads where they forage for food, bask on the road surface, scavenge for carrion, and use corridors for travel (Smith-Patten and Patten 2008; Fahrig and Rytwinski 2009). The risk of vehicle-wildlife collisions is not uniform in regards to species, with amphibians having a high mortality risk from crossing roads because of their small size and slow movement speed (Hels and Buchwald 2001; Fahrig and Rytwinksi 2009). The search for prey and carrion can attract carnivores and raptors to roads (Fahrig and Rytwinski 2009) where they are insensitive to the threat of traffic (Dickson and Beier 2002). The presence of salt-covered vegetation and increased sodium levels in roadside ditches can be attractive to moose (Laurian et al. 2008a, b).

During construction (three years), between 250 and 300 jobs are expected to be created with many of these positions being filled by workers from the local communities (Section 18.5.1.2). Most of the specialized or skilled workers will be transported by plane to the nearest airport at Stony Rapids. A shuttle will transfer incoming and outgoing workers between Stony Rapids and the site to reduce the use of personal vehicles. Peak traffic volumes during construction will occur on the site access road and are anticipated to be roughly 45 vehicles per day (Section 19.4.2). Limited parking will be available on-site thereby, reducing the use of personal vehicles. Following construction, it is estimated that between six and eight personnel are required for operation of the Project and peak traffic volumes on Highway 905 and the site access road are anticipated to be approximately 10 vehicles per day (Section 19.4.2).

Traffic speed and volume are the primary factors that contribute to road-related wildlife mortality. Speed limits will be clearly posted on construction roads and enforced to mitigate against potential wildlife mortalities during construction. Vegetation along the roadside will be mowed and cut to decrease the attractiveness to wildlife species (e.g., moose) and to increase visibility of wildlife along the road.

In summary, increases in vehicle traffic during Project construction and operation are expected to result in minor changes to wildlife populations as compared to baseline conditions. Therefore, collisions with Project vehicles are expected to have negligible residual effects on wildlife populations.

- **Failure of the embankment dykes around the settling ponds can change surface water and soil quality, which can affect wildlife habitat.**

Failure of embankment dykes around the settling ponds could result in the release of sediment laden water and potential contaminants to the surface water and terrestrial environments. Environmental controls will be in place to limit the potential for embankment dyke failure. For example, water from the waste rock disposal areas will be diverted to the settling ponds by gravity. The settling ponds will be engineered to provide adequate storage of process streams under normal and extreme operating conditions. Maximum operating levels will be developed to provide adequate storage volumes for the design storm event. In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling pond would be provided by the inclusion of an overflow spillway in the embankment.

The embankment dyke will be constructed around the settling pond to contain wastewater from site and from the waste rock disposal areas. Embankment dykes will be stripped of vegetation, topsoil, and roots to expose the mineral soil subgrade as necessary to accommodate the size of the settling pond. Fill material used for constructing the dyke will be clean mineral soil with sufficient moisture to allow for proper compaction and will be placed in lifts not exceeding 150 mm in compacted thickness and compacted to a minimum of 95% standard proctor maximum dry density. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap immediately following construction.

The settling pond will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. During the detailed design stage, additional mitigation will be identified and included as part of the EnvPP and the Emergency Response Plan. Consequently, embankment dyke failure was determined to have no linkage to effects on wildlife.

- **Fire**

Fire can affect the community infrastructure and services by potentially increase the number of emergency response services. Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. Fire safety measures and response will be reviewed with the communities of Black Lake and Stony Rapids. On-site personnel will be trained in established fire prevention and response procedures and appropriate firefighting equipment will be available on-site so that trained personnel will be able to respond promptly. The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail.

Each pump will be sized to meet the full demand of the largest component of the system with the addition of 31.5 litres per second (L/s) for hose demand. Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute).

Although a fire may result in a loss of wildlife habitat, the implementation of the abovementioned mitigation is anticipated to result in negligible effects on wildlife populations.

15.4.4 Primary Interactions

The following interactions were determined to be primary for effects on the maintenance of self-sustaining wildlife populations (including listed species) and are carried forward to the residual effects analysis (Section 15.5).

- **Direct loss, alteration, and fragmentation of habitat from the Project footprint can affect wildlife abundance, movement.**
- **Sensory effects (e.g., presence of buildings, lights, smells, noise, blasting activity, and vehicles) can affect wildlife.**

15.5 Residual Effects Analysis

The residual effects analysis considered all primary interactions that are expected to result in effects on the abundance and distribution of wildlife populations after implementing environmental design features and mitigation. The effects on continued opportunities for traditional and non-traditional use of wildlife VCs are also assessed in this section; however, changes to traditional use species is a measurement endpoint for land use (Sections 7.0 and 17.0). The residual effects assessment is completed by calculating and estimating changes to measurement endpoints associated with the primary Project interactions. These measurement endpoints include:

- habitat quantity and fragmentation;
- habitat quality;
- movement and behaviour of wildlife; and
- relative abundance and distribution of wildlife.

Assessment cases are defined for the effects analysis and included the baseline case and the application case (Project case, which includes construction, operations, and closure), and future case (if applicable; Table 15.5-1). The baseline case considers the current conditions in the RSA such as natural disturbances (e.g., fire) and previous and existing human developments and activities. The regional area surrounding the Project has experienced little industrial human development and activity. Previous activity includes exploration work for the Nisto uranium deposit (mineral property #1621), which is located on the west shore of Black Lake, approximately 23 km east of Stony Rapids (Government of Saskatchewan 2013). In 1950, two adits were driven and lateral work was completed. Ore was mined from the shoots accessible from the northeast adit in 1959. Only exploration work has been completed in the area since 1959. Existing human-related disturbance includes trails, roads, cabins, the Black Lake lagoon, and the communities of Black Lake and Stony Rapids. Existing wildlife populations have likely adapted to the low level of human industrial activity over the past 50 to 60 years. Therefore, current (baseline) conditions in the RSA are expected to reflect the cumulative influence of previous and existing human industrial activities on wildlife VCs relative to reference conditions. Reference conditions represent no to little human development, except for First Nation communities, which are assumed part of the historical natural ecosystem.

Table 15.5-1: Contents of Each Assessment Case

Baseline	Application
Conditions from all previous and existing developments prior to the Project	Baseline Case plus the Project

The application case occurs during the start of construction of the Project through closure, and the associated duration of predicted effects (i.e., until effects are reversed or are deemed irreversible). The magnitude of effects from the Project is expected to be greatest during construction and the initial period of operation. For example, changes to existing habitat quality and the movement and behaviour of wildlife from Project-related sensory disturbance mechanisms (increased noise levels, blasting, air emissions, dust deposition, and human presence) will be greatest during construction. The Project is expected to employ 250 to 300 people during construction and traffic volume along the access road could approach 42 vehicles per day. Following construction and initial operations, sensory disturbance will be limited to the powerhouse, tailrace channel, and care and maintenance with 6 to 8 staff, which could be associated with a traffic volume of 10 vehicles per day along the access road.

Similarly, the physical removal and alteration of existing habitat will be completed after construction, and the reclamation process will begin immediately during operation. Reclamation activities following construction will include the removal of portions of the temporary construction infrastructure not required during operation. Temporary infrastructure includes the construction camp and contractor’s work areas. Reclamation activities could result in the presence of natural succession trajectories and climax plant communities over the 90-year operation period. Because the differences in the magnitude and geographic extent of effects on wildlife are expected to be measurable between construction and operation, the analysis examined both phases. Analyses were quantitative where possible and qualitative where necessary.

There is potential for this Project to operate beyond the expected 90-year operational period; however, increasing the duration of the operation phase of the Project would have little influence on effects predictions. Most of the physical changes to habitat from the operations footprint are considered permanent because of the length of operations (i.e., the duration of the change will be well beyond the temporal boundary of the assessment). The outcome of reclamation activities with respect to the operation footprint is highly uncertain, particularly in an environment where natural succession processes are slow, and plant community trajectories can be altered by a number of factors (e.g., climate change, fire, and unforeseeable human development).

Closure is when power production operations end, and decommissioning and reclamation of the final infrastructure (i.e., powerhouse, water intake, power tunnel, tailrace channel, switchyard, access roads, distribution line, and waste rock disposal areas) is completed.

Both Project-specific (incremental) and cumulative effects from the Project and existing human developments and activities are analyzed in this section. The future case includes baseline and the Project, plus reasonably foreseeable developments or designated projects. The geographic extent (zone of influence) of residual effects from the Project on wildlife is expected to be limited to the RSA. No other major developments in the region are located within the RSA. Therefore, the zones of influence associated with the Project and existing developments are not expected to overlap and generate cumulative effects on wildlife. Currently, there are no reasonably foreseeable developments that could have an overlapping temporal boundary with the Project and potential to generate cumulative effects on wildlife.

15.5.1 Habitat Loss and Fragmentation, and Population Connectivity

Development of the Project is expected to change the abundance, distribution, and spatial arrangement of habitat in the RSA. Habitat loss includes the direct removal or alteration of habitat due to the Project and other developments. Habitat loss has negative environmental effects on population abundance and distribution (Best et al. 2001; Guthery et al. 2001; Hargis et al. 1999); as a specific habitat decreases, species that rely on that habitat also decrease (Andrén 1994). Habitat loss from the Project occurs at the local scale, but residual effects can be regional as some wildlife species are highly mobile and can interact with various developments in the RSA. As such, habitat loss was examined at the regional scale.

Fragmentation refers to the division of a landscape into smaller habitat patches that can become more isolated from each other (Andrén 1994). Habitat fragmentation occurs at the regional scale and can affect wildlife abundance and distribution by changing individual movement, dispersal success and population connectivity (Bélisle et al. 2001; With and King 1999), predation rates (Hartley and Hunter 1998; Bergin et al. 2000; Kurki et al. 2000), and foraging behaviour (Mahan and Yahner 1999).

The changes from habitat loss and fragmentation are likely to have greater residual effects on wildlife species with low movement abilities and species with small home ranges. Habitat loss and fragmentation can also affect species that have specific foraging or breeding requirements, such as large, continuous patches of boreal forest.

Changes to habitat were assessed to the maximum predicted point of development of the Project footprint (disturbance assessment area), which should have the largest geographic extent of residual effects on wildlife. During construction, the disturbance assessment area is estimated to be 1,619 ha. This area was used in the habitat loss and fragmentation analysis because wildlife might or might not use the vegetation islands interspersed among the Project footprint that will be created during construction. The actual anticipated Project footprint during construction is expected to be 989 ha. Thus, the analysis overestimates the changes to habitat loss and fragmentation from the Project, and the predicted effects on the abundance and distribution of wildlife VCs.

Most of the reclamation activities are expected to occur during and immediately following construction, with some reclamation activities occurring during operations. For example, once an area has been decommissioned, salvaged topsoil will be placed on disturbed areas and re-vegetated to encourage endemic species to re-populate the area. Reclamation activities following construction will include the removal of portions of the temporary construction infrastructure not required during operation. The remaining infrastructure required for operations is estimated to be 280 ha.

The Ecological Landscape Classification (ELC) was used to assign habitat types to the RSA (Section 14.3.2). The amount of different habitats and mean distance to nearest neighbour (MDNN) were determined for the baseline case and the application case (construction phase) using the program FRAGSTATS (Version 3.0; McGarigal et al. 2002) in a Geographic Information System (GIS) platform. The MDNN is calculated as the shortest straight-line Euclidean distance between the centroids of the closest cells of respective habitat patches (i.e., cell-centroid to cell-centroid of the two nearest equivalent habitat cells) (McGarigal et al. 2012).

Incremental changes in habitat quantity and MDNN were assessed at the regional scale by estimating the relative difference or net change between application case (construction phase) and the baseline case using the following equation:

- (application case value – baseline case value)/baseline case value x 100%.

The resulting value is the percent change in habitat area and provides both direction and magnitude of the effect. For example, a high negative value for habitat area would indicate a substantial loss of that habitat type. Alternately, a negative value for MDNN indicates an increase in patch connectivity.

15.5.1.1 Woodland Caribou

Historically, woodland caribou could have occurred in the RSA; however, local knowledge indicates that caribou have not been documented around Middle Lake since the mid-1980s (Black Lake and Stony Rapids KPI Program 2012). No caribou or caribou sign were observed during ungulate aerial surveys or winter track count surveys in the RSA (Section 15.3.4.1).

In general, woodland caribou use mature coniferous forests and wetlands (fens and bogs) and avoid clear cuts and young jack pine stands (Rettie and Messier 2000). Close to 40% of the RSA is comprised of recent burn and regenerating habitats. Gustine and Parker (2008) have shown that woodland caribou select against burned habitats in every season except summer. Rettie and Messier (2000) showed that woodland caribou in

Saskatchewan caribou tended to avoid young, early succession stands. Fire could alter the availability of terrestrial lichens, which is the most important winter food source for woodland caribou (Edmonds and Bloomfield 1984; Fuller and Keith 1981; Manitoba Model Forest 1995). In the RSA, terrestrial lichens (e.g., reindeer lichen species [*Cladina* spp.]) compose a large portion of the ground cover in Bedrock, Jack Pine, Jack Pine/Black Spruce, and Spruce habitats (Annex IV, Section 4.3.1.3). Key habitats for woodland caribou in the RSA are Bedrock, Jack Pine, Jack Pine/Black Spruce, Spruce, and Wetland habitats (Rettie and Messier 2000; Rettie pers. comm. 2013).

The primary threats to woodland caribou populations are high mortality rates from predation and over harvesting (Fuller and Keith 1981; Stuart-Smith et al. 1997; Rettie and Messier 2000; Dyer et al. 2001; Dzus 2001; Wittmer et al. 2007; Environment Canada 2012b). Habitat loss (or alteration) and fragmentation can increase predator abundance in an area by increasing alternate prey populations (e.g., moose). For example, a forested area that has been logged or burned can be attractive to moose because of the regenerating vegetation. Moose and moose tracks were observed in the RSA during baseline surveys (Section 15.3.4). The increase in moose density can attract predators such as wolves to the area. The increased density of wolves could negatively affect woodland caribou populations through a higher rate of predation on caribou calves and adults (Stuart-Smith et al. 1997; Rettie and Messier 2000; Wittmer et al. 2007; Latham 2009).

Under baseline conditions, the RSA is mainly composed of Open Water (22.7%), Recent Burn (31.1%), and Jack Pine (18.6%) habitats (ELC map units; Table 15.5-2). Spruce, Mixedwood, Deciduous, Wetland, Regenerating Jack Pine, and Regenerating Mixedwood habitats account for 1.7% to 7.7% of the RSA. Bedrock, Jack Pine/Black Spruce, Riparian, Regenerating Jack Pine/Black Spruce, Regenerating Spruce, Regenerating Deciduous, Regenerating Wetland, and Regenerating Riparian habitats compose less than 1% of the RSA. Human disturbance covers approximately 0.8% of the RSA under baseline conditions.

The maximum possible extent of disturbance during construction (disturbance assessment area), is 1.4% (1,620 ha) of the RSA. The Project is predicted to remove between 0.8% and 3.5% of Bedrock, Jack Pine, Jack Pine/Black Spruce, Spruce, and Wetland habitats in the RSA (Table 15.5-2). The Project is expected to decrease the MDNN for Jack Pine and Spruce habitats by less than or equal to 0.2% (<1 m) (Table 15.5-3). The MDNN for Bedrock and Wetland habitats are predicted to increase by 4.9% (12 m) and 1.0% (2 m), respectively and MDNN for Jack Pine/Black Spruce are predicted to decrease by 0.6% (2.4 m). Relative to the range size of female woodland caribou (200 to 1,200 km^2; Rettie and Messier 2001) and the 50th percentile for mean daily movement rate (900 m; Rettie and Messier 2000), the calculated changes in habitat loss and distance between nearest equivalent habitat patches in the RSA are predicted to have no ecological effect on woodland caribou.

Table 15.5-2: Absolute and Relative Changes in the Quantity of Habitats in the Regional Study Area from Baseline Conditions to the Application Case

Ecological Landscape Classification Map Unit	Baseline		Application[(a)]		
	Area (ha)	Proportion of RSA (%)	Area during Application (ha)	Net Change from Baseline (ha)	Net Change from Baseline Case (% Unit)
Bedrock	347	0.3	343	-4	-1.1
Jack Pine	21,492	18.6	21,257	-235	-1.1
Jack Pine/Black Spruce	117	0.1	116	-1	-0.8
Spruce	8,887	7.7	8,574	-313	-3.5
Mixedwood	3,658	3.2	3,642	-16	-0.4
Deciduous	2,971	2.6	2,953	-18	-0.6
Wetland	6,213	5.4	6,165	-49	-0.8
Riparian	53	<0.1	52	<-1	-0.9
Open Water	26,275	22.7	26,262	-12	<-0.1
Regenerating Jack Pine	4,793	4.1	4,259	-534	-11.1
Regenerating Jack Pine/Black Spruce	48	0.0	46	-2	-4.2
Regenerating Spruce	707	0.6	604	-103	-14.6
Regenerating Mixedwood	2,002	1.7	1,845	-158	-7.9
Regenerating Deciduous	854	0.7	805	-48	-5.7
Regenerating Wetland	229	0.2	179	-50	-21.9
Regenerating Riparian	23	<0.1	7	-16	-69.8
Recent Burn	35,993	31.1	35,990	-3	<-0.1

Note: the total area of the Regional Study Area is 115,600 ha.
A value <0.1 or <-0.1 approaches zero.
Negative numbers indicate a reduction or change in that ELC map unit. Positive numbers indicate an increase or gain in that ELC map unit.
(a) based on disturbance assessment area
% = percent; ha = hectares; RSA = Regional Study Area

Table 15.5-3: Changes in Mean Distance to Nearest Neighbour for Habitats in the Regional Study Area from Baseline Conditions to the Application Case

Ecological Landscape Classification Map Unit	Baseline	Application		
	Mean Distance to Nearest Neighbour (m)	Mean Distance to Nearest Neighbour (m)	Net Change between Baseline and Application (m)	Net Change between Baseline and Application (% unit)
Bedrock	256	268	12	4.9
Jack Pine	118	118	<1	0.2
Jack Pine/Black Spruce	412	413	-2.4	-0.6
Spruce	171	171	<-1	-0.1
Mixedwood	167	167	<-1	-0.2
Deciduous	205	204	<-1	-0.3
Wetland	186	188	2	1.0
Riparian	851	851	0	0
Open Water	274	274	<1	<0.1
Regenerating Jack Pine	96	101	5	4.9
Regenerating Jack Pine/Black Spruce	405	394	-7	-1.7
Regenerating Spruce	159	159	<-1	-0.2
Regenerating Mixedwood	106	109	3	3.1
Regenerating Deciduous	161	168	8	4.9
Regenerating Wetland	307	318	11	3.4
Regenerating Riparian	87	n/a	n/a	n/a
Recent Burn	215	131	-84	-39.1

Notes: A value with < (less than) indicates the value approaches zero.
Negative numbers indicate a reduction in MDNN. Positive numbers indicate an increase or gain in MDNN.
Changes in the MDNN for Regenerating Riparian habitat is not applicable (n/a) because the Project is expected to remove all but one patch of Regenerating Riparian habitat.
ha = hectares; % = percent; <= less than; MDNN = mean distance to nearest neighbour; n/a = not applicable

Industrial development and human activities have contributed to declining populations of caribou in Canada as developments can act as barriers to movements of woodland caribou (Dyer et al. 2002; Weir et al. 2007; Polfus et al. 2011; Festa-Bianchet et al. 2011). Dyer et al. (2002) showed that roads with moderate traffic acted as semipermeable barriers to caribou movements in the boreal forest of Alberta. Roads could make caribou more vulnerable to predation by increasing access and ease of travel for predators such as wolves (Ciucci et al. 2003; Gurarie et al. 2011). Wolves have a positive correlation with road density in areas with low road and human density (Thurber et al. 1994; Houle et al. 2010; Bowman et al. 2010). The 8 km site access road is expected to follow existing vehicle trails that are present near the Project site, which will limit the limit the potential increase in the density of linear features and associated effects from habitat fragmentation. There are predicted to be 45 vehicles per day using the access road during construction, and 10 vehicles per day during operation (Golder 2013). Most travel on the access road is likely to be restricted to two periods per day (i.e., workers travelling to and from site). For woodland caribou with ranges that overlap the RSA, the Project access road is predicted to have a minor (during construction) to negligible (during operation) influence on caribou movement and population connectivity.

Decreases in key habitats for woodland caribou in the RSA ranged from 0.8 to 3.5%. Overall, the Project was conservatively estimated to disturb 1.4% of the RSA during construction. Changes in distance to nearest neighbor among similar habitat patches are anticipated to have no ecological effect on caribou movement relative to their daily movement rates and home range size. Fire has disturbed approximately 450 km^2 (approximately 40%) of the RSA in the last 25 years and there are currently few large contiguous blocks of coniferous forest (Section 14.3.2.2, Figure 14.3-2). Local knowledge suggests that caribou have not been present in RSA since the mid-1980s (Black Lake and Stony Rapids KPI Program 2012) and fire has likely had an influence on caribou distribution. Changes to habitat loss and fragmentation from the Project are predicted to be within baseline conditions and have a negligible influence on the abundance, distribution, and connectivity of woodland caribou across the population range.

15.5.1.2 Barren-Ground Caribou

Caribou have not been documented around Middle Lake since the mid-1980s (Black Lake and Stony Rapids KPI Program 2012) and there were no observations of caribou or caribou sign in the RSA during the 2012 wildlife baseline surveys (Section 15.3.5.1). Data from satellite-collared caribou individuals (1996 to 2005) in the Bathurst, Ahiak, Beverly, and Qamanirjuaq herds have indicated their proximity to the RSA in the past. In 2001, caribou from the Bathurst herd were recorded approximately 17 km north of the RSA (Stimson 2009). Satellite tracking data from 2004 and 2006 indicate that some of the Ahiak herd was recorded 89 km north of the RSA and some of the Beverly herd was recorded 62 km north of the RSA, respectively. In the winter of 1979, the Beverly herd overwintered in northern Saskatchewan (Thomas et al. 1998). In the winter of 2004 to 2005, the Qamanirjuaq herd was radio–tracked into northeastern Saskatchewan near Wollaston Lake (BQCMB 2005).

Barren-ground caribou have the potential to occur in the RSA during the winter months, likely from December through March/April. During the winter, barren-ground caribou select habitats that have an abundance of lichen cover (Sharma et al. 2009). A large portion of the ground cover in Bedrock, Jack Pine, Jack Pine/Black Spruce, and Spruce habitats in the RSA is comprised of terrestrial lichen (Annex IV, Section 4.3.1.3). The Project is predicted to remove between 0.8% and 3.5% of Bedrock and mature forest habitats that provide terrestrial lichen cover (Table 15.5-2). Overall, the Project was conservatively estimated to disturb 1.4% of the RSA during construction. Changes to the MDNN of key habitats for barren-ground caribou are predicted to be less than or equal to 1.0% (≤2 m), except Bedrock habitat (increase of 4.9% [12 m]) (Table 15.5-3).

Roads can negatively influence caribou populations by reducing habitat quality, acting as barriers to movement and increasing access for predators (Bergerud and Page 1987; Vistnes and Nelleman 2008; Festa-Bianchet et al. 2011). The 8 km site access road is expected to follow existing vehicle trails that are present near the Project site, which will limit the potential increase in the density of linear features and associated effects from habitat fragmentation (i.e., increase in predator movement). There are predicted to be 42 vehicles per day using the access road during construction, and 10 vehicles per day during operation (Golder 2013). Most travel on the access road is likely to be restricted to two periods per day (i.e., workers travelling to and from site).

Changes in habitat loss, distance between the nearest equivalent habitat patches (MDNN) and traffic volume in the RSA is anticipated to have no measurable effect on the abundance, distribution, and connectivity of barren-ground caribou herds. The winter and annual ranges of the Bathurst, Ahiak, Beverly, and Qamanirjuaq herds can vary from 100,000 to 400,000 km^2. In addition, the frequency and number of animals that might use the

RSA during the 4 to 5 month winter period is expected to be low and linked with the changes in herd size. The seasonal and annual range sizes of migratory barren-ground caribou expand and contract with increasing and decreasing herd size (Bergerud et al. 2008; Adamczewski et al. 2009; Gunn et al. 2011). Barren-ground caribou exhibit population cycles over 30 to 60 years (Zalatan et al. 2006; Adamczewski et al. 2009). Thus, the occurrence of barren-ground in the RSA and potential encounter rate with the Project is predicted to be highest during the peak phase of the population cycle, which could occur from three to five times during construction and operation of the Project.

15.5.1.3 Moose

Moose prefer dense coniferous forest is preferred during the winter as it provides easier movement and protection from inclement weather and predators (MNR 2000). In the summer, moose select habitats such as regenerating areas, deciduous forest, and mixedwood forest that have an abundance of deciduous browse (Allen et al. 1987). Moose obtain the majority of their annual salt requirements from aquatic plants such as pondweed (*Potomageton* spp.), yellow water lily (*Nuphar lutea*), and water milfoil (*Myriophyllum* spp.) (Peek 1974; MNR 2000). Moose are adapted to withstand cold temperatures but are intolerant of high temperatures. Upper critical temperatures are thought to be between 14°C and 20°C during the summer (Renecker and Hudson 1986). As such, treed lowland areas (e.g., treed bog and treed fen) are important for moose during the summer because of their cooler microclimates (Allen et al. 1987). Key habitats identified for moose in the RSA are Jack Pine/Black Spruce, Mixedwood, Deciduous, Wetland, Riparian, Spruce, and Regenerating Wetland, Regenerating Riparian, Regenerating Mixedwood, and Regenerating Deciduous habitats. The composition of habitats in the RSA under baseline conditions is presented in Section 15.5.1.1.

Overall, the Project was conservatively estimated to disturb 1.4% of the RSA during construction. The Project is predicted to remove between 0.4% and 0.9% of Jack Pine/Black Spruce, Mixedwood, Deciduous, Wetland, and Riparian habitats relative to baseline conditions (Table 15.5-2). Between 3.5% and 7.9% of Spruce, Regenerating Mixedwood, and Regenerating Deciduous habitats are predicted to be removed by the Project. Approximately 21.9% and 69.8% of Regenerating Wetland and Regenerating Riparian habitats, respectively, are predicted to be removed by the Project. Regenerating Wetland and Regenerating Riparian habitats are expected to have a high proportion of loss because there is little of this habitat in the RSA under baseline conditions (0.2% and less than 0.1% for Regenerating Wetland and Regenerating Riparian, respectively). Given the abundance of regenerating habitat in the RSA, the removal of Regenerating Wetland and Regenerating Riparian areas is not expected to limit the moose population.

Changes in distance between similar habitat patches could affect the ability of moose to travel across the land (Stewart and Komers 2012) and access important habitats (e.g., winter refuge habitat) (Naylor 2005). The Project is predicted to decrease the MDNN for Riparian, Spruce, Mixedwood, and Deciduous habitats by less than 1%, relative to baseline conditions (Table 15.5-3). The MDNN for Wetland, Regenerating Mixedwood, Regenerating Deciduous, and Regenerating Wetland habitats is predicted to increase by between 0.3% and 4.9% (1 to 11 m), relative to baseline conditions.

There are predicted to be 45 vehicles per day using the access road during construction and 10 vehicles per day during operation. Most travel on the access road is likely to be restricted to two periods per day (i.e., workers travelling to and from site). Ungulate movements in the Rocky Mountains were inhibited when traffic levels were between 500 and 5,000 vehicles per day (Alexander et al. 2005). Vehicle traffic from the Project during construction is expected to have minor influence on moose movement, but the effect should diminish during operations.

Studies using simulation models found that the effect of habitat fragmentation on a species depends on its habitat requirements, amount of habitat remaining, and movement or dispersal ability (With and Crist 1995; Flather and Bevers 2002; Swift and Hannon 2010). Changes to moose habitat quantity and fragmentation from the Project are predicted to be within baseline values. Moose are a resilient species and are anticipated to adapt to changes in habitat loss and fragmentation from the Project. Moose have high reproductive capability (Franzmann 1981) and populations in northern Saskatchewan are stable (MOE 2013). Changes to habitat loss and fragmentation from the Project in the RSA are anticipated to have a negligible influence on the abundance, distribution, and connectivity of the moose population.

15.5.1.4 Beaver

The disturbance assessment area for the Project is 1,620 ha (1.4% of the RSA). The composition of habitats in the RSA under baseline conditions is presented in Section 15.5.1.1. Beavers are dependent on aquatic habitats and key habitats for beaver within the RSA are Wetland, Riparian, Regenerating Wetland, Regenerating Riparian, and Open Water. The Project is predicted to remove less than 1% of Wetland, Riparian, and Open Water habitats (Table 15.5-2). Approximately 21.9% and 69.8% of Regenerating Wetland and Regenerating Riparian habitats are estimated to be removed by the Project. Regenerating Wetland and Regenerating Riparian habitats are expected to have a high proportion of loss because there is little of these habitats in the RSA under baseline conditions (0.2% and less than 0.1% for Regenerating Wetland and Regenerating Riparian, respectively), and most of these habitats occurs in the LSA. However, these habitats do not contain unique features for beaver that are not found in Open Water, Riparian, and Wetland habitats, and should not limit the population.

Changes to the MDNN of key beaver habitats are predicted to be less than or equal to 3.4% (≤11 m), relative to baseline conditions (Table 15.5-3). Beaver can travel long distances during juvenile dispersal (range 0.4 to 21 km; McNew and Woolf 2005). Thus, the small changes in distance between similar habitats are not expected to have measurable ecological effects on the beaver population in the RSA.

Changes to beaver habitat quantity and fragmentation from the Project are predicted to be within or slightly exceed baseline values. Beaver are a resilient species and are anticipated to adapt to the minor changes in habitat loss and fragmentation from the Project. Following construction, reclamation activities are likely to result in the establishment of early successional and regenerating habitat, which should decrease the effects of habitat loss and fragmentation during operations. Beaver have high reproductive capability (Jenkins and Busher 1979). Although population trends for beaver in Saskatchewan are unknown, it is likely that populations are stable because beaver are ranked as 'very common' in Saskatchewan by SKCDC (2012b) and there is little harvesting of beavers in the RSA (N-80 FMZ; Section 15.3.2.1). Changes to habitat loss and fragmentation from the Project are anticipated to have a negligible influence on the abundance, distribution, and connectivity of the beaver population in the RSA.

15.5.1.5 American Marten

Marten require approximately 350 ha of forested habitat within their home range (Naylor et al 1999). At least 75% of this forested area (263 ha) should consist of good quality habitat. Although marten prefer forested areas, vertical and horizontal structural components that can provide, for example, foraging habitat or a den could be more important to marten than forest type (Chapin et al. 1997; Poole et al. 2004).

During baseline field studies, marten (and fisher) tracks were observed in all habitat types in the RSA (Section 15.3.3.1). Habitat selection for American marten during the winter could not be determined because of small sample size of winter track counts. However, mean density of tracks was highest in Open Water (Ice), Jack Pine, Spruce, and Regenerating habitats (Table 15.3-2). Open Water (Ice) is not considered a key habitat for marten and changes to this habitat are not discussed. The composition of habitats in the RSA under baseline conditions is presented in Section 15.5.1.1.

The Project footprint during construction was conservatively assumed 1,619 ha, which is 1.4% of the RSA. The Project is predicted to remove less than 1% of Jack Pine/Black Spruce, Mixedwood, Deciduous, Wetland, and Recent Burn habitats in the RSA (Table 15.5-2). Between 1.1% and 4.2% of Jack Pine, Spruce, and Regenerating Jack Pine/Black Spruce habitats are predicted to be disturbed by the Project. The Project is predicted to remove 5.7%, 7.9%, and 11.1% of Regenerating Deciduous, Regenerating Mixedwood, and Regenerating Jack Pine habitats, respectively. Approximately 14.6% and 21.9% of Regenerating Spruce and Regenerating Wetland habitats, respectively, is expected to be removed by the maximum Project footprint (disturbance assessment area). Although marten will use regenerating habitats for foraging, the decrease in the availability of these habitats is not expected to limit the population. Following construction, reclamation activities are likely to result in the establishment of early successional and regenerating habitat during operations, which should reverse the effects from the loss of these habitats during construction.

The Project is predicted to decrease the MDNN for Jack Pine/Black Spruce, Spruce, Mixedwood, Deciduous, Regenerating Jack Pine/Black Spruce, and Regenerating Spruce by less than or equal to 1.7% (≤7 m), relative to baseline conditions (Table 15.5-3). The MDNN for Jack Pine, Wetland, Regenerating Jack Pine, Regenerating Deciduous, and Regenerating Mixedwood habitats is predicted to increase by less than or equal to 5.0% (≤11 m) with the development of the Project. The Project is predicted to decrease the MDNN for Recent Burn habitat by 39.1% (84 m). These changes in MDNN should have no measurable ecological effect on the connectivity of the marten population.

An 8 km access road will connect the Project with Highway 905. The access road is will follow existing vehicle trails that are present near the Project site, which will limit the potential increase in the density of linear features and associated effects from habitat fragmentation. However, marten have been found to avoid crossing gaps wider than 10 to 100 m (Spencer et al. 1983; Marklevitz 2003; Cushman et al. 2011; Caryl et al. 2012) and the access road will have a 40 m right-of-way. Marten could avoid the access road because of sensory disturbance associated with roads (Robitaille and Aubry 2000; Alexander et al. 2005). Traffic volumes greater than 3,000 vehicles per day were found to negatively affect carnivore (i.e., coyote, wolf, cougar, lynx, marten, and wolverine) movement in the Rocky Mountains of Alberta (Alexander et al. 2005). There are predicted to be 45 vehicles per day using the access road during construction, and 10 vehicles per day during operation. Most travel on the access road is likely to be restricted to two periods per day (i.e., workers travelling to and from site). As such, the access road is predicted to have a minor influence on marten movement and population connectivity in the RSA.

Overall, the marten population in the RSA is anticipated to have the capacity to adapt to changes in habitat loss and fragmentation from the Project. Marten populations are not thought to be limited by habitat loss and fragmentation until it covers 20% to 40% of an area (e.g., RSA; Chapin et al. 1998, Hargis et al. 1999, Potvin et al. 2000). Previous and existing developments and the Project are estimated to alter less than 5% of the RSA. Changes to loss and fragmentation of habitat from the Project in the RSA are anticipated to have a negligible influence on the abundance, distribution, and connectivity of the marten population.

15.5.1.6 *Upland Breeding Birds*

Decreases in habitat area can directly influence upland breeding bird populations by reducing the carrying capacity of the environment. Upland breeding birds are expected to nest in all habitats in the RSA, except open water habitat, and bird densities recorded during BBS were similar in all habitat types, except Recent Burn habitat, which had significantly fewer birds than Jack Pine habitat (Section 15.3.7.1). Olive-sided flycatcher (one individual) was the only provincially tracked (SKCDC 2012a) or federally listed (COSEWIC 2013; *SARA* 2013) upland breeding bird species observed in the RSA during baseline surveys (Appendix IV.3, Table IV.3-2). Other provincially tracked and federally listed species that have a moderate to high potential to nest in the RSA include common nighthawk (*Chordeiles minor*), pileated woodpecker (*Dryocopus pileatus*), barn swallow (*Hirundo rustica*), and rusty blackbird (*Euphagus carolinus*) (Appendix IV.3, Table IV.3-2).

Barn swallows primarily nest on human-made structures such as buildings (Brown and Bomberger-Brown 1999). Common nighthawks nest in open areas such as recent burns and open forests (Brigham et al. 2011). Similarly, rusty blackbirds nest in riparian habitat adjacent to recently burned areas and open forests (Avery 1995). Pileated woodpeckers rely on late successional mixedwood and deciduous forests (Bull and Jackson 2011).

The Project is predicted to disturb less than 1% of Jack Pine/Black Spruce, Mixedwood, Deciduous, Wetland, Riparian, and Recent Burn habitats in the RSA (Table 15.5-2). Between 0.8% and 5.7% of Bedrock, Jack Pine, Spruce, Regenerating Deciduous, and Regenerating Jack Pine/Black Spruce habitats are predicted to be removed by the Project. The Project is expected to remove 7.9%, 11.1%, and 14.6% of Regenerating Mixedwood, Regenerating Jack Pine, and Regenerating Spruce habitats, respectively. Approximately 21.9% and 69.8% of Regenerating Wetland and Regenerating Riparian habitats, respectively, will be removed by the Project footprint. This large percentage of loss is due to low amount of these two habitat types under baseline conditions. No bird species were unique to Regenerating habitats (Section 15.3.7.1) so the decrease in availability of these habitat types should not limit upland breeding bird populations.

A species with very specific habitat requirements and low dispersal ability (or ability to move) is more likely to be negatively affected by habitat fragmentation than a generalist or highly mobile species. Species that can move effectively (such as most birds) could consider habitat patches to be connected even when covering only 35 to 40% of the landscape (With and Crist 1995). In other studies, effects from habitat fragmentation on populations are small until habitat amounts decrease below a threshold level (approximately 60 to 90% habitat loss) (Flather and Bevers 2002; Swift and Hannon 2010). Gaps in forest cover of 50 to 200 m have been reported to effectively isolate songbirds in forested landscapes (Desrochers and Hannon 1997; Schmiegelow et al. 1997; St. Clair et al. 1998). The ability and willingness of a bird to cross a matrix (i.e., less preferred habitat portions of the landscape) could be influenced by the quality of the matrix. For example, a matrix could decrease the survival probability of an individual because of increased risk of predation or collision with a vehicle (St. Clair 2003; Swift and Hannon 2010).

The Project is predicted to increase the MDNN for Bedrock, Jack Pine , Wetland, Regenerating Jack Pine, Regenerating Mixedwood, Regenerating Deciduous, and Regenerating Wetland habitats by less than or equal to 5.0% (≤12 m) (Table 15.5-3). The MDNN for Jack Pine/Black Spruce, Spruce, Mixedwood, Deciduous, Regenerating Jack Pine/Black Spruce, and Regenerating Spruce is predicted to decrease by less than or equal to 1.7% (≤7 m) with the development to the Project. The Project is predicted to decrease the MDNN for Recent Burn habitat by 39.1% (84 m). These changes in distance to nearest equivalent habitat patch are expected to have no measurable ecological effect on upland breeding birds in the RSA.

The access road is likely to follow existing vehicle trails that are present near the Project site. There are predicted to be 42 vehicles per day using the access road during construction and 10 vehicles per day during operations (Golder 2013). Most travel on the access road is likely to be restricted to two periods per day (i.e., workers travelling to and from site). In addition, the access road is expected to have a 40 m ROW. As such, the access road is predicted to have a negligible influence on upland breeding bird movement and population connectivity in the RSA.

Upland breeding bird populations are anticipated to adapt to the changes in habitat loss and fragmentation from the Project. Most upland breeding bird species have high reproductive capability (BNA 2013) and have long effective dispersal distances (i.e., are highly mobile). Fragmentation effects have less influence than habitat loss when there is a large proportion of natural habitat on the landscape (Fahrig 1997, 2003; Andrén 1999; Flather and Bevers 2002; Swift and Hannon 2010), which is the predicted state and condition of habitat in the RSA with the Project. Changes to the loss and fragmentation of habitat from the Project are anticipated to have a negligible influence on the abundance, distribution, and connectivity of upland breeding bird populations.

15.5.1.7 Waterbirds

Decreases in habitat area can directly influence waterbird populations by reducing the carrying capacity of the environment. Waterbirds are a diverse group of species and nesting habitats for this group are diverse. Provincially tracked and federally listed species observed during baseline surveys included horned grebe (*Podiceps auritus*), swan species (*Cygnus* spp.), and sandhill crane (*Grus canadensis*) (Appendix IV.3, Table IV.3-2). Horned grebe and sandhill crane are the only listed waterbird species that have a moderate to high potential of nesting in the RSA. Both trumpeter swan (*Cygnus buccinator*) and tundra swan (*Cygnus columbianus*) are not expected to nest in the RSA; observations made during baseline surveys (Section 15.3.1) were likely migrating tundra swans. Red-throated loons are rarely found nesting in northern Saskatchewan (Barr et al. 2000). Yellow rails (*Coturnicops noveboracensis*) prefer sedge meadows, which are uncommon in the RSA, and are considered to have a low potential of nesting in the RSA.

Horned grebes prefer shallow, freshwater water bodies less than 10 ha in size (Stedman 2000). Sandhill cranes prefer to breed in isolated open bogs and marshes (Tacha et al. 1992). Key habitats identified in the RSA for waterbirds are Wetland, Regenerating Wetland, Riparian, and Open Water. The Project is predicted to remove less than 1% of Wetland, Riparian, and Open Water habitats in the RSA (Table 15.5-2). Approximately 21.9% and 69.8% of Regenerating Wetland and Regenerating Riparian habitats are predicted to be disturbed by the Project. The high predicted amount of loss for Regenerating Wetland and Regenerating Riparian habitats is due to the low amount of these habitats in the RSA under baseline conditions. However, these habitats do not contain unique features for waterbirds that are not found in Open Water, Riparian, and Wetland habitats, and should not limit the population. The calculated changes to MDNN for Open Water (<1 m), Riparian (0 m), Wetland (2 m) and Regenerating Wetland habitat (11 m) are expected to have no measurable ecological effect on the abundance and connectivity of waterbird populations in the RSA.

Waterbird populations have been in decline throughout the world but the reasons for the declines are not fully understood. Loss of critical breeding habitat and staging areas could be contributing factors (Slattery 2013). The RSA is located in the Western Boreal Forest of North America, which is considered an important breeding area for waterfowl (Slattery 2013). However, there was a low abundance of waterbirds recorded during baseline surveys (Section 15.3.8.1) and no important breeding or staging areas are present in the RSA (Poston et al. 1990; SKCDC 2013). The small and local changes in habitat loss and fragmentation from the Project are expected to be within the resilience limits of waterbirds and result in a negligible influence on the abundance, distribution, and connectivity of populations.

15.5.1.8 Bald Eagle

Bald eagles generally nest in forested areas adjacent to large, fish bearing bodies of water (Blood and Anweiler 1994; Buehler 2000). Fourteen bald eagle individuals and two bald eagle nests were observed during baseline surveys. One bald eagle nest was approximately 5 km north of the anticipated powerhouse and one nest was located approximately 5 km northwest of the powerhouse (Figure 15.3-6). Potential nesting and foraging habitats for bald eagle in the RSA are Jack Pine, Jack Pine/Black Spruce, Spruce, Mixedwood, Deciduous, Riparian, and Open Water habitats.

Habitat loss is thought to be the major limiting factor for bald eagle populations in areas with large amounts of human disturbance (e.g., Florida and southern Ontario) (Blood and Anweiler 1994). In undeveloped areas such as the RSA, food supply could be the most limiting factor for bald eagles (Dzus and Gerrard 1993). Previous and existing developments and the Project are estimated to remove less than 5% of the RSA. Adult bald eagles are highly mobile and the changes in distance between similar habitat patches (≤12 m) are predicted to have no measurable ecological effect on bald eagles occupying the RSA.

Bald eagles are anticipated to adapt to the minor and local changes in habitat loss and fragmentation from the Project. Bald eagles have high reproductive capability (Buehler 2000) and it is likely that food supply, not habitat quantity, is the limiting factor for bald eagles currently breeding in the RSA. Changes to habitat loss and fragmentation from the Project in the RSA are anticipated to have a negligible influence on the abundance, distribution, and connectivity of the bald eagle population.

15.5.2 Habitat Quality

Project development could generate sensory disturbances including increased noise levels and visual disturbances from moving vehicles and humans during construction and operations. The area surrounding human activities where sensory disturbances could affect animal behaviour and movement is often referred to as the zone of influence (ZOI). Animals could respond to sensory disturbances by reducing their occupancy and use of habitats within the ZOI, which can lead to local changes in abundance and distribution (Tyler 1991; Fortin and Andruskiw 2003; Bayne et al. 2008; Benítez-López et al. 2010).

Individuals could respond to sensory disturbances by changing the timing of feeding activities and reducing the amount of time spent feeding. In some situations, these behavioural changes can lead to a reduction in fitness (Harrington and Veitch 1992; Habib et al. 2007). Effects can vary and responses appear to be species-specific (Dickson and Beier 2002; Habib et al. 2007; Bayne et al. 2008; Fahrig and Rytwinski 2009; Benítez-López et al. 2010). Factors that seem to influence the magnitude of effects include the type of disturbance, the frequency and intensity of the disturbance, and the level of habituation to disturbance (Fortin and Andruskiw 2003; Bayne et al. 2008; Fahrig and Rytwinksi 2009).

Similar to habitat loss and fragmentation (Section 15.5.1), changes to habitat quality were assessed for the maximum predicted point of development of the Project footprint (disturbance assessment area), which should have the largest geographic extent of residual effects on wildlife. For all VCs, except upland breeding bird, a qualitative analysis was completed using the numerical estimates of changes to habitat in Section 15.5.1, the scientific and grey literature, and experienced opinion. For upland breeding birds, point counts surveys provided robust density estimates among habitat so that a quantitative analysis of direct and indirect changes to habitat quality could be completed.

15.5.2.1 Woodland Caribou

Caribou generally avoid roads, resource developments, infrastructure, and human communities (Murphy and Curatolo 1987; Dyer et al. 2001; Vistnes and Nelleman 2001; Joly et al. 2003; Weir et al. 2007; Polfus et al. 2011; Pinard et al. 2012). In northeastern Alberta, Dyer et al. (1999) found that woodland caribou in open coniferous wetlands (i.e., peatlands) avoided areas within 250 m of roads during all times of the year. Road avoidance was generally less when woodland caribou were in closed coniferous forest that provided effective security cover. Caribou limited their use of habitat within 1,000 m of new well sites. Avoidance of well sites was generally greatest during late winter when human activity was highest and during the calving season. Bradshaw et al. (1995) found that noise disturbance led to increased rates of movement of woodland caribou, but did not lead to complete displacement from the area. Weir et al. (2007) showed that the abundance of woodland caribou decreased within 4 to 6 km of an active mine site.

Habitat quality for woodland caribou in the RSA is low. Caribou require large areas of continuous tracts of undisturbed habitat that has a high proportion of mature to old-growth coniferous forest and peatlands (Rettie and Messier 2000; Festa-Bianchet et al. 2011). Woodland caribou in the Athabasca Plain Ecoregion use mature conifer-dominated uplands and open forests with dense lichen cover. Bedrock, Wetland, and mature coniferous forest habitats account for 32.1% of the RSA (Table 15.5-2). Caribou avoid recently burned, shrubby (e.g., regenerating), and deciduous-dominated habitats, likely because of higher numbers of other ungulates (e.g., moose) and predators (e.g., black bear and wolf) (Schwartz and Franzmann 1991; Rettie and Messier 2000 Wittmer et al. 2007; Festa-Bianchet 2011). Recent Burn habitat (31.1%), regenerating habitats (7.3%), and existing human disturbance (0.8%) cover approximately 39.2% of the RSA under baseline conditions (Table 15.5-2).

Changes from the Project on woodland caribou habitat quality and associated movement and behaviour of animals that could use the RSA are predicted to be at or slightly exceed baseline values. The quantity and spatial arrangement of quality caribou habitat is expected to change little relative to baseline conditions (Section 15.5.1.1). Woodland caribou have not been observed in the RSA since the mid-1980s (Black Lake and Stony Rapids KPI Program 2012) and fire has likely had an influence on their distribution in northern Saskatchewan. Sensory disturbance is expected to result in minor changes in caribou occupancy and distribution near the Project during construction, which should last three years. During operations, few people will be on site and the only noise will be from the powerhouse, which should result in decreasing effects on caribou abundance and distribution. Changes to habitat quality from the Project in the RSA are anticipated to have a negligible influence on the abundance and distribution of woodland caribou populations.

15.5.2.2 Barren-ground Caribou

Studies in the NWT indicate that the influence on barren-ground caribou abundance and distribution from operating diamond mines appears to be greater than the estimated spatial extent of the independent effects from infrastructure, activities, dust, air emissions, or noise. Most studies show that the estimated ZOI for caribou distribution varies from 10 to 30 km (Johnson et al. 2005; Golder 2011). Recent analyses by Boulanger et al. (2012) found that caribou were four times more likely to occur at distances greater than 11 to 14 km from the Ekati-Diavik diamond mine complex in the Northwest Territories. A review by Vistnes and Nelleman (2008) indicated that the average ZOI on caribou distribution from human development in the open tundra landscape was 5 km. A similar ZOI from the Project is predicted in the forested environment of the RSA (Weir et al. 2007).

The conclusion of most noise studies is that the effects of acute (short term, high level) and chronic (long-term, low level) noise on caribou results in variable types of disturbance responses occurring over variable time frames (Webster 1997). For example, after acute exposure to low level (less than 150 m) helicopter or fixed wing aircraft, caribou demonstrated panic responses (Calef et al 1976; Valkenburg and Davis 1983). After chronic noise exposure, caribou were found to alter significantly their daily activity cycles and movements because of overhead flights (Maier et al. 1998). Long-term monitoring studies at the Ekati Diamond Mine found that sensory disturbance events (e.g., blasting and moving vehicles) cause a behavioural response in barren-ground caribou about 55% of the time, and the response can vary from a temporary stop in feeding and look in the direction of disturbance to running away from the disturbance (BHPB 2009).

During winter, barren-ground caribou prefer similar habitats as woodland caribou (i.e., late successional conifer stands, peatlands, and wetlands). The quantity and spatial arrangement of quality caribou habitat is expected to change little relative to baseline conditions (Section 15.5.1.1). Construction activities could result in minor changes to the behaviour and movement of caribou within 5 km of the Project, but the effect should decrease soon into operations. However, the frequency, duration, and number of animals that could be influenced by the changes in habitat quality from the Project are anticipated to have no measurable effect on the abundance and distribution of barren-ground caribou herds (Section 15.5.1.2).

15.5.2.3 Moose

Moose were less likely to be found within 1 km of seismic lines during seismic operations (Horesji 1979). Humans elicit flight responses in moose at greater distances than disturbances that were recognized as mechanical (Andersen et al. 1996). For example, the noise of a jet flying at an altitude of 150 m did not trigger any flight response in moose, while people approaching moose on foot or skis from a distance of 200 to 400 m caused the animals to run. Andersen et al. (1996) found that the home range size for moose increased during active military manoeuvres (e.g., using helicopters and jet fighters), but no collared individuals abandoned the area.

Changes from the Project on moose habitat quality and associated movement and behaviour of individuals in the RSA are predicted to be at or slightly exceed baseline values. The Project should have a minor influence on the quantity and configuration of quality moose habitat in the RSA. Construction activities will likely result in local changes in the habitat occupancy of moose near the Project, but the change in distribution should decrease during operations. Changes to moose habitat quality from the Project in the RSA are anticipated to have a negligible influence on the abundance and distribution of the moose population.

15.5.2.4 Beaver

Literature is not available for the effects of sensory disturbance on beavers. Construction activities could result in local changes to the movement and behaviour of individuals, but effects from sensory disturbance should disappear at the end of construction. The Project is predicted to have a minor influence on habitat quantity and fragmentation for beavers (Section 15.5.1.4). Similarly, changes to habitat quality from the Project are anticipated to have a negligible influence on the abundance and distribution of the beaver population in the RSA.

15.5.2.5 American Marten

Marten appear to be sensitive to human disturbance as detection rates decrease with increasing levels of disturbance from roads, seismic lines, and pipelines (Moses et al. 2002). Alternately, a study by Zielinski et al. (2008) in California showed that there was no effect from off-highway vehicle use on habitat occupancy or probability of detection of marten. Marten in northern Alberta avoided pipeline clearings but did not demonstrate a negative response to habitats adjacent to the clearings (Eccles et al. 1985; Eccles and Duncan 1986).

During construction, there will likely be a minor decrease in the occupancy of habitats by marten near the Project, and the local change in distribution is predicted to slightly exceed baseline values. These changes should be limited to individuals with home ranges that overlap the Project and associated infrastructure, and should diminish during operations. Long-term changes from the Project on marten movement and behaviour should be minor and limited to the area around the access road. Overall, changes to habitat quality from the Project are predicted to have a negligible influence on the abundance and distribution of the marten population.

15.5.2.6 Upland Breeding Birds

Indirect effects on upland breeding bird communities from sensory disturbance associated with the Project were assessed by calculating changes in density using data from baseline studies (Section 15.3.7.1; Table 15.5-3). Effects from sensory disturbance on upland breeding bird communities were predicted using raster file types within a GIS platform. Each 25 m by 25 m raster cell in the RSA that represented a habitat type was assigned a density value equal to the mean density estimate for the habitat type (Table 15.5-4). Open Water habitat was not included in the analysis because upland breeding birds do not nest in this habitat type. Unclassified habitat, as determined from the ELC (Section 14.3.2.2) was excluded from the analysis.

An estimate of the abundance of upland breeding birds in the RSA during the baseline case was calculated by multiplying mean density estimates (number of birds per hectare) for each habitat type by the area of the habitat (Table 15.5-4). No BBS were completed in Bedrock habitat, Riparian habitat, and all regenerating habitats, except Regenerating Jack Pine. Bedrock habitat was assigned the same density value as Recent Burn habitat because tree and shrub cover in both habitat types were similar (Annex IV, Section 4.3.1.3). Riparian habitat was assigned the same density value as Wetland habitat. All regenerating habitats (except Regenerating Jack Pine) were assigned the same density value of habitats that were not regenerating. For example, the Jack Pine/Black Spruce habitat density was assigned to the Regenerating Jack Pine/Black Spruce habitat.

Table 15.5-4: Mean Relative Abundance of Upland Breeding Birds in Habitat Types within the Regional Study Area under 2012 Baseline Conditions

Habitat Type	Number of Plots Surveyed during Baseline Studies	Density (birds per ha)	Area in Regional Study Area under Baseline Conditions (ha)
Bedrock	0	1.27[(a)]	347
Jack Pine	32	2.24	21,492
Jack Pine/Black Spruce	23	1.44	117
Spruce	21	1.97	8,887
Mixedwood	15	2.03	3,658
Deciduous	31	1.51	2,971
Wetland	28	1.98	53
Riparian	0	1.98[(b)]	26,275
Regenerating Jack Pine	15	2.12	4,793
Regenerating Jack Pine/Black Spruce	0	1.44[(c)]	48
Regenerating Spruce	0	1.97[(c)]	707
Regenerating Mixedwood	0	2.03[(c)]	2,002
Regenerating Deciduous	0	1.51[(c)]	854
Regenerating Wetland	0	1.98[(c)]	229
Regenerating Riparian	0	1.98[(b,c)]	23
Recent Burn	46	1.27	35,993

(a) Bedrock habitat was assigned the same density value as Recent Burn habitat because tree and shrub cover were similar in both habitat types (Annex IV, Section 4.3.1.3).
(b) Riparian habitat was assigned the same density value as Wetland habitat
(c) Regenerating habitats were assigned the same densities as the habitat that was not regenerating. For example, Regenerating Jack Pine/Black Spruce habitat was assigned the same density value as Jack Pine/Black Spruce habitat.

The quality of habitats (i.e., raster cell bird density values) associated with habitat types within the Project footprint were reduced to zero (direct effects). The effects of sensory disturbance were captured in the model using a 1 km ZOI (Figure 15.5-1). That is, raster cell bird density values were reduced by the sensory disturbance modifier according to the distance of the raster cell to the Project. Indirect changes to habitat suitability were estimated using four concentric ZOIs around the Project footprint that were delineated in a GIS platform (0 to 100 m, >100 to 200 m, >200 to 500 m, and >500 to 1,000 m) (Table 15.5-5). Variability in the responses of upland breeding birds to indirect effects was assessed by defining possible low and high responses to sensory disturbance (rather than applying the median response for each concentric ZOI). Responses per zone were described using minimum and maximum coefficients from the sensory disturbance curve for each concentric ZOI (Figure 15.5-1; Table 15.5-6).

A 1 km zone of influence was used in the upland breeding bird habitat quality analysis as scientific literature suggests that most sensory disturbance to upland breeding birds are limited to within 1 km of infrastructure. A study by Bayne et al. (2008) found that only one-third of boreal songbird species showed abundance patterns that were influenced by anthropogenic noise. For those species affected by noise, the zone of influence was estimated to be 300 m. A study in the central Arctic found limited environmental effects within 1 km of an operating diamond mine on the upland bird community and no measurable environmental effect on the reproductive success of Lapland longspurs (*Calcarius lapponicus*) (Male and Nol 2005; Smith et al. 2005). Similarly, a meta-analysis completed by Benitez-Lopez et al. (2010) found that environmental effects on bird densities extended to approximately 1 km from infrastructure.

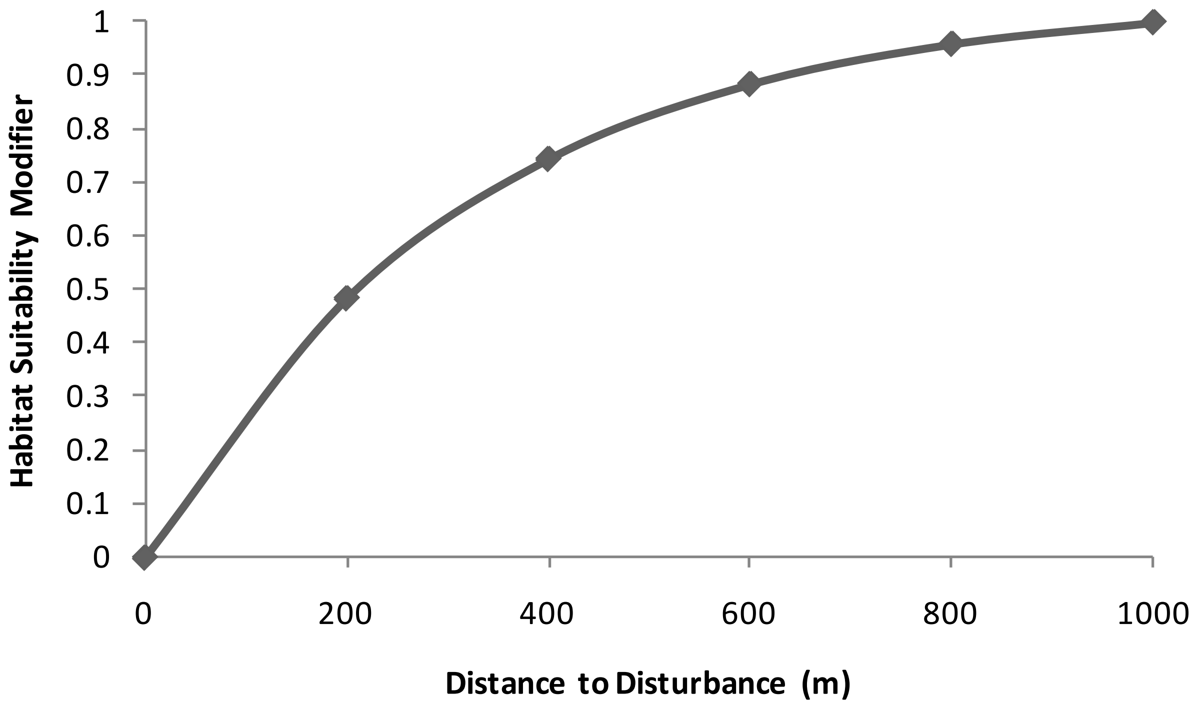


Figure 15.5-1: Predicted Zone of Influence and Changes in Raster Cell Upland Breeding Bird Densities Adjacent to Human-Related Disturbance Features

Table 15.5-5: Area of Habitat Types within the Project Footprint and Concentric Zones of Influence around the Project

Habitat Type	Project Footprint (ha)	Edge of Project Footprint to 100 m (ha)	>100 to 200 m (ha)	>200 to 500 m (ha)	>500 to 1,000 m (ha)
Bedrock	4	<1	1	<1	1
Jack Pine	235	84	79	229	401
Jack Pine/Black Spruce	1	2	<1	2	2
Spruce	313	33	30	114	122
Mixedwood	16	2	2	20	33
Deciduous	18	4	6	15	24
Wetland	49	11	26	89	147
Riparian	<1	1	1	2	0
Regenerating Jack Pine	534	32	32	100	229
Regenerating Jack Pine/Black Spruce	2	1	1	<1	<1
Regenerating Spruce	103	5	9	30	30
Regenerating Mixedwood	158	21	17	38	75
Regenerating Deciduous	48	6	4	7	10
Regenerating Wetland	50	4	4	6	19
Regenerating Riparian	16	2	3	2	0
Recent Burn	3	0	0	0	15

Note: Values with a less than (<) sign indicate that the value approaches 0.
> = greater than; < = less than; ha = hectares; m = metre

Table 15.5-6: Percent Reduction in Abundance from Sensory Disturbance Coefficients within Each Concentric Zone of Influence

Concentric Zone of Influence	Minimum Sensory Disturbance Coefficient	% Reduction in Abundance Using Minimum Coefficient	Maximum Sensory Disturbance Coefficient	% Reduction in Abundance Using Maximum Coefficient
0 to 100 m	0.27	73	0.01	99
100 to 200 m	0.48	53	0.28	72
200 to 500 m	0.82	18	0.49	52
500 to 1,000 m	0.99	1	0.83	17

% = percent; m = metre

These adjusted densities were then multiplied by the habitat area within the respective concentric zone of influence (Table 15.5-6) to get an estimate of bird abundance. Abundances were then summed by habitat type across all concentric ZOI to estimate the reduction in bird abundance caused by indirect effects from the Project. Baseline abundances estimated for the Project footprint and concentric ZOIs were used to predict the absolute and relative number of birds that will be lost and displaced within the RSA from the Project.

The following equations were used to calculate the relative change in upland breeding bird abundance for the different conditions on the landscape:

- (application abundance – 2012 baseline abundance)/2012 baseline abundance.

The resulting value was then multiplied by 100 to give the percent change in habitat-specific bird abundance, and provides both direction and magnitude of the effect.

Direct effects from habitat removal by the Project footprint are predicted to decrease bird abundance by less than 5% in Bedrock, Jack Pine, Jack Pine/Black Spruce, Spruce, Mixedwood, Deciduous, Wetland, Riparian, Recent Burn, Regenerating Jack Pine/Black Spruce, and Recent Burn habitats (Table 15.5-7). The Project could directly affect 11.1%, 7.9%, 5.7%, and 14.6% of birds in Regenerating Jack Pine, Regenerating Mixedwood, Regenerating Deciduous, and Regenerating Spruce habitats, respectively. Approximately 21.8% and 69.8% of birds in Regenerating Wetland and Regenerating Riparian habitats are predicted to be affected by direct effects from the Project.

Indirect sensory disturbance effects from the Project could influence between 0.2% and 5.9% of birds in all habitat types, except Regenerating Riparian habitat (Table 15.5-7). It is estimated that the Project could influence between 14.4% and 22.3% of birds in Regenerating Riparian habitat.

Birds could be more sensitive to disturbances early in the nesting season because the amount of energy invested in brood rearing is not outweighed by nest abandonment (Bisson et al 2009). Birds could be more vulnerable to disturbance during the molting season as they will have less energy to use towards stress responses (e.g., fleeing) (Cyr et al. 2008).

Few studies have focused on the effects of noise and disturbance to upland bird behaviour and movement. Behaviours most likely to be affected are nest site selection, territory selection, mate attraction, and foraging. Noise could inhibit predator detection and interfere with mate/chick communication (Habib et al. 2007). Many boreal upland breeding bird species have lower abundance in noisy areas than pristine areas (Habib et al. 2007; Bayne et al. 2008). According to Trombulak and Frissell (2000), disturbances such as roads have the potential to change the reproductive success of wildlife species. Habib et al. (2008) found that pairing success of ovenbirds was significantly lower in noisy areas by compressor stations. Conversely, a study by Canaday and Rivadeneyra (2001) found noise to be a disturbance to birds only over distances less than 300 m. A study of Lapland longspurs by Male and Nol (2005) showed no difference in nest success between sites with high and low levels of human noise at the Ekati Diamond Mine. Overall, it appears as though some bird species might benefit from human disturbance (i.e., roads) while others do not (Spellerberg and Morrison 1998).

According to Jalkotzy et al. (1997), many studies have found a relationship between traffic volume and bird densities adjacent to roads. For example, a 12% to 15% reduction in bird densities was observed within 500 m of roads with more than 50 cars per day (Reijnen et al. 1996). There are predicted to be 42 vehicles per day using the access road (Golder 2013). Most travel on the access road is likely to be restricted to two periods per day (i.e., workers travelling to and from site).

Decrease in upland breeding bird habitat quality from the Project is predicted to be within or slightly exceed baseline values for most habitats. A few habitats such as Regenerating Riparian and Regenerating Wetland show values exceeding baseline values but this is because those habitats compose a small portion of the RSA under baseline conditions. No bird species were unique to Regenerating habitats (Section 15.3.7.1) so the decrease in quantity and quality of these habitat types should not limit upland breeding bird populations.

Table 15.5-7: Relative Direct and Indirect Changes in the Abundance of Upland Breeding Birds in the Regional Study Area from Baseline Conditions to Application

Habitat Type	2012 Baseline Abundance (number of birds)	Change from Baseline to Application		
		% Direct Effect[(a)]	% Indirect Effect[(b)] (Minimum Coefficient)	% Indirect Effect[(b)] (Maximum Coefficient)
Bedrock	441	-1.1	-0.2	-0.3
Jack Pine	48,141	-1.1	-0.7	-1.5
Jack Pine/Black Spruce	168	-0.8	-1.5	-2.8
Spruce	17,507	-3.5	-0.7	-1.5
Mixedwood	7,426	-0.4	-0.2	-0.5
Deciduous	4,486	-0.6	-0.3	-0.7
Wetland	12,302	-0.8	-0.6	-1.6
Riparian	104	-0.9	-2.5	-4.4
Regenerating Jack Pine	10,160	-11.1	-1.2	-3.0
Regenerating Jack Pine/Black Spruce	70	-4.2	-2.4	-3.7
Regenerating Spruce	1,392	-14.6	-1.9	-4.5
Regenerating Mixedwood	4,065	-7.9	-1.5	-3.3
Regenerating Deciduous	1,289	-5.7	-0.9	-1.7
Regenerating Wetland	453	-21.9	-2.8	-5.9
Regenerating Riparian	46	-69.8	-14.4	-22.3
Recent Burn	45,712	<0.1	<-0.1	<-0.1

(a) Loss of birds due to Project footprint(s)
(b) Loss of birds due to sensory disturbance
% = percent

Changes in habitat quality from the Project are expected to be within the resilience limits of affected bird populations. Direct loss of habitat is expected to be associated with minor changes in bird abundances. Although the analysis has assumed that indirect habitat effects result in a decrease in bird abundance, changes in habitat quality from sensory disturbance, do not necessarily result in demographic consequences to populations (Gill et al. 2001). Most of the effects from indirect changes in habitat quality could be related to a local shift in distribution with little influence on survival and reproduction rates. Most upland breeding bird species have high reproductive capability (BNA 2013). Changes to habitat quality from sensory disturbance effects associated with the Project are anticipated to have a negligible to minor influence on the abundance and distribution of upland breeding bird populations.

15.5.2.7 Waterbirds

Few studies have focused on the effects of noise and disturbance to waterbird behaviour and movement. However, some studies (Korschgren et al. 1985; Ward and Stein 1989; Dahlgren and Korschgren 1992) have found that noise and motion disturbances originating from man-made sources can negatively affect waterbird behaviour. Disturbance effects on waterbirds could include displacement, nest abandonment, reduced nest success, or reduced foraging efficiency (Hockin et al. 1992; Dahlgren and Korschgren 1992). Concerns regarding noise and birds include noises that startle or disturb nesting birds. Studies have found that several waterbird species could eventually become habituated to high noise levels (Busnel and Briot 1980; Ronconi et al. 2004).

Although noise and sensory disturbance can alter the movement and behaviour of waterbirds (Bommer and Bruce 1996), the specific effects of the Project-related sensory disturbance on many species of waterbirds are unknown. Loons are relatively sensitive to human disturbance (Ehrlich et al. 1988). Alternately, analysis of information collected at the Ekati Diamond Mine suggested that the level of mining activities had not negatively influenced the presence of loons adjacent to the mine site (BHPB 2003). Minimum distance recommendations to reduce the effects on waterbird behaviour from man-made noise are 200 to 300 m for traffic disturbance (Fruzinski 1977; Mooij 1982; Madsen 1985) and 3 to 4 km for aircraft disturbances (Davis and Wisely 1974; Berger 1977).

Decreases in waterbird habitat quality from the Project are predicted to be within or slightly exceed baseline values. Waterbird species are anticipated to adapt to changes in habitat quality from the Project. Most waterbird species have high reproductive capability (BNA 2013). Construction activities could result in local changes to the movement and behaviour of individuals, but effects from sensory disturbance should disappear at the end of construction. There were low numbers of waterbirds recorded in the LSA (Section 15.5.1.7), which is likely due to natural limited availability of quality breeding habitat near the Project. Changes to habitat quality from sensory disturbance effects associated with the Project are anticipated to have a negligible influence on the abundance and distribution of waterbird populations in the RSA.

15.5.2.8 Bald Eagle

Studies on responses of bald eagles to human disturbance are limited, so effects on bald eagle from Project-related sensory disturbance were qualitatively assessed using scientific literature on bald eagles and other raptor species. Studies of prairie falcon responses to blasting activities found that falcons showed behavioural reactions to blasting in 54% of blasts (Holthuijzen et al. 1990). Incubating or brooding falcons flushed from their aeries in 22% of the blasts, but returned to their nests within an average of 3.4 minutes. The authors suggested that blasting associated with limited human activity does not need to be restricted at distances greater than

125 m from occupied prairie falcon nests, if peak noise levels do not exceed 140 dB at the aerie and no more than three blasts occur on a given day or 90 blasts during the nesting season. Blasting at the Project is anticipated to occur once per day. Maximum explosive loads for the Project are not expected to exceed 120 dBL at the construction camp, which is closer than the known bald eagle nests on Middle Lake (5 km from the anticipated Project).

Increasing frequency and duration of disturbance could exacerbate the effects of sensory disturbance. Cooper's hawk (*Accipiter cooperii*), peregrine falcon, bald eagle, golden eagle (*Aquila chrysaetos*), and osprey were found to nest further than 200 m from roads, likely because of the presence of humans (sensory disturbance) (Martínez-Abraín et al. 2010). In Oregon, bald eagles nesting in areas with shoreline development and human activity had nests further from the shoreline in developed areas compared to nests in less developed areas (Anthony and Isaacs 1989).

However, there are indications that some raptor species are able to habituate to disturbance. For example, raptors (peregrine falcon, gyrfalcon, and rough-legged hawks) have successfully nested in open pits and on buildings and other infrastructure at operating diamond mines in the NWT (BHPB 2010; DDMI 2010). Long-term monitoring (15 years) has found high nest occupancy rates near the mine sites and no strong negative effects on falcon nest productivity (De Beers 2010; Golder 2011; Coulton et al. 2012).

Generally, raptors flush more often when approached by humans on foot than by vehicles. For example, rough-legged hawks flushed when humans on foot were, on average, 177 m (range 55 to 900 m) from the nest (Holmes et al. 1993). In contrast, hawks flushed when vehicles were, on average, 71 m (range from 9 to 170 m) from the nest. Bald eagles flushed fewer times when nests were overflown by aircraft (within 20 to 200 m) than when nests were approached by pedestrians (within 57 to 991 m) (Fraser et al. 1985; Grubb and King 1991). Red-tailed hawks (*Buteo jamaicensis*) shifted the locations of their activities away from areas with heavy artillery firing but returned after activities ceased (Andersen et al. 1986). Prairie falcons (*Falco mexicanus*) reacted to blasting activities that were greater than 560 m from nests by changing their behaviour and flushing from nests 16% and 7% of the time, respectively (Holthuijen et al. 1990). Prairie falcons changed their behaviour and flushed from the nest 68% and 58% of the time, respectively, when blasting activities were from120 to 140 m from the nest.

Decreases in bald eagle habitat quality from the Project are predicted to be within or slightly exceed baseline values. Construction activities could result in local changes to the movement and behaviour of individuals, but effects from sensory disturbance should disappear early in operations. Bald eagles have high reproductive capability (Buehler 2000) and populations for most raptor species are considered 'very common' in Saskatchewan (SKCDC 2012a). As discussed above, bald eagles are likely able to habituate to human disturbance. In addition, the abundance of bald eagles observed near the Project during baseline surveys was low, which is likely due to natural limited availability of quality breeding habitat near the Project. Changes to habitat quality from the Project are anticipated to have a negligible effect on the abundance and distribution of the bald eagle population.

15.5.3 Management of Uncertainty

Ecosystems are complex and interactions among abiotic and biotic components of the ecosystem occur across multiple scales and are typically nonlinear (Boyce 1992; Holling 1992; Levin 1998; Wu and Marceau 2002). These characteristics can confound our understanding of ecosystem processes and limit our capacity to make predictions. Like all scientific results and inference, residual effects predictions will have uncertainty associated with the data and current knowledge of the system. The confidence in residual effect predictions is related to the following:

- adequacy of baseline data for understanding current conditions and future changes unrelated to the Project (e.g., climate change or catastrophic events);
- model inputs in the upland breeding bird habitat quality assessment (i.e., ZOI from development);
- accuracy of the ELC;
- understanding of Project-related effects on complex ecosystems that contain interactions across different scales of time and space (e.g., exactly how the Project will influence wildlife species); and
- knowledge of the effectiveness of the environmental design features (mitigation) for limiting effects on wildlife (e.g., revegetation of wildlife habitat).

There is a high degree of confidence that wildlife habitat will be disturbed within the Project footprint. The affected areas have been identified using the current Project footprint. However, the exact locations of Project infrastructure were not known at the time this assessment was completed. As such, a conservative estimate of the Project footprint size (1,620 ha) was used to assess changes to wildlife habitat. The Project footprint that was used in the wildlife assessment is larger than the actual area expected to be disturbed during construction (approximately 869 ha) and larger than the anticipated Project footprint that will remain for the 90-year life of the Project (approximately 280 ha).

Uncertainty was addressed in the assessment by incorporating information from available and applicable literature and from using experience in similar projects and environments. Conservative estimates were used so residual effects were not underestimated. Best management practices during construction, operations, and closure will be implemented to mitigate residual effects on wildlife and wildlife habitat.

15.6 Determination of Significance

The determination of significance considers all primary Project interactions that are expected to result in residual effects on wildlife VCs, after implementing environmental design features and mitigation. The classification of residual effects from primary interactions provides the foundation for determining environmental significance from the Project and other developments on the maintenance of self-sustaining wildlife populations. The main sources of residual effects are related to the construction of the Project.

15.6.1 Residual Effects Criteria

The purpose of the residual effects classification is to describe the incremental and cumulative effects from the Project and other developments on VCs using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment. The following criteria will be used to classify the residual effects from the Project in the EIS:

- direction;
- magnitude;
- geographic extent;
- duration;

- reversibility;
- frequency; and
- likelihood.

Definitions for each of the criteria for the determination of the significance of residual effects on wildlife used in this assessment are provided below and summarized in Table 15.6-1.

Direction: Direction indicates whether the residual effect on wildlife is negative (i.e., less favourable), positive (i.e., improvement), or neutral (i.e., no change). While the focus of the residual effects assessment is to predict whether the development is likely to cause significant residual effects on wildlife or cause public concern, the positive changes associated with the Project are reported. Neutral changes are not assessed.

Magnitude - Magnitude is a measure of the intensity of a residual effect, or the degree of change caused by the Project relative to baseline conditions (i.e., effect size). It is classified into three scales: negligible to low, moderate, and high. For wildlife, magnitude is a function of the numerical and qualitative changes in measurement endpoints and the associated influence on the resilience of VCs. Changes in physical (e.g., habitat quantity, quality, and fragmentation) and biological (e.g., survival, reproduction, movement, and behaviour) measurement endpoints result in effects on the abundance and distribution of populations. Because the assessment endpoint for wildlife is self-sustaining populations, the magnitude of residual effects is assessed at the population level and considers ecological properties of wildlife. Evaluating and classifying magnitude considers the residual effects from changes in measurement endpoints on abundance and distribution, and the resilience of populations. Resilience represents the ability of a population to adapt to change (e.g., rate and degree of fluctuation in population abundance and distribution after a disturbance). For example, behavioural plasticity that allows for adaptation to disturbance, high birth rates that allow for replacement of harvested individuals, and good dispersal ability that allow for connection of fragmented populations (Weaver et al. 1996). Thus, the classification of the magnitude of effects is VC specific.

Geographic Extent – Geographic extent refers to the spatial extent of the effect, and is different from the spatial boundary (i.e., study area) for the effects analysis. The geographic extent of effects can occur on a number of scales within the spatial boundary of the assessment (i.e., effects study area). Geographic extent refers to the area affected, and is categorized into three scales of local, regional, and beyond regional. Effects at the local scale are largely associated with the predicted maximum spatial extent of combined direct and indirect effects from the Project (i.e., zone of influence). Effects at the regional scale are associated with incremental and cumulative changes from the Project and other developments. The beyond regional scale includes cumulative residual effects from the Project and other developments that extend beyond the RSA. The principle applied when using geographic extent to understand magnitude is that local effects from the Project are less severe than effects that extend to the regional or beyond regional scales.

Table 15.6-1: Effects Criteria Used in the Determination of Significance for Wildlife

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood
Negative: There is a less favourable change relative to baseline values or conditions **Positive:** There is an improvement over baseline values or conditions	**Negligible to Low:** There is no measurable residual effect on wildlife **Moderate:** The residual effect on wildlife is measurable, but within the anticipated resilience limits of the wildlife population **High:** The residual effect is near or exceeding the anticipated resilience limits of the wildlife population	**Local:** Predicted maximum spatial extent of direct and indirect effects from the Project **Regional:** Project-specific effects exceed the local scale and can include cumulative effects from other developments in the RSA **Beyond Regional:** Effects from the Project and other developments extend beyond the RSA	**Short-term:** The residual effect is reversible at end of construction **Medium-term:** The residual effect is reversible at a defined length of time beyond construction following initial decommissioning and reclamation activities **Long-term:** The residual effect is reversible within a defined length of time beyond closure and final decommissioning and reclamation activities **Permanent:** The residual effect is irreversible	**Reversible:** The residual effect is reversible within a time period that can be identified when the Project no longer influences wildlife populations processes (e.g., survival and reproduction) and properties (e.g., stability and resilience) **Irreversible:** The residual effect is predicted to influence wildlife populations indefinitely (duration is permanent or unknown)	**Isolated:** The residual effect is confined to a specific discrete period (i.e., construction) or Project activity **Periodic:** The residual effect occurs intermittently, but repeatedly over the temporal boundary of the assessment (95 years) **Continuous:** The residual effect will occur continually over the temporal boundary of the assessment (95 years)	**Unlikely:** The residual effect is possible but unlikely within the temporal boundary of the assessment (95 years; <10% chance of occurring) **Possible:** the residual effect is possible within a year, or a chance of occurring within the temporal boundary of the assessment (95 years) **Likely:** The residual effect is probable within a year, or at least a change of occurring in the next 10 years (>80% chance of occurring) **Highly Likely:** The residual effect is certain

Note: resilience is the capacity for a population to accommodate or recover from disturbance; it varies among VCs.

Duration - Duration is defined as the amount of time (usually in years) from the beginning of a residual effect on when the residual effect on wildlife populations is reversed. Typically duration is expressed relative to Project phases. Both the duration of individual events and the overall time frame during which the residual effect could occur are considered. Some residual effects could be reversible soon after the effect has ceased, while other residual effects could take longer to be reversed. By definition, residual effects that are short-term, medium-term, or long-term in duration are reversible.

In some cases, available scientific information and professional judgment could predict that the residual effect is irreversible. Alternately, the duration of the residual effect could not be known, except that it is expected to be extremely long and well beyond the temporal boundary of the assessment (95 years). As such, any number of factors could cause wildlife populations to never return to a state that is unaffected by the Project. In other words, science and logic predict that the likelihood of reversibility is so low that the residual effect is irreversible.

Reversibility - After removal of the Project activity or stressor, reversibility is the likelihood that the Project will no longer influence wildlife at a future predicted period in time. This term usually has only one alternative: reversible or irreversible. The period is provided for reversibility (i.e., duration) if a residual effect is reversible. Permanent residual effects are considered irreversible.

Frequency - Frequency refers to how often a residual effect will occur and is expressed as isolated (confined to a discrete period), periodic (occurs intermittently, but repeatedly over the temporal boundary of the assessment), or continuous (occurs continuously over the temporal boundary of the assessment). Frequency is explained more fully by identifying when the residual effect occurs (e.g., once at the beginning of the Project). If the frequency is periodic, then the length of time between occurrences, and the seasonality of occurrences (if present) is discussed.

Likelihood - Likelihood is the probability of an effect occurring and is described in parallel with uncertainty. Four categories are used: unlikely (residual effect is possible, but unlikely to occur within the temporal boundary of the assessment [95 years; less than 10% chance of occurring]), possible (residual effect is possible within a year, or a chance of occurring within the temporal boundary of the assessment [95 years], but is not certain), likely (residual effect is likely to occur or probable within a year, or at least a change of occurring in the next 10 years, and highly likely [greater than 80% chance of occurring]), and highly likely (the residual effect is certain).

15.6.2 Classification of Residual Effects

The classification of incremental and cumulative effects from the Project and previous and existing developments on wildlife is provided in Table 15.6-2. Residual effects were analyzed and assessed for woodland caribou, barren-ground caribou, moose, beaver, American marten, upland breeding birds, waterbirds, and bald eagle. Determining the significance of residual effects from the Project on wildlife (and vegetation) VCs provides an indication of the magnitude and spatial extent of the influence of the Project on the ecosystem within the RSA. The significance of incremental and cumulative effects from the Project and other developments on self-sustaining populations and the continued opportunity for use of wildlife by people are discussed in Section 15.6.3.

Residual effects from Project interactions and other developments influencing wildlife VCs were determined to be of negligible to low or moderate magnitude, local to regional in geographic extent, reversible in the medium or long-term or irreversible, and likely to highly likely to occur (Table 15.6-2). The range in scales in the residual effects classification reflects the different interactions and related mechanisms that are predicted to affect wildlife VCs.

Effects from direct loss, alteration, and fragmentation of habitats from the Project and previous and existing developments are expected to be of negligible to low magnitude (effects are anticipated to be not measurable or within baseline values) and highly likely to occur (Table 15.6-2). Overall, the Project was conservatively estimated to disturb 1.4% of the RSA during construction. Previous and existing developments have resulted in the loss and alteration of approximately 1% of land cover in the RSA. Changes in distance to nearest equivalent habitat patch were less than or equal to 12 m, which should have negligible effects on the movement of individuals and connectivity of wildlife populations. The Project is predicted to remove between 0.4% and 0.9% of Jack Pine/Black Spruce, Mixedwood, Deciduous, Wetland, and Riparian habitats relative to baseline conditions. Between 3.5% and 7.9% of Spruce, Regenerating Mixedwood, and Regenerating Deciduous habitats are predicted to be removed by the Project.

Approximately 21.9% and 69.8% of Regenerating Wetland and Regenerating Riparian habitats, respectively, are predicted to be removed by the Project. Regenerating Wetland and Regenerating Riparian habitats are expected to have a high proportion of loss because there is little of this habitat in the RSA under baseline conditions (0.2% and less than 0.1% for Regenerating Wetland and Regenerating Riparian, respectively). However, no detected upland breeding bird species were unique to these habitats, and given the abundance of regenerating habitat in the RSA, the removal of Regenerating Wetland and Regenerating Riparian areas is not expected to limit VC populations. Project-specific changes to habitat loss and fragmentation are expected to have local-scale effects on wildlife, while cumulative changes from previous and existing developments and the Project are anticipated to have regional-scale effects on wildlife populations (Table 15.6-2).

Residual effects from habitat loss, alteration, and fragmentation on wildlife could be reversible or irreversible. The reversibility of residual effects is expected to vary among species, and could depend on factors such as habitat and food preferences. For example, some ground-nesting species of upland breeding birds could use the reclaimed areas soon after vegetation is established (effect is reversible in the medium-term). Woodland caribou would not be expected to use the reclaimed areas until mature forest cover is established. The establishment of mature forest could occur within the temporal bounds of the assessment (effect is reversible in the long-term) or could occur outside of the temporal boundary of the assessment (effect could be permanent). Natural succession processes in the RSA are slow, and plant community trajectories can be altered by a number of factors (e.g., climate change, fire, and unforeseeable human development). The effect from direct habitat loss and fragmentation on wildlife is continuous over the life of the Project.

Sensory disturbance associated with the Project, which can change habitat quality, is anticipated to occur at the local scale and have negligible to low, or moderate magnitude effects on populations (Table 15.6-2). Cumulative effects from previous and existing developments (e.g., Highway 905, roads, and trails) plus the Project are expected to occur at the regional scale. Local changes in abundance and distribution of VCs from existing roads, trails and other human activities have likely already occurred and populations have probably adapted to these disturbances. Effects from sensory disturbance vary among species. Some VCs, such as beaver and waterbirds, could experience little residual effects from sensory disturbance (Busnel and Briot 1980; Ronconi et al. 2004).

Table 15.6-2: Summary of Residual Effects on the Abundance and Distribution of Wildlife Valued Components

Project Phase	Residual Effect	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood
Construction Operations Closure	Direct loss, alteration, or fragmentation of vegetation (wildlife habitat) from the Project footprint can affect wildlife movement and behaviour, and population connectivity	Negative	Negligible to Low	Local and Regional	Long-term and Permanent	Reversible and Irreversible	Continuous	Highly Likely
	Sensory disturbance (e.g., presence of buildings, lights, smells, noise, blasting activity, and vehicles) can decrease habitat quality and alter movement and behaviour of wildlife	Negative	Negligible to Low or Moderate	Local and Regional	Long-term	Reversible	Continuous	Likely or Highly Likely
	All interactions	Negative	Negligible to Moderate	Local to Regional	Long-term	Reversible	Continuous	Highly Likely

For other VCs, construction activities will likely result in local changes in the movement and behaviour of animals, and occupancy of habitats near the Project. Several studies have determined that effects from human disturbance on mammals, including caribou, in forested environments occur within 5 km of developments (Weir et al. 2007; Vistnes and Nelleman 2008; Benítez-López et al. 2010; Polfus et al. 2011). Zones of influence are usually determined from observations of behavioural changes in wildlife species (Gill et al. 2001). However, changes in behaviour could not be sufficient to cause changes in survival and reproduction and so could not negatively affect population abundance. Alternately, construction activities could result in moderate magnitude effects on some upland breeding birds. For example, local populations could decline if they incur high fitness costs in a noisy area (e.g., higher predation rates due to difficulty in detecting predators) and there is no suitable habitat nearby for the species to occupy. However, the local change in abundance and distribution from construction activities should decrease during operations and the effects are expected to be reversible in the medium-term (Table 15.6-2). Some individuals and populations could habituate to the low noise emissions from the powerhouse and low, intermittent traffic levels during operations. As such, residual effects from sensory disturbance are likely for some VCs (not necessarily certain) to occur.

15.6.3 Significance of Residual Effects

The classification of residual effects on primary interactions provides the foundation for determining environmental significance from the Project and other developments on wildlife VCs. Magnitude, geographic extent, and duration (which include reversibility) are the principal criteria used to predict significance (FEARO 1994). Other criteria, such as frequency and likelihood are used as modifiers (where applicable) in the determination of significance.

The determination of significance considers all primary interactions that are expected to result in residual effects on the maintenance of self-sustaining wildlife populations. The relative contribution of each interaction is used to determine the significance of the Project and other developments on the population, which represents a weight of evidence approach. For example, an interaction with a high magnitude, regional geographic extent, and long-term duration is given more weight in determining significance relative to interactions with smaller scale effects. The relative effect from each primary interaction is discussed; however, interactions that are predicted to have the greatest effects on self-sustaining populations are assumed to contribute the most to the determination of environmental significance. Significance is determined for the residual effect of the Project overall, as well as for the cumulative effects from the Project and previous and existing developments (there a currently no known reasonably foreseeable developments that overlap the spatial and temporal boundaries of the assessment [Section 15.5]).

Environmental significance is used to identify predicted effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to the abundance, distribution, and resilience of wildlife populations. Effects that are approaching or exceeding the resilience limits of a population would be expected to increase the risk to a self-sustaining (persistent) population (Weaver et al. 1996). A number of high magnitude and long-term or irreversible effects at the population level (beyond local scale) would likely be significant. Non-significant effects are measurable at the individual level, and strong enough to be detectable at the population level, but are not likely to decrease resilience and increase the risk to self-sustaining populations.

In summary, the following information is used in the evaluation of the significance of residual effects from the Project on wildlife:

- results from the residual effects classification;
- magnitude, geographic extent, and duration of the effect as principal criteria, with frequency and likelihood as modifiers; and
- application of professional judgment and ecological principles, such as resilience, to predict the duration and associated reversibility of residual effects.

The incremental and cumulative effects from the Project and previous and existing developments are not predicted to be large enough to alter the state of wildlife populations and adversely influence self-sustaining wildlife populations. The scale of residual effects from the Project interactions, independently or combined, should not be large enough to cause irreversible changes at the population level and decrease the resilience of wildlife populations. Overall, the cumulative effects from the Project and previous and existing on wildlife are predicted to be not significant.

15.7 Environmental Management, Monitoring, and Follow-up

Prior to construction of Project components, detailed site assessments will be completed to identify listed wildlife species that could be present in the areas to be disturbed, which were not identified during previous surveys. Additional wildlife surveys will be completed prior to construction if construction activities are to take place during the breeding season. If listed wildlife species are observed appropriate mitigation will be implemented to limit residual effects. For example, construction activities could be completed outside of the breeding season for bald eagle, waterbirds, and upland birds. It is anticipated that data reporting will occur yearly, with data analysis being communicated in the form of Annual Reports.

Environmental monitoring data reporting will be undertaken as part of a comprehensive Monitoring and Follow-up Plan. The plan will provide flexibility for SaskPower and MOE to effectively identify and respond to unanticipated changes to habitat quality and quantity, to adapt to new regulatory frameworks such as the Saskatchewan Environmental Code, and to provide appropriate feedback required to improve future environmental assessments. It is anticipated that data reporting will occur yearly, with data analysis being undertaken every five years and communicated in the form of Status of the Environment Reports.

Follow-up programs are typically implemented when the accuracy of the determination of significance needs to be verified or the resulting residual effects cause sufficient public concern to warrant an increased effort to determine the accuracy of the predictions or test the effectiveness of the mitigation/compensation. There is no follow-up program anticipated for wildlife.

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15.9 List of Acronyms

Term	Definition
ARD	acid rock drainage
ANFO	Ammonium nitrate/fuel oil
BBS	breeding bird survey
BLFN	Black Lake First Nation
BNA	Birds of North American Online
Br-	bromide
Ca_{2+}	calcium
CCME	Canadian Council of Ministers of the Environment
Cl-	chloride
CO	carbon monoxide
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
D&R	Decommissioning and Reclamation
DOEP	Department of Electricity Development
ELC	Ecological Landscape Classification
EnvPP	Environmental Protection Plan
FMZ	Fur Management Zone
GIS	Geographic Information System
H+	hydrogen
HSD	Honestly Significant Difference
K+	potassium
KPI	Key Performance Indicator
LSA	local study area
MBCA	*Migratory Birds Convention Act*
MDNN	mean distance nearest neighbour
Mg_{2+}	magnesium
ML	metals leaching
MOE	Saskatchewan Ministry of Environment
MSDS	Material Safety Data Sheet
MW	megawatt
ORNL	Oak Ridge National Laboratory
Na+	sodium
NFCA	Northern Fur Conservation Area
NH_{4+}	ammonium
NO_{2-}	nitrite
NO_x	oxides of nitrogen
NRC	Natural Resources Canada
NWT	Northwest Territories

Term	Definition
OH-	hydroxide
Project	Tazi Twé Hydroelectric Projec
RSA	regional study area
SAAQS	Saskatchewan Ambient Air Quality Standards
SARA	*Species at Risk Act*
SE	Standard Error
SKCDC	Saskatchewan Conservation Data Centre
SO_2	sulphur dioxide
SO_x	oxides of sulphur
TDG	Transportation of Dangerous Goods
TIV	turbine inlet valves
TKD	track density
TSP	total suspended particulate
VCs	valued components
WHMIS	Workplace Hazardous Materials Information Sheet
WMP	Waste Management Plan
WMZ	Wildlife Management Zone
WTC	winter track count
ZOI	zone of influence

15.10 List of Units

Term	Definition
%	percent
µg/m^3	micrograms per cubic metre
cm	centimetre
cm/h	centimetres per hour
ha	hectare
kg/ha/year	kilograms per hectare per year
kg/m^3	kilograms per cubic metre
km	kilometre
km^2	square kilometre
L/day	litre per day
m	metre
m^2	square metre
m^3	cubic metre
m^3/d	cubic metre per day
m^3/s	cubic metre per second
mm	millimetre
ºC	degrees Celsius
PM	particulate matter
ppm	parts per million

16.0 HERITAGE RESOURCES

16.1 Introduction

The purpose of the heritage resources section is to describe the heritage resources that could be affected by the Tazi Twé Hydroelectric Project (Project), and to assess the potential for effects on heritage resources. The scope of the heritage resources section includes an analysis of Project-related changes during construction, operation, and closure, and considers accidents, malfunctions, and unplanned events. The overall residual effects from the Project and potential for cumulative residual effects from the Project and previous, existing, and reasonably foreseeable developments on heritage resources are also assessed.

The assessment endpoint is the key property that should be protected for use by future human generations and for heritage resources considers the protection and preservation of heritage resources. Heritage resources in Saskatchewan include all archaeological, historical, and paleontological objects and sites, as well as any property deemed to be of interest for its architectural, historical, cultural, environmental, aesthetic, and scientific value (Government of Saskatchewan 1980). The measurement endpoints are quantifiable and qualitative expressions of change to the assessment point, and for heritage resources include the value and quantity of archaeological and sacred sites located within the study areas.

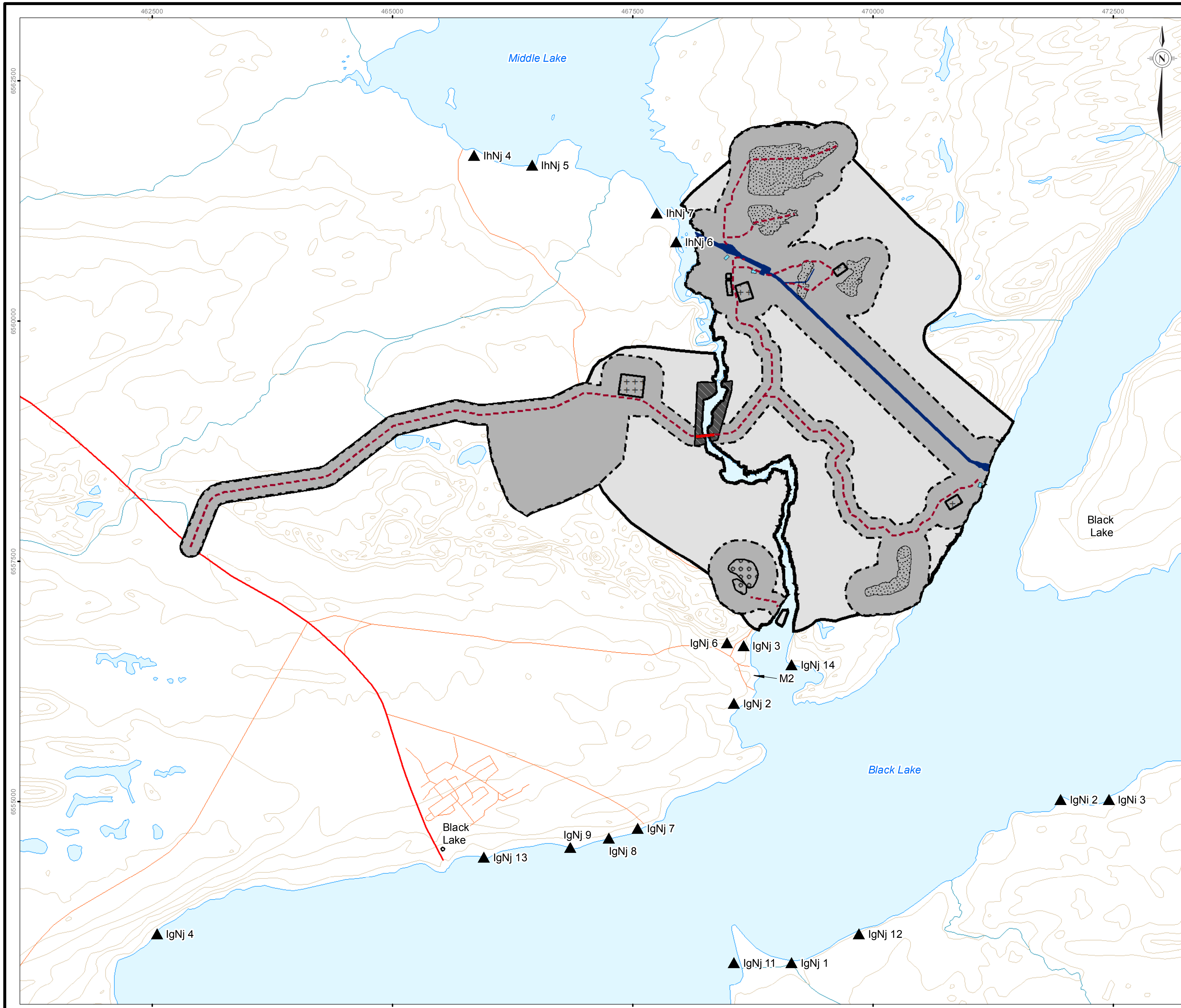
Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples and the public. The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development. Identified VCs are used to predict the effects of the Project on all environmental components and rationale for selection of heritage resources as a VC is as follows:

- Heritage resources are important for revealing past and present land use, cultural identity, and relationships with other cultures and the social and biophysical environments.
- Potential alteration or loss of heritage resources can have an effect on Aboriginal people.
- Several known heritage sites exist near the Project including a historic *Denésuline* cemetery.

16.2 Spatial Boundaries

To quantify baseline conditions and evaluate potential environmental effects on heritage resources, a single study area was defined (Figure 16.2-1). The study area is based on the predicted direct and indirect potential effects from the Project on heritage resources. Potential effects on heritage resources are primarily associated with construction activities within the Project footprint, which includes preferred and alternative locations for Project infrastructure (Figure 16.2-1).

Potential effects on heritage resources are limited to direct disturbance and loss of archaeological sites during Project construction activities. Heritage resources are non-renewable and they can be damaged or destroyed during these activities. There are no expected effects on heritage resources outside the Project footprint. Heritage resources outside of the Project footprint were identified to provide archaeological and cultural historical context.



LEGEND

- HAMLET OR COMMUNITY
- CONTOUR LINE
- HIGHWAY
- ROAD
- RIVER
- WATERBODY
- HERITAGE RESOURCE
- HERITAGE RESOURCES STUDY AREA
- PREDICTED PROJECT FOOTPRINT

SPECIFIC CONSTRUCTION SITES

- POTENTIAL BRIDGE ALIGNMENT
- PERMANENT ROAD
- CONTRACTOR CAMP / LAYDOWN AREA
- BORROW AREA
- SETTLING POND
- SPOIL DISPOSAL AREA
- POTENTIAL BRIDGE ALIGNMENT AREA
- TUNNEL AND TAILRACE ALIGNMENT

REFERENCE

SASKATCHEWAN MINISTRY OF PARKS, CULTURE AND SPORT, 2012
NAD83 UTM ZONE 13
NTS MAPSHEET: 74P/03, 04

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

HERITAGE RESOURCES STUDY AREA

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	SM	05/11/13	**FIGURE: 16.2-1**	
CHECK	PY	15/11/13		
REVIEW	BN	15/11/13		

16.3 Existing Environment

16.3.1 Heritage Resources

Under the *Canadian Environmental Assessment Act* 2012 (*CEAA 2012)*, any changes to the environment that could affect the physical and cultural heritage with respect to aboriginal peoples must be taken into account (Section 5[1][c][ii]). This includes effects on heritage or archaeological resources. The Saskatchewan *Heritage Property Act (*Government of Saskatchewan 1980*)* and the requirements established by the Saskatchewan Heritage Conservation Branch were followed to direct the heritage resources baseline studies.

Baseline studies for heritage resources consisted of the collection of historical information, conducting Elder interviews, and carrying out field assessments within the study area. The results of the baseline studies are detailed in Annex V and a summary is provided below.

16.3.1.1 Literature Review

To understand the cultural setting and existing heritage resources documented in the study area, several data sources were consulted. These included provincial databases maintained by the Heritage Conservation Branch (Saskatchewan Ministry of Parks, Culture and Sport), Heritage Resources Impact Assessment (HRIA) reports, articles from various peer-reviewed journals, relevant publications, online resources and government reports. Information from Traditional Land Use Studies carried out for the Project was also consulted.

Information from these sources was used to identify previous archaeological research carried out in the region, as well as the types of heritage resources known to occur or that could potentially occur in the study area. These data were also used to summarize the Precontact Culture History and early European exploration of the region.

The results of the database and historic records search identified eight previously recorded heritage resources along the Fond du Lac River between Black and Middle Lake. These sites were recorded as part of academic and environmental assessment programs during the 1970's (Envirocon 1974; Minni 1972, 1975 and 1976). Six of the known heritage resources consist of small Precontact artifact find and scatter sites, two of which contained diagnostic tools. IhNj 6 contained a distinct microblade typical of the Arctic Small Tool Tradition (ASTt) that dates from approximately 3,500 to 2,600 Before Present (BP), and IgNj 2 contained a diagnostic Early Taltheilei point suggested to date from 2,600 to 1,800 BP. The remaining two heritage resources were historic *Denésuline* sites that included a cemetery (IgNj 6) immediately northwest of Camp Grayling dating from the late 19th to mid-20th centuries, and a campsite and single grave (IhNj 5) located on the south shore of Middle Lake also suggested to date from the late 19th century through to contemporary times.

16.3.1.2 Elder Interviews

Elder interviews were carried out in an effort to gain additional local and historic knowledge of the study area. The objective was to identify potential archaeological sites or heritage sensitive areas based on oral history and traditional land use information provided by the Elders. Two Elders from BLFN were identified (a woman 86 years old and a man 82 years old) and interviews were carried out at the same time as the field assessment (Annex V). The majority of the Elder's stories involved living, trapping and hunting on lakes in their traditional lands in the Northwest Territories. Information regarding the study area was more limited, with areas along the Fond du Lac River generally avoided because of the dangers posed by Elizabeth Falls. However, they did relate stories of their families portaging between Middle Lake and Black Lake when travelling to and from Stony

Rapids. The traditional portage trail was later bladed and developed in the 1950's and is the current road/trail between these two lakes.

16.3.1.3 Field Assessment

Prior to initiation of the field assessment, the proposed Project footprint was submitted to the Heritage Conservation Branch for review to identify heritage concerns. The Heritage Conservation Branch (File No. 12-1445; Appendix 16.1) determined that several of the Project components will impact heritage sensitive areas, specifically the water intake and road along the north shore of Black Lake, bridge locations on the Fond du Lac River, and the tailrace channel on the east side of the river. The area west of the Fond du Lac River was considered to have greater heritage potential and was of greater heritage concern than the more rugged eastern side. One previously recorded heritage resource (IhNj 6) was identified in potential conflict with the Project.

The review by the Heritage Conservation Branch, combined with the Elder interviews and Traditional land Use Studies, were used to help direct the field assessment. The objective of the field assessment was to examine heritage sensitive areas in the study area for unrecorded heritage resources, as well as to revisit previously recorded sites in the immediate area to determine their relationship to the proposed Project.

Field assessments were completed between July 13 and July 18, 2012 under Archaeological Resource Investigation Permit No. 12-162 issued by the Ministry of Parks, Culture and Sport. The field crew consisted of two Golder archaeologists and William Toutsaint of the community of Black Lake. Standard investigation methods were used, including systematic pedestrian reconnaissance and subsurface test exploration to identify potential heritage resources. The assessment included examination of portions of the Fond du Lac River shoreline and the west shore of Black Lake focussing on areas identified by the Heritage Conservation Branch (water intake, bridge locations, and tailrace channel). Other areas included proposed construction camp options, construction facilities and a borrow area on the west side of the Fond du Lac River. An attempt was also made to revisit the eight previously recorded heritage resources along the Fond du Lac River between Black Lake and Middle Lake.

Approximately 35 hectares (ha) and 8 linear kilometres (km) were examined, including the excavation of 342 shovel tests. Details of the assessment can be found in Annex V and the Archaeological Investigation Permit report (Golder 2013). Although no new heritage resources were recorded during the 2012 baseline studies, four of eight previously recorded heritage resources were successfully identified (IgNj 3, IgNj 6, IgNj 14, and IhNj 6) (Table 16.3-1).

None of these heritage resources (including IhNj 6) is located within the study area or proposed footprint areas and all will be avoided by the Project. However, it should be noted that the historic *Denésuline* cemetery dating from the late 19th to mid-20th centuries (IgNj 6) is within 60 metres (m) of an existing road extending north from Camp Grayling towards the proposed submerged weir location.

Table 16.3-1: Previously Recorded Heritage Resources Near the Local Study Area

Borden No.	Site Type	Year Recorded/Revisited	Cultural Affiliation	Evidence of Site Observed	Within the Study Area	Observations
IgNj 2	Artifact scatter	1972/1974/2012	Late Taltheilei	No	No	Not within the study area; no further concern
IgNj 3	Artifact scatter	1972/1974/2012	Unknown Precontact	Yes	No	Not within the study area; no further concern
IgNj 6	Cemetery	1972/1974/2012	Historic Dené	Yes	No; Within 60 m of existing road	Flag for avoidance if adjacent road is upgraded
IgNj 14	Artifact find	1974/2012	Unknown Precontact	Yes	No	Not within the study area; no further concern
IhNj 4	Unknown	1972/2012	Unknown Precontact	No	No	Not within the study area; no further concern
IhNj 5	Single Grave/artifact find	1972/1974/2012	Historic/Dené	No	No	Not within the study area; no further concern
IhNj 6	Artifact scatter	1974/2012	ASTt	Yes	No	Not within the study area; no further concern
IhNj 7	Artifact find	1974/2012	Unknown Precontact	No	No	Not within the study area; no further concern

Artifact Find= archaeological site consisting of five or fewer artifacts. An artifact is any object used or modified by people (e.g., arrow head, pottery sherd, stone flakes).
Artifact Scatter = archaeological site consisting of 6 or more artifacts; ASTt = Arctic Small Tool Tradition; m = metre

16.4 Screening of Project Interactions and Mitigation

This section identifies and evaluates the interactions between Project components or activities, and the correspondent potential environmental effects on heritage resources. The process begins with the identification of all potential interactions for the Project. To provide a robust assessment of potential effects, each interaction is initially considered to have a potential linkage to change in the environment and associated potential effects on heritage resources.

Each potential interaction (ground disturbance during construction) is evaluated to determine if mitigation can be developed and incorporated to remove the interaction or limit the potential effect on heritage resources. Mitigation includes Project design elements, environmental best practices, and management policies and procedures, and are developed through an iterative process between the Project's engineering and environmental teams. Knowledge of the environment and mitigation is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for a residual effect on heritage resources.

Interactions are determined to be primary, secondary, or as having no linkage using scientific knowledge, professional judgment of technical specialists, logic, and experience with similar developments and mitigation. Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by environmental design features and mitigation so that the Project results in no detectable (measurable) change and no residual effects on heritage resources relative to baseline values;
- secondary – interaction could result in a minor change, but would have a negligible residual effect on heritage resources relative to baseline values and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary – interaction is likely to result in a measureable change that could contribute to residual effects on heritage resources relative to baseline values.

Primary interactions are anticipated to result in a residual effect on heritage resources if present, and therefore, require further analysis to determine the significance of the residual effect. Interactions with no linkage to change or changes that are considered minor (secondary) are not analyzed further or classified in the Environmental Impact Statement (EIS) because mitigation and environmental design features will remove the interaction (no linkage), or residual effects can be determined to be negligible through a simple qualitative or quantitative evaluation. Project interactions determined to have no linkage or those that are considered secondary are not predicted to result in significant effects on heritage resources.

Project components/activities and the associated mitigation implemented during the various Project phases, including accidents and malfunctions are summarized in Table 16.4-1. Potential effects on heritage resources for each Project interaction and its associated classification are summarized in Table 16.4-1, with more detailed descriptions provided in the subsequent sections.

16.4.1 Interactions with No Linkage to Effects

An interaction can have no linkage to effects if the activity does not occur, or if the interaction is removed by mitigation or environmental design features so that the Project results in no detectable change and subsequently no residual effect on heritage resources is expected. The following interaction was determined not to have linkages to effects and will not be carried forward to the residual effects analysis:

- **Ground disturbance can alter or destroy heritage resources.**

A database and literature search, Elder interviews, and a pre-construction field assessment was carried out as part of baseline studies to determine if heritage resources were present in heritage sensitive areas of the Project footprint (Annex V; Golder 2013). No heritage resources were identified in conflict. However, a historic *Denésuline* cemetery (IgNj 6) is within 60 m of an existing road extending north from Camp Grayling towards the submerged weir structure. Appropriate mitigation measures (e.g., flagging off or barricading access) should be taken to avoid this cemetery in the event that any road upgrade activities are planned. In a letter dated July 17, 2013 (Appendix 16.1) the Heritage Conservation Branch agreed with the above findings and recommendations outlined in the baseline assessments and have no concerns with the Project proceeding.

16.4.2 Interactions with Secondary Linkages

In some cases, both a source and an interaction exist, but because the change caused by the Project is anticipated to be minor it is expected to have a negligible residual effect on heritage resources. No interactions were identified as having secondary linkages to heritage resources (Table 16.4-1).

Table 16.4-1: Project Interactions, Environmental Design Features and Mitigation, and Potential Effects on Heritage Resources

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Effects on Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ Infrastructure Footprints ▪ Temporary infrastructure – construction camp – overburden and Waste Rock Disposal Areas – construction area and materials laydown area ▪ Operational infrastructure – power generation station – water intake structure – power tunnel – tailrace channel – submerged weir – bridge – transmission line – water diversion structures around the Project footprint – potable water and wastewater intake and discharge structures – site access roads (including source material)	Construction	Ground disturbance can alter or destroy heritage resources.	■ Ground disturbance will be limited to only those areas required for construction and operation of the Project. ■ Project plans will be submitted to and reviewed by the Heritage Conservation Branch, Ministry of Parks, Culture and Sport, who will determine the need for a Heritage Resource Impact Assessment in areas not previously reviewed (i.e., permanent access road alignment). ■ If unanticipated archaeological materials or features (including but not limited to, hearth features, lithic, ceramic and faunal artifacts, and human remains) are encountered during construction activities, the following will apply: ▪ all construction activity in the immediate vicinity will cease; ▪ the Heritage Conservation Branch will be contacted (306) 787-2817; ▪ based on the information provided, a mitigation plan will be formulated and implemented in consultation with the Heritage Conservation Branch; and ▪ construction at the site can resume only after the Heritage Conservation Branch has granted permission. ■ If any esker or kame used as an alternate granular material falls within the scope of HCB's HRIA requirements will require then a submission and review by the Heritage Conservation Branch, Ministry of Parks, Culture and Sport will be completed.	No Linkage
■ Accidents, Malfunctions, and Unplanned Events	Construction Operations Closure	Ground alteration because of unplanned events (e.g., spills or containment failure) may cause disturbance or destruction to heritage resources.	■ Management options for archaeological or heritage materials fortuitously discovered during because of unplanned events will be developed in consultation with the Saskatchewan Heritage Conservation Branch.	No Linkage

16.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events occurring on-site have the potential to affect adversely heritage resources. The following event was identified as having the potential to interaction with heritage resources.

- **Ground alteration because of unplanned events (e.g., spills, containment failure, or underground pipeline leaks) may cause disturbance or destruction to heritage resources.**

Accidents, malfunctions, and unplanned events occurring in the Project have the potential to adversely affect heritage resources. This may occur if additional and unexpected ground disturbance occurs because of clean-up during spills (e.g., petroleum products, non-hazardous or hazardous, or reagents) or containment failures (e.g., fuel storage tanks). During the design stage mitigation will be identified and included in the Environmental Protection Plan (EnvPP) and Emergency Response and Contingency Plan. Management options for archaeological or heritage materials fortuitously discovered because of unplanned events will be developed in consultation with the Heritage Conservation Branch, Ministry of Parks, Culture and Sport. The implementation of mitigation is anticipated to result in no linkage to effects on heritage resources.

16.4.4 Primary Interactions

No interactions were identified as having primary linkages to heritage resources (Table 16.4-1). As such, an effects assessment is not required in the EIS.

16.5 Environmental Management, Monitoring, and Follow-up

Most mitigation practices for heritage resources are applied and completed in advance of ground disturbance activities; however, unanticipated heritage resources may be found during site clearing activities. Management options for archaeological or heritage materials discovered during construction activities will be developed in consultation with Aboriginal Affairs and Northern Development Canada and the Saskatchewan Ministry of Parks, Culture and Sport - Heritage Conservation Branch. The management plan will provide a procedure and steps to follow that will limit negative effects on unanticipated archaeological resources found during site clearing activities.

Subsequent to the 2012 assessment, the Project footprint shifted slightly and proposed access road options were added. Updated Project plans were submitted to the Heritage Conservation Branch for review to determine any additional heritage assessments. In a letter dated June 24, 2013 (File No. 12-1445; Appendix 16.1), the Heritage Conservation Branch observed that the access road options will traverse areas of native boreal forest adjacent to unnamed creeks that drain into Middle Lake. As a result, additional Heritage Resource Impact Assessment is required only for portions of the access road within 250 m of these creeks prior to construction activities.

In the future, should Project components be proposed that are outside of the current Project footprint, plans will need to be submitted and reviewed by the Saskatchewan Ministry of Parks, Culture and Sport - Heritage Conservation Branch to determine if heritage sensitive lands will be affected and whether there is a need for additional heritage assessments. Assessments will be carried out by a qualified archaeologist.

16.6 References

Envirocon Ltd. 1974. Elizabeth Falls: Fisheries Resources and Environmental Overview.

Government of Canada. 2012. *Canadian Environmental Assessment Act*.

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Golder Associates Ltd. 2013. Tazi Twé Hydroelectric Project. Heritage Baseline Study. Permit No. 12-162. Report on File with Heritage Conservation Branch, Regina, SK.

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16.7 Glossary

Term	Description
ASTt	Arctic Small Tool Tradition. A term for an archaeological culture that lived in the Canadian Arctic and Subarctic between 3,500 to 2,600 BP.
Archaeology	The study of past cultures through the scientific investigation of their material remains.
Artifact	Any object created, used or modified by people.
Artifact Find	A category for archaeological sites consisting of five or fewer artifacts.
Artifact Scatter	A category for archaeological sites consisting of more than five artifacts.
BP	Before Present. Archaeologists use this term to refer to dates that were obtained through the radiocarbon method and means "years Before the Present". As the present year is a moving target, 1950 is considered the origin of the age scale and reflects the fact that radiocarbon dating became practicable in the 1950's. For example, 1,000 B.P. = 1,000 years before 1950 A.D. or approximately 1,000 A.D.
Feature	The remains of any non-portable human activity that cannot be removed from a site without disturbing it (e.g., hearth, cabin remains, grave).
Flake	A stone fragment intentionally detached from a source rock during tool manufacture. Three flake types are generally recognized: primary flakes represent early stages of reduction where the original cortex is present on the dorsal surface; secondary flakes represent later stages of reduction where no cortex is present; and tertiary flakes represent the final stages of reduction where small pressure flakes are removed to produce the cutting or scraping edge of a tool.
Heritage Resource	Any human or natural artifact or feature that is of interest for its architectural, historical, cultural, environmental, archaeological, paleontological, aesthetic or scientific value.
Lithics	A general term used to refer to stone artifacts such as tools, cores, or debitage.
Microblade	A small blade (a flake that is at least twice as long as it is wide with parallel sides), generally less than 5 cm long. A characteristic artifact of the ASTt.
Projectile Point	An inclusive term for a hafted arrow, spear, or dart point.

Term	Description
Precontact	Refers to the period in North America prior to the arrival and contact with Europeans. In Saskatchewan, this is generally considered the period prior to Henry Kelsey's journey to the plains in 1690.
Shovel Probe	A 40 cm by 40 cm subsurface test where the excavated soils and sediments are hand trowelled for cultural materials.
Site	Any location with detectable evidence of past human activity.
Taltheilei	A term for an archaeological culture that lived in the Canadian Subarctic between 2,600 and 200 BP. It is divided into Early, Middle, and Late Periods and considered related to ancestral Dené.

16.8 List of Acronyms

Term	Definition
ASTt	Arctic Small Tool Tradition
BP	Before Present
CEAA	*Canadian Environmental Assessment Act*
EIS	Environmental Impact Statement
EnvPP	Environmental Protection Plan
HRIA	Heritage Resources Impact Assessment
Project	Tazi Twé Hydroelectric Project
VC	valued component

16.9 List of Units

Term	Definition
ha	hectares
km	kilometre
m	metre

17.0 LAND AND RESOURCE USE

17.1 Introduction

The purpose of this section of the Environmental Impact Statement (EIS) is to discuss the effects of the Tazi Twé Hydroelectric Project (Project) on land and resource use, including domestic and commercial resource use activities. Renewable resource uses include traditional resource uses by Aboriginal people, such as domestic hunting and fishing, along with resource use for commercial purposes, such as commercial fishing, trapping, and outfitting. Non-renewable resource uses are less common in the Athabasca region, with the mining industry being the main sector.

Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples, and the public. The value of a component relates to its role in the ecosystem and to the value placed on it by humans. The identification of the key Project-environment interactions and the initial selection of VCs built on the preliminary Project scoping meetings with government, public, and First Nations and Métis. Rationale for selection of land and resource use as a VC is described below:

- Pursuant to Section 5 of the *Canadian Environmental Assessment Act* (*CEAA* 2012), the potential to affect the ability of Aboriginal people to maintain traditional land and resource use must be evaluated.
- Several fish, plant, and wildlife species are considered VCs by local Aboriginal people for hunting, trapping, fishing, and gathering for domestic and commercial use:
  - Fish species include Arctic grayling, cisco species, lake trout, lake whitefish, longnose sucker, northern pike, walleye, and white sucker.
  - Plant species include blueberries, bog cranberries, moss berries, and strawberries, as well as other edible vegetation, like mushrooms, when available.
  - Wildlife species include black bear, wolf, coyote, red fox, arctic fox, lynx, wolverine, fisher, American marten, weasel species, mink, beaver, muskrat, river otter, red squirrel, and waterbirds (e.g., snow geese, Canada geese, and ptarmigan).
- Increased access to the Project area is a topic of interest for the Black Lake First Nation (BLFN).

The assessment endpoint is the key property that should be protected for use by future human generations. For land and resource use, this is considered the continued opportunity for traditional and non-traditional activities such as hunting, fishing, trapping, and plant and berry gathering. The land and resource use assessment endpoint is focused on the maintenance of fish, vegetation, and wildlife populations that have been identified as important to the BLFN and other local land and resource users.

Measurement endpoints are quantifiable (i.e., measureable) or qualitative expressions of change to the assessment endpoint. Measurement endpoint information is generally the basis for discussions of uncertainty of effects on VCs, as well as for identification of the variables to be used in monitoring and follow-up programs. The measurement endpoints identified for land and resource use include:

- relative abundance and distribution of fish species;
- relative abundance and distribution of plant species;

- relative abundance and distribution of wildlife species; and
- capacity for traditional and recreational land use.

17.2 Spatial Boundaries

A local study area (LSA) and regional study area (RSA) were defined for the land and resource use component of the environmental assessment. The LSA for the land and resource use includes the communities of BLFN in addition to the Northern Hamlet of Stony Rapids. The Project is located on BLFN reserve land. The Chicken Indian Reserve No. 224 was created under the Order in Council (OIC) 1978-1647; that is the land is set aside for the exclusive use and benefit of the members of the BLFN. The LSA also includes Black Lake (the waterbody), the section of the Fond du Lac River from Black Lake to Stony Rapids, and associated shoreline areas. This area also encompasses Stony Lake and Middle Lake, which are important areas for resource use by the BLFN, as well as Camp Grayling, the outfitter located closest to the Project.

The RSA represents the area where potential effects on land and resource use are expected to be experienced at a broad scale. The RSA includes consideration of the Athabasca region of northern Saskatchewan and is described from the perspective of BLFN and the Northern Hamlet of Stony Rapids land use.

17.3 Existing Environment

This section provides an overview of land and resource use in the area around the Project near the communities of Black Lake and Stony Rapids. The characterization of land and resource use by residents of the communities of Black Lake and Stony Rapids incorporates a review of both primary and secondary data sources. The primary sources of information for this section come from a Key Person Interview (KPI) program, along with mapping, and land and resource use workshops completed from 2011 to 2013 in the communities of Black Lake and Stony Rapids. Other sources of information include the Statistics Canada Aboriginal Peoples Survey 2001, ethnographic literature, as well as reports on historical and contemporary land and resource use in northern Saskatchewan, focused on the Athabasca region and the communities of Black Lake and Stony Rapids. Further information about land and resource use can be found in Annex VI.

17.3.1 Land and Resource Use for Traditional and Domestic Purposes by Aboriginal People

The Project is located in the traditional territory of the BLFN, which extends from Black Lake throughout the Athabasca region and north into what is now the Northwest Territories and Nunavut (PAGC 2011a; Raby 1973; Black Lake and Stony Rapids KPI Program 2011-2013). While members of the BLFN are active throughout their entire traditional territory, including north and south of the community, many activities take advantage of resources near the community of Black Lake, such as around Stony Lake, Middle Lake, and the Fond du Lac River. Members of the BLFN also use the areas south of the community near Riou Lake, Wapata Lake, Pasfield Lake, Theriau Lake, and Waterbury Lake for trapping and commercial fishing. Residents also travel northeast toward the Milton Lake area. Hunting activity is extensive along the Athabasca Seasonal Road (Highway 905) connecting the communities of Stony Rapids and Black Lake with Points North and Southend (Black Lake and Stony Rapids KPI Program 2011-2013).

Among northern Aboriginal peoples, traditional resource use is a defining feature of their cultures and identities. Natcher (2008) equates traditional resource use to a social economy, which he describes as the harvest and use of wild foods and resources. "Having endured profound social and economic change, Aboriginal peoples throughout northern Canada have maintained a lasting connection with the environment through hunting, fishing and gathering resources. Aboriginal people from across the north harvest, process, distribute, and consume considerable volumes of wild foods annually. Collectively, these activities have come to be known as 'subsistence', and together comprise an essential component of northern Aboriginal Culture" (Natcher 2008). Northern residents continue to pursue activities such as hunting, fishing, and trapping to supplement their diet and incomes and maintain connections to the land, history, and cultural traditions of their ancestors. However, the prevalence of these activities, particularly from a commercial perspective, has been declining over the last few decades (McNab 1992; Brown 2007a; Brown 2007b; Black Lake and Stony Rapids KPI Program 2011-2013).

17.3.1.1 Historical Land and Resource Use

The Aboriginal people of the region have traditionally used the LSA and RSA for generations. The Denésuline ("People of the Barrens") are descendants of the Taltheilei Tradition, a tradition understood by archaeologists as the most recent period on a continuum of technological adaptation by the Denésuline people and their ancestors, which dates back about 2,600 years (Jarvenpa 2003; PAGC 2008). Denésuline peoples and their ancestors have lived throughout the northern regions of what are now Alberta, Saskatchewan, Manitoba, the Northwest Territories, and Nunavut for thousands of years, with archaeological evidence of continuous occupation in northern Saskatchewan for an estimated 8,000 years (Meyer 1981). Archaeological work completed on the south shore of Black Lake in the 1970s recovered tool fragments attributed to the Paleo-Indian period, from approximately 6,000 to 5,000 before present (BP). Local archaeological sites also suggest a Pre-Dorset presence from 1,500 to 1,000 BP. For the last three millennia, the area experienced a prolonged period of Chipewyan[4] occupation, with shorter periods of use by Northern Plains and Woodland Cree peoples (Minni 1975). Several major regional groups of Dene have been known historically in northern Saskatchewan, including the *Gáne-kúnan-hot!inne* ("jack pine home they dwell"), centered along the eastern Fond du Lac River; The community of Black Lake is historically connected to this regional group (Irimoto 1981; Jarvenpa 2003).

Prior to the mid-1700s the Denésuline were known to live off the caribou on the northern edge of the boreal forest and into the barren grounds. The abundance of caribou for food and skins and the relatively easy access to the animals were important factors in keeping the Denésuline out of the fur trade and on the margins of the boreal forest (Smith 1976). Eventually, as the Denésuline learned to trap and produce valuable furs that could be exchanged for goods at the trading posts, they moved further south into the boreal forest where there was a greater abundance of fur-bearing animals

In 1899, Maurice's Band signed an adhesion to Treaty 8 at Fond du Lac (INAC 2011). According to the Indian Claims Commission (1993), "Maurice's Band was named after Maurice Piche (also known as Moberly), the Chief who Signed Treaty 8 in 1899; it later split into the Fond du Lac and Black Lake (Stony Rapids) Bands". While a Hudson Bay Company (HBC) post and Catholic mission were already well established at Fond du Lac by the time the Treaty was signed, most members of Maurice's Band continued to live a nomadic lifestyle. They

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[4] The Denesuline or Dene peoples were historically referred to as the Chipewyan. The term Chipewyan continues to be used in some anthropological texts, particularly with reference to pre-contact and historic occupations by Dene peoples; where used in this report, it should be understood as interchangeable with the terms Denesuline or Dene.

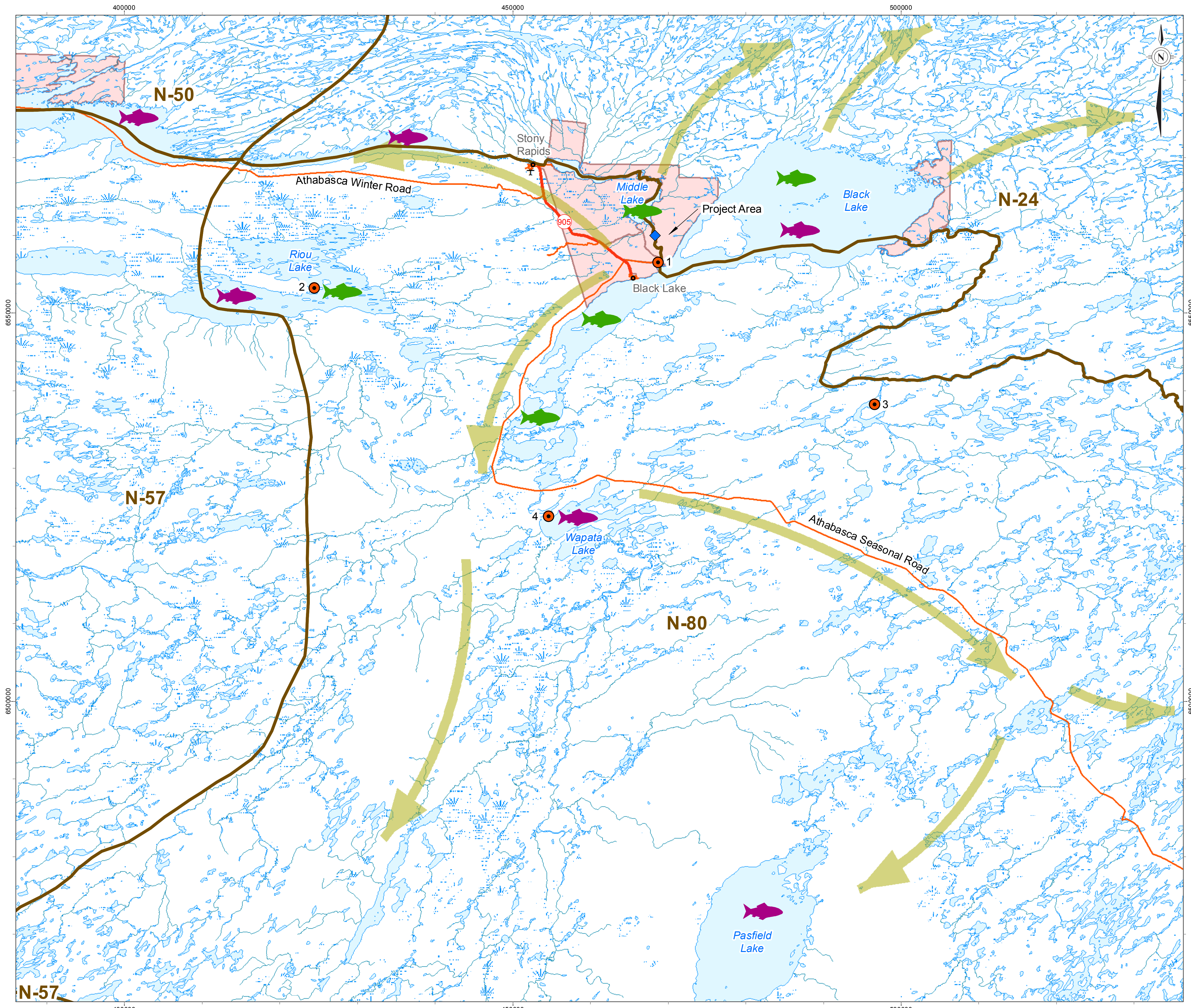
followed the caribou herds and fished, hunted, and trapped in the boreal forest throughout the Athabasca region and north into the barren lands of what is now the Northwest Territories (PAGC 2011b; Raby 1973; Black Lake and Stony Rapids KPI Program 2011-2013). Those members of Maurice's Band who frequented the area around Stony Rapids, Middle Lake, and Black Lake eventually came to be known as the Stony Rapids Denésuline; today they are known as the Black Lake Denésuline First Nation (Mease, no date [n.d.]).

Dennis F. K. Madill (1986) reports that during negotiations for Treaty 8, to which Black Lake and Fond du Lac signed adhesion, signatories expressed concern and opposition to reserves, preferring to continue their traditional economic activities of hunting, fishing, and trapping. It was not until the 1930s that the government began exploring the possibility of setting aside reserve lands (Indian Claims Commission 1993). This possibility was revisited several times throughout the 1940s and 1950s. By the mid-1950s, the Denésuline of the Athabasca region had settled into the three regional communities of Fond du Lac, Black Lake, and Hatchet Lake (Heber 2005). In 1960, the Department of Indian Affairs acknowledged an outstanding treaty land entitlement to the Denésuline of the Athabasca region (Indian Claims Commission 1993; Mease n.d.; PAGC 2011b). Settlement into present day communities occurred over the course of many years and was influenced by many activities, including the establishment of missions, trading posts, and other government policies. Additional information describing the historical land and resource use of the Denésuline people of northern Saskatchewan can be found in Annex VI.

Middle Lake, a small lake between Stony Lake and Black Lake in the LSA, was a traditional camping area for families following the migration route of the caribou. Due to the lake's small size and the influence of Fond du Lac River flows, the ice breaks up much earlier than at Black Lake and the spot became a popular spring fishing site. Denésuline families would camp on the lake for several weeks each spring; this practice continued through the 1970s (Black Lake and Stony Rapids KPI Program 2011-2013; Bone 1973; Shannon 1973).

Stony Lake, located a few kilometres east of Stony Rapids on the Fond du Lac River, became the preferred short-term settlement for Dene families while trading furs in Stony Rapids. Stony Rapids is called *Deschaghe* in Denésuline, meaning "settlement on the other side of the rapids" (Saskatchewan Indian Cultural Centre [SICC] 2011). As time went by, families would spend summers at Stony Lake instead of their traditional camps on Middle Lake. Eventually, the establishment of a church and school at Stony Lake provided further incentive to settle. However, as the settlement grew, local fishing and hunting became poorer and then, with the encouragement of Father Porte, the resident Catholic priest, most community members abandoned Stony Lake in 1952 to form a new settlement on the north shore of Black Lake, also known as *Tazen tuwé* in Denésuline (Shannon 1973; SICC 2011). A school and the Black Lake reserve territories (Chicken 224, 225, and 226) were established in the following decades (Mease n.d.; PAGC 2011b).

Members of BLFN have identified specific lands as their traditional territory, including Fur Blocks N-24 and N-80, as well as north beyond present-day settlements and the border of Saskatchewan and the Northwest Territories traditional territory. These fur blocks and the general movement of BLFN members within their traditional territory are shown on the map in Figure 17.3-1. Figure 17.3-1 illustrates the main patterns of use, but not all of the land and resource use activities that occur throughout the region (Black Lake and Stony Rapids KPI Program 2011-2013).



LEGEND

- ELIZABETH FALLS
- VILLAGE
- PROVINCIAL ROAD
- ATHABASCA WINTER/ SEASONAL ROAD
- INDIAN RESERVE
- FUR BLOCK BOUNDARY

LODGES AND OUTFITTER CAMPS

1. CAMP GRAYLING
2. CAMP GRAYLING ON RIOU LAKE
3. HAWKROCK WILDERNESS ADVENTURES
4. CREE RIVER LODGE

- DOMESTIC FISHING LAKE
- COMMERCIAL FISHING LAKE
- BLACK LAKE FIRST NATION RESOURCE USE MOVEMENT

REFERENCE

CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

10 0 10
SCALE 1:500,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

REGIONAL BLACK LAKE FIRST NATION LAND AND RESOURCE USE

Tazi Twé Hydroelectric Project

PROJECT		10-1365-0004
DESIGN		
GIS	SM/LR	28/06/13
CHECK	KD	24/07/13
REVIEW	HS	25/06/13

FILE No.
SCALE AS SHOWN REV. 0

FIGURE: 17.3-1

17.3.1.2 Contemporary Land and Resource Use

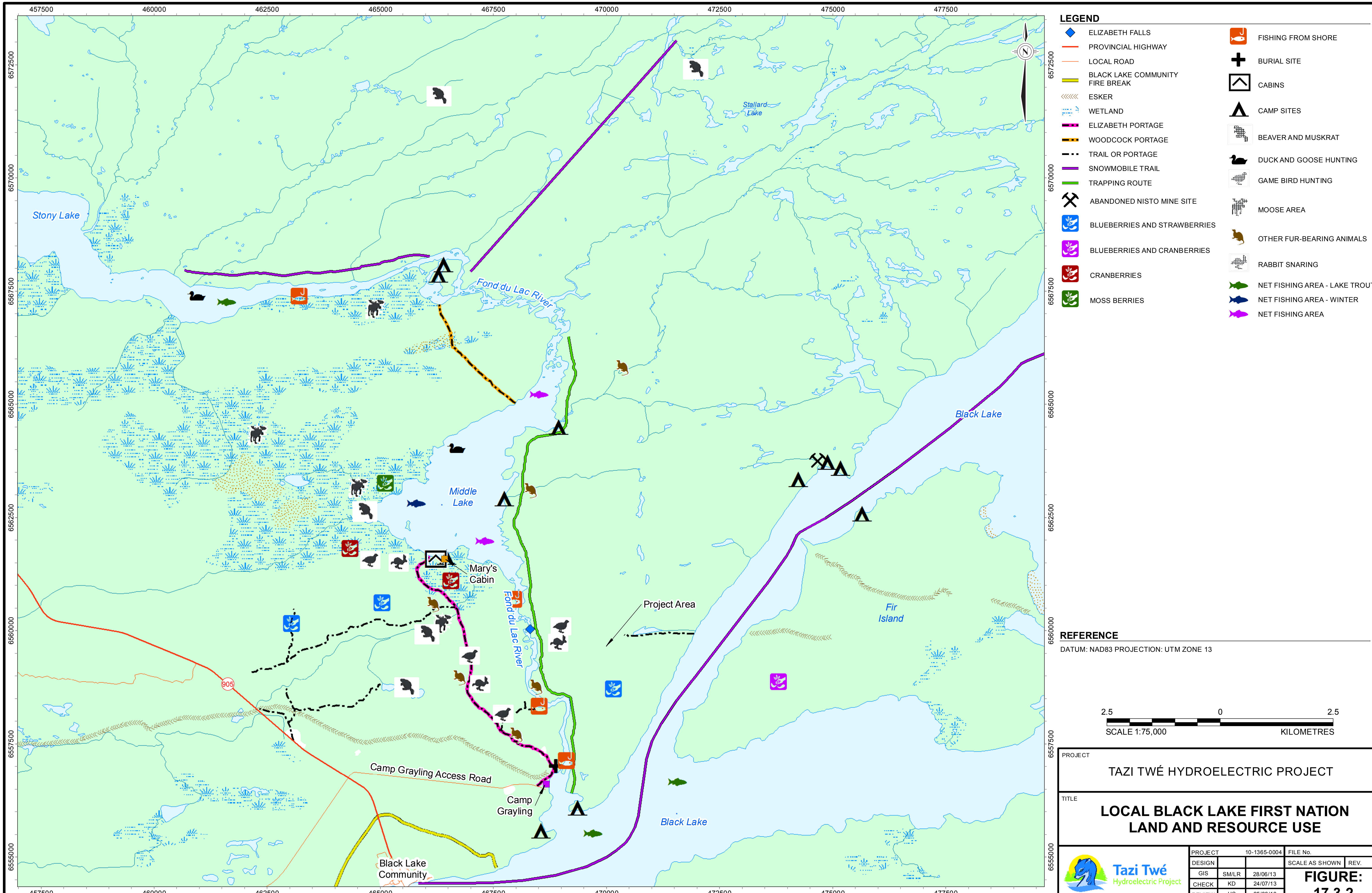
Many people from the communities of Black Lake and Stony Rapids take advantage of resources near Black Lake, in addition to travelling south as far as Pasfield and Theriault lakes, and as far north as Selwyn and Wholdaia lakes in the Northwest Territories. A number of members have cabins and camps in the Selwyn Lake area, as well as further north into the Northwest Territories, for use in subsistence hunting, fishing, and trapping. There are cabins and campsites around Black Lake, Stony Lake, and Middle Lake, as well as near Chipman Lake and other small lakes close to the communities. Residents of the communities of Black Lake and Stony Rapids travel south to the area around Wapata Lake and Riou Lake. These areas are used for trapping, gathering and subsistence hunting and fishing. Some BLFN members travel northeast toward the Milton Lake area (Black Lake and Stony Rapids KPI Program 2011-2013). This section of the EIS focuses on the land and resource use activities in the LSA and overlaps into the RSA. Additional information about land and resource use can be found in Annex VI.

Contemporary use of waterways is important for participating in traditional activities for the people of the Black Lake community. Traditionally, members of the BLFN and their ancestors have traveled for resource use by way of land trails and waterways. These trails and waterways provide natural corridors for on-foot travel and dog teams in the winter and canoe in the summer, and helped to establish the extent of traditional territories (Elias pers. comm. 2001; ALUPIAP 2003; Black Lake and Stony Rapids KPI Program 2011-2013). Waterways continue to be used for subsistence fishing, hunting, gathering, and general transportation for people in the Athabasca region. Today, members of the BLFN use land trails and frozen waterways to hunt in winter (Black Lake and Stony Rapids KPI Program 2011-2013).

Hunting, domestic harvesting activities and commercial resource use activities are carried out by BLFN members throughout the LSA and the RSA through the following transportation routes:

- the lakes and rivers in the region;
- the all-season road between Stony Lake and Black Lake;
- the Athabasca Seasonal Road (Hwy 905) connecting the communities of Stony Rapids and Black Lake with Points North Landing and the southern half of the province;
- the winter road heading west from Stony Rapids towards the community of Fond du Lac and the south shore of Lake Athabasca; and
- numerous exploration trails and other access corridors leading off these roads that are used to access a wider area for hunting, other domestic harvesting activities, and commercial resource use activities (Black Lake and Stony Rapids KPI Program 2011-2013).

Figure 17.3-2 illustrates the general movement patterns of BLFN members in a portion of their traditional territory. It is recognized that BLFN members' land and resource use extends throughout Fur Blocks N-80 and N-24 and into the Northwest Territories (Black Lake and Stony Rapids KPI Program 2011-2013). Fur blocks N-24 and N-80 are divided by the Fond du Lac River, with N-24 on the east and N-80 on the west side of the river.



PROJECT
TAZI TWÉ HYDROELECTRIC PROJECT

TITLE
LOCAL BLACK LAKE FIRST NATION LAND AND RESOURCE USE

PROJECT	10-1365-0004	FILE No.	
DESIGN		SCALE AS SHOWN	REV. 2
GIS	SM/LR	28/06/13	
CHECK	KD	24/07/13	
REVIEW	HS	25/06/13	

FIGURE: 17.3-2

17.3.1.3 Domestic Land and Resource Use

Resource use for subsistence purposes by residents of the communities of Black Lake and Stony Rapids provides insight into the role of traditional or country foods by local residents. Residents of Black Lake and Stony Rapids communities report that caribou[5] and fish are the most consumed traditional foods (Black Lake and Stony Rapids KPI Program 2011-2013). This is supported by the findings in the Hatchet Lake Dietary Survey, a study that describes the consumption of traditional food among members of the Hatchet Lake First Nation, and is often considered as representative of other communities in the Athabasca region (CanNorth 2000). Residents of the Black Lake and Stony Rapids communities report preference for traditional meats compared to store-bought foods, with some residents of BLFN stating that they rarely use store-bought foods (Black Lake and Stony Rapids KPI Program 2011-2013). Similarly, in Hatchet Lake, consumption of store-bought meats is substantially lower than consumption of traditional meat, poultry, and fish. The Hatchet Lake survey found that approximately 73 percent (%) of meat consumed in the summer and 78% of meat consumed in the winter, by weight, were from traditional sources. The BLFN and Stony Rapids Elders and older adults report that they consume more traditional foods than their children and grandchildren (Black Lake and Stony Rapids KPI Program 2011-2013). This is comparable with the results of the Hatchet Lake survey, which revealed that older individuals (41 to 60 years of age) tend to consume more traditional foods than children and adolescents (2 to 20 years of age; CanNorth 2000).

Barren-ground caribou is the most important traditional food source of the people of the Athabasca region, including those residing in the communities of Black Lake and Stony Rapids. Residents of the Black Lake and Stony Rapids communities undertake caribou harvesting for domestic use and tend to follow the Beverly caribou herd[6] (Meyer 1981; InterGroup 2008). Due to the unpredictable patterns of caribou migration, residents of the Athabasca region often must travel into the Northwest Territories, Nunavut, and northern Manitoba to hunt caribou; Black Lake and Stony Rapids residents tend to travel to the Northwest Territories. According to residents of the Black Lake community, caribou used to migrate through the Stony Lake-Middle Lake-Black Lake area, as well as further south to the Cree River and Wollaston Lake region. However, caribou have not been seen around Middle Lake since the mid-1980s (Black Lake and Stony Rapids KPI Program 2011-2013).

Forest fires are believed to have affected the migration patterns of caribou. As noted, caribou used to travel to the region between Wollaston Lake and Black Lake, and as far as Cree Lake in the 1950s and 1960s. Caribou last returned to the Black Lake area in the 1980s, before fires had burnt much of the forest in the area. Some people do not believe the caribou will return to the area until the forest has grown back and can be useful habitat for the caribou. As the caribou no longer come as far south as they used to, the majority of hunting activity takes place in the Northwest Territories. Residents of the Black Lake and Stony Rapids communities travel to Selwyn Lake and use it as a base to go hunting further north. Caribou are typically hunted during the winter months (Black Lake and Stony Rapids KPI Program 2011-2013).

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[5] First Nations and Metis peoples living in more southern communities in Saskatchewan hunt woodland caribou; however, there is no evidence to suggest that residents of the Athabasca region, particularly those living in Black Lake and Stony Rapids, hunt these animals. All references to caribou in this document should be understood as barren-ground caribou.

[6] The mixing of the Beverly and Qamanirjuaq herds, including overlapping ranges that extend into the territory occupied by other herds like the Bathurst and Ahiak herds, create uncertainties regarding community affiliation with specific herds. In recent years, the BQCMB has reported that residents of Black Lake and Stony Rapids have increased their hunt of the Qamanirjuaq herd due to fewer Beverly animals in their traditional hunting territories (BQCMB 2011).

While caribou is the preferred species hunted by residents of the Athabasca region, moose, black bear, and waterfowl, such as geese and ducks, are also harvested. Residents of the Black Lake community also hunt smaller mammals, such as beaver and rabbit, and ptarmigan and grouse, which are locally referred to as "chicken." Hunting for these species tends to take place opportunistically, often off the roads and trails that criss-cross the region. In addition to hunting, some residents of the Black Lake community report gathering duck and other bird eggs in spring (Black Lake and Stony Rapids KPI Program 2011-2013).

Similar to caribou, it has been observed that many of the animals (including beaver, porcupine, rabbit, muskrat, and grouse) have left the area near Middle Lake because of forest fires and low water levels. Some animals are slowly returning to the area, including beaver, as well as larger mammals such as moose, wolves, and bear. Some people noted that the grouse to the north and south of the Middle Lake area are different colours than those that were at Middle Lake historically (Black Lake and Stony Rapids KPI Program 2011-2013).

Since the forest has started to regenerate, rabbits, ptarmigan, and grouse have become more common and some hunting, trapping, and snaring takes place in the LSA. These animals are hunted and snared year-round by BLFN members, including the principal resource user/cabin owner on Middle Lake. Moose are also hunted year-round, particularly on the northwest side of Middle Lake and along the Fond du Lac River near Stony Lake. Summer and fall months are preferred moose hunting seasons. Ducks and geese are hunted in spring and fall during their annual migration through the area, mainly on Stony Lake and Black Lake. Small mammals that live along the tributaries of the river and lakes, such as beaver, otter, marten, mink, and muskrat, are sometimes trapped for domestic and commercial use, although the area does not support extensive trapping activities. Larger mammals, such as wolves, foxes, and lynx, are also occasionally hunted and trapped in the area (Figure 17.3-1; Black Lake and Stony Rapids KPI Program 2011-2013).

Fish have been a vital part of traditional life in the Athabasca region and continue to be prepared for consumption using local cultural practices (Marles et al. 2000; Black Lake and Stony Rapids KPI Program 2011-2013). Fishing for domestic use occurs throughout the year for various species. Subsistence fishing among residents of Black Lake tends to be small-scale, with fishers using 100 metre (m) gill nets to bring in 13.6 to 18.1 kilogram (kg) of fish per harvest. Due to the use of gill nets, domestic fishing is rarely targeted to specific species. Fish are usually smoked for preservation in the spring and summer months and can be prepared in other ways, including frying, roasting and baking, drying, and use in soups (Black Lake and Stony Rapids KPI Program 2011-2013). Studies indicate that fish have traditionally provided approximately 15% of the protein requirements of Athabasca residents (Cigar Lake Mining Corporation 1995). Black Lake also has a small commercial fishery (see Figure 17.3-1).

Most fishing for domestic use takes place on Stony Lake, with some fishing on Middle Lake and Black Lake. Ice fishing takes place on Black Lake and Stony Lake, but is less prevalent on Middle Lake due to open water and thin ice during the winter months. The principal resource user/cabin owner on Middle Lake is the main year-round domestic fisher on the lake, though other residents use the area in spring before the ice on Black Lake has melted. Fishing on Middle Lake is mainly by net, and as such, does not tend to target specific species. Lake whitefish, lake trout, northern pike, walleye, suckers, and grayling are among the preferred species. Lake trout fishing occurs near the junctions of the Fond du Lac River and local lakes, particularly in fall, and Arctic grayling are prevalent in the Fond du Lac River near Elizabeth Falls (Black Lake and Stony Rapids KPI Program 2011-2013). Fewer people have been fishing on Middle Lake in recent years because of low water levels. While a few people continue to set nets on the lake, these efforts are less frequent than in the past. This may be due to fewer dogs to feed in the community or because of a shift in eating practices among residents (Black Lake and Stony Rapids KPI Program 2011-2013).

There are many traditional uses of forest plant species. Wood continues to be collected for heating by residents. Some trees and plants have cultural importance and are used in medicinal, ceremonial, and spiritual activities. Traditional knowledge of plants for medicinal purposes and the importance of these plants have been transmitted orally from one generation to the next. A few members of the BLFN have knowledge of traditional plants and their uses (Black Lake and Stony Rapids KPI Program 2011-2013).

In the community of Black Lake, gathering for domestic use is largely for berries, particularly blueberries, bog cranberries, and moss berries, as well as other edible vegetation, such as mushrooms, when available (some locations are identified in Figure 17.3-1; Black Lake and Stony Rapids KPI Program 2011-2013). Traditionally, the location of good patches of berries was shared with community and family members, and extended family groups camped nearby to gather the fruit together and socialize (Cigar Lake Mining Corporation 1995). To this day, many residents are aware of good berry-picking spots around the communities and traplines, including the Middle Lake area and on Fir Island on Black Lake, and use these activities to interact socially with family and friends. Berry picking is done opportunistically while out on the land for hunting, trapping, and fishing (Black Lake and Stony Rapids KPI Program 2011-2013).

Recent burn areas around Middle Lake and on Fir Island in Black Lake support several plant species, particularly berries. Blueberries, bog cranberries, moss berries, and strawberries are gathered by community members for domestic use, such as jam production and freezing, from mid-summer to late fall (Black Lake and Stony Rapids KPI Program 2011-2013).

17.3.1.4 Access, cabins, and campsites

The LSA has been used historically as a travel corridor when following the caribou herds, as well as for temporary campsites, particularly for spring fishing prior to ice break-up on Black Lake. There are two main portage routes in the area, one between Black Lake and Middle Lake (i.e., the Elizabeth Portage) and the other between Middle Lake and Stony Lake (i.e., the Woodcock Portage). The Fond du Lac River on either side of Middle Lake is too dangerous to travel by boat because to a series of rapids, including Elizabeth Falls. Residents avoid using boats on these stretches of the river. In the winter, people travel through the LSA by snowmobile. Trails lead north to caribou hunting grounds from the outlet of Stony Lake, near Stony Rapids, as well as from the outlet of Middle Lake (Black Lake and Stony Rapids KPI Program 2011-2013).

There are small trails throughout the region, most of which are trunk trails that connect larger roads. These trails are used to access cabins and campsites and to portage through the area. Trails are located off the road leading to Camp Grayling, off road that provides access to the cabin on Middle Lake, and to the east of the Elizabeth Falls Portage along the Fond du Lac River. These trails also provide access to campsites used for community cultural camp activities (Black Lake and Stony Rapids KPI Program 2011-2013).

One member of BLFN has lived in a cabin on the southern shore of Middle Lake year-round since the late 1970s and is considered the principal resource user in the LSA. Prior to building a cabin at the site, the current occupant and family lived in a tent structure on the same site. At one time, several seasonally used cabins were located near this residence, but fires in the last decade have destroyed these structures. The location of the cabin roughly corresponds to a traditional spring Denésuline campsite on Middle Lake (Black Lake and Stony Rapids KPI Program 2011-2013). The remaining one-room log cabin is a relatively new building, having replaced a cabin that was destroyed by fire around 2006. It is heated by woodstove and does not have electricity or running water. In the summer, drinking water is collected from a deep spot in the middle of the lake; in the winter, clean snow is collected and melted for use. The current occupant uses Middle Lake for domestic fishing year-round and hunts around the lake for small animals (e.g., spruce grouse and rabbit) and larger animals (e.g., moose). The area is suitable for berry picking in the summer and is used by the local resident as well as families from the communities of Black Lake and Stony Rapids (Black Lake and Stony Rapids KPI Program 2011-2013).

There are several campsites located off the main trails and roads between Stony Rapids and Middle Lake, including a few locations near Camp Grayling that are used for community cultural camps. The cultural camps are organized by BLFN Education and provide community members, particularly children and youth, opportunities to spend time on the land learning traditional skills (e.g., setting snares, identifying animal tracks, cleaning fish and game to make dry meat, preparing animal pelts, playing games and learning crafts) and hearing stories and receiving guidance from local Elders. Several campsites are located off the Athabasca Seasonal Road, to the southeast of the community of Black Lake (Black Lake and Stony Rapids KPI Program 2011-2013). The sites are located off the east side of Highway 905 starting about 4.5 km northwest of Black Lake and further to the east of the road along the bush roads in the area. Throughout the summer, family groupings may also set up pole tents and spend time together living on the land and sharing resources (Black Lake and Stony Rapids KPI Program 2011-2013).

17.3.2 Commercial Land and Resource Use

Dene people have carried out commercial land and resource use activities since they began participating in the commercial fur trade. Several resource use activities currently provide residents with economic gain. These include trapping, commercial fishing, and outfitting and lodge operation.

17.3.2.1 Trapping

Aboriginal people in northern Saskatchewan have been involved in trapping animals for financial gain since they were first drawn into the fur trade by the HBC in the 1700s. Trapping provides benefits to trappers, their families, and their communities, including money from fur sales, meat from certain species, and furs for domestic purposes, in addition to having ties to local land stewardship. Trapping continues to be an important activity for some community members, particularly for Elders who spent considerably more of their lives living on the land than most community members. Most trappers will also hunt opportunistically while on the trapline (Black Lake and Stony Rapids KPI Program 2011-2013).

Trapping continues in Fur Blocks N-24 and N-80 (Figure 17.3-2), although the number of active trappers in these areas is low. In N-24, the total number of registered trappers declined to four in the 2010/2011 season from a high of 25 in 1991/1992. At the same time, the total number of marketed pelts also declined to 101, from a high of 912 in the 1991/1992 season. The total value of pelts was $7,210.98 in 2010/2011, down from a high of $46,534.00 in 1991/1992. Similarly, in N-80, the total number of registered trappers fell to five in the 2010/2011 season from a high of 28 in 1991/1992. The total number of marketed pelts also declined that year to 127 from a high of 587 in the 1993/1994 season. The total value of pelts was $9,459.48 in 2010/2011, down from a high of $31,595 in 1991/1992. Overall, there is recognition that the number of active trappers in Fur Blocks N-24 and N-80 has been decreasing over the years. In recent years, most trappers in N-24 and N-80 trap as a means of supplementing their income. The few community members who continue to trap as their primary employment do so in the Northwest Territories (Black Lake and Stony Rapids KPI Program 2011-2013; Koback pers. comm. 2012; MOE 2005b, 2006b, 2008b, 2009b, 2010, 2011, 2012).

In recent years, marten, which is abundant in the region, has attracted a high price for its fur and become one of the most highly sought animals among local trappers (Black Lake and Stony Rapids KPI Program 2011-2013; Statistics Canada 2010; Winnipeg Free Press 2009). In 2012, fur prices in general were above average compared to previous years. In particular, there were record high prices for fox fur pelts, with some selling for more than three times the average price of previous years (Trapping Today 2012).

The BLFN reserve land (specifically reserve parcel Chicken 224) is designated as an area that any Black Lake member can trap (i.e., the area is not allocated to a single trapper). However, trappers without active trapping licenses are not permitted to sell furs commercially and tend to trap on reserve land for personal use (Black Lake and Stony Rapids KPI Program 2011-2013). Some trapping occurs along the Fond du Lac River from Black Lake to Stony Lake. People who trap this area live in the LSA communities and trap off the Elizabeth Portage trail between Black Lake and Middle Lake. Fox, marten, mink, beaver, otter, and muskrat were once abundant around Middle Lake; however, the area has burned in several wildfires over recent decades, including three fires in the area since 2006. Because of these fires, there is a reduced amount of habitat for furbearing populations in the area and current trapping activities tend to be for personal use (Black Lake and Stony Rapids KPI Program 2011-2013).

17.3.2.2 Commercial Fishing

Residents of Black Lake and Stony Rapids participate in the commercial fishery on Lake Athabasca, Black Lake, Riou Lake, Pasfield Lake, and Wapata Lake (Table 17.3-1; Black Lake and Stony Rapids KPI Program 2011-2013). In the LSA, Black Lake is the only commercial fishery and is primarily a summer fishery. Commercial fishermen on Black Lake may fish until they reach their quota and if they do not reach the quota over the summer months, they may extend the fishery into the winter season. The commercial fishing quota on Black Lake is approximately half of the overall allocation for the lake, with the other portion allocated to Camp Grayling. The Black Lake quota for commercial fishing is 1,100 kg of pike and walleye, 55,000 kg of lake whitefish, and 3,200 kg of lake trout per year (MOE 2008c). In 2012, there was one active commercial fisher on Black Lake, although in the past there have been other operators. The current commercial fisherman peddles directly to buyers, mainly residents of Black Lake and Stony Rapids communities, including the Athabasca Health Facility and local schools. The communities of Black Lake and Stony Rapids do not currently have fish processing facilities (Black Lake and Stony Rapids KPI Program 2011-2013).

17.3.2.3 Outfitting and Lodges

Outfitter and Guide Regulations passed under *The Natural Resources Act* of Saskatchewan control outfitting and guiding in Saskatchewan. These regulations set licensing requirements and conditions to control outfitting and guiding and are administered by the Saskatchewan Ministry of Environemtn (MOE) (Saskatchewan Outfitters Association 2003). There are 26 lodges operating in the Athabasca region, with one lodge and outfitter (Camp Grayling) offering sport fishing and hunting services in the LSA and the RSA.

Outfitters rent equipment, offer guide services, and may offer accommodation and meals. Guides assist clients in locating game or fish, providing campsite services, as well as providing field dressing and cleaning services. Guides, on the other hand, cannot provide equipment or accommodation to a client. Guiding services can be provided by outfitters and guides, but guides must be employed by a licensed outfitter (Saskatchewan Outfitters Association 2003).

Table 17.3-1: Commercial Fishing in Athabasca Region, Selected Lakes, and Years, 2004-2009

Lake[a]	Year[b]	Kilograms[c]	Total $[c, d]
Freshwater Fish Marketing Corporation[e]			
Fond du Lac River	2004-2005	694	$1,439
Pasfield Lake	2004-2005	316	$259
Theriau Lake	2004-2005	554	$381
Black Lake	2005-2006	1,035	$817
Riou Lake	2007-2008	698	$552
Wapata Lake	2008-2009	1,004	$4,839
Peddled[e]			
Riou Lake	2006-2007	1,764	n/a
Wapata Lake	2006-2007	13,097	n/a

Source: MOE, 2004, 2005a, 2006a, 2007a, 2008a, 2009a.
[a] Data are not available for all Athabasca region lakes where commercial fishery is present; data presented represents recent lake production where data are available.
[b] Total fish production for each lake is unavailable for every year; years presented represent most recently available data for each lake and production type.
[c] The total kilograms and dollars include lake whitefish, lake trout, walleye, northern pike, cisco, and others; each species of fish has its own market value.
[d] Prices paid for peddled fish are unknown; n/a = not applicable.
[e] Freshwater Fish Marketing Corporation and Peddled refer to the production type; bait fishing is not included.

Most of the outfitters and lodges in Saskatchewan provide guided and self-directed fishing activities in the open water season, though there are a few outfitters in the Athabasca region who offer hunting only. Fishing-related activities usually include a shore lunch, with game fish including Arctic grayling, lake trout, lake whitefish, walleye, and northern pike. A few lodges offer services that bring clients to other nearby lakes either by floatplane or all-terrain vehicle (ATV; Saskatchewan Outfitters Association 2003).

Camp Grayling, the only lodge located within the LSA, opened in 1952. The camp has a large active area used for fishing and hunting, including outpost fishing on 22 lakes including Black Lake and Middle Lake. Outposts also include McDonald Lake, two leases on Riou Lake, Selwyn Lake, and Dodge Lake. The camp has boats on about half of these lakes, with 11 near the main site and another 15 on Riou Lake. Several lakes have camp-owned infrastructure, such as docks, and Riou Lake has a lodge, cabins, a cookhouse and staff buildings (Black Lake and Stony Rapids KPI Program 2011-2013; Fredrickson pers. comm. 2012).

Camp Grayling's main site is located on the Fond du Lac River at its outflow point from Black Lake and includes more than 10 acres of titled and leased land. The main draw of Camp Grayling is sport fishing for Arctic grayling on the Fond du Lac River, as well as northern pike in Black Lake. The location provides sport fishers with easy access to sections of the Fond du Lac River using trails along the west shore of the river. The camp receives 50 percent (%) of the commercial fishing allocation for Black Lake. The main site includes cabins, maintenance buildings, and a lodge. Over the last 10 years, the camp has averaged approximately 200 guests per season, fluctuating from a high of about 400 to a low of about 100. Most guests are repeat customers, including families and sport fishers who return annually (Black Lake and Stony Rapids KPI Program 2011-2013; Fredrickson pers. comm. 2012).

17.3.3 Community Land Use and Land Designations

The Chicken Indian Reserve No. 224 was created under the Order in Council (OIC) 1978-1647; that is the land is set aside for the exclusive use and benefit of the members of the BLFN. The area surrounding the Chicken Indian Reserve No. 224 is provincial crown land and accessible to all aboriginal people for the pursuit of traditional and cultural activities. The BLFN has a community development plan (Bullée Consulting 2010) that identifies the types of use within the inhabited portion of the Chicken 224 reserve. Land use on BLFN land is either for residential units, commercial and economic development, or community facilities. Most of the developed land on reserve is used for housing. Commercial economic development use includes the Northern Store, a gas bar and store, and two pool halls. Community facilities include the school, the Band office, the Band hall, and the arena (Bullée Consulting 2010). The BLFN is currently working on the second stage of a subdivision in the community (Black Lake and Stony Rapids KPI Program 2011-2013).

The Northern Hamlet of Stony Rapids has an Official Community Plan (2011) that designates appropriate land use. Land use in the Northern Hamlet of Stony Rapids is primarily residential, with other zones established for recreational activities and parks, community services, commercial use, tourism, and industrial use (Northern Hamlet of Stony Rapids 2011). Commercial and tourist commercial development use includes Scott's General Store, Al's Place hotel and restaurant, the Water Front Inn, and the White Water Inn (Black Lake and Stony Rapids KPI Program 2011-2013). Community facilities include the school and Hamlet office.

17.4 Screening of Project Interactions and Mitigation

This section identifies and evaluates the interactions between Project components or activities, and the correspondent potential effects on land and resource use. The process begins with the identification of all potential interactions for the Project. Each interaction is initially considered to have a linkage to a change in the environment and the associated potential effect on land and resource use. Potential interactions between the Project and land and resource use are identified in Table 17.4-1.

Table 17.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Land and Resource Use

Project Component/ Activity	Expected Project Phase	Potential Effects on Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ General Construction, Operation, Closure Activities	Construction Operations Closure	Changes to commercial fishing resulting from effects fish and fish habitat associated with the loss or alteration of habitat (e.g., submerged weir, diversion and discharge for power generation, changes to surface water quality).	■ See mitigation to reduce effects on fish habitat and fish in Section 12.0 of this EIS. ■ SaskPower currently considers claims presented by active licensed commercial fishers for loss or damage to equipment while being used in their commercial fishing operations resulting from project activities.	No Linkage
		Changes to water consumption arising from changes to water quality resulting from site disturbances, clearing and excavation, and management and discharge of wastewater.	■ See mitigation to reduce effects on surface water quality in Section 11.0 of this EIS.	Secondary
		Changes to commercial trapping resulting from changes to vegetation and wildlife abundance and distribution.	■ An access management plan will be developed by the Proponent to address overall access to the SSA during construction and operation of the Project, with consideration given to both land based and water/ice based travel. ■ Compensation for demonstrated losses will be considered on a case-by-case basis. ■ See mitigation policies and procedures to reduce sensory disturbances including noise and vibrations in Section 8.0 of this EIS. ■ See mitigation policies and procedures to reduce effects on vegetation and habitat in Section 14.0 of this EIS. ■ See mitigation policies and procedures to reduce effects on wildlife in Section 15.0 of this EIS.	Secondary
		Changes to traditional and domestic resource use resulting from changes to vegetation, wildlife and wildlife habitat, fish and fish habitat, and surface water quality.	■ Placement of Project access roads and infrastructure considered inputs for public involvement activities and avoids areas of importance to the communities, including the location of cultural camps while improving long-term access to the sites. ■ Pressures to wildlife and fish associated with the presence of a non-local workforce will be minimized through several resource management strategies, including the prohibition of firearms, hunting, trapping, harvesting, and fishing for all employees. All-terrain vehicle use will also be prohibited at the construction site. ■ An access management plan will be developed by the Proponent to address overall access to the SSA during construction and operation of the Project, with consideration given to both land based and water/ice based travel. ■ The Proponent is committed to timely and effective communication with local resource users about construction and operation activities, including providing information about any restrictions that may be put in place to limit risks to public safety. ■ Compensation for demonstrated losses will be considered on a case-by-case basis. ■ See mitigation policies and procedures to reduce sensory disturbances including noise and vibrations in Section 8.0 of this EIS. ■ See mitigation policies and procedures to reduce effects on fish habitat and fish in Section 12.0 of this EIS. ■ See mitigation policies and procedures to reduce effects on vegetation and habitat in Section 14.0 of this EIS. ■ See mitigation policies and procedures to reduce effects on wildlife in Section 15.0 of this EIS.	Primary
		Changes to outfitting and lodge activities resulting from changes to wildlife and fish habitat.	■ An Access Management Plan will be developed by the Proponent to address overall access to the Project area during construction, operation of the Project, with consideration given to both land based, and water and ice based travel. ■ The Proponent is committed to working with the owner of Camp Grayling to discuss any potential Project impacts and the mitigation or compensation that may be appropriate in the circumstances. ■ See mitigation policies and plans to reduce sensory disturbances including noise and vibrations in Section 8.0 of this EIS. ■ See mitigation policies and plans to reduce effects on fish habitat and fish in Section 12.0 of this EIS.	Primary

Table 17.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Land and Resource Use (continued)

Project Component/ Activity	Expected Project Phase	Potential Effects on Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ General Construction, Operation, Closure Activities	Construction Operations	During the construction and operation phases of the Project reserve lands will be unavailable for other uses.	■ The Partnership will negotiate a lease agreement for land at fair market value. This lease agreement and Black Lake's participation as a partner on the Project on their reserve lands will result in an inflow of substantial financial benefits to the community that will compensate for the use of this land.	Secondary
■ Site Infrastructure	Construction Operations Closure	Physical hazards (e.g., blasting activities, tailrace channel, buildings, waste rock disposal areas) from the Project that can cause injury or mortality to wildlife and affect wildlife populations and human activities.	■ Open trenches or pits will be fenced to exclude wildlife or one of the ends and sides will be sloped to allow escape. ■ The water intake, powerhouse structures, and tailrace channel will be fenced to prevent wildlife from entering this area and falling into channel. ■ During winter construction periods, gaps will be left in some snow windrows along access roads and around the site to allow escape routes for mid to large sized wildlife. ■ Good housekeeping will be practiced to prevent wildlife from becoming entangled with or injured by on-site material. ■ A detailed Blasting Plan will be developed for the Project and distance during blasting of the water intake foundation, powerhouse foundation, and tailrace channel will be included as part of this plan. ■ Surface blasting will be temporarily suspended if large mammals are observed within the danger zone identified by the blast supervisor. ■ Waste rock excavated from the power tunnel will be checked for the potential to generate ARD and metals leaching (ML) prior to placing in a permanent waste rock disposal area. If necessary, this waste rock could be contained in a lined waste rock pile.	No linkage
■ Site Access	Construction Operations Closure	Changes to access and navigation resulting from the creation of access roads, bridges, tailrace, and the water intake on Black Lake.	■ An access management plan will be developed by the Proponent to address overall access to the SSA during construction and operation of the Project, with consideration given to both land based and water/ice based travel. ■ Access limitations during construction will include road controls, signage, fences, and other security features. ■ Permanent fencing will restrict access to the intake and powerhouse structures, as well as the tailrace channel and any storage facilities on the east side of the Fond du Lac River during both construction and operation. ■ Communication with the communities regarding potential changes associated with travel. ■ Establish and mark safe travel routes during the ice-covered season. ■ The water intake will have a light, which will act as a warning beacon for travel after dark.	Secondary
■ Accidents and Malfunctions ▪ emergency shutdowns of power turbines ▪ hazardous materials spills ▪ physical hazards ▪ vehicle-wildlife collisions ▪ embankment failure	Operations	Emergency shutdowns of power generation activities can change surface hydrology, which can affect soils, vegetation, wildlife, wildlife habitat, fish, fish habitat, and human activities.	■ Planned or unplanned shutdowns longer than 15 minutes during the spring spawning and rearing period (May 15 to July 15) and winter low flow period, downstream flows will be maintained by bypassing the water around the powerhouse turbine generation units using a bypass conduit.	No linkage

Table 17.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Land and Resource Use (continued)

Project Component/ Activity	Expected Project Phase	Potential Effects on Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ Accidents and Malfunctions ▪ emergency shutdowns of power turbines ▪ hazardous materials spills ▪ physical hazards ▪ vehicle-wildlife collisions ▪ embankment failure	Construction Operations Closure	Release or spills of hazardous substances (e.g., fuel, oil) can change surface water and soil quality, which can affect vegetation, fish habitat, wildlife habitat, and human activities.	■ Individuals working on-site and handling hazardous materials will be trained in WHMIS and TDG. ■ Controlled products will not be allowed on-site unless accompanied by approved labels and MSDS. ■ All fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard; a lined and dyked containment area around these tanks will be provided to contain any potential fuel spills. The design of the containment area will be based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum and Allied Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. ■ The storage containers will be regularly inspected for leakage or damage, and replaced when necessary. ■ Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled, and located in lined and bermed containment areas. ■ Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers. ■ Regular maintenance and cleaning of construction equipment. ■ Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. ■ Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills of fuel would flow to the sump, which would be pumped out to a container for shipment off-site. ■ An Emergency Response Plan will be developed. ■ Spill response material (e.g., sorbent pads) will be stored on-site in designated areas and in vehicles. ■ Contaminated (impacted) soils will be removed and disposed of in an approved landfill or waste management facility.	No linkage

Table 17.4-1: Project Activities, Environmental Design Features and Mitigation, and Potential Interactions to Land and Resource Use (continued)

Project Component/ Activity	Expected Project Phase	Potential Effects on Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ Accidents and Malfunctions ▪ emergency shutdowns of power turbines ▪ hazardous materials spills ▪ physical hazards ▪ vehicle-wildlife collisions ▪ embankment failure ▪ fire	Construction Operations Closure	Increased traffic can increase the potential for vehicle-wildlife collisions, which can cause injury or mortality to wildlife.	■ Speed limits will be clearly posted on construction roads and enforced to mitigate against potential road mortalities during construction. ■ Vegetation along the roadside will be mowed and cut to increase visibility of wildlife passing through or using the roadsides or ditches. ■ Unpaved roads within the limits of the Project will be regularly graded and maintained to avoid washboarding and rutting. ■ Safety policies will be developed by SaskPower and the general contractor will address safe driving practices for all construction personnel on public roads. SaskPower and the general contractor will monitor all reported incidents of speed violations and provide appropriate disciplinary measures, where necessary. ■ Shuttle vehicles will be used by the contractor to transport workers between the construction site and the Stony Rapids airport to reduce the use of personal vehicles.	Secondary
	Construction Operations	Failure of the embankment dykes around the settling ponds can change surface water quality, soil, and vegetation quality, which can affect fish and wildlife habitat, and human uses.	■ Fill material used for constructing the embankment dykes around the settling pond will be clean mineral soil with sufficient moisture to allow for proper compaction. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap as soon as practical following construction. ■ Water produced during construction or runoff through the site will be contained, tested and treated if required before release in accordance with the regulations. ■ The settling ponds will be engineered to provide adequate storage of wastewater streams under normal and extreme operating conditions (e.g., settling ponds will be designed to contain the 1:100 year storm event). In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling ponds would be provided by the inclusion of an overflow spillway in the embankment. ■ The settling ponds will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. ■ During the detailed design stage, additional mitigation could be identified and included as part of the Environmental Protection Plan and the Emergency Response Plan.	No Linkage
	Construction, Operations, and Closure	Fire	■ The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail. ■ Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. ■ Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute).Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. ■ Personnel will be trained in fire prevention and response procedures. ■ Firefighting equipment will be available on site.	Secondary

EIS = Environmental Site Assessment; MSDS = Material Safety Data Sheet; TDG = Transportation of Dangerous Goods; WHMIS = Workplace Hazardous Materials Information System; CCME = Canadian Council of Ministers of the Environment; ARD = acid rock drainage; SSA = site study area

Each potential interaction is evaluated to determine if mitigation can be developed and incorporated to remove the interaction, limit the potential negative effect, or enhance the potential positive effect of the Project on land and resource use. Mitigation includes Project design elements, environmental best practices, and management policies and procedures. Mitigation is developed through an iterative process between the Project's engineering and environmental teams. Knowledge of the environment and mitigation is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for residual effects on land and resource use.

Interactions are determined to be primary, secondary, or as having no linkage using scientific knowledge, the professional judgement of technical specialists, logic, experience with similar developments, and mitigation. Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by mitigation so that the Project results in no detectable change in measurement endpoints, and therefore, no effect on land and resource use relative to baseline values;
- secondary – interaction could result in a minor change to measurement endpoints, but would have a negligible effect on land and resource use relative to baseline values and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary – interaction is likely to result in a detectable change in the measurement endpoints that could contribute to a measurable or detectable effect on land and resource use relative to baseline values.

Any interactions that require a comprehensive assessment in order to determine if there is a residual effect are also considered primary. Primary interactions are anticipated to result in a residual effect on land and resource use, and require further analysis to determine the significance of the residual effect. Project interactions determined to have no linkage or those that are considered secondary are not predicted to result in significant effects on land and resource use. As such, interactions with no linkage or that are considered secondary are not analyzed further in the EIS.

Often a combination of pathways affects the endpoint resource user for land and resource use. For example, the removal of vegetation itself may not result in an overall reduction of resource use; however, the combination of the removal of vegetation, sensory disturbances to wildlife, and overall presence of a construction camp may reduce opportunities for individuals using the areas between Black Lake and Middle Lake. Further to this, not all resource users will be affected equally. For example, the cabin owner on Middle Lake, who uses the area between Black Lake and Middle Lake extensively throughout the entire year, will be affected differently than those participating in general community resource use (e.g., participating in annual cultural camps, which are located near the Project access road).

Because land and resource use is affected by compounding pathways, an overview of all of the potential pathways is provided here, while the subsequent sections describing primary interactions, secondary interactions, and interactions with no linkages on effects are focused on the different types of resource users. The resource use types considered in the assessment include:

- domestic resource use, including activities undertaken by the cabin owner on Middle Lake such as hunting, fishing, and gathering for domestic use;
- general community resource use, including activities undertaken by residents of the LSA for recreational purposes, travel for resource use, and activities associated with the BLFN cultural camps;

- commercial resource use, including activities undertaken by local outfitters and lodges, as well as trapping and commercial fishing by residents of the LSA; and
- overall land use designations (i.e., those lands that have specific uses designated by community plans or otherwise).

Even with mitigation in place, some effects are likely to be experienced by affected resource users. The following categories of land and resource use are examined and considered according to whether there is no linkage to effects, secondary effects, or primary effects:

- traditional and domestic resource use;
- access and navigation;
- commercial fishing;
- commercial trapping;
- outfitting and lodges;
- water consumption; and
- land use (designations).

A suite of mitigation policies and practices to limit overall effects on the various other VCs is provided in each VC's respective section of the document (e.g., see Section 14.0 of this EIS for mitigation to reduce effects on vegetation). In addition, mitigation practices described within each VC section, the following programs and policies are expected to limit effects on land and resource use.

- **Access Management Plan -** An Access Management Plan will be developed by the Proponent to address overall access to the Project site during construction and operation, with consideration given to land-based and water and ice-based travel. This will include effective and timely communication with resource users (including members of BLFN, residents of Stony Rapids, and the owner of Camp Grayling) about Project activities and any restrictions that will be put in place for overall public safety.
- **Participation of BLFN in Resource Management Strategies -** Since the Project is located on BLFN reserve land, it is expected that the Band will play a major role in determining appropriate resource management policies. Such policies would be more applicable to non-local construction workers than to local residents; however, in instances where public safety could be at risk, such policies would apply to everyone. The policies expected to be implemented include:
  - prohibition of firearms (including bows and cross bows) within a specified boundary of Project activities;
  - prohibition of hunting, trapping, harvesting, and fishing by employees and contractors, including mechanisms to enforce this policy; and
  - hunting restrictions for resource users near the Project site (signs will be posted in those areas where restrictions apply).
- **Practices to Address Local Resource Users Concerns -** The Proponent will communicate with local resource users in an effective and timely manner regarding the timing of activities in their resource areas, in

addition to any restrictions that can apply for public safety reasons. Further to this, a mechanism for registering local concerns regarding activities will be identified in discussion with resource users prior to the onset of construction.

- **Compensation for Demonstrated Losses -** On a case-by-case basis, the Proponent will consider compensation for demonstrated losses.

17.4.1 Interactions with No Linkage to Effects

An interaction may have no linkage to effects if the activity does not occur or if the interaction is removed by mitigation so that the Project results in no detectable change in measurement endpoints, and subsequently, no effect on land and resource use. The following were determined as having no linkage to effects on land and resource use.

- **Changes to commercial fishing resulting from effects fish and fish habitat associated with the loss or alteration of habitat (e.g., submerged weir, diversion and discharge for power generation, and changes to surface water quality).**

Changes to commercial fishing could arise from anticipated effects on fish habitat and fish, including loss or alteration of fish habitat from Project construction (e.g., changes associated with the submerged weir), water diversion and discharge for power generation, and changes to surface water quality associated with Project activities. The construction and operation of the Project will reduce water flows in some areas of the Fond du Lac River between Black Lake and Middle Lake. It is anticipated that these reduced flows could result in the loss or changes to the quality of fish habitat.

Commercial fishing in the LSA is limited to Black Lake. As discussed in Section 17.3.2.2, there currently is only one commercial fisher operating on Black Lake. Black Lake's commercial fishing allocations have exceeded the total weight of fish reported by the commercial fisher by a large margin in recent years.

While the Project water intake will be located on Black Lake, mitigation will decrease Project-related effects on fish in the lake, particularly related to in-water work during construction of the Project's water intake structure. Residual effects of the Project on Black Lake are not predicted to be large enough to alter the state of fish health, abundance, distribution, or habitat. While the Project's effects on fish and fish habitat are anticipated to be moderate and will continue through operations, these effects are largely concentrated downstream of the current outlet of Black Lake and through the Fond du Lac River to Middle Lake where there are no commercial fishing operations. As such, commercial fishing in the LSA and RSA is not anticipated to be affected by the construction or operations of the Project.

While there are no anticipated effects from construction or operation of the Project, SaskPower currently considers claims presented by active licensed commercial fishers for loss or damage to equipment resulting from project operations. It is anticipated that a similar program of compensation would apply to the Project should proven losses result.

17.4.2 Interactions with Secondary Linkages

In some cases both a Project-source of effect and an interaction with an assessment endpoint exist, but mitigation is expected to cause minor changes to the environment and a negligible effect on land and resource use relative to existing baseline conditions. The following are expected to result in negligible effects on land and resource uses and will not be examined further in the EIS.

- **Changes to water consumption arising from changes to water quality resulting from site disturbances, clearing and excavation, and management and discharge of wastewater.**

The cabin owner on Middle Lake currently collects water from the lake for domestic consumption. Surface water quality modeling results for settling pond discharges indicated only minor changes in the water quality of the Fond du Lac River. For example, predicted concentrations of various parameters are within the range of baseline concentrations measured in 2010 and 2011 (Section 11.0). As well, applicable water quality guidelines for drinking water and protection of aquatic life are expected to be met under fully mixed conditions, and at the edge of the mixing zone (see Appendix 11-1). Loads of ammonia and nitrate from blasting residues also were incorporated into the surface water quality model; only minor changes to water quality were predicted, with guidelines being met at the edge of the mixing zone. These changes are expected to be reversible, with water quality in the LSA returning to background conditions during early operations. As such, changes to surface water quality are expected to have a negligible residual effect on water consumption, and thus, land and resource use.

- **Changes to access and navigation resulting from the creation of access roads, bridges, tailrace, and the water intake on Black Lake.**

Construction and operation of the Project will result in changes to the way resource users access areas in the LSA. This includes changes through the creation of new Project infrastructure, such as the access road, bridge, water intake, powerhouse, tailrace channel, and waste rock disposal areas, in addition to changes resulting from Project activities, particularly during the construction phase where risks to public safety can be present. The Proponent will develop an Access Management Plan to address overall access to the Project site during construction and operation of the Project. This will include effective and timely communication with resource users (including members of BLFN and residents of the Northern Hamlet of Stony Rapids, along with the owner of Camp Grayling) about Project activities and any restrictions that will be put in place to provide public safety.

Access to some land-based trails in the LSA will be limited during the construction phase to reduce potential risks to public safety. Access restrictions during construction will include road controls, signage, fences, and other security features. Similar measures, such as permanent fencing, will restrict access to the water intake and powerhouse structures, as well as the tailrace channel and any storage facilities on the east side of the Fond du Lac River during both construction and operation. Where appropriate and safe to do so, some overland access may be provided to allow resource users to travel through the LSA and on to other locations for resource use. The proposed combination of access management measures is expected to result in a small amount of inconvenience and minimal safety risk in trail usage in the immediate area of the Project activities.

Some areas on Black Lake currently used for water and ice-based travel will not be accessible during construction (e.g., water intake on Black Lake). On Black Lake, construction activities will be limited to the location of the water intake, and boat or snowmobile travelers will have to travel further offshore to avoid any interactions with construction activities. The Fond du Lac River between Black Lake and Middle Lake is dangerous to navigate and Elizabeth Falls is impassable by boat. Travel near this section of the river occurs by way of land-based trails, which may not be accessible during construction. Aside from construction site restrictions, additional changes to open water travel are not expected to result from the Project during operation. No risks have been identified with respect to travel on open water beyond the existing navigation hazards.

During the winter, there may be changes to how ice forms near the water intake on Black Lake and near the tailrace channel outlet as it enters Middle Lake. This may affect the ability of people to travel safely on ice by snow mobile. Under existing conditions, the ice on Middle Lake near the Fond du Lac River is generally considered unsafe and crossing is avoided. This trend will continue with the operation of the Project and may result in small changes that are within current variation. On Black Lake, the area near the water intake is located on a snow mobile route that extends between the shoreline and Fir Island. Warning buoys and signage will be installed in front of the water intake and at the tailrace channel outlet into the Fond du Lac River to restrict boaters from the hazardous areas and to mark sections of unsafe ice conditions on the lake in front of the intake during winter. Mitigation policies and practices are predicted to result in minor changes to access and navigation relative to baseline conditions and have negligible residual effects on land and resource use.

- **Changes to commercial trapping resulting from changes to vegetation and wildlife abundance and distribution.**

The Project, through changes to the physical and biophysical environment, has the potential to affect commercial trapping activities. As described in Section 17.3.2.1, trapping in the LSA is divided into two fur block areas, N-24 on the east side of the Fond du Lac River, and N-80 on the west side of the Fond du Lac River. Commercial trapping within these fur blocks is regulated by the provincial government, with only a few trappers currently registered in each block. The Project is located within BLFN reserve territory, which is separate from the provincial fur block system; there are no specific allocations of fur blocks on reserve territory and all members of BLFN may trap in the area. The area on the east side of the Fond du Lac River has traditionally been trapped by one member of BLFN, although trapping in the area has only been periodic in recent years.

As discussed in Section 17.3.2.1, beaver and marten are species that have been identified as widely trapped in the LSA and RSA. During construction, there will likely be a minor decrease in the occupancy of habitats by marten near the Project, and the local change in distribution is predicted to slightly exceed baseline values (Section 15.5.2.5). These changes should be limited to individuals with home ranges that overlap the Project and associated infrastructure, and should diminish during operations. Long-term changes from the Project on marten movement and behaviour should be minor and limited to the area around the access road. Overall, changes to habitat quality from the Project are predicted to have a negligible influence on the abundance and distribution of the marten population.

Construction activities could result in local changes to the movement and behaviour of beaver, but effects from sensory disturbance should disappear at the end of construction. The Project is predicted to have a minor influence on habitat quantity and fragmentation for beavers (Section 15.5.2.4). Similarly, changes to habitat quality from the Project are anticipated to have a negligible influence on the abundance and distribution of the beaver population in the RSA.

Overall, the Project is not predicted to alter the state of self-sustaining populations and the continued opportunity for use by resource harvesters. Mitigation policies and practices are predicted to result in minor changes to commercial trapping relative to baseline conditions and have negligible residual effect on land and resource use. The Proponent will consider compensation for demonstrated losses associated with Project construction and operations. Claims will be assessed on a case-by-case basis.

- **During the construction and operation phases of the Project reserve lands will be unavailable for other uses.**

The Project is located on Chicken Indian Reserve 224. The Chicken Indian Reserve No. 224 was created under the OIC 1978-1647; that is the land is set aside for the exclusive use and benefit of the members of the BLFN.

The area surrounding the Chicken Indian Reserve No. 224 is provincial crown land and accessible to all aboriginal people for the pursuit of traditional and cultural activities.

The presence of the Project during construction and operation means that the area will no longer be available for other uses by the BLFN. During construction, approximately 869 hectares (ha) of land from the Chicken 224 reserve parcel will be disturbed; this represents roughly 3.3% of the Chicken 224 reserve parcel (25,819 ha). In addition, all public access to the construction, laydown, and camp areas will be restricted to the public until Project construction is completed.

Mitigation for the disturbance and restricted access to reserve land includes negotiating a lease agreement for land at fair market value. This lease agreement and Black Lake's participation as a partner in the Project on their reserve lands will result in an inflow of substantial financial benefits to the community that will compensate for the use of this land. Other community land use in the LSA, including the communities of Black Lake and Stony Rapids, will remain available for use as designated in existing community land use plans. As such, mitigation policies and practices are predicted to result in minor changes to land use designations relative to baseline conditions; however, residual effects on land and resource use are predicted to be negligible.

17.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events occurring on-site have the potential to affect land and resource use. The following events were identified as having a potential interaction with land and resource use.

- **Emergency shutdowns of power generation activities can change surface hydrology, which can affect soils, vegetation, wildlife, wildlife habitat, fish, fish habitat, and human activities.**

It is estimated that the plant will undergo between 10 and 50 emergency shutdowns per year, with most of these occurring during the summer months (i.e., weather-related). Most of the shutdowns would be for 10 to 60 minutes in length. Emergency shutdowns often are caused by the effect of adverse weather conditions on the electrical grid and the frequency, distribution, and duration can vary significantly from year to year. When the generating station is shut down, flow through the powerhouse will be diverted through a bypass conduit. The bypass conduit will be designed so that it will maintain flows near the tailrace channel outlet in the Fond du Lac River during the emergency shutdowns. The use of the bypass system is expected to maintain surface flows during sensitive periods of the year (i.e., spring spawning and winter low flow periods).

The power plant will be shut down without advance notice if there is a load rejection in the transmission system due to transmission line failure. These unplanned shutdowns are expected to be relatively brief, typically from a few minutes to 4 or 5 hours. On occasions during the spring fish spawning and rearing period (May 15 to July 15), when the unplanned shutdown exceeds 15 minutes, the bypass conduit at the powerhouse will begin releasing flow to reduce drawdown effects on the Fond du Lac River below the tailrace channel outlet and upstream of Middle Lake. During these periods, flows through the natural outlet would slowly increase as water levels in Black Lake respond to reduced power tunnel outflows.

The turbine generator units for the proposed station will be equipped with turbine inlet valves (TIV) to handle the sudden requirement to stop flow. These will act as the spigot at the end of the power tunnel and control the flow through the powerhouse. The TIVs will be designed to close at a rate that will avoid undesirable increases in water pressure in the power tunnel. The sudden curtailment or start up of flow within the power tunnel will trigger a pressure surge or transient condition within the power tunnel. Although the pressure will rise in the power tunnel as the pressure wave migrates upstream toward the water intake, it will dissipate rapidly once it reaches the open water of Black Lake. The pressure fluctuations in the tunnel will also be dampened by the open water surface of the surge facility located upstream of the powerhouse. Minor disturbances (e.g., small waves and local surging) are expected at the entrance, which will be confined to a small area near the intake structure. Due to the depth of the lake in this area, the increase in water level is expected to be local, extending in a radial pattern for approximately 50 to 100 m, and dissipating quickly in the open water.

Modelling has been completed to simulate a worst-case scenario when all turbine generator units suddenly shut down for an extended period. The modelling results suggest that the sudden shutdown of the units and subsequent bypass 80 m^3s of power generation flows would subject Middle Lake to a maximum drop in water level of approximately 0.4 m. The maximum rate of water level drop was determined to be approximately 5 centimetres per hour (cm/h). The plant will be equipped with measures that allow flows to be bypassed through the plant when the turbine generator units are shutdown or cannot be connected to the transmission line grid, with the size of the bypass conduit selected to be in the order of 50% of the plant capacity.

Environmental design features are expected to mitigate surface flows during an emergency shutdown and therefore no detectable change to hydrology is expected. This interaction was determined to have no linkage to effects on wildlife and wildlife habitat, and therefore, no linkage to effects on land and resource use.

- **Release or spills of hazardous substances (e.g., fuel, oil) can change surface water and soil quality, which can affect vegetation, fish habitat, wildlife habitat, and human activities**.

Spills during construction, operations, or closure activities following closure have the potential to change surface water and soil quality, which can adversely affect vegetation, wildlife, wildlife habitat, and human health. Spills that occur in high enough concentrations could contaminate surface water and soils and cause direct toxicity to aquatic organisms, soil organisms, and vegetation. The effects of these spills could affect human health should local residents and resource users consume contaminated water, vegetation, or wildlife.

Spills are generally preventable and localized. All spill incidents will be promptly reported and managed according to the procedures identified in the Emergency Response and Contingency Plan. Mitigation identified in the Environmental Protection Plan (EnvPP) will be implemented to reduce the likelihood and extent of spills associated with the Project.

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks at the Project site. Spill containment supplies will be available in designated areas in the LSA and within Project vehicles. An ERP will be developed and will include instruction for the rapid response, control, and management of spills or releases of hazardous substances. All spills will be isolated and immediately cleaned up. Spills will be reported to the appropriate agency if the spill exceeds reportable volumes for the material spilled, as outlined in the provincial Environmental Spill Control Regulations. In the unlikely event of a spill, disposal of all contaminated soil will be handled by a licensed contractor and will be hauled off-site to an approved facility. Alternative approaches for in-situ treatment of contaminated soils may also be considered (e.g., phyto- or bio- remediation), depending on the substance spilled and capacity to treat the volume of material affected.

Storage facilities for hazardous wastes will meet regulatory requirements. All fuel storage tanks will be designed and constructed based on the requirements of the CCME Environmental Code of Practice for Above-Ground Storage Tank Systems Containing Petroleum and Allied Petroleum Products (CCME 2003), the National Fire

Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. The storage containers will be regularly inspected for leaks or damage, and replaced when necessary. Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double-walled and located in lined and bermed containment areas. Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers.

Vehicles will be regularly maintained and cleaned and will carry fire extinguishers and standard emergency clean-up kits. Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills on the fueling stations would flow to the sump, which would be pumped out to a container for shipment off-site.

Access to the Project site for resource use and travel will be limited during construction, further reducing the opportunity for local residents to be exposed to spills or release of hazardous materials. Access limitations will include road controls, signage, fences, and other security features. Where appropriate and safe to do so, some overland access could be provided to allow resource users to travel through the site onto other locations for resource use; however, this will be based on the premise that areas traversed do not present any risks to public safety. While these limitations and restrictions will be reduced during Project operations, the implementation of the EnvPP and Emergency Response Plan will limit the potential for ingestion of accidentally contaminated water, vegetation, or wildlife from the site.

Implementation of the above environmental design features are expected to reduce the likelihood and extent of the release or spills of hazardous materials occurring on-site. No detectable changes to surface water and soil quality are expected. Furthermore, access restrictions will limit the possibility of ingestion of contaminated water, vegetation, and wildlife by local resource users. Therefore, these interactions are determined to have no linkage to effects on land and resource use.

- **Physical hazards (e.g., blasting activities, tailrace channel, buildings, and waste rock disposal areas) from the Project can cause injury or mortality to wildlife and affect wildlife populations and human activities.**

Physical hazards related to Project construction and infrastructure can cause injury or mortality to wildlife, thereby affecting wildlife populations and land and resource use activities. As described in Section 15.0 of this EIS, a number of design features and mitigation will reduce hazards to birds and wildlife associated with the Project. A Blasting Plan will be developed for the Project to outline mitigation practices to be implemented to reduce effects on fish and wildlife. The implementation of these mitigation practices will provide safety and limit the chance for accidents or malfunctions associated with blasting activities. Good housekeeping practices and maintenance of Project equipment will be practiced to prevent wildlife entanglement or injury by on-site material. During winter construction periods, gaps will be left in snow windrows along access roads and around the Project site to allow escape routes for d wildlife.

Furthermore, resource users and travellers will have limited access to the Project site during construction and operations. Project design such as road controls, signage, fences, and other security features along access roads and at the Project site will likewise reduce the effects of physical hazards associated with the Project on wildlife. With little resource use and active harvesting at the Project site due to limited access, the physical hazards of the Project are expected to have limited effect on resource use activities.

The implementation of environmental design features and mitigation are expected to reduce the likelihood and extent of accidents involving injury or mortality to wildlife. This interaction was determined to have no linkage to effects on wildlife and wildlife habitat, and therefore, no linkage to effects on land and resource use.

- **Increased traffic can increase the potential for vehicle to wildlife collisions, which can cause injury or mortality to wildlife**

The Project will increase vehicle traffic during construction, which could result in increased injury and mortality to wildlife. Wildlife (primarily mammals, reptiles, and amphibians) often are attracted to roads where they forage for food, bask on the road surface, scavenge for carrion, and use corridors for travel (Smith-Patten and Patten 2008; Fahrig and Rytwinski 2009). The risk of vehicle-wildlife collisions is not uniform in regards to species, with amphibians having a high mortality risk from crossing roads because of their small size and slow movement speed (Hels and Buchwald 2001; Fahrig and Rytwinksi 2009). The search for prey and carrion can attract carnivores and raptors to roads (Fahrig and Rytwinski 2009) where they are insensitive to the threat of traffic (Dickson and Beier 2002). The presence of salt-covered vegetation and increased sodium levels in roadside ditches can be attractive to moose (Laurian et al. 2008a, b).

During construction (about three years), up to 250 jobs are expected to be created, with many of these positions being filled by workers from the local communities (Section 18.5.1.2). Most of the specialized or skilled workers will be transported by plane to the nearest airport at Stony Rapids. A shuttle will transfer incoming and outgoing workers between Stony Rapids and the site to reduce the use of personal vehicles. Peak traffic volumes during construction will occur on the site access road and are anticipated to be roughly 45 vehicles per day (Section 19.4.2). Limited parking will be available on-site thereby, reducing the use of personal vehicles. Following construction, it is estimated that between six and eight personnel are required for operation of the Project and peak traffic volumes on Highway 905 and the site access road are anticipated to be approximately 10 vehicles per day (Section 19.4.2).

Traffic speed and volume are the primary factors that contribute to road-related wildlife mortality. Speed limits will be clearly posted on construction roads and enforced to mitigate against potential wildlife mortalities during construction. Vegetation along the roadside will be mowed and cut to decrease the attractiveness to wildlife species (e.g., moose) and to increase visibility of wildlife along the road.

In summary, increases in vehicle traffic during Project construction and operation are expected to result in minor changes to wildlife populations as compared to baseline conditions. Therefore, collisions with Project vehicles are expected to have negligible residual effects on land and resource uses.

- **Failure of the embankment dykes around the settling ponds can change surface water quality, soil, and vegetation quality, which can affect fish and wildlife habitat, and human uses.**

Failure of embankment dykes around the settling ponds could result in the release of sediment laden water and potential contaminants to the surface water and terrestrial environments. Environmental controls will be in place to limit the potential for embankment dyke failure. For example, water from the waste rock disposal areas will be diverted to the settling ponds by gravity. The settling ponds will be engineered to provide adequate storage of process streams under normal and extreme operating conditions. Maximum operating levels will be developed to provide adequate storage volumes for the design storm event. In the event of increased precipitation (i.e., during a storm event), additional flow capacity from the collection ditch to the settling pond would be provided by the inclusion of an overflow spillway in the embankment.

The embankment dyke will be constructed around the settling pond to contain wastewater from site and from the waste rock disposal areas. Embankment dykes will be stripped of vegetation, topsoil, and roots to expose the mineral soil subgrade as necessary to accommodate the size of the settling pond. Fill material used for constructing the dyke will be clean mineral soil with sufficient moisture to allow for proper compaction and will be placed in lifts not exceeding 150 mm in compacted thickness and compacted to a minimum of 95% standard proctor maximum dry density. The embankment will be covered with topsoil, seeded, or protected with gravel or riprap immediately following construction.

The settling pond will be regularly inspected for sediment accumulation and stability of embankments, outlet, and spillway to confirm that they are functioning properly. During the detailed design stage, additional mitigation will be identified and included as part of the EnvPP and the Emergency Response Plan. Consequently, embankment dyke failure was determined to have no linkage to effects on land and resource use.

- **Fire**

Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. Fire safety measures and response will be reviewed with the communities of Black Lake and Stony Rapids. On-site personnel will be trained in established fire prevention and response procedures and appropriate firefighting equipment will be available on-site so that trained personnel will be able to respond promptly. The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail.

Each pump will be sized to meet the full demand of the largest component of the system with the addition of 31.5 litres per second (L/s) for hose demand. Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute). Although a fire may result in loss and alterations to soil, the implementation of the abovementioned mitigation is anticipated to result in negligible residual effects on land and resource use.

17.4.4 Primary Interactions

The Project is expected to result in the following primary effects on land and resource use that are carried forward to the residual effects assessment.

- **Changes to traditional and domestic resource use resulting from changes to vegetation, wildlife and wildlife habitat, fish and fish habitat, and surface water quality.**
- **Changes to outfitting and lodge activities resulting from changes to wildlife and fish habitat.**

17.5 Residual Effects Analysis

The residual effects analysis considered all primary interactions that are expected to result in effects on land and resource use after implementing environmental design features and mitigation. The residual effects assessment is completed by calculating and estimating changes to measurement endpoints associated with the primary Project interactions. These measurement endpoints include:

- relative abundance and distribution of fish species;

- relative abundance and distribution of plant species;
- relative abundance and distribution of wildlife species; and
- capacity for traditional and recreational land use.

17.5.1 Traditional and Domestic Resource Use

The discussion of effects on traditional and domestic resource use focuses on activities undertaken by members of the BLFN. By virtue of the Project's location on BLFN reserve land, domestic resource use by other communities is limited. The discussion of traditional and domestic resource use includes consideration of a principal resource user, who is most likely to experience effects related to Project construction and operation. Other community resource use is discussed; however, while effects on other community resource users is expected to be similar, the extent of effects on the broader community will be less than those experienced by the principal resource user.

17.5.1.1 Principal Resource User

The principal resource user in the LSA has a cabin on the south shore of Middle Lake, which serves as a permanent residence. The cabin owner accesses the LSA for domestic land and resource use purposes, including hunting, snaring, trapping, fishing, and gathering (including firewood). In addition, the resource user travels on the local access trails and makes regular trips between Black Lake and the cabin. Further to this, the cabin owner uses water from Middle Lake for household purposes, including drinking water. Species that are harvested in the LSA by the cabin owner include beaver, moose, ptarmigan and grouse, and rabbits. The cabin owner harvests ducks and geese, wolf, fox, lynx, otter, marten, mink, and muskrat periodically. The cabin owner is the main domestic fisher on Middle Lake, adjacent to the Project, although other residents of the LSA may periodically fish the lake for domestic purposes, particularly during the spring months prior to ice break-up on Black Lake. Using nets, fish species for domestic consumption are variable and include lake whitefish, lake trout, walleye, northern pike, Arctic grayling, and suckers.

There are no ecologically significant effects anticipated on the species of greatest importance to resource users. Beginning with the construction of the Project, the LSA will see an overall reduction in vegetation associated with the development of the the construction camp, access roads, bridge, water intake, and powerhouse, power tunnel, and tailrace channel. According to Section 14.5.1.4 of this EIS, habitats with high or moderate potential to support traditional use plant species are expected to decrease by 6.3% and 6.2%, respectively, relative to existing conditions. Overall, the residual effects from the Project and previous and existing developments are not predicted to be large enough to alter the state of plant communities and significantly influence self-sustaining plant populations and communities.

There will also be habitat loss for important locally harvested species, including beaver, moose, marten, and waterbirds (Section 15.5.1). Effects from direct loss, alteration, and fragmentation of habitats from the Project and previous and existing developments are expected to be of negligible to low magnitude. Overall, the Project was conservatively estimated to disturb 1.4% of the RSA during construction. These changes should have negligible effects on the movement of individuals and connectivity of wildlife populations (Section 15.6.2).

Most of the reclamation activities are expected to occur during and immediately following construction, with some reclamation activities occurring during operations. Reclamation activities following construction will include the removal of portions of the temporary construction infrastructure not required during operation.

Wildlife can be affected by sensory disturbances such as noise, light, smells, and vehicle movement in the LSA. These effects can reduce habitat quality for wildlife and alter movement and behaviour. Sensory disturbances from the Project are predicted to be highest during construction when blasting activities and the largest number of personnel will be present on-site. Residual effects on wildlife from sensory disturbance associated with the Project, is anticipated to occur at the local scale and have negligible to low, or moderate magnitude effects on populations Local changes in abundance and distribution of VCs from existing roads, trails and other human activities have likely already occurred and populations have probably adapted to these disturbances. Effects from sensory disturbance vary among species. Some VCs, such as beaver and waterbirds, could experience little residual effects from sensory disturbance (Busnel and Briot 1980; Ronconi et al. 2004). The local change in abundance and distribution from construction activities should decrease after construction and some individuals and populations could habituate to the low noise emissions from the powerhouse and low, intermittent traffic levels during operations.

Overall, the incremental and cumulative effects from the Project and previous and existing developments are not predicted to be large enough to alter the state of wildlife populations and adversely influence self-sustaining wildlife populations; effects are predicted to be not significant.

Some fish currently drift downstream out of Black Lake into the Fond du Lac River via the Black Lake outflow; during Project operation, fish are expected to drift downstream via the natural river outflow and the water intake. However, the total number of fish leaving the Black Lake fish community is not expected to change over the current level of out-migration because overall Black Lake outflow rates and volumes will not change with the development of the Project. Out-migration of fish from Black Lake once the Project is operating is expected to be similar to current levels (Section 12.6.2).

As described in Section 12.6.2, fish injuries and mortalities are expected to occur because of impingement or entrainment of fish in the water intake during Project operations. Although the number of fish moving downstream out of Black Lake is not expected to change because of Project development, a higher rate of injury and mortality is expected for fish that are impinged at or entrained by the water intake structure versus fish that pass downstream through the natural Black Lake outflow.

Loss and alteration of fish habitat is expected due to the Project footprint. Although appropriate and applicable mitigation practices will be used and sensitive habitats will be avoided to the best extent possible, construction and operation of the Project is expected to result in some HADD of fish habitat. However, with successful design and implementation of the Fish Habitat Offsetting Plan, it is not expected that there will be a net loss of fish habitat resulting from the Project footprint or construction of Project components. The loss and alteration of fish habitat is also expected because of changes to hydrology in the Fond du Lac River, between Black Lake and Middle Lake during Project operations. The quantity of suitable overwintering habitat available to Arctic grayling in the bypassed section of the Fond du Lac River during Project operation is expected to be greater than that available under historically normal flow conditions (i.e., without the Project in place). It is anticipated that hydrological changes in the Fond du Lac River will alter the relative abundance of prey items available to Arctic grayling and other fish species; however, this change is not expected to extend beyond the resilience limits of fish populations in the Fond du Lac River.

Overall, the combined residual effects from the Project are not predicted to be large enough to alter the state of fish health, abundance, distribution, or habitat, and therefore, influence the maintentance of self-sustaining fish populations. Therefore, domestic fishing on Middle Lake is predicted to continue as it does presently. In addition, other local lakes, such as Stony Lake and Black Lake, will be unaffected by the Project and will continue to be accessible for domestic fishing.

Wildlife and fish populations can be affected by the presence of the construction workforce, who can place added pressures on the resource relative to existing hunting and fishing activities. Resource management strategies, including the prohibition of firearms, hunting, trapping, harvesting, and fishing for all employees will be implemented to reduce pressures on wildlife and fish populations. These strategies also should assist in limiting the number of people exploring the LSA, which will help to reduce any potential interactions between the cabin owner and the non-local workforce at Middle Lake. In addition, public access to the site will be restricted to the public until Project construction is completed.

Project infrastructure will limit the ability of the cabin owner to travel freely throughout the LSA. Access limitations during construction will include road controls, signage, fences, and other security features. Public access will be controlled because of safety considerations on-site. Similar mitigation, such as permanent fencing, will restrict access to the water intake and powerhouse structures, as well as the tailrace channel and any storage facilities on the east side of the Fond du Lac River during construction and operation. Finally, during operation there could be changes in the way ice forms near the water intake, which will alter existing snowmobile travel routes. The Proponent will work with the cabin owner on Middle Lake so that they are provided with safe access through the RSA and LSA, including locations where public access may be restricted.

The principal resource user's activities are likely to be affected by certain aspects of Project construction. Sensory effects, such as noise, lights, and vehicle traffic, may be a deterrent to resource use, not only as a result of wildlife avoiding the area during construction, but from an aesthetic perspective for the cabin owner who is accustomed to residing in a relatively quiet environment, away from the community of Black Lake. Results of the noise assessment predict that noise levels at the principle resource user's permanent residence will be below Health Canada's guidelines for noise-induced hearing loss, sleep disturbance, interference with speech comprehension, complaints, and change in percent highly annoyed (Section 8.5.5.3). Therefore, it is anticipated that the construction noise will not result in nuisance for the principle resource user living in the area; however, construction activities will be audible, especially activities resulting in a noise peak, such as passing traffic, back up alarms, and dropping of hard material in empty trucks. The Proponent is committed to working with the contractor to limit Project-related disruption to the principle resource user. The Proponent will provide effective and timely communication about Project activities and whether any restrictions to activities will be applied (e.g., for safety concerns). Finally, the Proponent will consider compensation for demonstrated losses resulting from the Project.

17.5.1.2 General Community Resource Use

Other members of BLFN access areas in the LSA for resource harvesting purposes, though less frequently than the principal resource user. These local resource users typically access and harvest resources in nearby areas within the LSA and RSA. Although changes to vegetation, fish and wildlife have the potential to affect broader community resource use (similar to changes that will be experienced by the principle resource user), other community members tend to be active within the LSA, RSA, and beyond; meaning that suitable alternative locations for resource use will continue to be available for use.

There are a number of campsites used throughout the LSA, including an historical campsite used by members of BLFN near Middle Lake, and areas used for annual community cultural camp activities located closer to Highway 905. The location of Project access roads was discussed during public involvement activities and resulted in the routing of the main access road to avoid community cultural camps while improving long-term access to the sites. Furthermore, the community's cultural camps have historically been mobile and it is anticipated that a suitable alternative location can be identified during the construction phase when sensory disturbances might occur (e.g., traffic). Access to these sites will remain important for future generations of BLFN members and, following completion of the construction phase, will become more accessible with the new road. New areas, such as the east side of the Fond du Lac River (not including the Project operations infrastructure) will become more accessible by way of the bridge.

In addition to road alignment that avoids cultural campsites and protects public safety, the Proponent is committed to timely and effective communication with local resource users about construction and operation activities, including providing information about any restrictions that may be put in place to limit risks to public safety.

17.5.2 Outfitting and Lodges

As described in Section 17.3.2.3, there is one outfitter, Camp Grayling, operating a fishing lodge on the Fond du Lac River adjacent to the Project site. Camp Grayling facilities include a lodge and cabin buildings, as well as storage facilities. The camp offers sport-fishing activities on the Fond du Lac River, as well as on several lakes in the LSA and RSA, focusing on sport (rod) fishing for Arctic grayling on the Fond du Lac River near Elizabeth Falls and northern pike on Black Lake. Camp Grayling provides access through leases to 22 regional lakes including Middle Lake and receives half of the commercial fishery allocation on Black Lake. The lodge's proprietor remains on-site year-round, although the lodge is open for fishing guests only during the months of June to mid-September.

As with the effects on domestic fishing for other resource users, Project effects on most of the lakes used by Camp Grayling are expected to be negligible or not measurable. This includes Black Lake and Middle Lake. Effects of Project operations on Arctic grayling on the Fond du Lac River relate to changes in the quantity and quality of habitat, in addition to the potential for injury and mortality. The quantity of suitable overwintering habitat available to Arctic grayling in the bypassed section of the Fond du Lac River during Project operation is expected to be greater than that available under historically normal flow conditions (i.e., without the Project in place). Under average to below-average spring flow conditions, Project operation is expected to result in a net decrease in the quantity of suitable spawning habitat available to Arctic grayling. Foraging habitat is expected to improve under reduced riparian flows proposed for the Project. It is anticipated that hydrological changes in the Fond du Lac River will alter the relative abundance of prey items available to Arctic grayling and other fish species; however, this change is not expected to extend beyond the resilience limits of fish populations in the Fond du Lac River. The overall size of the Arctic grayling population in the Fond du Lac River and Black Lake outlet near Grayling Island, as well as in the lower section of the Fond du Lac River near Middle Lake, is expected to remain similar to current levels. The Arctic grayling population in the middle, by-passed section of the Fond du Lac River is expected to persist, but may be reduced in numbers due to lower flows and volumes in the river. However, reduced flows on the Fond du Lac River because of Project operations may improve access for shoreline fishing.

Similar to effects on the principle resource user in the LSA, Camp Grayling is likely to be affected by sensory disturbances associated with construction of the Project, including noise, lights, and traffic. This is particularly true for certain aspects of Project construction that will occur near Camp Grayling's lodge, such as the construction of the weir. The owner of Camp Grayling has expressed concern that construction activities could affect the enjoyment of guests at the lodge, which in turn, could affect return business in future years. Results of the noise assessment predict that noise levels at Camp Grayling will be below Health Canada's guidelines for noise-induced hearing loss, sleep disturbance, interference with speech comprehension, complaints, and change in percent highly annoyed (Section 8.5.5.3). Therefore, the increase due to Project construction at the Camp Grayling is predicted to be negligible. It is anticipated that the construction noise will not result in nuisance for the camp; however, construction activities will however be audible, especially activities resulting in a noise peak, such as passing traffic, back up alarms, and dropping of hard material in empty trucks.

It is difficult to predict with certainty the extent of potential effects on Camp Grayling, particularly with respect to the potential for demonstrable losses. This is due, in part, to the multiple factors that may influence a tourist's decision to visit a location, in addition to the fact that changes in visitor behaviour may or may not be directly or indirectly attributable to the Project. The Proponent is committed to working with the contractor to limit Project-related disruption to the owner of Camp Grayling. The Proponent will provide effective and timely communication about Project activities and whether any restrictions to activities will be applied (e.g., for safety concerns). Finally, the Proponent will consider compensation for demonstrated losses resulting from the Project.

17.5.3 Management of Uncertainty

Effects on land and resource use are affected by direct changes to individual or group behavior and through the changes that affect the environment in which activities occur. Ecosystems are complex and interactions among abiotic and biotic components of the ecosystem occur across multiple scales and are typically nonlinear (Boyce 1992; Holling 1992; Levin 1998; Wu and Marceau 2002). These characteristics can confound our understanding of ecosystem processes and limit our capacity to make predictions. Similar to all scientific results and inference, residual effects predictions will have uncertainty associated with the data and current knowledge of the system. The confidence in residual effect predictions for land and resource use relate to the understanding of land and resource use itself, in addition to the understanding of effects on vegetation and wildlife.

As noted in Sections 14.5.2 and 15.5.3, there is a high degree of confidence that there will be disturbances to vegetation and wildlife, although the extent to which this is understood is limited by a lack of precise knowledge on the locations of Project infrastructure. A conservative estimate of the Project footprint size was used to assess changes to vegetation and wildlife and uncertainty was addressed by incorporating information from available and applicable literature, and experience in similar projects and environments. Best management practices during construction, operations, and closure will be implemented to mitigate residual effects on vegetation and wildlife. These practices, in turn will help to reduce the overall effects on land and resource use.

There is also a high degree of confidence that some fish and fish habitat will be disturbed, altered, or destroyed because of Project construction and operation. Section 12.5.3 reviews the sources of uncertainty in the assessment of fish and fish habitat. These sources include the degree to which residual effects could occur due to the time required for fish habitats and species distribution and abundance not be influenced by the Project. In addition, there is some uncertainty associated with the hydrodynamic data and HSI models used to evaluate the quantity and quality of fish habitat available to Arctic grayling in the Fond du Lac River. Field ground-truthing surveys, model calibration, and professional experience and judgement were used to reduce these uncertainties. Furthermore, uncertainty was addressed by incorporating information from available and applicable literature, and knowledge from experience with similar locations, species, and project types. Conservative estimates were used so that residual effects were not underestimated. Proven best management practices will be implemented to mitigate residual effects and loss or alteration of fish habitat will be offset as part of the Fish Habitat Offsetting Plan for the site.

Uncertainty with respect to land and resource use was addressed by considering all of the information collected from those most likely to be affected, including the following:

- results from key person interviews conducted in the LSA, which included discussions with the resource users identified in this section;
- inputs from a land and resource use workshop held in Black Lake in April of 2013 that included a mapping exercise; and
- inputs from the public involvement process.

The above information was initiated with discussions about the existing environment and continued as the Project planning progressed. Potential effects from the Project were discussed with the communities. Further to this, experience with other similar projects in similar environments was considered in the analysis. Some uncertainty exists with respect to the degree in which resource users will tolerate activities in their surrounding areas; however, strategies have been identified for continued dialogue to address challenges to local resource users as they arise.

17.6 Determination of Significance

The changes in measurement endpoints associated with primary interactions provide the foundation for determining significance from the Project on land and resource use. Direction, magnitude, duration, and geographic extent, are the main factors of consideration used to predict significance. For land and resource use, the assessment of significance considers the scale of these factors considered, in addition to professional opinion based on the context of the Project in combination with other relevant experience. The assessment of significance considers the efficacy of the proposed mitigation and enhancement measures to limit residual adverse effects and enhance potential benefits on land and resource use. The determination of significance assessment considers all primary interactions that are expected to result in residual effects on land and resource use.

Frequency is not considered in evaluating the significance of residual effects on land and resource use. For socio-economic changes, the residual effects are generally continuous; therefore, criterion frequency is typically not used. Similarly, reversibility is not used in determining effects on the socio-economic environment as effects associated with a project are typically part of an ongoing process of interdependent economic and social change extending into the future; it cannot be reversed.

17.6.1 Residual Effects Criteria

Table 17.6-1 describes the criteria used when evaluating effects on land and resource use.

Direction – Direction refers to the overall nature of the effect. A negative effect would be one where there is an adverse effect on the VC, relative to the existing environment. A positive rating anticipates that the effect will be of benefit to the VC relative to the existing environment.

Magnitude - Magnitude refers to the degree of change in a measurement endpoint and the resulting residual effect on land and resource use. Magnitude may be low, moderate, or high. Low magnitude predicts a small, but hardly discernible effect on natural, cultural, and social features of the environment. A moderate rating anticipates that the effect on a VC is likely to be a noticeable change relative to the existing environment. High magnitude suggests that the change will be large and a meaningful effect will occur relative to resource use or users.

Table 17.6-1: Residual Effects Criteria for Changes to Land and Resource Use

Direction	Magnitude	Duration	Geographic Extent
Negative: An adverse effect relative to the existing environment **Positive:** A beneficial effect relative to the existing environment	**Low:** Effects are likely to result in a small, hardly discernible change relative to the existing environment **Moderate:** Effects are likely to result in a noticeable or detectable change relative to the existing environment **High:** Effects would be likely to result in a large, meaningful and readily detectable effects relative to the existing environment	**Short-term:** Effects will only occur during the construction phase **Medium-term:** Effects will extend to the first 10 years of operation of the Project, or for one human generation relative to land and resource use **Long-term:** Effects will last for more than 10 years, or for more than one human generation relative to land and resource use	**Site:** Effects will be limited to the Project footprint **Local:** Effects may affect resource use activities in relative proximity to the communities of Black Lake and Stony Rapids, including Black Lake (the waterbody), the section of the Fond du Lac River from Black Lake to Stony Rapids (including Middle Lake), and associated shoreline areas **Regional:** Effects extend to the Athabasca region

Duration - Duration is defined as the amount of time that land and resource use is affected by Project activities, phases, or outcomes. Short-term effects are anticipated to occur over the course of construction only. Medium-term effects can occur within the first 10 years of operations of the Project, or for one human generation relative to land and resource use. Long-term effects are those effects that are likely to persist beyond the first 10 years of Project operations or for more than one human generation relative to land and resource use.

Geographic Extent - Geographic extent considers the location in which effects are likely to be measurable relative to the existing environment. For land and resource use, these include site, local, and regional areas. A site-specific rating anticipates that changes will be measurable within the Project footprint. A local rating anticipates that effects will be measurable in relative proximity to the communities of Black Lake and Stony Rapids, including Black Lake (the waterbody)**,** the section of the Fond du Lac River from Black Lake to Stony Rapids (including Middle Lake), and associated shoreline areas. A regional rating anticipated that effects would extend beyond the site and local areas and would be measurable within the Athabasca region.

17.6.2 Project-specific Residual Effects

The analysis of residual effects on land and resource use considers the effects of the loss of access on land used for traditional and domestic, and commercial land and resource use. This land access is associated with the removal of the Project footprint for the construction and operations of the Project. Most of the effects are expected to accrue near the Project footprint and will affect the small number of resource users who regularly undertake activities in the area. Mitigation will include design features to reduce the Project footprint area and provide compensation for proven losses. Despite this mitigation, some land and resources will be removed from current usage because of the Project.

Based on the assessment described in Section 17.6.1, effects on land and resource use are expected to be negative in direction, moderate in magnitude, and local in geographic extent. Effects could be short to long term in duration, as certain effects will be limited to the construction phase (e.g., sensory disturbances; short-term), while the presence of new Project infrastructure and associated new access roads and bridge will remain as long as the facilities are in place (long-term). Overall, with the proposed mitigation policies and practices, it is anticipated that land and resource uses will persist in the area. Further to this, access created by the Project could make it easier for members from BLFN to access areas east of the Fond du Lac River, recognizing that access to the operation itself will be limited to protect public safety. Given that land and resources use are expected to continue, there is no significant adverse effect of the Project on land and resource use.

17.6.3 Cumulative Residual Effects

Cumulative effects are those effects from the Project, combined with the effects from prior development, existing activities, and reasonably foreseeable future developments that are sufficiently certain to proceed. The key is to determine if the effects from the Project and one or more additional developments and activities overlap or interact with the temporal or spatial distribution of land and resource use.

For land and resource use, one additional development was identified as having potential spatial overlap for the RSA: the Highway 968 All-weather Road Project, a proposed 88.5 km road from Highway 905 (near Stony Rapids) to the community of Fond du Lac. The proposed roadway would extend from approximately 3.5 km south of the Stony Rapids airport at its intersection with Highway 905 and generally following the existing winter road location west for 31.9 km towards the community of Fond du Lac. The remaining 56.6 km of roadway would be entirely new, terminating on the south shore of Lake Athabasca near Fond du Lac. The project would take approximately three years to construct, and would result in an estimated 300 person years of employment (SMHI 2010). This could result in additional people and traffic coming through the RSA during the construction phase and would change the seasonality of travel during the operation of the road.

At present, there is no evidence to suggest that there would be a temporal overlap of construction activities for the Project and the construction of proposed roadway. Saskatchewan Ministry of Highways and Infrastructure budget announcements for 2013-2014 do not include the proposed road and the environmental assessment process has not moved beyond the submission of a project description in 2010 (SMHI 2010; Government of Saskatchewan 2013). However, as the Project has the potential to last for more than 90 years, it is possible that construction of the roadway will occur during operation of the Project. The construction and operation phases of the roadway could cause increased access for land and resource use. It is unlikely that traffic would increase substantially, however the seasonality of travel would change to year-round vehicular access. Current information regarding the implications of a new all-weather road is not sufficient to determine the extent to which there would be effects on vegetation and wildlife, and subsequently resource use. As such, it is not possible to determine whether there is potential for cumulative effects to accrue.

17.7 Environmental Management, Monitoring, and Follow-up

Monitoring and follow-up programs associated with effects on vegetation (Section 14.7), wildlife (Section 15.7), and fish (12.7) are also relevant to land and resource use, as changes to these components affect resource users. Monitoring activities associated with vegetation include reviewing re-vegetation techniques and success following construction and during reclamation activities, as well as surveys for weed species during construction and operations, and implementation of a Weed Management Plan if required. Analysis and assessment of re-vegetation techniques will provide input into the Decommissioning and Reclamation Plan and the objectives and methods of re-vegetation will be determined with input from regulators and the communities.

Prior to construction of the Project, detailed site assessments will be completed, with additional wildlife surveys undertaken if construction is scheduled for the breeding season of key species identified as important by resource users. Should listed wildlife species be observed, appropriate mitigation would be implemented to limit residual effects. Environmental monitoring is a key component of adaptive management and continuous improvement strategies and will provide flexibility for SaskPower and MOE to identify effectively and to respond to unanticipated changes to habitat quality and quantity, to adapt to new regulatory frameworks, and to provide appropriate feedback required to improve future environmental assessments.

Construction and operation of the Project will result in injury and mortality to fish. The Project will affect hydrology within the bypassed section of the Fond du Lac River, resulting in the loss and alteration of fish habitat in the river during operations. It is anticipated that monitoring of fish habitat offsetting activities, as defined in the Fish Habitat Offsetting Plan, will be required during Project operation. The objectives and methods used to offset changes to fish habitat within the LSA will be determined with input from regulators and local communities.

Monitoring related to land and resource use, including broad community concerns on resource use, will be managed by a Project Advisory Committee consisting of the Project proponents. This committee will meet at least monthly or as otherwise agreed to by the Committee to review the status of the Project, including environmental, engineering and construction activities and community matters that relate to the completion of the Project. It is anticipated that the committee will discuss on-going concerns about socio-economic effects;

including effects on land and resource use, and that, the Elizabeth Falls Hydroelectric Limited Partnership and SaskPower will work collaboratively on measures to address community concerns.

17.8 References

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17.9 Glossary

Term	Description
Country Food	The traditional diets of Aboriginal people (the First Nations, Metis, and Inuit), especially in remote northern regions where Western food is an expensive import, and traditional foods are still relied upon.
Environmental Impact Statement	A report that documents the information required to evaluate the environmental effect of a project.
Nomadic Lifestyle	The lifestyle where people do not have permanent settlements and travel from place to place.
Non-Renewable Resource	A resource that does not renew itself at a sufficient rate for sustainable economic extraction in meaningful human timeframes.
Renewable Resource	A natural resource which can replenish with the passage of time, either through biological reproduction or other naturally recurring processes.
Residual Effect	An environmental effect that remains, or is predicted to remain, even after mitigation measures have been applied.

17.10 List of Acronyms

Term	Definition
ALUPIAP	Athabasca Land Use Plan Interim Advisory Panel
BLFN	Black Lake First Nation
BP	Before Present
CCME	Canadian Council of Ministers of the Environment
EIS	Environmental Impact Statement
HBC	Hudson Bay Company
INAC	Indian and Northern Affairs Canada
KPI	Key Person Interview
LSA	local study area
ND	No Date
MSDS	Material Safety Data Sheet
OIC	Order in Council
PAGC	Prince Albert Grand Council
RSA	regional study area
SSA	site study area
TDG	Transportation of Dangerous Goods
VC	valued component
WHMIS	Workplace Hazaradous Materials Information System

17.11 List of Units

Term	Definition
$	dollar
ha	hectare
lbs	pound(s)
kg	kilogram
km	kilometre
mm	millimetre
#	number
%	percent

18.0 ECONOMY

18.1 Introduction

The purpose of this section is to describe the socio-economic environment that may be affected by the Tazi Twé Hydroelectric Project (Project) and to assess the effects on economy. Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples, and the public. The value of a component relates to its role in the ecosystem and to the value placed on it by humans. During engagement sessions, local Aboriginal groups and community members expressed interest in economic and employment opportunities that will be generated by the Project. As such, economy was selected as a VC for this Environmental Impact Statement (EIS).

This scope of this section focuses on the economy of northern Saskatchewan where the Project is located. Economic activities affect the material well-being of people, as well as other factors that affect society as a whole (Vanclay 2002). Northern Saskatchewan's economy is primarily service and resource-based, and skilled people are needed in almost every trade and across every sector (e.g., mining and construction, health care, education, and social work; Northern Labour Market Committee 2011). Details on the characteristics that shape the economy of northern Saskatchewan are presented in Annex VI Socio-economic Environment.

18.2 Spatial Boundaries

The local study area (LSA) for economy includes the communities of Black Lake First Nation (BLFN) in addition to the Northern Hamlet of Stony Rapids. The Project is located on BLFN reserve land. The BLFN is a co-proponent for the Project through the Elizabeth Falls Hydroelectric Limited Partnership (EFHLP) and stands to benefit from training and employment opportunities, income opportunities (including equity in the Project), in addition to business opportunities associated with Project construction and operation. The Northern Hamlet of Stony Rapids is also included in the LSA as the community is near the Project and is likely to benefit from employment opportunities, in addition to economic spinoffs associated with Project construction.

The regional study area (RSA) represents the boundary where potential economic effects are expected to be dispersed at a broader scale. This could be a result of participation in Project employment, or through the business and contracting opportunities created by the Project. The RSA includes consideration of the Athabasca region of northern Saskatchewan; in addition, this section provides contextual and comparative information on northern Saskatchewan and the province of Saskatchewan as a whole.

18.3 Existing Environment

The primary sources of information for this section are Statistics Canada and a Key Person Interview (KPI) program conducted from 2011-2013 in the communities of Black Lake and Stony Rapids. Other sources of information include Saskatchewan Regional Health Authorities, community-related websites, other federal and provincial government websites, and reports on northern Saskatchewan. Limitations to available data affect the degree of completeness and comparability between data sources. Statistics Canada census data was identified as the most complete and comparable over time; however, data for some smaller communities has been suppressed or combined with other communities' data by Statistics Canada in order to maintain confidentiality. Statistics Canada publishes census methods that allow analysis to consider these limitations. Other data were collected where available and used to triangulate with the Statistics Canada data where possible.

The communities of Black Lake and Stony Rapids are located in the northern-most part of the province of Saskatchewan, an area often referred to as Athabasca region. The Athabasca region is sparsely populated compared to other parts of the province, with residents scattered across seven communities including First Nations, northern settlements, and northern hamlets. The community of Black Lake is a Denésuline First Nation with members residing on the reserve, and in other locations. The Black Lake community has three registered reserve locations; two of these are unpopulated. Each reserve parcel has permanent, seasonal, or historical ties to the community and is described in more detail in Section 19.3. The Northern Hamlet of Stony Rapids is located along the Fond du Lac River, about 22.2 kilometres (km) northwest of Black Lake. The two communities are historically interconnected, but are separate administrative entities.

18.3.1 Labour Force and Education

Potential labour force is the percentage of the total population in a specific geographical region that may be economically active. Statistics Canada considers the potential labour force to be comprised of the entire population that is 15 years or older, including persons aged 65 and older. In 2006, the potential labour force in Saskatchewan was 79.1 percent (%), while the potential labour force in northern Saskatchewan was smaller at 66%. The difference between the potential labour forces for the entire province and northern Saskatchewan can be explained by the differing demographic profile of each entity. Overall, northern Saskatchewan has a younger population than the province as a whole, which increases the proportion of the dependent population. The potential labour force in the community of Black Lake is consistent with northern trends at a rate of 64.5%, while Stony Rapids has a slightly higher rate at 70.5%. Combined, the two communities had approximately 950 people in the potential labour force in 2006 (Statistics Canada 2007).

Education attainment is one of the key factors that contribute to an individual's ability to enter successfully into the labour market (Hango and de Broucker 2007). The data presented in Table 18.3-1 outlines the highest level of schooling achieved by residents of the communities of Black Lake and Stony Rapids, as well as comparison data for the Athabasca region, northern Saskatchewan and Saskatchewan.

In the community of Black Lake, 83.9% of the population over 15 years of age had not completed high school in 2006. Approximately 50% of the population over 15 years of age in the Northern Hamlet of Stony Rapids had not completed high school in 2006. The proportion of non-graduates is much higher than in the province as a whole (30.2%) and, for Black Lake; the rate is higher than in northern Saskatchewan (58.4%). The low rates of high school completion in Black Lake could result from the community not offering high school courses and graduation until 1994. Before the community of Black Lake offered these courses, residents had to leave the community to complete their high school education (Black Lake and Stony Rapids KPI Program 2011-2013). The low rate of high school completion in the Northern Hamlet of Stony Rapids likely results from the local school not offering high school-level classes. Residents who want their children to pursue education beyond the Grade 9 level have to send them to other communities like La Ronge, Prince Albert, or Saskatoon. A few students travel to the community of Black Lake for high school; in the 2010-2011 school year two students from the Northern Hamlet of Stony Rapids were completing their high school education at Father Porte Memorial Dené School in the community of Black Lake through an arrangement between the Band and Northern Lights School Division (NLSD) #113 (Black Lake and Stony Rapids KPI Program 2011-2013).

Table 18.3-1: Highest Level of Schooling for Population 15 Years of Age and Over for the Community Black Lake, the Northern Hamlet of Stony Rapids, the Athabasca Region, Northern Saskatchewan, and Saskatchewan: 2006[a]

Highest Level of Schooling	Black Lake[b]	Stony Rapids[b]	Athabasca Region[c]	Northern Saskatchewan[d]	Saskatchewan
Total population in the labour force[e]	745	180	2,020	22,370	766,230
No certificate, diploma or degree	83.9% (625)	50.0% (90)	77.8% (1,570)	58.4% (13,055)	30.2% (231,730)
High school certificate or equivalent	4.7% (35)	11.1% (20)	7.4% (150)	15.6% (3,500)	26.8% (205,495)
Apprenticeship or trades certificate or diploma	2.7% (20)	13.9% (25)	5.0% (100)	8.4% (1,875)	11.3% (86,310)
College, CEGEP or other non-university certificate or diploma	1.3% (10)	13.9% (25)	1.7% (35)	8.5% (1,910)	14.6% (111,770)
University certificate, diploma or degree	4.0% (30)	11.1% (20)	5.4% (110)	9.4% (2,010)	17.1% (130,930)
University certificate or diploma below bachelor level	0.0% (0)	5.6% (10)	1.0% (20)	3.2% (715)	4.2% (32,175)

Source: Derived from Statistics Canada 2007.
(a) 20% sample data; totals may not add up due to rounding.
(b) Statistics Canada refers to Black Lake as Chicken 224 and 225.
(c) The Athabasca region reported by Statistics Canada includes the communities of Stony Rapids, Fond du Lac, Black Lake (Chicken 224 and 225), and Hatchet Lake (Lac La Hache 220). The communities of Camsell Portage, Uranium City, and Wollaston Lake were not included in these calculations, as Statistics Canada does not report on the communities individually.
(d) Northern Saskatchewan is defined as Census Division No. 18.
(e) Total population aged 15 and older.
% = percent

In Black Lake, the rate of apprenticeship or trades certificate or diplomas is lower than the Athabasca Region (5.0%), northern Saskatchewan (8.4%), and the province as a whole (11.3%), at a rate of 2.7%. The Northern Hamlet of Stony Rapids, on the other hand, has a higher rate of apprenticeship or trades certificate or diplomas, at 13.9%. (Statistics Canada 2007).

The uranium mining industry has played an influential role in education attainment rates in northern Saskatchewan, particularly as it relates to apprenticeship and technical training. Much of this has been accomplished through a Multi-Party Training Plan, a collaborative effort among governments, industry, and First Nations and Metis stakeholders to maximize northern hiring, training and advancement within the uranium-mining sector (InterGroup Consultants Ltd. 2013). Although the programs implemented under the Multi-Party Training Plan have had success, most residents feel that training programs need to occur locally, as many programs occur at the mine sites or in communities further south (e.g., La Ronge). There is a sense that training needs to precede major projects in the region by months or even years so that community members can gain the necessary qualifications to apply for jobs once projects are initiated (Black Lake and Stony Rapids KPI Program 2011-2013).

18.3.2 Employment and Income

Table 18.3-2 reports the participation rate, employment rate, and unemployment rate for the community of Black Lake, the Northern Hamlet of Stony Rapids, the Athabasca region, northern Saskatchewan, and Saskatchewan. The employment rate in the Black Lake community in 2006 was 22.5%, which ranges from 10.1 to 42.1 percentage points lower than the employment rate in the Athabasca region (32.6%), northern Saskatchewan (40.3%), and Saskatchewan (64.6%) (Statistics Canada 2007). According to the KPI program, official statistics may not accurately represent annual employment levels in the Black Lake community as local employment is often seasonal, contract, or part time, whereas Statistics Canada collects employment data for only the week prior to Census Day (May 16, 2006) (Black Lake and Stony KPI Program 2011-2013). The employment rate in the Northern Hamlet of Stony Rapids in 2006 was 66.7%, which is higher than the Athabasca region (32.6%), northern Saskatchewan (40.3%), and Saskatchewan (64.6%). Unemployment rates in the community of Black Lake are considerably higher than the rest of Saskatchewan (17.9% compared to 5.6% provincially), although are consistent with other trends in northern Saskatchewan. Unemployment in the Northern Hamlet of Stony Rapids was slightly higher than provincial rates at 8%, but lower than northern Saskatchewan (20.2%) and the Athabasca region (19.8%).

Table 18.3-2: Labour Force Indicators for the Community Black Lake, the Northern Hamlet of Stony Rapids, the Athabasca Region, Northern Saskatchewan, and Saskatchewan: 2006[a]

Location	Participation Rate[b] (%)	Employment Rate[c] (%)	Unemployment Rate[d] (%)
Black Lake[e]	27.5	22.5	17.9
Stony Rapids	69.4	66.7	8.0
Athabasca Region Average[f, g]	40.3	32.6	19.8
Northern Saskatchewan[h]	50.4	40.3	20.2
Saskatchewan	68.4	64.6	5.6

Source: Statistics Canada 2007.
(a) Based on 20% sample data; totals may not add up due to rounding.
(b) Participation rate refers to the labour force in the week (Sunday to Saturday) prior to Census day (May 16, 2006) and is expressed as a percentage of the population 15 years of age and over.
(c) The employment rate refers to the number of persons employed in the week (Sunday to Saturday) prior to Census day and is expressed as a percentage of the population 15 years and over.
(d) The unemployment rate is the percentage of persons unemployed in the labour force in the week (Sunday to Saturday) prior to Census day.
(e) Statistics Canada refers to Black Lake as Chicken 224 and 225.
(f) The Athabasca region reported by Statistics Canada includes the communities of Fond du Lac, Black Lake Denésuline First Nation (Chicken 224 and 225), the Northern Hamlet of Stony Rapids, and Hatchet Lake First Nation (Lac La Hache 220). The communities of Camsell Portage, Uranium City, and Wollaston Lake are not included in these calculations, as Statistics Canada does not report on the communities individually.
(g) The Athabasca region average was calculated by InterGroup as the weighted average rates of participation, employment, and unemployment of the Athabasca region communities.
(h) Northern Saskatchewan is defined by Statistics Canada as Census Division No. 18.
% = percent

The labour force indicators for Black Lake reflect trends in Aboriginal labour force participation in Canada. Location, distance to work sites, and lack of education (which often results in poor qualifications), can impede the participation of Aboriginal people in the labour force (INAC 2005). The limited number of opportunities available in the LSA intensifies this. Table 18.3-3 describes employment by industry, and demonstrates that in some instances entire industry sectors are not an active part of the economy in the community of Black Lake and the Northern Hamlet of Stony Rapids (e.g., professional, scientific, and technical services; finance and insurance industries). The top five industries in which residents of the Black Lake community were employed in 2006 were education services industries (23.6%), mining and oil and gas extraction (23.5%), health care and social assistance industries (17.6%), public administration (14.7%), and construction industries (8.8%). The top industries in which residents of the Northern Hamlet of Stony Rapids were employed in 2006 were health and social assistance industries (24.0%), mining and oil and gas extraction (20.0%), retail services (16.0%), and education service industries (12.0%).

Table 18.3-3: Employment by Industry Type for the Community of Black Lake, the Northern Hamlet of Stony Rapids, the Athabasca Region, Northern Saskatchewan, and Saskatchewan: 2006[(a)]

Industry Division	Black Lake[(b)]	Stony Rapids	Athabasca Region[(c)]	Northern Saskatchewan[(d)]	Saskatchewan
Total – All Industries	**170 people**	**125 people**	**710 people**	**10,220 people**	**517,480 people**
Agriculture, forestry, fishing, and hunting	5.9%	0.0%	1.4%	3.7%	11.6%
Mining and oil and gas extraction industries	23.5%	20.0%	21.8%	9.5%	3.7%
Utilities	0.0%	0.0%	0.0%	1.0%	1.0%
Construction industries	8.8%	0.0%	4.9%	6.5%	5.8%
Manufacturing industries	0.0%	8.0%	1.4%	4.3%	5.8%
Wholesale trade industries	0.0%	0.0%	0.0%	0.9%	3.7%
Retail trade industries	5.9%	16.0%	7.7%	9.0%	11.0%
Transportation and warehousing industries	5.9%	8.0%	4.2%	3.9%	4.7%
Information and cultural industries	0.0%	0.0%	1.4%	1.1%	2.3%
Finance and insurance industries	0.0%	0.0%	0.0%	1.0%	3.6%
Real estate and rental and leasing industries	0.0%	0.0%	0.0%	0.9%	1.3%
Professional, scientific and technical services	0.0%	0.0%	0.0%	1.0%	3.7%
Management of companies and enterprises	0.0%	0.0%	0.0%	0.0%	0.1%
Administrative and support, waste management, and remediation services	5.9%	0.0%	2.8%	2.6%	2.8%
Education service industries	23.6%	12.0%	25.4%	15.6%	7.8%
Health care and social assistance industries	17.6%	24.0%	14.8%	13.6%	11.3%
Arts, entertainment and recreation industries	0.0%	0.0%	1.4%	1.1%	1.8%
Accommodation and food service industries	0.0%	8.0%	3.5%	6.9%	6.7%
Other services (except public administration)	0.0%	0.0%	0.0%	2.8%	5.0%
Public administration	14.7%	8.0%	14.1%	14.5%	6.4%

Source: Statistics Canada 2007.
(a) 20% sample data; total may not add up due to rounding.
(b) Statistics Canada defines Black Lake as Chicken 224 and 225 in 2006.
(c) The Athabasca region reported by Statistics Canada includes the communities of Stony Rapids, Fond du Lac, Black Lake (Chicken 224 and 225), and Hatchet Lake (Lac La Hache 220). The communities of Camsell Portage, Uranium City, and Wollaston Lake were not included in these calculations, as Statistics Canada does not report on these communities individually.
(d) Northern Saskatchewan is defined by Statistics Canada as Census Division No. 18.
% = percent

With lower employment rates and limitations in the types of opportunities available, Black Lake experiences lower rates of income than the Athabasca region, northern Saskatchewan and Saskatchewan as a whole (Table 18.3-4). The differences in average employment income may, in part, be explained by differences in the proportion of persons who worked full-time during the census year compared to all those with earnings. In Black Lake, the Athabasca region, and northern Saskatchewan, 33%, 36%, and 38% of persons with employment income, respectively, worked full time during the year, while 52% of the population of Saskatchewan with employment income worked full time throughout the year.

Table 18.3-4: Average Employment Income in the Community of Black Lake, the Northern Hamlet of Stony Rapids, the Athabasca Region, Northern Saskatchewan, and Saskatchewan: 2006[a, b]

	Black Lake[c, d]	Stony Rapids	Athabasca Region[d, e]	Northern Saskatchewan[f]	Saskatchewan
All persons with employment income	275	140	860	11,885	553,655
Average employment income (all persons with earnings)[g]	$21,860	$34,427	$26,070	$25,614	$30,773
Worked full year (full time)	90	60	310	4,595	286,895
Average employment income (worked full year, full time)[g]	$33,924	$44,151	$37,780	$39,983	$42,298

Source: Statistics Canada 2007.
(a) 20% sample data; totals may not add up due to rounding.
(b) Employment income calculated calendar year 2005 in 2005 dollars, reported in Census of Canada 2006.
(c) Statistics Canada refers to Black Lake as Chicken 224 and 225.
(d) Data for Black Lake Chicken 225 reserve parcel were not included in these calculations due to the suppression of income data for 2006.
(e) The Athabasca region reported by Statistics Canada includes the communities of Fond du Lac, Black Lake (Chicken 224 and 225), Stony Rapids, and Hatchet Lake (Lac La Hache 220). The communities of Camsell Portage Uranium City and Wollaston Lake were not included in these calculations, as Statistics Canada does not report on the communities individually.
(f) Northern Saskatchewan is defined by Statistics Canada as Census Division No. 18.
(g) Average employment income before taxes.
$ = dollar

Table 18.3-4 shows that average employment income for residents of the Northern Hamlet of Stony Rapids was higher than that of the Athabasca region, northern Saskatchewan, and Saskatchewan. In addition, the average employment income for residents of the Northern Hamlet of Stony Rapids who worked full-time throughout the year was greater than that of residents of the Athabasca region, northern Saskatchewan, and Saskatchewan.

18.3.3 Local Business

The communities of Black Lake and Stony Rapids have community-based businesses that range from taxi services to local contractors (Keewatin Career Development Corporation 2012). A more complete list of the retail and hospitality services in the LSA is provided in Section 19.3.2.1. Both locals actively seek to build capacity and expand their business holdings. In the community of Black Lake, the Band employs a dedicated representative to focus on bringing training to the community and nurturing local businesses. In the Northern Hamlet of Stony Rapids, the approach to developing local business is less organized, but it is a goal of community members that more residents become employed and more local business initiatives succeed (Black Lake and Stony Rapids KPI Program 2011-2013).

The Athabasca Basin Development Limited Partnership (ABDLP) is an investment company that focuses on business and training initiatives in the mining and exploration service sector (ABDLP 2012). The ABDLP's interest in work for the resource industry, and primarily mining and exploration companies arises from the prevalence of gold and uranium deposits and mining operations in northern Saskatchewan. The communities of Black Lake and Stony Rapids are both stakeholders in the ABDLP.

As stakeholders, the communities are part owners of ten joint ventures, including (ABDLP 2012):

- Athabasca Labour Services;
- Points North Group of Companies;
- Athabasca Basin Security;
- Flyer Electric;
- Points Athabasca;
- Team Drilling;
- West Wind Aviation;
- Double Diamond Industrial Structures;
- Mudjatik Thyssen Mining; and
- Lonona Contracting.

In addition, BLFN is a partner in Pronto Airways (Pronto Airways 2012) and Northern Resource Trucking (Northern Resource Trucking 2013), Athabasca Catering (Athabasca Catering 2007), the Prince Albert Development Corporation (PADC), which supplies investment and business development services, and Black Lake Business Ventures Limited Partnership, an investment holding company (Northern Saskatchewan Regional Suppliers 2013).

Other local businesses in the LSA with construction-related experience include A&L Transportation, Athabasca Fuel Services, E&L Enterprises, Medal's Contracting, and Torson Contracting (Northern Saskatchewan Business Directory 2013).

18.4 Screening of Project Interactions and Mitigation

This section identifies and assesses the interactions between Project components or activities and the correspondent potential effects on economy. The process begins with the identification of all potential interactions with the Project. Each interaction is initially considered to have a potential linkage to change in the socio-economic environment and the associated VC of the economy. Potential interactions between the Project and employment and economy are identified in Table 18.4-1.

Table 18.4-1: Project Interactions, Environmental Design Features and Mitigation, and Potential Effects on Economy

Project Component/ Activity	Project Phase when the Component/Activity Occurs	Potential Interactions to Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ General Construction, Operations, and Closure	Construction	Project construction and operation will increase local education and training opportunities.	■ A pre-employment training program will be deployed that is designed to prepare individuals for employment during construction through a combination of academic upgrading, industry safety training, and job readiness skills. ■ During construction contractors will provide on the job training including small tool training, personal protective equipment (PPE) training, fall protection, rigging and crane signaling, lockout tagout training, confined space training, and cultural awareness orientation. ■ Contractors will be required to support apprenticeship-training programs and implement a craft-mentoring program that pairs trainees and apprentices with experienced craftsmen and foremen.	Primary
	Operation		■ Train individuals from Black Lake to maintain and operate the plant once it is commissioned. Individuals demonstrating aptitude will be recruited during the construction phase, and will be sent to other hydroelectric facilities in Saskatchewan for on-the-job training.	Primary
	Construction	Project construction and operation will result in increased opportunities for employment within the LSA and RSA.	■ Requirements of the General Contractor to optimize the participation of workers from the BLFN. ■ Preferential hiring priority will be as follows: ▪ First preferences to BLFN members; ▪ Second preference to residents of the rest of the Athabasca region; and ▪ Third preference to residents of the rest of Saskatchewan. ■ The Proponent will work with the general contractor on recruitment and retention strategies. This will include on-the-job training targeted at residents of the LSA and RSA. ■ The general contractor will hire an employment counselor for the course of construction, ideally of Aboriginal ancestry, whose role would be to recruit local employees and to provide on-site counseling services.	Primary
	Operation		■ Employ people from the local community to maintain and operate the Project once it is commissioned.	Primary
	Construction and Operation	Project construction and operation will result in increased opportunities for local businesses to participate on contracting opportunities.	■ Requirements of the General Contractor to optimize the participation of businesses/contractors owned or partially owned by BLFN. ■ Commitment to establish a fair and transparent subcontracting strategy that gives meaningful opportunities to Athabasca region contractors, subject to being commercially reasonable, SaskPower's legally required procurement policies and to each business's capacity and ability to deliver with respect to quality, timeliness, and cost competitiveness.	Primary
■ BLFN Project Income	Construction and Operation	Project construction and operation will result in income opportunities, including income associated with employment in addition to equity income resulting from BLFN's participation as a partner in the Project.	■ BLFN is consulting members to determine appropriate use of the new income for the community.	Primary

LSA = local study area; RSA = regional study area; BLFN = Black Lake First Nation; Project = Tazi Twé Hydroelectric Project

Each potential interaction is evaluated to determine if mitigation can be developed to remove or limit potential adverse interactions, in addition to identifying enhancement measures to improve positive effects on economy. Mitigation and enhancement measures include best practices, management policies and procedures, and features of the Terms of Reference (TOR) agreed to by the BLFN and the proponent. Knowledge of the socio-economic environment and mitigation or enhancement is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for a residual socio-economic effect on the economy.

Interactions are determined to be primary, secondary, or as having no linkage using scientific knowledge, professional judgement of technical specialists, logic, and experience with similar developments and mitigation. Each potential interaction is evaluated and classified as follows:

- no linkage - interaction is removed by mitigation so that the Project results in no detectable change to the socio-economic environment and, therefore, no residual effect on economy relative to baseline values;
- secondary - interaction could result in a minor change that is measurable to the socio-economic environment, but would have a negligible residual effect on economy relative to baseline values and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary - interaction is likely to result in a measurable change in the socio-economic environment that could contribute to a measurable or detectable residual effect on economy relative to baseline values.

Any interactions that require comprehensive assessment to determine if there is a residual socio-economic effect are considered to be primary interactions. Primary interactions require further analysis to determine the significance of the residual socio-economic effects. Project interactions determined as having no linkage or as secondary interactions are described where appropriate, however are not analysed further in the EIS.

18.4.1 Interactions with No Linkage to Effects

There are no Project interactions with economy that are considered as having no linkage.

18.4.2 Interactions with Secondary Linkages

There are no Project interactions with economy that are considered as secondary linkages.

18.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events are not likely to have meaningful implications for the VC economy.

18.4.4 Primary Interactions

Project interactions that are considered as primary interactions are as follows:

- project construction and operation will increase local education and training opportunities;
- project construction and operation will result in increased opportunities for employment within the LSA and RSA;
- project construction and operation will result in income opportunities, including income associated with employment in addition to equity income resulting from BLFN's participation as a partner in the Project; and

- project construction and operation will result in increased opportunities for local businesses to participate on contracting opportunities.

18.5 Residual Effects Analysis

The residual effects analysis considered all primary Project interactions that likely result in measureable environmental changes and residual effects on economy after implementing environmental design features, mitigation, and enhancement measures. The residual effects assessment is completed by calculating and estimating changes to measurement endpoints associated with the primary Project interactions. These measurement endpoints include changes to the following:

- education and training;
- employment;
- business and contracting; and
- income.

18.5.1 Changes to Economy

Changes to the economy, particularly in the LSA, are influenced by several factors. The current socio-economic conditions, including available labour force, education levels, local business capacity (Section 18.3.3) ultimately influence the ability of local residents and businesses to take advantage of and benefit from Project activities. Recognizing that there are capacity challenges in the LSA, the BLFN and the proponent are working together to enhance the potential for residents and businesses alike to participate in economic opportunities. Enhancement measures that are already in development include:

- development of the "Tazi Twé Employment and Training Charter" (hereafter "the Charter");
- requirements of the General Contractor to optimize the participation of workers, businesses, and contractors from BLFN members and businesses owned or partially owned by BLFN; and
- commitment to establish a fair and transparent subcontracting strategy that gives meaningful opportunities to Athabasca region contractors, subject to being commercially reasonable, SaskPower's legally required procurement policies and to each business's capacity and ability to deliver with respect to quality, timeliness, and cost competitiveness.

18.5.1.1 Education and Training

The Project has the potential to generate education and training opportunities associated with the construction and operation of the facility, particularly for BLFN members residing in the LSA. The BLFN and SaskPower, as partners in the Project, are working together to address the shortages of qualified labour locally through pre-employment training programs, on-the-job training, and strategies to retain employees. The Charter developed specifically for the Project outlines the key challenges and opportunities to enable the development of the local labour force. Strategies and measures are proposed in the Charter that will contribute to qualifying local residents for Project employment opportunities, increasing the number of qualified local residents while expanding the local labour force that can work on the Project and raise the potential for local employment on the Project. Expanding the qualified local labour force is a crucial catalyst for achieving increased levels of local employment. Prospects for local employment will be further strengthened by explicit local hiring preferences that will be applied to construction. The Charter proposes a very practical and reasonable approach to pre-employment training, building on the institutions, partnerships, strategies and programs that have been successfully developed in northern Saskatchewan to increase the capability of northern residents to participate in existing industrial employment opportunities, particularly the northern Saskatchewan uranium industry. Training opportunities generated by the Project will focus on five essential skills identified by Human Resources and Skills Development Canada including reading, writing, working with others, document use, and oral communication. Other designated skills include, problem solving, critical thinking, numeracy, and computer use. Northlands College commenced initial training opportunities in September 2013 at the facility in the community of Black Lake, sufficiently in advance of the Project so that individuals will be ready to begin work at the onset of construction. Agreements to fund initial training have already been secured with Aboriginal Affairs Northern Development Canada, Saskatchewan's Ministry of Economy, the Prince Albert Grand Council-Dené, and possible funding from Northern Career Quest. Additional training beyond 2013 will be re-evaluated as the Project advances through the environmental assessment process.

The Tazi Twé Training and Employment Program has identified 64 candidates ready for training, including recent high school graduates, mine workers who currently are seasonally employed, and others interested in employment. An additional eight candidates were selected as alternates for training programs. Activities completed in 2013 as part of the Tazi Twé Training and Employment Program are summarized in Appendix 18.1.

The Program includes many of the components of training programs that have been successfully applied in Northern Saskatchewan. The following are examples.

- A pre-employment training program will be deployed that is designed to prepare individuals for employment during construction through a combination of academic upgrading, industry safety training, and job readiness skills.
- During construction contractors will provide on the job training including small tool training, personal protective equipment (PPE) training, fall protection, rigging and crane signaling, lockout tagout training, confined space training, and cultural awareness orientation.

Contractors will be required to support apprenticeship-training programs and implement a craft-mentoring program that pairs trainees and apprentices with experienced craftsmen and foremen. In addition to the above programs that are focused primarily on construction opportunities, those individuals identified as potential candidates for operations employment will be required to successfully complete the SaskPower Hydro Station Operator Course.

18.5.1.2 Employment

Workforce requirements for the Project during construction, operation, and closure, will generate employment opportunities for residents of the LSA, residents from other parts of Saskatchewan, and potentially for some highly specialized positions from beyond the province. The analysis of employment effects focuses on the potential for residents of the LSA, and in particular for members of the BLFN, to attain Project employment.

During construction, the Project is estimated to generate 450 total person-years of employment, with 325 person-years attributed to designated trades[7], non-designated trades[8], and construction support, while the other 125 person-years attributed to mostly senior SaskPower and key contractor personnel. There will be some

[7] Designated trades are governed by regulations under provincial legislation that describe the standards and conditions for training in specific trades, including how to become an apprentice, curriculum content and certification or accreditation protocols.

[8] Non-designated trades are skilled occupations that are not governed by regulations under provincial legislation.

annual and seasonal variation in the number and types of workers required to construct the Project; at the peak of construction activities it is estimated that up to 250 people will be employed at the construction site.

The estimated Project employment for the construction of the Project is shown in Tables 18.5-1 and 18.5-2. Worker rotation systems and schedules will be implemented similar to what is employed for other industrial activities in Northern Saskatchewan (i.e., two-week work rotations). Most workers will work 10 to 12 hour days, 7 days a week with 14 days on shift, and have 7 days off between shifts.

The work force will fluctuate based on the season, with the lowest numbers in winter (Q1 and Q4) and peaks in summer (Q2 and Q3). Peak workforce numbers will be associated with construction activities in the summers of 2015, 2016, and 2017. The workforce estimates represent the maximum on-site workforce for the periods shown. The quarterly workforce estimates are based on estimates for the total number of craft positions required for the various activities on the Project plus supervisory positions (managers, engineers, superintendents, and foremen), which are calculated at a 4:1 ratio (craft position to supervisor).

During construction the workforce will include a local employment coordinator/liaison position from BLFN that is of Aboriginal/Métis ancestry. This individual would:

- be involved in recruitment of local employees. He/she would be directly connected to key contractor personnel engaged in recruitment and hiring and would be kept abreast of upcoming opportunities;
- provide on-site counselling services (or provide access to professional services) for all employees who may encounter problems with their work or home situations while working on the Project; and
- facilitate communication between the construction site staff and the communities, including keeping leadership apprised of activities or keeping individuals aware of why they may not have been successful.

The exact number of people employed during operations will be determined once the design of the power plant is finalized. However, based on similar facilities located in remote, northern regions, it is anticipated that between six and eight people could be required to operate the plant, with additional staff could be required during special projects such as maintenance and monitoring procedures.

There will be opportunities for employment of local residents for construction monitoring and post-construction follow-up monitoring programmes. The Proponent will be proactively seeking employees from the local community and will provide training opportunities for this work.

SaskPower will advertise several operations positions through SaskPower Human Resources and hire the most qualified individuals, with a preference for BLFN and Athabasca Region applicants. The following trades have been identified by SaskPower for the operational phase of the Tazi Twé Hydroelectric Station (TTHS):

- In-scope Foreman/Work leader (Journeyman Electrician or Electrical Engineering Technologist) - the in-scope supervisor position is typically filled with experienced tradespeople or technicians qualified at the journeyperson level;
- Journeyman Electricians;
- Journeyman Millwrights (Industrial Mechanics);
- Utility Persons - general labourer, storekeeper, or heavy equipment operator; and

- Hydro Station Operators.

During operations it is anticipated that the Project would follow a work rotation of Monday to Friday (37 1/3 hour work week) with a rotational "on call" shift for overnights and weekends and to be available to work extended hours during plant overhauls and during emergencies.

Table 18.5-1: Peak Construction Workforce Estimates for the Project

Positions	Job Description	2014 (Q4 Only)	2015	2016	2017
Field Positions	CAT 769/773 operator	0	15	15	6
	Truck Driver (concrete, transport)	2	6	6	2
	Loader Operators	1	4	4	2
	Back Hoe Operator	2	8	8	4
	Dozer, Grader Operators	1	4	4	4
	Crane Operator	1	3	3	3
	Boom Truck Operator	1	2	2	1
	Labourer	4	30	30	10
	Concrete Finisher	0	2	3	3
	First Aid Attendant	2	6	6	2
	Carpenter	4	20	20	10
	Electrician	0	2	6	6
	Millwright	0	0	6	6
	Batch Plant	1	2	2	2
	Surveyor	1	6	6	6
	Surveyor Rodman	1	6	6	6
	Mechanic	3	6	6	6
	Lube Person	2	4	4	4
	Driller	6	12	12	6
	Blaster (Surface)	3	3	3	3
	Powder Men (Surface)	3	3	3	3
Clerical	Reception	1	1	1	1
	Office Clerk	1	1	1	1
	Engineer Student	2	2	2	2
Subcontractor Positions	Cooks	2	4	4	4
	Housekeeping	4	6	6	6
	Jumbo Driller	6	6	6	6
	Blaster (underground)	3	3	3	3
	Powder Men (Underground)	3	3	3	3
	Rig Welder	0	0	2	2
	CAT 769/773 operator	4	4	4	4
	Back Hoe Operator	1	1	1	1
	Dozer, Grader Operators	1	1	1	1
	Electrician	0	0	8	8
	Rebar Placer	0	20	10	0
Total Craft Positions		***66***	***196***	***207***	***137***
Total Craft and Supervisory (4:1)		***83***	***245***	***259***	***171***

Table 18.5-2: Tazi Twé Projected Quarterly Workforce Estimates

Quarterly Workforce Estimates	2014 (Q4 Only)	2015	2016	2017
Q2 and Q3 (peak workforce)	n/a	245	259	171
Q1 and Q4 (off-season)	33	98	104	69

n/a = not applicable

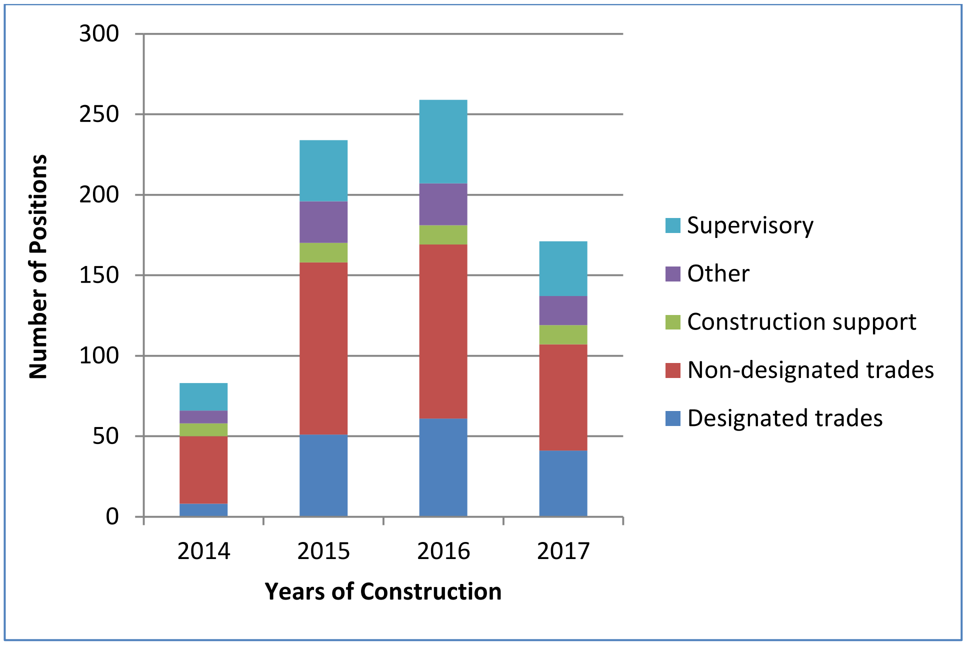
18.5.1.3 Project Employment

There are two main factors that influence the ability of residents of the LSA to access employment opportunities. The first factor is the ability of residents of the LSA to access employment is qualifications. Most of the jobs available during Project construction require some level of education, and in many instances require skilled and technical capabilities. The second factor is attraction, or the relative appeal of the Project compared to other opportunities. People may be attracted to work on the Project based on the opportunities for employment and associated income, in addition to the relative proximity of the Project to peoples' home communities. There are few direct employment opportunities in the communities of the LSA and the construction of the Project represents an opportunity where people would otherwise need to travel away from home.

Figure 18.5-1 shows the breakdown of the general types of positions that will be available during construction of the Project. During each year of construction, most of jobs fall into the category of non-designated trades, or positions considered as trades or skilled occupations that are not governed under provincial regulations. This means that some level of skill is required for the position; however, it does not fall under provincial standards and conditions (e.g., curriculum content, certification, and accreditation protocols, including apprenticeships) or what is referred to as designated trades.

The next largest job categories are designated trades, which in most years of construction account for between close to 22% and 24% of the workforce, followed closely by supervisory positions, which account for between 16% and 20% of the annual workforce. It is likely that the majority of supervisory positions will be filled with workers from outside the LSA, with positions many being filled by the proponent and the general contractor. The smallest proportion of the workforce is construction support positions, which account for less than 10% of the annual workforce. However, these positions are required throughout the course of the entire Project and will not vary considerably by season. Although Saskatchewan has no recent examples of hydroelectric development to gauge the proportion of northern Saskatchewan residents that is likely to attain construction employment, construction in the uranium mining industry has enough similarities with the Project to provide an indication of the likelihood of local participation in the workforce. Recent uranium mining experience suggests that during construction, anywhere from 25% to 45% of the workforce can be sourced from northern Saskatchewan, with residents of Saskatchewan's north most likely to fill positions in the non-designated trades and construction support opportunities (Junor pers. comm. 2012). Applying this information to the Project suggests that at the peak of construction approximately 65 to 120 residents of Saskatchewan's north, including residents of the LSA, could be employed by the Project.

Figure 18.5-1: Jobs Created by Project Construction



Uranium mining employment in northern Saskatchewan also provides an indicator of the job qualifications of local residents. Since the early 1990s, residents of Saskatchewan's north have dominated entry-level job categories such as equipment operators, mill operators, and support services (Northern Labour Market Committee 2008). From 1992 to 2007, the number of northerners employed in advanced positions such as supervisory roles, trades, and professional positions in the uranium mining industry has increased substantially. However, northern residents still represented a lower proportion of overall employment compared to their southern counterparts (InterGroup 2013). Based on this basic understanding of employment trends, it can be assumed that similar trends might apply to construction employment, with entry-level positions such as the undesignated trades and construction support more likely to be filled by local residents. Certain jobs such as labourers, office clerks, cooks, and housekeeping could be filled entirely by local residents.

Furthermore, it is likely that some individuals in the LSA have the necessary skills to participate in a more skilled position, such as carpentry and other trades; however, these individuals are more likely to be employed in other opportunities. Members of BLFN and residents of the Northern Hamlet of Stony Rapids with the qualifications for more skilled opportunities are likely already employed, and might need to consider whether leaving their current permanent positions (e.g., in the uranium mining industry) is a worthwhile pursuit. The ability to reside in their home communities may be a factor in attracting skilled labour from the LSA to the construction site.

To facilitate the employment of qualified residents from Black Lake and other communities in the Athabasca region during construction, the proponent, in cooperation with the contractor, will provide hiring preferences. Preferential hiring priority during construction will include:

- first preferences to BLFN members;
- second preference to residents of the Athabasca region; and
- third preference to residents of Saskatchewan.

The success of programs identified in the Tazi Twé Employment and Training Charter, which identifies a potential 64 candidates for training opportunities, will also influence the overall likelihood of BLFN members participating in the construction workforce.

Furthermore, the proponent will work with the general contractor on recruitment and retention strategies. This will include on-the-job training targeted at residents hired from the LSA and RSA. Furthermore, the contractor will hire an employment counselor from BLFN of Aboriginal or Métis ancestry for the course of construction whose role would be twofold:

- assist with recruitment of local employees. He/she would be directly connected to key contractor personnel engaged in recruitment and hiring, and would be kept abreast of upcoming opportunities; and
- provide on-site counseling services (and or provide access to professional services) to all employees who may encounter problems with their work or home situations while working on the Project.

This individual could play a role in communicating between the construction site and the communities, including keeping leadership apprised of activities, or individuals aware of why they may not have been successful in applying for jobs. Additional strategies to support worker retention include providing local construction employees with the option of residing at the construction camp, as opposed to having to commute to and from the construction site daily.

With the above measures in place, a conservative estimate that somewhere between 20% and 50% of the 65 to 120 jobs could be filled by residents of the LSA, or at peak construction, between 24 and 60 people. While these are short-term jobs, they provide important benefits to these communities with limited job opportunities and high rates of unemployment, particularly in Black Lake (see Table 18.3-2). Furthermore, with some projects in northern Saskatchewan winding down (e.g., such as construction at the Cigar Lake Operation and the decommissioning of the Gunnar and Lorado sites near Lake Athabasca) the employment opportunities provided by the Project may fill some regional employment needs in the short-term.

As with all major construction projects, Project-related construction employment levels will increase and decline throughout the course of construction and will cease eventually, contributing to a minor “boom and bust” situation. During the “bust”, unemployment levels are likely to return to similar conditions found in the existing environment. However, the experience acquired from working on the Project will have a lasting effect, contributing to an increase in the future employability of participating local residents.

It is the intent of the Proponent to train and employ people from the local community to maintain and operate the powerhouse once it is commissioned. The construction phase will provide the opportunity to identify residents of the LSA to target for operations employment. Individuals demonstrating aptitude will be recruited during the construction phase, and will be sent to other hydroelectric facilities in Saskatchewan for on-the-job training. This will provide individuals with the opportunity to train in a working and operating environment similar to the Project. It is anticipated that a total of six to eight full-time permanent jobs will be created for Project operation, which for the purposes of the assessment, is anticipated to last for about 90 years. The operational workforce requirements will be consistent with SaskPower’s requirements for power plant operation with additional staff potentially required during special projects, such as maintenance and monitoring procedures. Although the number of job number is small, it represents an important contribution to employment opportunities, which are otherwise limited in the LSA (Table 18.5-1), particularly in the community of Black Lake where there are few jobs available locally relative to the size of the population.

18.5.1.4 Contracting

Construction represents a large opportunity for contracting opportunities with an estimated $300 to 400 million or more in contracts available. There will be three major contracts associated with Project construction, including the General Contractor for the overall construction of the facility, the power tunnel contract, and the turbine and generator contract. The Proponent is committed to maximizing opportunities for Aboriginal individuals and businesses from the Athabasca region for the supply of goods and services during Project construction and operation, subject to the availability and capacity of suppliers to deliver with respect to quality, timeliness, and cost. The General Contractor will develop a strategy to facilitate the participation of businesses from northern Saskatchewan, including local Aboriginal and community contractors.

Subcontractor opportunities may be filled within the LSA or by businesses that are owned in part by BLFN and the Northern Hamlet of Stony Rapids. Locally owned companies that have the potential capacity to participate in contracting opportunities include the Athabasca Enterprise Region Corporation and the ABDLP (discussed in Section 18.3.3). As stakeholders in the ABDLP, the Northern Hamlet of Stony Rapids and BLFN have part ownership of companies that provide services such as cooking, housekeeping, blasting and drilling, and heavy equipment operation. For example, ABDLP owns Points Athabasca Contracting Limited Partnership, a company with considerable experience derived from its participation in mining activities. Black Lake is also a part owner in other businesses that work and create capacity in northern Saskatchewan, including Athabasca Catering and Pronto Airways. As such, both communities in the LSA, in addition to communities in the RSA who are also stakeholders in the Athabasca Enterprise Region Corporation and the ABDLP, are likely to benefit from the contracting opportunities associated with Project construction.

During operation of the Project, there will be fewer opportunities for contracting; however, a small number of activities (e.g., road maintenance and clearing, and sewage hauling) could be sourced locally.

18.5.1.5 Income

The Project will generate two sources of income: income associated with employment during construction and operation and equity income and other payments to BLFN through their partnership in the Project.

18.5.1.5.1 Employment Income

During construction, the estimated 450 person years of employment will result in income opportunities for those participating in job opportunities. Based on the types of positions available, a weighted average income for the construction phase estimates that approximately $87 million will be generated in wages, a portion of which will go to employees of the LSA.

During operations approximately six to eight positions will be created. SaskPower's base salary range for northern operations is between $75,000 and $80,000 annually, plus applicable overtime. This represents a meaningful income opportunity for local residents who are qualified to work in operations jobs. The Proponent intends to train and employ people from the LSA to maintain and operate the powerhouse once it is commissioned (Section 18.5.1.2).

18.5.1.5.2 Partnership Income

The BLFN, through the EFHLP, will hold 30% interest in the Project, with SaskPower holding the remaining 70% interest. Once the third party loans for its share of the equity in the Project are paid, SaskPower would favourably consider increasing BLFN equity in the Project to as much as 49%, subject to SaskPower's ownership policies applicable at that time. As an owner, BLFN will receive monthly cash distributions from the

Project based on its contributed equity, which in the early years of operations will be largely used to pay for equity loans. While the amount of these distributions is confidential, it will be sizeable and add substantially to the income base of BLFN once the equity loans are paid.

Further to this, Canada, on behalf of BLFN, would lease to the Project the necessary lands and would provide registered right of ways for access and the transmission line. These leases and right of ways would result in annual payments to the BLFN (or a trust established by the BLFN). In addition, community services payment would be paid annually. Finally, an initial investment in the Trust will also be established for approved BLFN community purposes to reflect the value of community support for the Project and the on-going relationship between SaskPower and BLFN.

All income (i.e., net of equity financing costs) resulting from BLFN partnership in the Project will result in new income for community purposes. In August of 2013, BLFN undertook a survey of all households in Black Lake to determine the eligible purposes of the Tazi Twé Hydro Trust, including seeking inputs on the management, administration and reporting for the Trust. The confidential results of the survey will be used by the community to identify priority areas for use of community income.

18.5.2 Management of Uncertainty

"There are few clear significance thresholds for economic impacts" (Lawrence 2004) and interpreting the effects of a proposed development remains subjective. Like all scientific results and inference, residual effects predictions will have uncertainty associated with the data and current knowledge of the system. The confidence in residual effect predictions is related to the following:

- adequacy of baseline data for understanding conditions in the local and regional study areas;
- the understanding of Project-related residual effects on the system; and
- knowledge of the effectiveness of environmental design features and mitigation at limiting effects.

Sources of uncertainty that affected employment predictions included a lack of precise understanding of the number of local residents with the qualifications to fill Project jobs, inability to determine confidently the extent to which the qualified workforce will want to work on the Project or leave their current job, and the scale and effectiveness of pre-Project training programs. Furthermore, the assessment was not able to determine precisely the number and type of businesses that will be hired from within the LSA, the Athabasca communities, and beyond the Athabasca communities.

Uncertainty was addressed by incorporating information from available and relevant literature, interviews with local people, and inputs from the public involvement process. Consideration was given to other comparable projects and industries in northern Saskatchewan. Where applicable, ranges were presented to demonstrate that a range of outcomes is possible. Conservative estimates were used for determining the likelihood of employment, business, and income to be allocated to the LSA so that positive residual effects were not overestimated.

With respect to economy, the single most beneficial effect is the income to BLFN that will result from equity and negotiated lease payments. This represents a flow of income to the community that will be managed through the Tazi Twé Trust. Although the exact value of this income has not been estimated, the income will be substantial and represents an opportunity to improve the community over many generations.

18.6 Determination of Significance

The changes in measurement endpoints associated with primary interactions provide the foundation for determining significance from the Project on economy. Direction, magnitude, duration and geographic extent, are the main factors of consideration used to predict significance. For economy, the assessment of significance considers the scale of these factors, in addition to professional opinion, which is based upon the context of the Project in combination with other relevant experience. The assessment of significance also analyzes the efficacy of the proposed mitigation and enhancement measures to limit residual adverse effects and increase potential benefits to economy. The determination of significance assessment considers all primary interactions that are expected to result in residual socio-economic effects on economy.

Frequency is not considered in evaluating the significance of residual socio-economic effects on economy. For socio-economic changes, the residual socio-economic effects are generally continuous; therefore, the criterion frequency is typically not used. Similarly, reversibility is not used, as effects on the socio-economic environment associated with a project are typically part of an ongoing process of interdependent economic and social change extending into the future. These effects generally cannot be reversed to pre-project development conditions (e.g., even if employment ends with construction, the skills gained during employment may be applicable to future opportunities, making it easier to find a job).

18.6.1 Residual Effects Criteria

Table 18.6-1 describes the criteria used when evaluating effects on economy.

Table 18.6-1: Residual Effects Criteria for Economy

Direction	Magnitude	Duration	Geographic Extent
Negative: An adverse effect relative to the existing environment **Positive:** A beneficial effect relative to the existing environment	**Low:** Effects are likely to result in a small, hardly discernible change relative to the existing environment **Moderate:** Effects are likely to result in a noticeable or detectable change relative to the existing environment **High:** Effects would be likely to result in a large, meaningful, and readily detectable change relative to the existing environment	**Short-term:** Changes will only occur during the construction phase **Medium-term:** Changes will extend to the first 10 years of operation of the Project, or for one generation relative to economy **Long-term:** Changes will last for more than 10 years, or for more than one generation relative to economy	**Local:** Changes would affect communities in the LSA including the communities Black Lake and Stony Rapids. **Regional:** Changes would extend to the RSA including the Athabasca region and to Saskatchewan as a whole. **Beyond Regional:** Changes would extend to areas beyond Saskatchewan.

LSA = local study area; RSA = regional study area

Direction – Direction refers to the overall nature of the effect. A negative effect would be one where there is an adverse effect on the VC, relative to the existing environment. A positive rating anticipates that the socio-economic effect will be of benefit to the VC relative to the existing environment.

Magnitude - Magnitude refers to the degree of change in a measurement endpoint and the resulting residual socio-economic effect on economy. Magnitude may be low, moderate, or high. Low magnitude predicts a small, but hardly discernible socio-economic effect on natural, cultural, and social features of the environment. A moderate rating anticipates that socio-economic effects on a VC are likely to result in noticeable change relative to the existing environment. High magnitude suggests that the change will be large and meaningful relative to the existing environment.

Duration - Duration is defined as the amount of time that economy is exposed to Project activities or phases. Short-term effects are anticipated to occur over the course of construction only. Medium-term effects are those changes anticipated to last for the first ten years of Project operation, or for one human generation. Long-term effects are expected to last more than 10 years, or for more than one human generation relative to economy.

Geographic Extent - Geographic extent considers the location in which effects are likely to be measurable relative to the existing environment. A local rating anticipates that effects will be measurable in the communities of Black Lake and Stony Rapids, or the LSA. A regional rating anticipated that changes would extend beyond the local area, and be measurable within the RSA (i.e., the Athabasca region or in other parts of Saskatchewan). A beyond regional rating anticipates that effects on economy would occur beyond Saskatchewan.

18.6.2 Project-specific Residual Effects

The analysis of residual effects on economy considers several relevant indicators including potential changes to education and training, employment, contracting and businesses, and to income (both individual and community). In most instances, the overall magnitude of effects is expected to be most discernible during the construction phase, when training and employment opportunities will be the greatest. However, the effects from operation are most likely to produce meaningful outcomes for the community, be it through long-term permanent employment opportunities, or through the equity associated with BLFN's partnership in the Project.

Based on the analysis of effects described in Section 18.5 of this EIS, effects on economy are expected to result in a noticeable or detectable positive change relative to the existing environment. Residual effects are predicted to be, long-term in duration and regional in geographic extent. Depending upon how equity and other Project income is spent by the BLFN, the magnitude of these effects may even be higher, and is likely to represent a significant source of improvement to various measurement endpoints for economy. Overall, there is no significant adverse effect of the Project on economy.

18.6.3 Cumulative Residual Effects

Cumulative effects are those effects from the Project, combined with the effects from prior development, existing activities, and reasonably foreseeable future developments that are sufficiently certain to proceed. Reasonably foreseeable developments or designated projects that would be included in the EIS are activities or projects that:

- would be developed in the spatial and temporal boundaries of the Project;
- have been proposed and scoped to a reasonable level of detail;
- could be induced by the Project;

- are currently undergoing regulatory review; and
- have the potential to change the Project or the effects predictions.

For economy, numerous existing and potential projects have the potential to overlap with the Project, particularly given that the geographic extent of the RSA extends to the entire province of Saskatchewan. A complete list of potential projects has not been examined, however would include projects such as northern uranium mining operations, and proposed mines in northern Saskatchewan. Conceptually, the issues in relation to economy, particularly the local economy, result from the fact that additional projects or developments represent opportunity and competition for local resources (e.g., employment or contracting). Cumulative effects on the economy would translate into higher levels of local and regional employment and business opportunities. These higher levels of economic activity, while beneficial overall, could place additional demands on the local and regional workforce and businesses, and could lead to capacity challenges, particularly in the LSA. However, this could result in additional benefits in the RSA. Given the overall positive nature of effects on economy, no significant adverse effects from the Project, combined with existing and reasonably foreseeable developments on economy are predicted.

18.7 On-going Engagement

A Project Advisory Committee, including equal representation from the EFHLP and SaskPower will meet at least monthly or as otherwise agreed to by the Committee, and will review the status of the Project including environmental, engineering and construction activities including community matters that relate to the completion of the Project. It is anticipated that this committee will discussion on-going concerns about socio-economic effects and that the proponent will work on measures to address any community concerns.

With respect to the longer-term effects associated with Project operation, the BLFN may want to consider monitoring the investment of their equity and the associated outcomes for the community.

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18.9 Glossary

Term	Description
Cumulative Effects	Cumulative effects are changes to the environment that are caused by an action in combination with other past, present and future human actions.)
Employment Income	Employment income can consist of amounts you receive as salary, wages, commissions, bonuses, tips, gratuities, and honoraria.
Environmental Impact Statement	A report that documents the information required to evaluate the environmental effect of a project.
Residual Effects	Residual effects include all primary Project interactions that result in measureable environmental changes after implementing environmental design features, mitigation, and enhancement measures.

18.10 List of Acronyms

Term	Definition
ABDLP	Athabasca Basin Development Limited Partnership
AERC	Athabasca Enterprise Region Corporation
BLFN	Black Lake First Nation
EFHLP	Elizabeth Falls Hydroelectric Limited Partnership
EIS	Environmental Impact Statement
INAC	Indian and Northern Affairs Canada
KPI	Key Person Interview
LSA	Local Study Area
NLSD	Northern Lights School Division
ND	No Date
OJT	on-the-job training
Project	Tazi Twé Hydroelectric Project
RSA	regional study area
SATCC	Saskatchewan Apprenticeship and Trade Certification Commission
TTHS	Tazi Twé Hydroelectric Station
VC	valued component

18.11 List of Units

Term	Definition
$	dollar
km	kilometre
%	percent

19.0 INFRASTRUCTURE AND COMMUNITY SERVICES

19.1 Introduction

The purpose of this section is to describe the socio-economic environment that can be affected by the Tazi Twé Hydroelectric Project (Project) and to assess the effects on infrastructure and community services. Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples, and the public. The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. During engagement sessions, local Aboriginal groups and community members expressed interest in increased traffic volume on local access roads from the Project. As such, infrastructure and community services were selected as a VC for this Environmental Impact Statement (EIS).

This section presents an overview of infrastructure and services available near the Project, including consideration of transportation infrastructure and services (including road and air transportation) and community facilities and services (including education, health, water and waste management, and emergency services) and housing. Additional details on existing community infrastructure and services are found in Annex VI Socio-economic Environment.

19.2 Spatial Boundaries

The local study area (LSA) for infrastructure and services encompasses the communities of Black Lake (including reserve land) and Stony Rapids, and the section of Highway 905 that links the two communities. These are the areas that are most likely to be affected by the Project and its activities, for example through the influx of a non-local construction workforce, or through Project-related traffic. The regional study area (RSA) is where there will be Project related traffic, specifically Highway 905, with a focus on the area north of Points North Landing, a section of road often referred to as the Athabasca Seasonal Road.

19.3 Existing Environment

The primary sources of information for this section are a Key Person Interview (KPI) program completed in 2011 to 2013 in Black Lake First Nation (BLFN) and the Northern Hamlet of Stony Rapids, and Saskatchewan Ministry of Highways and Infrastructure. Other sources of information include community-related websites, federal and provincial government websites, and reports on northern Saskatchewan.

The community of Black Lake and the Northern Hamlet of Stony Rapids are located in a remote and sparsely populated area in the far north of Saskatchewan commonly referred to as the Athabasca Region (Northern Hamlet of Stony Rapids 2011). The community and hamlet are located in an isolated region of Saskatchewan that is only accessible by air and seasonal road. Access beyond the Northern Hamlet of Stony Rapids towards Fond du Lac is only available by winter road or barge. Air transportation is the only way to access the region year around. Services are limited, with long distances between communities and southern urban centres.

The BLFN is a Dené First Nation with members residing on the reserve and in other locations. The BLFN has three registered reserve locations; two are unpopulated. The reserve parcels have permanent, seasonal, or historical ties to the community and include the following:

- Chicken 224 – populated – 25,819.4 hectares (ha; Federal Order-in-Council [OIC] 1978-1647);
- Chicken 225 – no resident population – 2,193.4 ha (Federal OIC 1970-1822); and

- Chicken 226 – no resident population – 4,216.9 ha (Federal OIC 1970-1657) (Aboriginal Affairs and Northern Development Canada [AANDC] 2012a).

The Chicken 224 Reserve parcel includes an earlier settlement at Stony Lake, as well as the current settlement of the Black Lake community. The reserve extends to an area just east of Stony Rapids, where several BLFN homes are located.

The Northern Hamlet of Stony Rapids, a municipal community administered under the jurisdiction of the *Northern Municipalities Act,* is located on the Fond du Lac River, about 22 kilometres (km) north-west of the community of Black Lake, connected by an all-weather section of Highway 905. The two communities are historically interconnected, but are separate administrative entities. They share some of the same infrastructure and services, including an airport, a landfill, and medical facilities. The Northern Hamlet of Stony Rapids is a central hub for the Athabasca region (Black Lake and Stony Rapids KPI Program 2012).

19.3.1 Transportation Infrastructure and Services

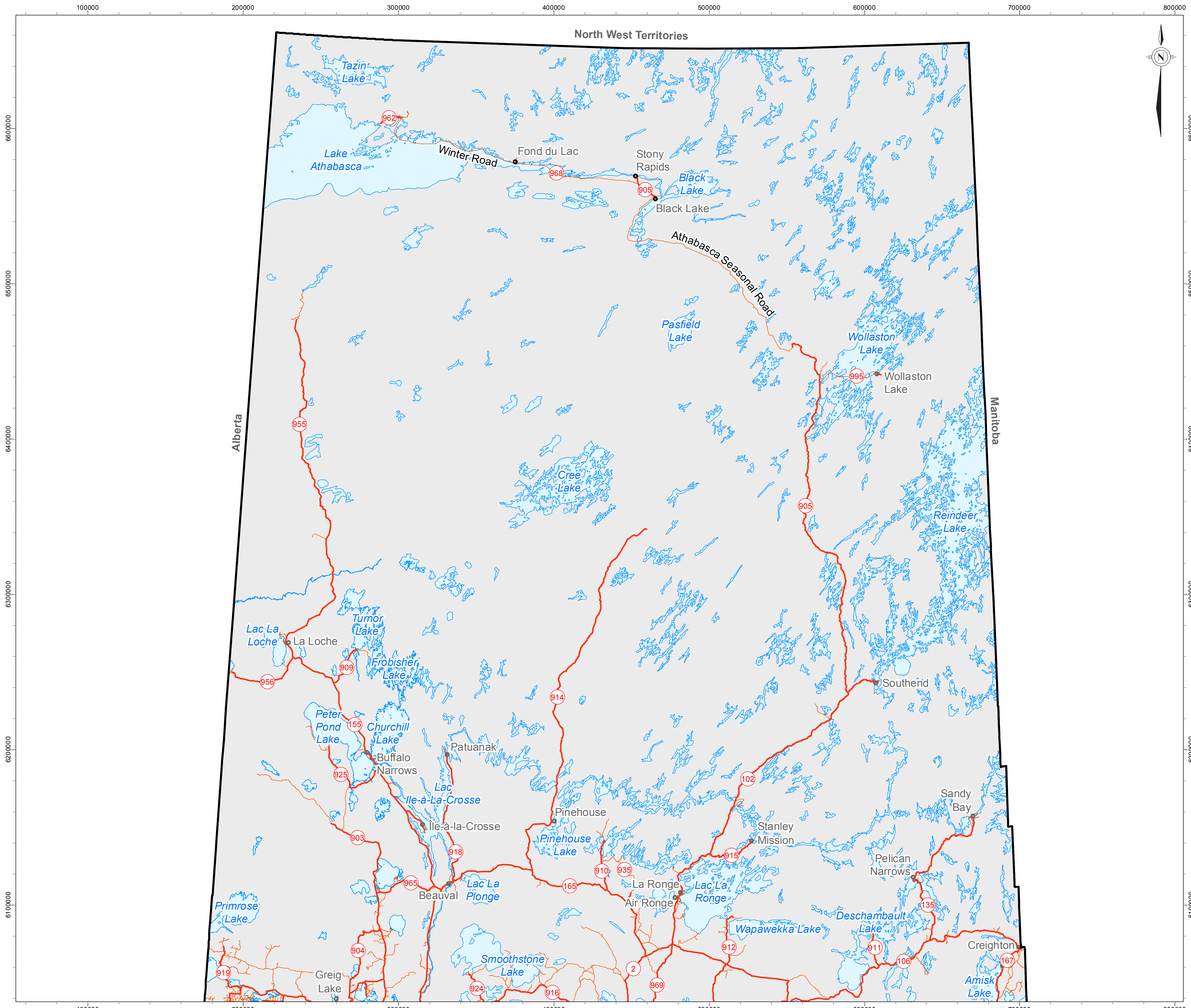
19.3.1.1 Road Infrastructure

Road access to the Athabasca region of northern Saskatchewan in the RSA originates at Highway 102, which extends north from La Ronge to its terminus in Southend. Highway 905 branches north off Highway 102 near Southend and ends at the Northern Hamlet of Stony Rapids as shown in Figure 19.3-1.

The Black Lake to Points North Landing portion of Highway 905, a seasonal, gravel highway, is referred to as the Athabasca Seasonal Road. This portion of Highway 905 was built in the late 1990s and completed in 1999 (MOE 2010). Since it was built, no major work has been completed on the road (Hoehn pers. comm. 2012). The Athabasca Seasonal Road provides improved access to communities in the Athabasca Region beyond the short season provided by the previous winter road. The total length of this section of Highway 905 is approximately 185 km (Saskatchewan Government Insurance [SGI] 2012). This portion of the Athabasca Seasonal Road is typically subject to closure each year due to spring break-up from the middle of April to the middle of May (Hoehn pers. comm. 2012).

Athabasca region community members, suppliers, businesses, mining exploration teams, and others use the Athabasca Seasonal Road throughout the year, often during the partial closure period. The road occurs through very rough terrain, with many large stones, bedrock, and occasional soft spots. It is recommended that only half-ton trucks and four-wheel drive vehicles travel the road in the off-season, with an average a speed of 40 kilometres per hour (km/h). The condition of the road improves during the winter months, when the ground is frozen and rough spots are evened out by packed snow (Hoehn pers. comm. 2012).

Travel on Highway 905 is restricted to a maximum gross vehicle weight (GVW) of 41,500 kilograms (kg) year around due to weight restrictions on all bridges (Ministry of Highways and Infrastructure 2013a). A further restriction is the height and width of the Churchill River Bridge on Highway 102 and the width of bridges along Highway 905 (Ministry of Highways and Infrastructure 2012). Local residents talked about the challenges of travelling Highway 905 between the communities of Black Lake and Points North in the spring and fall seasons as the road is “softer” than during the winter (Black Lake and Stony Rapids KPI Program 2011-2013).



LEGEND

- VILLAGE
- HIGHWAY
- ROAD
- WATERBODY

REFERENCE

CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

50 0 50
SCALE 1:2,500,000 KILOMETRES

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

PROVINCIAL HIGHWAYS IN NORTHERN SASKATCHEWAN

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004		FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	SM/LMR	28/06/13	**FIGURE: 19.3-1**
CHECK	KD	24/07/13	
REVIEW	HS	25/06/13	

The Ministry of Highways and Infrastructure issues annual fleet permits to carriers operating on Highway 905. For the carriers granted the permit, it effectively changes the designation of Highway 905 to a primary weight highway, which increases accessibility and reduces costs for transporting goods to northern Saskatchewan. The permit is required for transport trucks that exceed 41,500 kg in GVW on Highway 905 from July 1 to March 30 of the following year. From April 1 to June 20, vehicle weights revert to regulated limits for secondary weight highways (Ministry of Highways and Infrastructure 2013a; 2013b).

Formerly Highway 964, the Black Lake to Stony Rapids portion of Highway 905, located in the LSA, is an all-weather gravel highway. The total length of this section of Highway 905 is approximately 22 km (SGI 2012). In the snow-free season, this portion of Highway 905 is bladed and graded as required, which often depends on environmental conditions. During the winter months, this portion of Highway 905 receives a high level of snow removal service since the maintenance crew is locally based in the Northern Hamlet of Stony Rapids. Other maintenance, such as ice control using sand mixed with road salt, is performed on an as-needed basis. Calcium chloride is applied to this portion of Highway 905 for dust suppression at least once every year during the snow-free season (Toutsaint pers. comm. 2012).

A winter road between the communities of Stony Rapids and Fond du Lac is established every year and continuing from Fond du Lac to Uranium City (Black Lake and Stony Rapids KPI Program 2011-2013). A potential future project is upgrading part of this road to an all-weather road and building an additional section of an all-weather road that would terminate on the south shore of Lake Athabasca, providing access to the community of Fond du Lac by ferry or winter road (Ministry of Highways and Infrastructure 2010).

19.3.1.2 Traffic

While the Athabasca Seasonal Road is used throughout the year despite spring closures, conditions of the road vary by season and weather conditions. There is seasonal variation in traffic volumes, with the Average Annual Daily Traffic (AADT) much lower than 20 vehicles in the spring, summer, and fall, and at least double in the winter months when the ice road to Fond du Lac and Uranium City, and Camsell Portage is in operation (Guitard pers. Comm. 2013). According to Ministry of Highways and Infrastructure data, most the traffic (75 percent [%] or 15 vehicles per day) is personal vehicles with a variety of transport trucks making up the remainder (25% or 5 trucks per day). The traffic between the communities of Black Lake and Stony Rapids is mostly personal vehicles (about 83% to 88% or 100 to 150 personal vehicles) with transport trucks making up the remainder (12% to 17% or 20 trucks per day; Muhr pers. comm. 2012).

The Ministry of Highways and Infrastructure does not conduct regular traffic counts on northern highways because of the relatively low traffic density. The current practice by Ministry of Highways and Infrastructure is to use portable vehicle classifiers (PVCs) to count traffic volumes on an occasional basis. These PVCs are placed across the entire roadway, counting vehicles traveling in both directions for 48 hours. The Ministry of Highways and Infrastructure staff use data received from these counts, traffic data acquired in earlier years, and known travel patterns on other similar highways to produce estimated AADT volumes for northern highways (Anderson pers. comm. 2010).

Table 19.3-1 presents AADT estimates for total traffic on the Athabasca Season Road (Highway 905) and the section between the communities of Black Lake and Stony Rapids. The level of traffic on the Athabasca Seasonal Road is quite low compared to traffic on highways in other regions of Saskatchewan. The section of Highway 905 between the communities of Black Lake and Stony Rapids has the highest level of traffic. Traffic data also showed that transport trucks account for a portion of the overall traffic, with a transport truck average annual daily count between five and twenty, depending on the section of road.

Table 19.3-1: Traffic Data for Provincial Highway 905 from Points North Landing to Stony Rapids

Control Section	Location Description	Average Daily Traffic (ADT)[a]
CS905-05	Points North Landing to Hawkrock River Bridge	20
CS905-06	Hawkrock River Bridge to Black Lake Access	20
CS905-07 south section	Black Lake Access to Highway 966 (Fond du Lac Winter Road)	132
CS905-07 north section	Highway 966 (Fond du Lac Winter Road) to Stony Rapids Access	132

Source: Muhr pers. comm. 2012; Brenner pers. com. 2013

[a] AADT: Annual Average Daily Traffic; the average 24-hour traffic volume for one year.

The Stony Rapids detachment of the Royal Canadian Mounted Police (RCMP) carries out periodic roadside checks on vehicles coming into the Black Lake and Stony Rapids area. The detachment does not have a radar system; it was noted that the road conditions make it difficult to speed. Typically, accidents are the result of driver error (Black Lake and Stony Rapids KPI Program 2011-2013).

19.3.1.3 Air Traffic and Airport Facilities

The communities of Black Lake and Stony Rapids are served by an airport in Stony Rapids (CYSF), which is one of 18 airports in northern Saskatchewan owned and operated by the Ministry of Highways and Infrastructure. The runway at the Stony Rapids airport has a treated gravel surface, is 1.5 km long and 30 m wide, and has runway lighting. Runway maintenance is conducted by Ministry of Highways and Infrastructure (Black Lake and Stony Rapids KPI Program 2011-2013). The airport is also used as a base for MOE's water bomber aircraft, is a stopover point for smaller aircraft, and provides a commercial fuel service (Ministry of Highways and Infrastructure 2002).

Scheduled passenger flights into the Northern Hamlet Stony Rapids are available from Pronto Airways and Transwest Air. Combined, these airlines offer daily flights to and from southern Saskatchewan, including Saskatoon. The airlines also offer flights to Fond du Lac, La Ronge, Points North, Prince Albert, Uranium City, and Wollaston Lake (Pronto Airways 2012a; Transwest Air 2012). Chartered airplanes and helicopters use the airport for regularly scheduled charter flights that transport workers to mine sites in northern Saskatchewan. On average approximately 30 aircraft per day (Statistics Canada 2013) use the Stony Rapids Airport making it one of the busiest airports in Saskatchewan (Saskatchewan Aviation Council 2012)?

Stony Rapids has a Water Aerodrome Seaplane Base (CKW5) on the Fond du Lac River immediately north of the community and there is a Water Aerodrome Seaplane Base (CJZ6) at Camp Grayling, on Black Lake at the outflow of the Fond du Lac River. Docks on the Stony Rapids waterfront allow charter companies to access the community (Airport Guide 2012).

19.3.2 Community Infrastructure and Services

19.3.2.1 Local Businesses

There are a few local retail and hospitality service businesses in the communities of Black Lake and Stony Rapids, (Northern Saskatchewan Business Directory 2013) including the following:

- Medal's Enterprises Gas Bar and convenience store in Black Lake;
- Northern Store in Black Lake;

- Camp Grayling;
- Al's Place, motel and restaurant in Stony Rapids;
- Northern Store in Stony Rapids;
- Scott's General Store (also provides expediting services) in Stony Rapids; and
- Whitewater Inn and Waterfront Lodge in Stony Rapids.

There are also several construction and contracting companies including

- E & L Enterprises in Black Lake;
- Medal's Contracting in Black Lake;
- Torson Contracting in Stony Rapids;
- Athabasca Fuel Services in Stony Rapids; and
- A & L Transport in Stony Rapids.

19.3.2.2 Education Facilities and Services

The Father Porte Memorial Dené School in the community of Black Lake, a First Nation school funded by the federal government, is a kindergarten to grade 12 school with approximately 50 staff and 410 full-time students during the 2011-2012 school year. The school currently provides Dené cultural programming for all students. All grade levels participate in an organized Dené-language program. The school has an annual cultural camp near the community that provides instruction to all grade levels in traditional activities. The school has a daycare as well as a Headstart program. The daycare is housed outside of school property, near the band office, while the Headstart program is in the school. There are plans to move the daycare services onto school property (Black Lake and Stony Rapids KPI Program 2011-2013). Adult education programs, which are funded by Northlands College and the Prince Albert Grand Council (PAGC), are offered in the community throughout the school year (Black Lake and Stony Rapids KPI Program 2011-2013).

The Stony Rapids School, part of the Northern Lights School Division (NLSD), is located in the Northern Hamlet Stony Rapids offering kindergarten to grade nine, with approximately 9 staff and 67 students in the 2011-2012 school year (NLSD 2013). The school has five large classrooms, a library, a gym, and an industrial arts shop (Black Lake and Stony Rapids KPI Program 2011-2013; NLSD, No Date [ND]). The gym is often used for community activities and the industrial arts shop is currently used for storage. One of the five classrooms is currently used as a daycare for infants. Since the Stony Rapids School does not offer grades 10 to 12, students wanting to complete the high school curriculum attend Father Porte Memorial Dené School in Black Lake or a school in a community further south such as La Ronge or Prince Albert.

Northlands College has a small training facility in Black Lake that offers training and adult education programs when a need is identified and funding is available. The BLFN has had members participate in the Northern Teacher Education Program (NORTEP), which is administered out of and offers classroom training in La Ronge. In 2013, there was one member from BLFN participating in this program. There are no post-secondary training facilities in the Northern Hamlet of Stony Rapids.

19.3.2.3 Health and Social Services

Residents of the communities of Black Lake and Stony Rapids have access to the Athabasca Health Authority (AHA), which operates a facility located just outside of the Northern Hamlet of Stony Rapids on BLFN reserve land, which is funded by both provincial and federal agencies. The Athabasca Health Facility has 14 beds in private and semi-private rooms and is considered a hub for AHA services in the Athabasca region. There is a health centre located in the community of Black Lake, which is funded exclusively by Health Canada. Combined, the health centre in Black Lake and the Athabasca Health Facility employ 55 staff members (Black Lake and Stony Rapids KPI Program 2011-2013).

The Athabasca Health Facility offers a range of services funded by the Government of Saskatchewan Health Ministry and Health Canada (Government of Saskatchewan 2003; Prince Albert Grand Council 2009), including:

- a 14-bed inpatient care unit;
- acute care;
- birthing and long-term care beds;
- emergency air medi-vac;
- emergency and out-patient services;
- long-term care;
- radiology and laboratory services;
- home care services;
- nurse practitioner services;
- palliative care; and
- community services, including:
  - mental health and holistic health services;
  - addictions therapy and traditional healing;
  - diabetes education; and
  - diabetic prevention services.

The health centre in the community of Black Lake, opened in 2004, is located centrally in the community, with day-to-day operations overseen by the Health Director for the Band. There are four full-time nurses on staff and members have access to a physician in the community twice per week (AHA 2011). More than 800 patients are seen at the Black Lake health centre each month. The health centre is currently at capacity (Black Lake and Stony Rapids KPI Program 2011-2013).

Social services in the Athabasca region communities are typically provided through the health centre or a related facility. In the community of Black Lake, social services in the community include the National Native Alcohol Program (NNADAP), Brighter Futures, Athabasca Denésuline Child and Family services and a residential schools resolution program (AHA 2011; Black Lake and Stony Rapids KPI Program 2011-2013). In the Northern

Hamlet of Stony Rapids, social services include a Meals on Wheels program for Elders and diabetes management classes (AHA 2011; Black Lake and Stony Rapids KPI Program 2011-2013). Service Canada Outreach Centres are open in the communities of Stony Rapids and Black Lake on a rotating basis to provide residents with assistance in accessing federal programs and services (Black Lake and Stony Rapids KPI Program 2011-2013; Service Canada 2013).

19.3.2.4 Housing

The 2006 Statistics Canada census indicates that there were 225 occupied private dwellings in the community of Black Lake with an average of five people per household (Statistics Canada 2007). Approximately ten houses are added to the community every year and currently work is taking place on the second stage of a subdivision plan as all the current lots are occupied. In addition, there are about 10 housing units located at the Northern Hamlet of Stony Rapids (Black Lake and Stony Rapids KPI Program 2011-2013; Bullée Consulting 2010). There are currently 80 people on the waiting list for housing in the community of Black Lake (Black Lake and Stony Rapids KPI Program 2011-2013).

In the Northern Hamlet of Stony Rapids, there are more than 100 homes, including approximately 20 housing units that have been added since 2006. The houses range in age from about 60 years old to a few years old; most units are older. About half of the housing in the Northern Hamlet of Stony Rapids is privately owned. Saskatchewan Housing, based in Regina with northern offices in Prince Albert, administers 27 rental units and 26 housing units in the community for provincial employees (Huculiak pers. comm. 2013). In addition, there are some residences owned by Northern Lights School division for teachers, RCMP housing, and some private rental housing (Black Lake and Stony Rapids KPI Program 2011-2013).

19.3.2.5 Water and Waste Management

19.3.2.5.1 Water and Sewage

The Black Lake water treatment plant, sewage pumping stations, sewage lagoon, and the water distribution and sewage collection systems were built in 1992, with a subdivision project completed in 1997. All houses in the community are connected to the sewer system. The water treatment plant was upgraded in 2004/2005. The raw water intake, sewage pumps, and treatment systems were upgraded in 2010 (Bullée Consulting 2010). The sewage treatment facility near the community of Black Lake was upgraded in 2010. A new standby generator was installed at one of three pumping stations, while new generators were installed at the other two pumping stations, and a three-cell lagoon was constructed (Bullée Consulting 2010).

In the Northern Hamlet of Stony Rapids, the water treatment facility and sewage system were installed between 2000 and 2005 to connect the entire community. All residential units and all but two businesses are connected to the water system. The community's water system and lagoon was expanded in 2010 as part of Saskatchewan's Northern Water and Sewer Program (Ministry of Municipal Relations 2010). The sewage lagoon expansion project was completed in 2012. There are no problems with water quality in the community, although the hamlet will occasionally issue boil water advisories during the spring thaw as a preventative measure.

Both communities have had boil water advisories during the last few years. For the community of Black Lake, the Chief and Council are responsible for issuing boil water advisories and for the Northern Hamlet of Stony Rapids, a boil water advisory is issued by the province.

19.3.2.5.2 Solid Waste Management

The communities of Black Lake and Stony Rapids share the solid waste disposal site, which is located on Crown Land about 5 km east of Stony Rapids and accessed from Highway 905. The facility is owned and operated by BLFN on land leased from the province. The most recent operating permit was issued by MOE in July 2012 and is valid through 2018. It is a four-cell solid waste disposal site and the communities are still filling the first cell with solid waste. The solid waste disposal site was built in 2005-06. The Northern Hamlet of Stony Rapids pays BLFN to maintain the site (Black Lake and Stony Rapids KPI Program 2011-2013).

19.3.2.5.3 Emergency Services

The community of Black Lake has a fire hall, a fire truck, and a team of voluntary firefighters. The Northern Hamlet of Stony Rapids has a fire truck and a team of volunteer firefighters. These firefighters are seasonal workers for the MOE during the forest fire season.

The Athabasca Health Facility operates Horizontal Transport Vehicles, which fulfill a similar function to ambulances. Physicians and nurses on-site can perform some emergency procedures (Black Lake and Stony Rapids KPI Program 2011-2013). The Athabasca Health Facility provides access to medical evacuation services for patients who need to be flown south for emergency services (AHA 2011). Patients requiring emergency services unavailable at the Athabasca Health Facility typically are flown to La Ronge, Prince Albert, or Saskatoon, depending on their needs.

The RCMP detachment in the Northern Hamlet of Stony Rapids serves the communities of Black Lake and Stony Rapids. There are 10 officers in the detachment, including the detachment commander. The RCMP periodically carry out roadside checks. It was noted that speeding is not an issue due to road conditions and typically accidents have been the result of driver error (Black Lake and Stony Rapids KPI Program 2011-2013).

The MOE identifies the Northern Hamlet of Stony Rapids as a Forest Protection Base. The Forest Protection base includes a staff bunkhouse, a warehouse of firefighting equipment, including sprinklers for remote facilities such as cabins and lodges, a truck mounted pump, and tanks at the airport for foam for aerial response. In addition to this, the communities of Black Lake and Stony Rapids have volunteer fire departments.

19.4 Screening of Project Interactions and Mitigation

Table 19.4-1 identifies and evaluates the interactions between Project components or activities, and the correspondent effects on infrastructure and community services. The process begins with the identification of all potential interactions with the Project. Each interaction is initially considered to have a potential linkage to a change in the socio-economic environment and the associated VC of the infrastructure and community services. Potential interactions between the Project and infrastructure and community services are identified in Table 19.4-1.

Table 19.4-1: Project Interactions, Environmental Design Features, and Mitigation and Potential Effects on Infrastructure and Community Services

Project Component/ Activity	Project Phase when the Component/Activity Occurs	Potential Effects on Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ Housing of Local and Non-local workers	Construction	Local population increase to take advantage of employment opportunities leading to increased demand on housing.	■ A temporary construction camp will be provided to house workers during construction.	No linkage
■ Reliance on the existing transportation infrastructure	Construction and Operations	Changes to traffic related to the Project may affect road maintenance requirements and local residents.	■ Shuttle vehicles will be used by the contractor to transport workers between the construction site and the Stony Rapids airport to reduce the use of personal vehicles. ■ Unpaved roads within the limits of the Project will be regularly graded and maintained to avoid washboarding and rutting. ■ Certain heavy loads can be seasonally restricted by road conditions, in particular during spring, and consideration will be given to road restrictions, which are weather dependent. ■ Increased signage. ■ Communication with local authorities in the event of major transport campaigns to deliver supplies in a concentrated period of time. ■ Transport trucks using the Athabasca seasonal road may be equipped with radios to allow them to call in and report on progress.	Secondary
■ Access road	Operations	During the operation phase of the Project the new road and bridge infrastructure will require on-going maintenance.	■ Build the access roads to Provincial road standards. ■ The Proponent will establish a service agreement with the Ministry of Highways and Infrastructure for the regular maintenance of the access road and bridge.	Secondary
■ Transporting the non-local workforce to the construction site.	Construction	During the construction phase of the Project, there will be additional use of the airport and airport facilities due to the influx of non-local workers.	■ Coordinate any charters to avoid regularly scheduled flights to minimize the number of passengers in the terminal at any point in time. ■ Coordinate shuttles to and from the construction camp to minimize wait times at the airport (this could involve transporting luggage separate from workers to reduce wait times). ■ Early and on-going communication with air service providers in the Northern Hamlet of Stony Rapids to address any issues as they arise. ■ A shuttle will be used to transfer incoming and outgoing workers between the Northern Hamlet of Stony Rapids and the site to reduce the use of personal vehicles.	Secondary
■ Presence of a non-local workforce	Construction	The Project may affect local retail and hotel services during construction and operations due to increased demand from the non-local workforce or through Project contracts with local services.	■ During construction, local community leadership will be informed about the timing and peaks of construction activities and work rotation schedules.	Secondary
■ Presence of a non-local workforce	Construction Operations Closure	The Project may affect local health and emergency services, which may be required to address serious accidents and injuries on the Project site; this may involve the local RCMP.	■ The construction site and camp will have a Class A respondent on site at all times, in accordance with the Saskatchewan Occupational Health and Safety Regulations (1996). ■ Throughout construction, site areas will be set aside as designated first aid stations so that a basic level of emergency response and health care can be provided on-site during construction; first aid stations will be located on-site at each contractor work area. ■ Local health services providers (including addictions-related programs) will be informed about the nature, timing, and peaks of construction activities. ■ Communication and coordination with local emergency responders so that response plans are in place to address the potential for workplace accidents, malfunctions, or unplanned events. This should include identification of emergency response plans and the types of issues that can be addressed at the Athabasca Health Facility, versus what would be required for transport or evacuation to southern centres. ■ Coordination with local RCMP about the timing of construction activities and peak influxes of non-local construction workers so that they are in a better position to respond to potential issues as they arise.	Secondary

Table 19.4-1: Project Interactions, Environmental Design Features, and Mitigation and Potential Effects on Infrastructure and Community Services (continued)

Project Component/ Activity	Project Phase when the Component/Activity Occurs	Potential Effects on Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ Potable and Industrial Water Supply	Construction, Operations, and Closure	Potable and industrial water will be required for the Project, which can affect the capacity of community infrastructure.	■ None	No Linkage
■ Site Water Management ▪ disposal of sewage and grey water	Construction, Operations, and Closure	Disposal of sewage and grey water can affect the capacity of community infrastructure.	■ A service agreement would be negotiated for the disposal of sewage and grey water in the Black Lake lagoon.	Secondary
■ Domestic and Industrial Waste Management	Construction, Operations, and Closure	Disposal of domestic and industrial waste in a local landfill site, can affect the capacity of community infrastructure.	■ Some recycling will take place at the construction camp with the recyclable materials hauled to southern facilities. ■ A service agreement would be negotiated for the disposal of non-hazardous waste in the local waste disposal site. ■ As part of the Environmental Protection Plan there will be training and reinforcement of proper waste management. This Plan will be reviewed annually, and the results of these reviews will be used to implement improvements through adaptive management. ■ A Waste Management Plan will be developed for the Project, which will include implementation of practices to reduce the amount of domestic and industrial waste generated.	Secondary
■ Overall operation activities.	Operations	During the operation phase of the Project BLFN may use revenue generated from their equity share in the Project to improve or develop new infrastructure and community services for their members.	■ BLFN leadership consultation with members to determine the most appropriate use of the new income for the community.	Primary
■ Accidents, Malfunctions, or Unplanned Events	Construction, Operations, and Closure	Fire	■ The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail. ■ Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. ■ Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute).Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. ■ Personnel will be trained in fire prevention and response procedures. ■ Firefighting equipment will be available on site.	No Linkage

RCMP = Royal Canadian Mounted Police; BLFN = Black Lake First Nation

Each potential interaction is evaluated to determine if mitigation can be developed and incorporated to remove the interaction, limit the potential negative socio-economic effect, or enhance the potential positive socio-economic effect on infrastructure and services. Mitigation includes Project design elements, environmental best practices, management policies, and procedures. Knowledge of the socio-economic environment and mitigation is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for residual socio-economic effects on infrastructure and community services.

Interactions are determined to be primary, secondary, or as having no linkage using scientific knowledge, the professional judgement of technical specialists, logic, and experience with similar developments, and mitigation. Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by mitigation so that the Project results in no detectable change in measurement endpoints, and therefore, no effect on Infrastructure and Community Services relative to baseline values;
- secondary – interaction could result in a minor change to measurement endpoints, but would have a negligible effect on infrastructure and community services relative to baseline values and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary – interaction is likely to result in a detectable change in the measurement endpoints that could contribute to a measurable or detectable effect on infrastructure and community services relative to baseline values.

Any interactions that require a comprehensive assessment to determine if there is a residual socio-economic effect are considered to be primary. Primary interactions require further analysis to determine the significance of the residual socio-economic effects. Project interactions determined as having no linkage or as secondary interactions are described where appropriate; however, these are not analyzed further in the EIS.

19.4.1 Interactions with No Linkage to Effects

An interaction can have no linkage to effects if the activity does not occur, or if the interaction is removed by mitigation or environmental design features so that the Project results in no detectable change in measurement endpoints. The following interactions are anticipated to have no linkage to effects on infrastructure and community services, and will not be carried through the residual effects assessment.

- **Local population increase to take advantage of employment opportunities leading to increased demand for housing.**

During construction, the workforce will be drawn from the local communities where feasible and specialized or skilled workers will be mobilized to and from the Project from outside of the LSA. Temporary accommodations, consisting of the construction camp, will accommodate the workforce. As a result, there are no Project-related stressors related to housing during the construction phase.

During operations, a small number of permanent positions will be created. The Proponent intends to identify local people and provide training so that the operation workforce is from the LSA. Even if a small number of individuals are required from outside the LSA (e.g., to fill positions that cannot be filled locally or to provide training to new hired personnel), the number of people coming to the area could easily be accommodated by existing hotel facilities in Stony Rapids. As such, there will be no requirement to provide additional housing to accommodate operation phase employees. Consequently, there is no linkage to residual effects on local infrastructure and services.

- **Potable and industrial water will be required for the Project, which can affect the capacity of community infrastructure.**

During construction, potable water will be provided at the construction camp and at various locations throughout the contractor's work areas. Water requirements for the construction phase can reach up to 4,700,000 litres (L) per year (i.e., approximately 13 cubic metres per day [m^3/d]) for industrial water and 7,000,000 L per year (19 m^3/d) for potable water. Potable water for the construction camp is anticipated to be sourced from one or more new wells located near the camp, although this water could be drawn from either Black Lake or the Fond du Lac River.

During operations, approximately 365,000 L/year (i.e., 1 m^3/d) of water will be required for the Project. Potable water will be drawn from the penstock and treated for use. A supply of industrial water will be required for dust suppression and fire-protection during Project operation. The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail. Each pump will be sized to meet the full demand of the largest component of the system with the addition of 31.5 litres per second (L/s) for hose demand. Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings.

A water treatment facility will be constructed on-site to meet daily water consumption requirements. The water treatment facility will meet provincial drinking water quality and safety standards and will be licensed under *The Water Regulations* (2002). Industrial water (i.e., used for fire suppression, preparing concrete, and controlling road dust) will be taken from Black Lake (i.e., intake location) and the Fond du Lac River (i.e., bridge location). Pump intakes would be screened to prevent entrainment of fish in accordance with the "Freshwater Intake End-of-Pipe Fish Screen Guideline" (DFO 1995). There is no treatment required for industrial water. As such, there is no linkage to effects on existing infrastructure and community services.

19.4.2 Interactions with Secondary Linkages

In some cases, both a source and an interaction exist, but because the change caused by the Project is anticipated to be minor, it is expected to have a negligible residual effect on existing infrastructure and services. The following interactions are expected to be minor and will not be carried through the residual effects assessment.

- **Changes to traffic patterns related to the Project may have affect road maintenance requirements and local residents.**
- **During the operations phase of the Project, the new road and bridge infrastructure will require on-going maintenance.**

The Project will result in a change in traffic during the construction, operation, and closure phases. The largest change will be during Project construction. There will be an initial mobilization of large construction equipment and construction-related freight for the Project. It is anticipated that construction-related traffic, bringing equipment, materials, fuel, camp supplies, and other freight, will use Highway 102 from La Ronge to Southend, Highway 905 from Southend to the community of Black Lake and then onto the site access road.

A traffic analysis was undertaken to determine locations, if any, where there could be notable increases in traffic volumes and types of traffic that could have an effect on the current traffic and safety on Highway 905 in particular. The following methods were used to examine traffic volumes:

- identifying provincial and local roads that will be affected by the Project;
- reviewing Ministry of Highways and Infrastructure information and traffic data;
- obtaining anticipated traffic data from the Project engineering team; and
- KPIs with residents and officials in the communities of Stony Rapids and Black Lake.

Predicted Project-related traffic for control sections on Highway 905 during construction is provided in Table 19.4-2. Freight haul is expected to average one additional transport truck per day on Provincial Highways 102 and 905 travelling north to the Project site. Due to seasonal variations in the road conditions it is likely that most of the construction materials and equipment will be shipped north during the winter season; meaning that Project-related transport campaigns will coincide with the time of year where the road experiences its highest traffic volumes. In addition, there will be an average of four transport trucks per week to deliver fuel and food to the construction camp. It is anticipated that traffic on control section CS905-07 of Highway 905 between the communities of Black Lake and Stony Rapids will increase by approximately 40 vehicle trips per day during the construction phase of the Project. This includes travel by local workers, shuttles used to transport out of town personnel between the site and the Stony Rapids airport, vehicles used for cargo pickup and delivery, and truck traffic related to waste disposal.

Table 19.4-2: Predicted Project Related Changes in Traffic for Select Sections of the Transportation Route from Prince Albert the Project Site during the Construction Phase.

Highway	Road Segment	Current ADT (veh/d)*	Project Related Traffic		Percent Change
			Truck	Small Vehicle	
905	CS905-06 Hawk River Bridge to Black Lake	20	1.7	0	8.5
905	North portion of CS905-07 Black Lake to Stony Rapids	132	0	40	30.3
905	South portion of CS905-07 Black Lake to Stony Rapids	132	1.7	20	16.4

Source: Brenner pers. com. 2013
*ADT is Average Daily Traffic measured in vehicles per day (veh/d)

An average of 1.7 tucks per day to Highway 905 to the Black Lake turn off (control section CS905-06) will result in an 8.5% increase in traffic. Control section vehicle counts show that five of the 20 vehicles are transport trucks or 25% of the existing traffic (Muhr pers. comm. 2012). The transport truck traffic will increase to 6.7 of 21.7 vehicles, or an increase in the transport truck traffic to 30.9% of the traffic. Given that the traffic volume is very low, the increase in overall traffic, particularly transport truck traffic is a low volume of traffic. Practices that will be considered to reduce risk include driver training, monitoring of road conditions and enhancing maintenance if it is determined as necessary (such as grading, dust control and culvert or stream crossing improvements), enforced speed limits, reduced speed for trucks, seat belt use, timely snow removal, increased signage, and communication with local authorities in the event of major transport campaigns to deliver supplies in a concentrated period of time.

The analysis shows that the greatest increase in traffic on Highway 905 during construction will occur along control section CS905-07 (Table 19.4-2). There will be an increase of 30.3%, an increase from 132 to 172 vehicles per day for the section north of the intersection with the access road, and an increase of 16.4%, an increase from 132 to 152 vehicles per day in the southern section. In spite of this increase in traffic volume, on this control section the traffic volume will remain quite low. Low traffic volumes combined with proposed practices that will be considered to reduce risk can be expected to result in acceptable levels of road wear and tear and public safety when using the roads, although residents continue to express concerns regarding overall road and driving conditions (Black Lake and Stony Rapids KPI Program 2011-2013).

Table 19.4-3 presents traffic data for control sections of Highway 905 during operation. There will be an increase in traffic because of local workers traveling to and from the powerhouse daily. It is anticipated that this will result in an increase of approximately 10 personal vehicles per day on the all-season section of Highway 905 between the communities of Black Lake and Stony Rapids and then onto the access road.

Table 19.4-3: Predicted Project Related Changes in Traffic for Select Sections of the Transportation Route from Prince Albert the Project Site during the Operation Phase.

Highway	Road Segment	Current ADT (veh/d)*	Project Related Traffic		Percent Change
			Truck	Small Vehicle	
905	North portion of CS905-07 Black Lake to Stony Rapids	132	0	10	7.6
905	South portion of CS905-07 Black Lake to Stony Rapids	132	0	10	7.6
Site Access Road	Starting at the junction with Highway 9	0	0	10	0

Source: Brenner pers. com. 2013

*ADT is Average Daily Traffic measured in vehicles per day (veh/d)

Changes from increased traffic volume during construction, operations, and closure and modifications to transportation routes can affect the maintenance of highways and municipal roads, and traffic flow. SaskPower and the General Contractor have initiated discussion with the Ministry of Highways and Infrastructure to learn more about road limitations and maintenance schedules. Transport trucks using the Athabasca seasonal road may be equipped with radios to allow them to call in and report on progress. This would provide an additional level of road safety for existing road users. With the practices described above, no further mitigation or enhancement practices should be required for the construction, operation, and closure phases of the Project.

The site access roads developed during construction will be controlled, limiting public access while they are in existence and maintained by the general contractor. The site access road would be constructed to provincial road standards so that it can be available for public use during the operation phase of the Project.

Project-related changes in traffic volume are expected to be minor relative to existing conditions, and the largest change will occur during construction. Overall, mitigation practices and policies should result in negligible residual effects on infrastructure and community services.

- **During the construction phase of the Project, there will be additional use of the airport and airport facilities due to the influx of non-local workers.**

Non-local construction workers and some cargo (e.g., supplies to the camp) will be transported to the LSA by airplane. This will cause an increase in air traffic to the Stony Rapids airport facilities. The aircraft cargo and non-local construction workers will be transported to the construction camp with a shuttle van.

Although it is anticipated that part of the construction workforce will come from the communities of Black Lake and Stony Rapids (see Section 18.5.1.2), it is expected that a large proportion of the workforce will fly in from other communities in the Athabasca region and other parts Saskatchewan. Throughout construction, the general contractor will use a combination of charter and scheduled flights from select locations in Saskatchewan. Use of charter flights will reduce disruption to air travel by local residents and cargo users.

Overlapping flights could overload airport passenger reception and cargo handling facilities at the Transwest Air Terminal and the Pronto Airways building. The Proponent recognizes that coordination with air service providers will be required so that local air services are not interrupted by Project activities and that the ability of local residents to access scheduled flights is not compromised.

The Proponent will work with local air service providers so that in-coming and out-going construction workers can be appropriately accommodated upon arrival or departure from the Stony Rapids airport. Coordination of Project-related air traffic will consider the following:

- coordination of any charters to avoid regularly scheduled flights and reduce the number of passengers in the terminal at any time;
- coordination of shuttles to or from the construction camp to reduce wait times at the airport (e.g., this could involve transporting luggage separately from workers to reduce wait times); and
- early and on-going communication with air service providers in Stony Rapids to address any issues as they arise.

A minor change in crowding at the airport, difficulty in booking seats on scheduled flights, or personal cargo bumped from a flight could occur. However, given the short-term duration of the construction phase and the plan to use charter flights, the frequency of interruptions on local passenger and cargo movement should be limited. As such, the residual effects on infrastructure and community services are predicted to be negligible.

- **The Project may affect local retail and hotel services during construction and operations due to increased demand from the non-local workforce or through Project contracts with local services.**

There are a limited number of retail and hospitality services in the LSA (Section 19.3.2.1). The hotels and restaurants primarily serve visitors to the community, although Al's Place, a licensed restaurant, occasionally serves local residents for lunch and dinner. Camp Grayling has a licensed restaurant for their guests. The retail stores primarily serve the local communities. During the construction phase of the Project, the presence of non-local construction workforce and their interaction with local residents can affect local retail and hospitality services.

During construction, the Proponent will communicate with local community leadership about the timing and peaks of construction activities and work rotation schedules. While the precise number of workers who might enter the communities of Black Lake or Stony Rapids on a given day is unknown, it is reasonable to expect that some will return to the communities of Black Lake or Stony Rapids and that the increase in the number of people will be noticeable in the communities.

The influx of a non-local construction workforce, in combination with the potential for higher income for local residents, could result in an increase in business for these service providers. At the same time, the increased demand is not expected to impede the ability of local residents to access these services. There is sufficient capacity and adaptability in the local business community to accommodate both. The Project will be a net benefit to the retail and hospitality service providers in the communities of Stony Rapids and Black Lake. Therefore, no additional mitigation or enhancement measures are required. The Project is expected to have a negligible adverse effect on infrastructure and community services.

- **The Project may affect local health and emergency services, which may be required to address serious accidents and injuries on the Project site; this may also involve the local RCMP.**

Local health services, including emergency response, could be affected by the influx of non-local workers, in addition to the potential for serious accidents associated with construction activities. The construction site and camp will comply with provincial and federal safety regulations. Standards for provincial health and safety legislation will apply, including the following:

- *Occupational Health and Safety Act of Saskatchewan (1993)*; and
- *Occupational Health and Safety Regulations of Saskatchewan* (1996).

Construction activities will be subject to the SaskPower Safety Management Policy. Furthermore, compliance with SaskPower Safety Policies and Standards is a condition of employment for all SaskPower personnel and contractors.

During construction, the level of emergency response provided on-site would include a Class A respondent, in accordance with the *Saskatchewan Occupational Health and Safety Regulations* (1996) for a construction site with 100 or more workers. Throughout the construction site, areas will be set aside as designated first aid stations so that a basic level of emergency response and health care can be provided on-site. First aid stations will be located on-site at each contractor work area.

In addition to the mitigation implemented on-site, the following policies and practices will be implemented to minimize potential stressors to local services:

- communication with local health services providers, including addictions-related programs, about the nature, timing, and peaks of construction activities;
- communication and coordination with local emergency responders so that response plans are in place to address the potential for workplace accidents or malfunctions. This should include identification of emergency response plans and the types of issues that can be addressed at the Athabasca Health Facility, versus what would be required for transport or evacuation to southern centres; and
- coordination with local RCMP about the timing of construction activities and peak influxes of non-local construction workers so that they are in a better position to respond to potential issues as they arise.

These mitigation practices and policies are expected to result in minor changes to local health and emergency services. As such, the Project is expected to have a negligible residual effect on infrastructure and community services.

Given that there is sufficient capacity to accept the projected volume of sewage and grey water from the Project and that the requirement would be short-term in duration for the construction phase, the Project is expected to result in minor changes to the existing sewage lagoon at Black Lake. Therefore, the Project is expected to result in negligible residual effects on infrastructure and community services.

- **Disposal of domestic and industrial waste in a local landfill site, can affect the capacity of community infrastructure.**

Both non-hazardous and hazardous waste will be produced by the Project. The non-hazardous waste stream is expected to consist of domestic waste (e.g., kitchen waste and office waste) and industrial waste (e.g., plastics, wood, metal, and other inert materials). The non-hazardous waste stream can be broken down into two categories, combustible materials, and non-combustible materials. The combustible material, including non-hazardous construction material (e.g., wood and paper products), could be burned on site or transported to an approved landfill site for disposal. If material is burned on-site, a permit from MOE as defined in *The Prairie and Forest Fires Act* (1982) would be required. Non-combustible material would be transported to a landfill for disposal. Domestic waste produced during the construction and operation phases of the Project, including food refuse and similar material, will be managed using bear-proof storage containers and hauled off-site to an existing permitted waste disposal facility.

The closest waste disposal facility to the Project, used by the communities of Black Lake and Stony Rapids, is located 14.5 km from the Highway 905 turn off to Black Lake and 5.5 km from Stony Rapids along Highway 905. The landfill facility is located on Provincial land and is operated by BLFN. The existing landfill site has four cells and has additional capacity to handle solid waste from the construction camp and from the Project site. In 2012, the first cell was still in use. On the Project site the temporary storage and transportation of solid waste to the waste disposal site will comply with the *Indian Reserve Waste Disposal Regulations* contained in the *Indian Act* (1985) and all waste destined for the solid waste disposal site will comply with *The Municipal Refuse Management Regulations (1986)* within the *Environmental Management and Protection Act (2002)*. Provincial regulations for the temporary on-site storage and transport of solid waste would be followed. A service agreement would be negotiated for the disposal of non-hazardous waste. Some recycling will take place at the construction camp with the recyclable materials hauled to southern facilities.

Hazardous industrial waste expected to be generated at the site during construction and operations includes waste hydrocarbons, chemicals, glycols, solvents, antifreeze, and batteries. The management of hazardous wastes will include collecting the wastes in suitable containers and storing them for either shipment off-site to recycle or disposal facilities via a licensed contractor. Where suppliers will accept them, empty containers used to ship these materials to site will be returned to the supplier. Those that cannot be returned will be shipped to recycle or disposal facilities.

An overall Environmental Protection Plan (EnvPP) will be developed for the construction and operations phases of the Project. As part of the EnvPP, a Waste Management Plan will be developed, which will include training and reinforcement of proper waste management. This Plan will be reviewed annually, and the results of these reviews will be used to implement improvements through adaptive management. Mitigation practices and implementation of the Waste Management Plan should reduce the amount of material being disposed of in the landfill or being stored and removed to a safe hazardous waste disposal facility. Overall, the Project is predicted to have a minor change on the local landfill site and negligible residual effects on infrastructure and community services.

- **Disposal of sewage and grey water can affect the capacity of community infrastructure.**

Sewage and grey water from the Project will be transported to the Black Lake lagoon for treatment. The amount of sewage and grey water produced at the site during Project construction and operation will be dependent upon the number of workers on site. The exact number of people employed will be determined when the design of the generating station is finalized. During the peak construction period, it is expected that the workers will produce about 30,000 L/day of sewage and grey water (e.g., the equivalent of two truckloads a day). Based on similar facilities located in remote northern regions, it is anticipated that between six and eight people could be required to operate the power plant. Therefore, it is estimated that during the operational phase the Project will produce approximately 1,400 L of wastewater per day. Sewage and grey water from plumbing fixtures will be directed to the sanitary system and pumped to an outdoor buried fiberglass sewage-holding tank. The sewage-holding tank will be pumped out as required (about once a week) and disposed of at the Black Lake lagoon.

The Black Lake lagoon was completed in 2009, and at the time of design had a design horizon to 2018 (Lukey 2013, pers. comm.). The lagoon will have the capacity to accommodate the peak Project camp requirements (Lukey 2013, pers. comm.). The storage cell at the lagoon has a volume of 165,500 m^3, while the primary cell has a volume of approximately 100,000 m^3 (Keleman 2013, pers. comm.). Treated water is released to the west of the Black Lake Lagoon into a wetland/swamp area once every six months (in spring and in fall). Prior to release, the treated water must meet applicable water quality criteria as per Wastewater Systems Effluent Regulations (Government of Canada 2013). Overall, the Project is predicted to have a minor change on the local sewage lagoon and negligible residual effects on infrastructure and community services.

19.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events occurring on-site have the potential to affect adversely Community Services and Infrastructure. The following event was identified as having the potential to interaction with community services and infrastructure.

- Fire

Fire can affect the community infrastructure and services by potentially increase the number of emergency response services. Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. Fire safety measures and response will be reviewed with the communities of Black Lake and Stony Rapids. On-site personnel will be trained in established fire prevention and response procedures and appropriate firefighting equipment will be available on-site so that trained personnel will be able to respond promptly. The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail.

Each pump will be sized to meet the full demand of the largest component of the system with the addition of 31.5 litres per second (L/s) for hose demand. Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute).

Although a fire may result in temporary increases in the number of emergency response services in the region, the implementation of the abovementioned mitigation is anticipated to result in no linkage effect on community Infrastructure and services.

19.4.4 Primary Interactions

The following interaction was determined to be primary for socio-economic effects on infrastructure and community services.

- **During the operation phase of the Project, the BLFN may use revenue generated from their equity share in the Project and other revenues to improve or develop new infrastructure and community services for their members.**

19.5 Residual Effects Analysis

19.5.1 Potential Changes to Infrastructure and Community Services

The BLFN, through the Elizabeth Falls Hydroelectric Limited Partnership (EFHLP), will have 30% interest in the Project at the outset of operations, which could increase to as much as 49% once loans are repaid. The BLFN will receive annual returns on their investment (see Section 18.5.1.4) over the operating life of the Project. These funds are expected to provide a sizeable increase in community income. All of the income resulting from BLFN's participation in the Project will result in new income for community purposes.

In August of 2013, BLFN undertook a confidential survey of all households in the community of Black Lake to determine the eligible purposes of the Tazi Twé Hydro Trust, including seeking inputs on the management, administration and reporting for the Trust. The confidential results of the survey will be used by the community to identify priority areas for this community income.

19.5.2 Management of Uncertainty

Like all scientific results and inference, residual effects predictions for the socio-economic environment will have uncertainty associated with the data and current knowledge of the system. The confidence in residual effect predictions is related to the following:

- adequacy of baseline data for understanding conditions in the local and regional study areas;
- the understanding of Project-related residual effects on the system; and
- knowledge of the effectiveness of environmental design features and mitigation at limiting effects on VCs.

The analysis of effects on infrastructure and community services uses conservative assumptions to reduce uncertainty, where possible. Sources of uncertainty in the assessment relate to the extent to which non-local construction workers will use facilities and services in the LSA. Further to this, how BLFN decides to use the funds acquired through their participation in the Project is beyond the scope of the EIS and as such, there is no guarantee that improvements to infrastructure and services will be immediately realized.

Uncertainty was addressed by incorporating information from available and relevant literature, interviews with local people, and inputs from the Public Information Program (PIP) to characterize the existing environment. Key person interviews included questions regarding the current capacity of local infrastructure and services as context when evaluating potential Project effects. Strategies have been identified and will be put into place to reduce potential challenges to local service providers.

19.6 Determination of Significance

The changes in measurement endpoints associated with primary interactions provide the foundation for determining significance from the Project on infrastructure and community services. Direction, magnitude, duration, and geographic extent are the main factors of consideration used to predict significance. For infrastructure and community services, the assessment of significance considers the scale of these factors, in addition to professional opinion based on the context of the Project in combination with other relevant experience. The assessment of significance considers the efficacy of the proposed mitigation and enhancement measures to limit residual adverse effects and enhance potential benefits to infrastructure and community services. The determination of significance assessment considers all primary interactions that are expected to result in residual effects on infrastructure and community services.

Frequency is not considered in evaluating the significance of residual effects on infrastructure and community services. For socio-economic changes, the residual socio-economic effects are generally continuous; therefore, criterion frequency is typically not used. Similarly, reversibility is not used in determining effects on the socio-economic environment, as effects associated with a project are typically part of an ongoing process of interdependent economic and social change extending into the future. In general, these processes cannot be reversed to return to pre-project development conditions.

19.6.1 Residual Effects Criteria

Table 19.6-1 describes the criteria used when evaluating effects on infrastructure and community services.

Table 19.6-1: Residual Effects Criteria for Infrastructure and Community Services

Direction	Magnitude	Duration	Geographic Extent
Negative: An adverse effect relative to the existing environment **Positive:** A beneficial effect relative to the existing environment	**Low:** Effects are likely to result in a small, hardly discernible change relative on the existing environment **Moderate:** Effects are likely to result in a noticeable or detectable change relative on the existing environment **High:** Effects would be likely to result in a large, meaningful and readily detectable change relative on the existing environment	**Short-term:** Changes will only occur during the construction phase **Medium-term:** Changes will extend to the first 10 years of operation of the Project, or for one generation relative to the VC **Long-term:** Changes will last for more than 10 years, or for more than one generation relative to the VC	**Local:** Changes would affect community of Black Lake (including reserve land), the Northern Hamlet of Stony Rapids and Highway 905 (including lands adjacent to the Highway) between the two communities **Regional:** Changes may occur along Highway 905 north of Points North Landing

VC = valued component

Direction – Direction refers to the overall nature of the effect. A negative effect would be one where there is an adverse effect on the VC, relative to the existing environment. A positive rating anticipates that the socio-economic effect will be of benefit to the VC relative to the existing environment.

Magnitude - Magnitude refers to the degree of change in a measurement endpoint and the resulting residual effect on infrastructure and community services. Magnitude can be low, moderate, or high. Low magnitude predicts a small, but hardly discernible socio-economic effect on natural, cultural, and social features of the environment. A moderate rating anticipates that socio-economic effects on a VC are likely to result in a noticeable change relative to the existing environment. High magnitude suggests that the change will be large, and meaningful relative to the existing environment.

Duration - Duration is defined as the amount of time that infrastructure and community services are exposed to Project activities or phases. Short-term effects are anticipated to occur over the course of construction only. Medium-term effects will extend to the first 10 years of operation of the Project, or for one human generation relative to the VC. Long-term effects will last for more than 10 years, or for more than one human generation relative to the VC.

Geographic Extent - Geographic extent considers the location in which effects are likely to be measurable relative to the existing environment. A local rating anticipates that effects will be measurable in the community of Black Lake (including reserve land), the Northern Hamlet of Stony Rapids, and Highway 905 (including lands adjacent to the Highway) between the two communities, or the LSA for infrastructure and community services. A regional rating anticipates that changes would extend beyond the local area, and be measurable within the RSA (i.e., along Highway 905 north of Points North Landing).

19.6.2 Project-specific Residual Effects

The analysis of residual effects on infrastructure and community services considers potential changes to health care, childcare, and education services and facilities, traffic volumes, and quality and development of infrastructure income resulting from BLFN's partnership in the Project. Effects on infrastructure and community services are expected to result in a noticeable or detectable positive change relative to the existing environment. Residual effects are predicted to be, long-term in duration and local in geographic extent. Depending upon how equity and other Project income is spent by the BLFN, the magnitude of these effects may even be higher, which, could result in meaningful changes to BLFN infrastructure and community services, given the positive rating of the effect. Overall, there is no significant adverse effect from the Project on infrastructure and community services.

19.6.3 Cumulative Residual Effects

Cumulative effects are those effects from the Project, combined with the effects from prior development, existing activities, and reasonably foreseeable future developments that are sufficiently certain to proceed. Reasonably foreseeable developments or designated projects that would be included in the EIS are activities or projects that:

- would be developed in the spatial and temporal boundaries of the Project;
- have been proposed and scoped to a reasonable level of detail;
- could be induced by the Project;
- are currently undergoing regulatory review; and
- have the potential to change the Project or the effects predictions.

For infrastructure and community services, one additional development was identified as having potential spatial overlap with the RSA: the Highway 968 All-weather Road Project, a proposed 88.5 km road from Highway 905 near Stony Rapids to the community of Fond du Lac. The proposed roadway would extend from approximately 3.5 km south of the Stony Rapids airport at its intersection with Highway 905 and generally follow the existing winter road location west for 31.9 km toward Fond du Lac. The remaining 56.6 km of roadway would be entirely new, terminating on the south shore of Lake Athabasca near Fond du Lac. The project would take approximately three years to construct and would result in an estimated 300 person years of employment. With respect to infrastructure and community services, this could result in additional workers accessing services in communities in the region, in addition to additional air and road traffic associated with transporting personnel and equipment to the site (Ministry of Highways and Infrastructure 2010). These higher levels of activity, while beneficial overall, could place additional demands on the local infrastructure and community services and could lead to capacity challenges, particularly in the LSA. However, this could result in additional benefits in the RSA.

At present, there is no evidence to suggest that there would be a temporal overlap with construction activities for the Project and the development of the proposed roadway. Although the duration of the Project has the potential to last over 90 years, it is only overall of the construction phase the present potential changes to the evaluation of cumulative effects. The Ministry of Highways and Infrastructure budget announcements for 2013-2014 do not include the proposed road and the environmental assessment process has not moved beyond the submission of a Project Description in 2010 (Ministry of Highways and Infrastructure 2010; Government of Saskatchewan 2013). Based on the assumption that construction phase for the Project and the road development are unlikely to overlap, no significant adverse effects from the Project, combined with existing and reasonably foreseeable developments on infrastructure and community services are predicted.

19.7 On-going Engagement

A Project Advisory Committee, including equal representation from the EFHLP and SaskPower will meet at least monthly or as otherwise agreed to by the Committee, and will review the status of the Project including environmental, engineering and construction activities including community matters that relate to the completion of the Project. It is anticipated that this committee will discussion on-going concerns about socio-economic effects, and that the EFHLP and SaskPower will work together collaboratively on measures to address any community concerns.

With respect to the longer-term effects associated with Project operation, BLFN might want to consider monitoring of how their equity is invested and the associated outcomes for the community.

19.8 References

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19.9 Glossary

Term	Description
Crown Land	Crown Land is a designated area belonging to the Queen in Right of Canada. Administration of Crown Land is generally divided between the provincial Crown and the federal Crown.
Environmental Impact Statement	A report that documents the information required to evaluate the environmental effect of a project.
Traffic Impact Assessment	An assessment of the anticipated traffic implications of a project.

19.10 List of Acronyms

Term	Definition
AADT	Average Annual Daily Traffic
AANDC	Aboriginal Affairs and Northern Development Canada (formerly Indian and Northern Affairs Canada [INAC])
ADT	Average Daily Traffic
AHA	Athabasca Health Authority
BLFN	Black Lake First Nation
EFHLP	Elizabeth Falls Hydroelectric Limited Partnership
EIS	Environmental Impact Statement
EnvPP	Environmental Protection Plan
GVW	Gross Vehicle Weight
KPI	Key Person Interview
LSA	Local Study Area
MOE	Saskatchewan Ministry of Environment
ND	No Date
NLSD	Northern Lights School Division
NNADAP	National Native Alcohol Program
NORTEP	Northern Teacher Education Program
OIC	Order in Council
PAGC	Prince Albert Grand Council
PIP	Public Information Program
Project	Tazi Twé Hydroelectric Project
PVC	Portable Vehicle Classifier
RCMP	Royal Canadian Mounted Police
RSA	Regional Study Area
SGI	Saskatchewan Government Insurance
VC	Valued Component

19.11 List of Units

Term	Definition
%	percent
ha	hectare
L	litre
L/s	litres per second
kg	kilogram
km	kilometre
km/h	kilometres per hour
m^3/d	cubic metres per day

20.0 HUMAN POPULATION AND HEALTH

20.1 Introduction

The purpose of this section is to describe the socio-economic environment that could be affected by the Tazi Twé Hydroelectric Project (Project) and to assess the effects on human population and health. Valued components (VCs) represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important or of concern by the proponent, government agencies, Aboriginal peoples, and the public. The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. During engagement sessions, local Aboriginal groups and community members expressed concern with the livability of the environment during construction and throughout operations. Local residents also identified aesthetics as an issue that would affect the quality of life of residents near the Project. As such, human population and health was selected as a VC for this Environmental Impact Statement (EIS).

This section addresses potential Project effects on human population and health, with a focus on the population and health of residents of the northern Saskatchewan communities of Black Lake and the Northern Hamlet of Stony Rapids. A full understanding of population demographics and health requires consideration of the social determinants of health – a community's social, physical, and economic environments as well as individual factors that contribute to overall health. Further details on the current population and health characteristics of northern Saskatchewan are presented in Annex VI Socio-economic Environment.

20.2 Spatial Boundaries

The local study area (LSA) for human population and health includes the communities of Black Lake and Stony Rapids. As the communities in closest proximity to the Project, residents' have the potential to be affected through many pathways that relate directly or indirectly to health and well-being. In addition, the Project is located on BLFN reserve land, and the community is a co-Proponent through the Elizabeth Falls Hydroelectric Limited Partnership (EFHLP). In terms of effects on human population and health, the LSA refers to the communities and the social and economic interactions that these communities have with each other.

For population and health, the regional study area (RSA) encompasses the Athabasca Health Authority (AHA), the public health agency responsible for programs and services for residents of the northern-most region of the province of Saskatchewan. The AHA includes the LSA communities of Black Lake and Stony Rapids and while it roughly corresponds with the Athabasca region referenced in other sections of this effects assessment, it does not include the communities of Hatchet Lake and Wollaston Lake that are located in another health authority (i.e., data is collected separately from the communities included in AHA).

20.3 Existing Environment

The primary sources of information for this section are Statistics Canada, Aboriginal Affairs and Northern Development Canada (AANDC), Saskatchewan Health, and a key person interview (KPI) program completed from 2011 to 2013 in the communities of Black Lake and Stony Rapids. Other sources of information include Saskatchewan Regional Health Authorities, community-related websites, other federal and provincial government websites, and reports on northern Saskatchewan.

The communities of Black Lake and Stony Rapids are located in the northern-most part of the province of Saskatchewan, an area often referred to as the Athabasca region. The area is sparsely populated compared to other parts of the province, with residents scattered across seven communities including First Nations, northern settlements, and northern hamlets. The remote location of these northern communities limits availability and access to health care services and programs. While the main facilities of the AHA are located near the Northern Hamlet of Stony Rapids, some services and programs, such as surgical care, are only available outside of the AHA in southern Saskatchewan. Other programs and services, such as dental and optometry, are only available during scheduled visits by specialists. Similarly, some limited health programs and services are administered at the Black Lake Health Centre in the community of Black Lake. Further details of health programs and services are provided in Section 19.0 and Annex VI Socio-economic Environment.

Much of the data presented in this section are provided at a regional level, (i.e., the AHA, which includes the LSA communities of Black Lake and Stony Rapids). Some population and health data are also presented for northern Saskatchewan and the province of Saskatchewan for comparison. Specific community level data are not presented due to the small size of the communities and the need to respect the confidentiality of residents; however, health concerns identified by community members are presented at the end of the section in order to understand current conditions in the communities of Black Lake and Stony Rapids.

20.3.1 Population

The population of northern Saskatchewan, including the communities of Black Lake and Stony Rapids, is young, with a large proportion of Aboriginal residents. This section describes the historic and current populations of the communities of Black Lake and Stony Rapids, as well as the sex and age characteristics of the Athabasca region of northern Saskatchewan.

Demographic factors influence the overall status of health and the population among individuals and communities. With the large proportion of adolescents and young adults in northern Saskatchewan, in addition to high birth rates and a relatively low population over the age of 65, there is an increase in the prevalence of conditions typically seen in younger age groups, such as injuries, pregnancies, and sexually transmitted infections (STIs). In addition, the fast-growing population can place strain on available health services in the region. As the regional population continues to grow and the demographics of these northern communities shift to the middle age groups, the number of residents affected by diseases such as diabetes, heart disease, chronic lung disease, and cancer are likely to increase.

Table 20.3-1 describes the population for the communities of Black Lake and Stony Rapids for 2001, 2006 and 2011, as well as the percentage of population change over the period for each population by data source. Data sources include Statistics Canada, Saskatchewan Health, and AANDC. Data available for 2011 for the community of Black Lake indicates that the largest enumerated population was just under 1,600 people (AANDC 2012a), while the population of the Northern Hamlet of Stony Rapids is smaller at 158 (Saskatchewan Health 2011) to 243 residents (Statistics Canada 2012).

The gender and age distributions of the 2011 populations of the Athabasca region and the province of Saskatchewan are presented in Figure 20.3-1. Figure 20.3-1 demonstrates that the Athabasca population has a much larger proportion of young people and a much smaller proportion of older adults compared to provincial demographics. The proportion of the population of the Athabasca region 19 years of age or younger was 48.83% with only 4.26% of the population at 65 years of age or older. In contrast to the Athabasca region, in 2011, the percentage of the population 19 years of age or younger in Saskatchewan as a whole was 27.85% and the proportion of the population 65 years of age and older was 15.88%.

Table 20.3-1: Population of the Communities of Black Lake and Stony Rapids (2001, 2006, and 2011)

	2001	2006	2011	Population Change (since 2001)[a]
Black Lake First Nation				
AANDC[b] – Black Lake on-reserve population[c]	1,281	1,408	1,592	24.3%
AANDC[b] – Black Lake total population	1,589	1,775	2,028	27.6%
Saskatchewan Health[d, e] – Black Lake	n/a	n/a	1,417	n/a
Statistics Canada[f] – Black Lake[g]	1,054	1,109	1,070	1.5%
Northern Hamlet of Stony Rapids				
Saskatchewan Health[d, e]	n/a	n/a	158	n/a
Statistics Canada[f]	189	255	243	28.6%

Sources: Statistics Canada 2002, 2007, 2012; INAC 2002, 2007 AANDC 2012c; Saskatchewan Health 2001, 2006, 2011.

(a) Where 2011 data is available, population changes are expressed for 2001-2011; where 2011 data are not available, population changes are expressed for 2001-2006.

(b) AANDC data refers to population as of December 31, 2001, December 31, 2006, and December 31, 2011.

(c) On-reserve residence includes individuals living on Crown land.

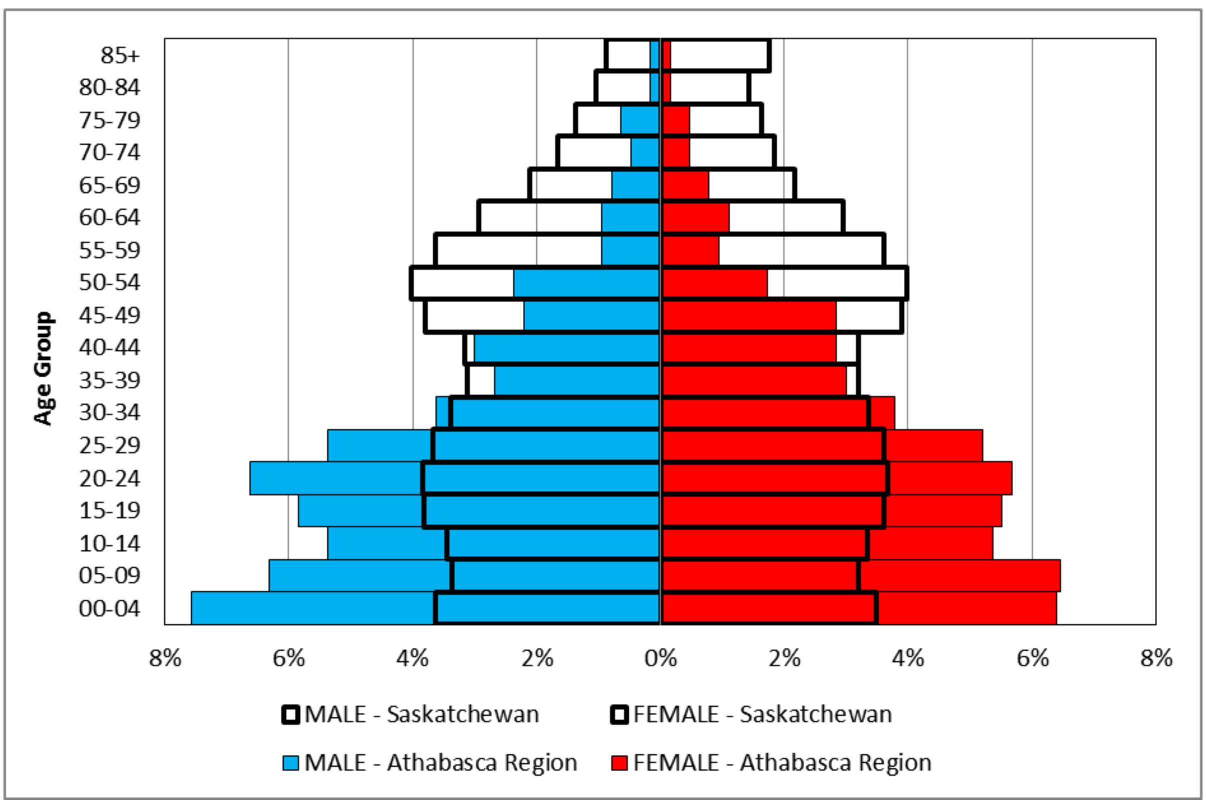
(d) Saskatchewan Health data refers to population as of June 30, 2001, June 30, 2006, and June 30, 2011.

(e) The data collection method for Saskatchewan Health is based on mailing address. Since many northern residents keep post boxes in locations other than their place of residence, for the purposes of Saskatchewan Health population counts they are considered residents of the community listed in their mailing address, not their home community (Saskatchewan Health 2011). For this reason, Saskatchewan Health data for Black Lake and Stony Rapids are not consistent with other data sources for 2001 and 2006 and have been omitted from the table.

(f) Statistics Canada data refers to population as of Census Day – May 15th 2001, May 16th 2006, and May 10, 2011.

(g) Statistics Canada defined Black lake as Chicken 224 in 2001, and Chicken 224 and 225 in 2006.

Figure 20.3-1: Sex and Age Characteristics of the Athabasca Region and Saskatchewan (Source 2011)



The population of the LSA is predominantly Aboriginal, with the majority of residents holding First Nations membership status and residing on reserve in Black Lake. The AANDC projects that Saskatchewan's on-reserve Registered Indian population will grow by 59 percent (%) between 2009 and 2034. In a medium-growth rate scenario, Saskatchewan's Registered Indian population (15 to 64 years of age) living on reserve will grow from 40,700 to 72,300 between 2009 and 2034 (AANDC 2012b).

While the Aboriginal population is young and exhibits higher birth rates than the overall population of Saskatchewan, over the next few decades, the Aboriginal population is expected to undergo a demographic shift. This shift will result in a slightly higher proportion of the Aboriginal population of working-age (15-64 years of age). For example, AANDC projects that, in a medium-growth rate scenario, the overall Aboriginal working-age (15-64 years of age) population of Saskatchewan is expected to grow by 61% between 2009 and 2034. In a medium-growth rate scenario, the median age of the Registered Indian population in Saskatchewan is estimated to rise from 22 years of age in 2009 to 31 years of age in 2034 (AANDC 2012b).

20.3.1.1 Health

The health of individuals, families, and communities is shaped by a variety of factors or determinants of health, which includes the social and economic environment, the physical environment, and the person's individual characteristics and behaviours (World Health Organization [WHO] 2009). Measuring these determinants of health can be challenging due to the breadth of factors influencing health and the availability of data. Several indicators of community health, such as education, income, housing, are discussed in other parts of the document. Other indicators, such as infant and maternal health, life expectancy, and causes of death, communicable and chronic diseases, and hospital utilization are summarized here.

Aboriginal status itself is one of the key determinants of health in Canada (Raphael 2004). The Aboriginal population in Saskatchewan represents the fastest growing segment of the population and, as noted in the report of the Indigenous Peoples' Health Research Centre (IPHRC), "experiences a disproportionate burden of illness" (Sinclair et al. 2006: p. 9). Aboriginal people are more likely than other Canadians to experience inequalities and disadvantages that act as barriers to overall health, including inequalities related to education, employment, income and social status, social support networks, physical environments, and access to services.

20.3.1.1.1 Infant and Maternal Health

Birth rates and infant health provide information about the health of a community in general. Infant mortality rates are one of the single best measures of health in a community, with higher rates of infant mortality corresponding with poor overall health. The birth rate in northern Saskatchewan is higher than the rate in Saskatchewan as a whole. In 2007, the crude birthrate (number of births per 1,000 residents per year) in Saskatchewan was 13.1, compared to 22.1 in northern Saskatchewan.

The infant mortality rate in northern Saskatchewan has been decreasing, but remains over 1.6 times greater than the provincial rate (AHA 2011). The infant mortality rate in northern Saskatchewan decreased from a rate of 13.6 in 1993 to 1999 to 10.4 deaths per 1,000 live births in 2000 to 2007. Over the same period, the provincial rate decreased from 8.3 to 6.3 deaths per 1,000 live births (Irvine et al. 2011).

The teen pregnancy rate in the AHA was 172.4 teen pregnancies per 1,000 females aged 15-19 years of age in 2008-2009, while the rate in northern Saskatchewan was 125.9 teen pregnancies per 1,000 females aged 15-19 years of age. The AHA rate was 1.4 times the northern Saskatchewan and 3.5 times the provincial rate of 58.8 teen pregnancies per 1,000 females aged 15-19 years of age for the same time (Irvine et al. 2011).

20.3.1.1.2 Life Expectancy and Causes of Death

Mortality data is another indicator in determining the health status of a community. The premature mortality rate (a death is considered "premature" if it occurs before the age of 75) has been identified as one of the best single measures of overall community health. Mortality data by cause helps determine the number of deaths that may have been preventable (e.g., death due to injury).

Between 2000-2002 and 2005-2007, life expectancy at birth in northern Saskatchewan increased by 1.1 years for females, from 76.2 years to 77.3 years, and by 0.6 years for males, from 71.9 years to 72.5 years. Despite this increase, life expectancy for northern residents remains lower than the provincial average: in 2005 to 2007, female life expectancy was 81.8 years and male life expectancy was 76.2 years (Irvine et al. 2011).

The leading causes of death in the AHA region between 1998 and 2007 were cancers, injuries, and circulatory diseases. In contrast, the leading causes of death in Saskatchewan were circulatory diseases, cancer, and respiratory diseases (Irvine et al. 2011). This difference reflects the much younger population in the northern half of the province, with a smaller proportion of middle and older age groups. After age and sex adjustments to the data, circulatory diseases, cancers, injuries, and respiratory diseases remain the four leading causes of death in the AHA region, with rates higher than the provincial averages (AHA 2010).

20.3.1.1.3 Communicable Diseases

Communicable disease transmission is often related to lifestyle and general health access to resources to promote personal hygiene. In northern Saskatchewan, STIs and tuberculosis are communicable diseases of concern, while methicillin-resistant staphylococcus aureus (MRSA) is considered an emerging issue (Irvine et al. 2011).

The prevalence of STIs in the northern health regions is greater than in southern Saskatchewan. In 2008, the last year for which the crude chlamydia rate is available for Saskatchewan as a whole, the crude rate in the AHA was 12 times greater than the provincial rate (AHA 2011). The greatest numbers of new cases of chlamydia in northern Saskatchewan were among young people, 15 to 24 years of age. Crude chlamydia rates in the health authority decreased by about half between 2008 and 2009, and remained steady between 2009 and 2010 (Irvine et al. 2011).The new active and relapsed crude tuberculosis rate in northern Saskatchewan in 2001 was 167.4 cases per 100,000, which fell to 159.1 cases per 100,000 in 2010. For comparison, southern Saskatchewan exhibited 5.8 cases per 100,000 residents in 2001 and 1.7 cases per 100,000 residents in 2010. Between 2001 and 2010, the proportion of new and relapsed tuberculosis cases in Saskatchewan that were located in the northern part of the province increased from 50% in 2001 to 76% in 2010 (Irvine et al. 2011). In 2010, the rate of tuberculosis infection for northern Saskatchewan was one of the highest in the country, about 28 times the Canadian average (AHA 2011).

New cases of tuberculosis continue to be diagnosed regularly in the AHA (AHA 2013). The health authority is working with the Northern Inter-Tribal Health Authority (NITHA) and TB Control to focus efforts on strategic planning, screening, contact tracing, and treatment of the disease among residents of the region (AHA 2013). Regular TB clinics for monitoring and follow-up are coordinated in the communities by TB Control (AHA 2013).

The rate of MRSA has similarly been on the rise in the northern regions. Methicillin-resistant staphylococcus aureus (MRSA) is a type of staph infection that is resistant to penicillin and other common antibiotics (Centers for Disease Control and Prevention 2010). Since 2006, the MRSA rate in the AHA region (total individual MRSA cases per 10,000) has been steadily increasing. In 2006, the rate was 52.1 cases per 10,000; in 2007, the rate was 189.7 per 10,000; and in 2008, the rate was 315.8 cases per 10,000 residents (Irvine et al. 2011).

20.3.1.1.4 Community Perspectives on Health

The Aboriginal and Métis populations in northern Saskatchewan often experience health issues that are distinct from other residents of the region. As such, a perspective that includes First Nation and Métis health indicators and concerns is crucial to better understand overall northern health.

First Nation and Métis residents of northern Saskatchewan identified a number of critical health issues in the 2006 IPHRC report (Sinclair et al. 2006). These issues included access and delivery of health services, chronic disease, nutrition and lifestyle, indigenous healing, mental health, addictions and fetal alcohol syndrome, disease prevention, and environmental health (Sinclair et al. 2006).

Residents of the communities of Black Lake and Stony Rapids echoed many of the same health concerns identified in the IPHRC report. For example, residents of the community of Black Lake commented that recreation and physical activities, as well as alcohol and drug abuse, are important health issues for local youth and young adults. Black Lake community residents also identified healthy eating and nutrition, the pursuit of traditional land use and consumption of country foods, and environmental health as local concerns. Specific health concerns in the community include tuberculosis, cancer rates, diabetes among Elders, alcohol and drug abuse, and housing conditions, such as overcrowding and lack of adequate housing (Black Lake and Stony Rapids KPI Program 2011-2013).

In the Northern Hamlet of Stony Rapids, health concerns include cancer, diabetes, and tuberculosis rates, with residents expressing a desire for more emphasis on preventative care in the community. In addition, residents would like to see increased mental health, addictions, and healing program services, with an expansion of recreational and sports programming for local children and youth. Residents of the Northern Hamlet of Stony Rapids also note differential access to health care services between First Nation members and non-members in the community, environmental health, and prenatal care and support services as important factors in community health (Black Lake and Stony Rapids KPI Program 2011-2013).

20.3.1.1.5 Other Determinants of Health

As previously noted, the health of individuals, families and communities is shaped by a variety of factors or determinants of health, which include the social and economic environment, the physical environment, and the person's individual characteristics and behaviours (WHO 2009). Several indicators related to these factors are described in other parts of the EIS including:

- characteristics of the physical environment such as air quality (Section 8.0), noise (Section 8.0), water quality (Section 11.0);
- socio-economic considerations such as education, employment, and income (Section 18.0);
- public safety considerations such as traffic (Section 19.0) and navigation (Section 17.0); and
- dietary practices, such as the consumption of country foods (Section 17.0).

20.4 Screening of Project Interactions and Mitigation

This section identifies and evaluates the interactions between Project components or activities, and the correspondent potential socio-economic effects on human population and health. The process begins with the identification of all potential interactions for the Project. Each interaction is initially considered to have a linkage to a change in the socio-economic environment and human population and health. Potential interactions between the Project and human population and health are identified in Table 20.4-1.

Each potential interaction is evaluated to determine if mitigation can be developed and incorporated to remove the interaction, limit the potential negative socio-economic effect, or enhance the potential positive socio-economic effect of the Project on human population and health. Mitigation and enhancement measures include best practices, management policies and procedures, and features of the agreement between BLFN and SaskPower with respect to the EFHLP. Knowledge of the socio-economic environment and mitigation or enhancement is applied to each interaction to determine the expected Project-related change to the environment (i.e., change in a measurement endpoint) and if there is potential for a residual socio-economic effect on human population and health.

Interactions are determined to be primary, secondary, or as having no linkage using scientific knowledge, the professional judgement of technical specialists, logic, experience with similar developments, and mitigation. Each potential interaction is evaluated and classified as follows:

- no linkage – interaction is removed by mitigation so that the Project results in no detectable change in measurement endpoints, and therefore, no effect on human population and health relative to baseline values;
- secondary – interaction could result in a minor change to measurement endpoints, but would have a negligible effect on human population and health relative to baseline values and is not expected to contrite to effects of other existing or reasonably foreseeable projects to cause a significant effect; or
- primary – interaction is likely to result in a detectable change in the measurement endpoints that could contribute to a measurable or detectable effect on human population and health relative to baseline values.

Any interactions that require a comprehensive assessment in order to determine if there is a residual socio-economic effect are considered primary. Primary interactions are anticipated to result in a residual socio-economic effect on human population and health, and require further analysis to determine the significance of the residual adverse socio-economic effect. Project interactions determined to have no linkage or those that are considered secondary are not predicted to result in significant socio-economic effects on human population and health. As such, interactions with no linkage or that are considered secondary are not analyzed further in the EIS.

Table 20.4-1: Project Interactions, Environmental Design Features, and Mitigation, and Potential Effects on Human Population and Health

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Effects on Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ General Construction, Operation, and Closure Activities	Construction, Operations, and Closure	Emissions of criteria air contaminants can cause changes to air quality that could affect human health. Deposition of criteria air contaminants can cause changes in the environment that could affect human health. Dust emissions can cause changes to air quality that could affect human health.	■ Equipment will be regularly maintained for compliance with provincial and federal air emission standards. ■ The equipment used for hauling and mucking operations will operate using diesel fuel with an ultra-low sulfur diesel content (less than 15 parts per million [ppm]). ■ The heavy-duty stationary and mobile diesel-fueled equipment fleet will meet or exceed EPA Tier 2/3 air quality emissions standards. ■ The gasoline-fueled equipment fleet will meet or exceed EPA Tier 2 Bin 6 air quality emissions standards. ■ An EnvPP will describe material handling protocols including dust management. ■ Soil salvage stockpiles or exposed soils will be seeded as appropriate for the area. ■ All unpaved roads will be watered on a regular basis to prevent wind driven fugitive dust. ■ A speed limit will be enforced on unpaved roads on site. ■ A forced air method of ventilation will be used for venting of dust, gases and fumes from inside the power tunnel following blasting and will be carried out until air quality inside the working environment returns to acceptable levels.	Secondary
		Changes in existing ambient sound levels and vibrations can affect human population and health.	■ The Proponent will communicate with the cabin owner regarding construction activities and will be prepared to address noise complaints should they arise. ■ The powerhouse will be located in a deep cut in the bedrock and insulated with rigid mineral wool material to reduce noise emissions from the building.	Secondary
■ Site Water Management ▪ collection and treatment of surface runoff within the project footprint ▪ discharge of runoff from the waste rock piles collection and discharge of groundwater in the tunnel	Construction and Operations	Changes to surface water quality can affect the health of resource users who collect or drink water while pursuing traditional activities on the land.	■ A Site Water Management Plan will be developed for the Project. ■ Construction and monitoring of settling ponds or water treatment areas will be part of the Site Water Management Plan. ■ Runoff from the waste rock disposal areas will be directed to settling ponds prior to discharge to the Fond du Lac River; water quality will be confirmed before release to the environment (e.g., Fond du Lac River). ■ Groundwater originating from construction of the tunnel will be collected, treated, if necessary, and monitored to confirm discharge criteria are met prior to release into the receiving environment. ■ Wastewaters released from the settling ponds will meet applicable water quality guidelines (e.g., CCME) at the end of the mixing zone in the Fond du Lac River. ■ Contingency plans for off-site disposal of dewatered settling pond sludge will be included in a Construction Environmental Management Plan. ■ Implementation of a Water Quality Monitoring Program.	Secondary
■ Power Generation Activities ▪ water withdrawal for power generation ▪ diversion of water through the power tunnel to the powerhouse	Operations	Changes to water and ice regime on the Fond du Lac River and in proximity to the intake on Black Lake may affect public safety during open water and ice travel among local residents.	■ Practices to improve safety for ice travel on Black Lake near the Project intake include: ▪ Establishing and marking safe travel routes during the ice covered season; ▪ Lighting the water intake to act as a beacon for travel after dark; and ▪ Communicating with the communities regarding potential changes associated with travel.	Secondary

Table 20.4-1: Project Interactions, Environmental Design Features, and Mitigation, and Potential Effects on Human Population and Health (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Effects on Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ General Construction and Operations Activities	Construction and Operations	Project construction and operation will result in income opportunities, including income associated with employment in addition to equity income resulting from BLFN participation as a partner in the Project. During the operation phase of the Project BLFN may use revenue generated from their equity share in the Project to improve or develop new infrastructure and community services for their members.	■ BLFN leadership consultation with members to determine the most appropriate use of the new income for the community. ■ Recruitment of an employment counsellor during the construction phase of the Project to provide support to local workers. ■ Coordination with local support and social services, such as health service providers, can help improve outcomes related to addictions in the context of increased disposable income. ■ Coordination between BLFN and educational institutions to provide life skills and financial management to local residents. ■ Mitigation will be introduced to prevent the introduction of drugs and alcohol at the construction camp.	Secondary
		The Project may affect the ability to access country foods during construction and operations, which could affect health and well-being.	■ The Proponent is committed to working with local resource users to mitigate the loss of some or all of their regular resource use areas; this may include compensation where appropriate.	
■ Presence of a construction workforce	Construction	The presence of short-term workers at the construction camp increases the potential risk for the spread of communicable diseases.	■ Installation of hand wash stations and workplace sanitary practices signage. ■ Coordination with local health service providers prior to the start of construction to identify if any health-related education strategies are required and appropriate. ■ Monitoring for an increase in the prevalence of communicable diseases will occur in the construction camp and adaptive management practices implemented should they be required. ■ During the construction phase, non-local workers will be flown into and out of Stony Rapids, with shuttle service provided from the airport to the construction camp and Project site. ■ Non-local workers will return to their home communities for their days off rather than remaining on-site or in the communities of Black Lake or Stony Rapids. ■ The non-local construction workers will be provided with accommodation at the construction camp during their work rotation, while local construction workers will be given the option to reside at home or at the construction camp. ■ The construction camp will be designated as a dry construction camp (i.e., no alcohol or illegal drugs will be permitted on-site) following regulations currently enforced on BLFN reserve land. ■ For overall safety, and in order to dissuade the potential for drugs to infiltrate the construction camp, the proponent will have a drug-testing program in place to screen workers prior to being employed as well as test workers if there is reason to believe they are under the influence of a banned substance. In addition, drug testing may occur if a safety incident has occurred. ■ The construction camp will provide recreational facilities for workers, including a canteen and cable and internet services. ■ The construction camp will be fenced and access will be controlled by a security gate staffed 24 hours a day. ■ Casual visitors to the construction camp will not be permitted. ■ Access to camp vehicles will be strictly limited. ■ Sanitary practices will be implemented in the camp to prevent the spread of communicable disease, including the installation of hand wash stations and workplace sanitary practices signage. ■ In the community of Black Lake, awareness programs will be developed to identify the risks associated with the presence of a construction camp and non-local workers, focusing on sensitive populations such as women and children. ■ The Partnership will coordinate with local service providers, such as the RCMP, health, and social services, to understand the potential strains that an influx of non-local workers could place on the communities. This will include the identification of appropriate local support and counselling should an incident occur. ■ Mechanisms for monitoring potential impacts, including monitoring for an increase in the prevalence of communicable diseases, will also be developed, so that if negative situations arise, the effects can be quickly identified, tracked, and adaptive management can be used to address the situation.	Secondary

Table 20.4-1: Project Interactions, Environmental Design Features, and Mitigation, and Potential Effects on Human Population and Health (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Effects on Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ Accidents and Malfunctions	Construction, Operations, and Closure	Release or spills of hazardous materials (e.g., fuel, oil) can cause changes in the environment that could affect human health.	■ All fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard; a lined and dyked containment area around these tanks will be provided to contain any potential fuel spills. The design of the containment area will be based on the requirements of the Canadian Council of Ministers of the Environment (CCME) Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. ■ The storage containers will be regularly inspected for leaks or damage and replaced when necessary. ■ Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled and located in lined and bermed containment areas. ■ Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers. ■ Regular maintenance construction equipment. ■ Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired within proximity of waterbodies. ■ Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills of fuel would flow to the sump, which would be pumped to a container for shipment off-site. ■ An Emergency Response Plan will be developed. ■ Spill response material (e.g., sorbent pads) will be stored on-site in designated areas and in vehicles. ■ Contaminated soils will be removed and disposed of in an approved landfill or waste management facility.	No Linkage
	Construction, Operations, and Closure	Increased traffic and degradation of transportation infrastructure can increase the potential for vehicle-to-vehicle collisions, which can cause injury or mortality to people.	■ Speed limits and reduced speed limits for trucks will be clearly posted and enforced to mitigate against potential accidents during construction. ■ Unpaved roads will be regularly graded and maintained to avoid wash boarding and rutting. Additional road maintenance could include dust control measures and stream crossing improvements. ■ Vegetation along the roadside will be mowed and cut to increase visibility of wildlife passing through or using the roadsides and ditches. ■ Safety policies will be developed by SaskPower and the general contractor will address safe driving practices for all construction personnel on public roads. SaskPower and the contractor will monitor all reported incidents of speed violations and provide appropriate disciplinary measures, where necessary. ■ Shuttle vehicles will be used by the contractor to transport workers between the construction site and the Stony Rapids airport to reduce the use of personal vehicles. ■ All workers and operations employees who will be driving as part of Project activities will be required to adhere to all driving rules and regulations, with particular attention to Saskatchewan distracted driver legislation. ■ Employees will be directed to respond appropriately to changing road and weather conditions and to identify and avoid potential driving hazards. ■ Vegetation along the access road will be mowed and cut to increase visibility of wildlife passing through or using the roadsides and ditches. ■ The contractor and Proponent will coordinate with local RCMP, health, and emergency services providers regarding traffic increases and possible issues affecting public health and safety.	Primary

Table 20.4-1: Project Interactions, Environmental Design Features, and Mitigation, and Potential Effects on Human Population and Health (continued)

Project Component/Activity	Project Phase when the Component/Activity Occurs	Potential Effects on Environmental Components	Environmental Design Features and Mitigation	Interaction Classification
■ Accidents, Malfunctions, or Unplanned Events	Construction, Operations, and Closure	Fire	■ The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail. ■ Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. ■ Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute).Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. ■ Personnel will be trained in fire prevention and response procedures. ■ Firefighting equipment will be available on site.	No Linkage

RCMP = Royal Canadian Mounted Police; CCME = Canadian Council of Ministers of the Environment; BLFN = Black Lake First Nation; EnvPP = Environmental Protection Plan

20.4.1 Interactions with No Linkage to Effects

An interaction may have no linkage to socio-economic effects if the activity does not occur, or if the interaction is removed by mitigation so that the Project results in no detectable change in measurement endpoints, and subsequently, no effect on human population and health. There were no interactions identified as having no linkage to effects on human population and health.

20.4.2 Interactions with Secondary Linkages

In some cases, both a source and an interaction exist, but the Project is anticipated to result in minor change to the environment and a negligible residual effect on human population and health relative to existing baseline or guideline conditions. The following interactions are expected to be minor and will not be carried through the residual effects assessment.

- **Emissions of criteria air contaminants can cause changes to air quality that could affect human health.**
- **Deposition of criteria air contaminants can cause changes in the environment that could affect human health.**
- **Dust emissions can cause changes to air quality that could affect human health.**

The air quality assessment presented in Section 8.4.1 and 8.4.2 predicts that emissions during construction will be mainly from heavy equipment, drilling and blasting, concrete production, and waste rock handling. These activities will produce combustion, emissions, and fugitive dust emissions. Emissions during operation will primarily be a result of backup diesel generators and powerhouse heating and air conditioning systems. Emissions during closure activities are likely to be negligible. The assessment focuses on emissions during the construction phase, as emissions during this phase are expected to be the greatest.

Ground level concentrations of criteria air contaminants (CACs) were modelled within the air quality study area using a screening level air dispersion model, in a manner consistent with Saskatchewan regulatory guidance including the *Clean Air Act* and Saskatchewan Air Quality Modelling Guidelines. Saskatchewan Ambient Air Quality Standards (SAAQS) were followed where possible, and in the absence of SAAQS standards, Canada-wide standards were applied, specifically the National Pollutant Release Inventory (NPRI).

An AERSCREEN model was used to predict air emission outcomes at various locations including a cabin on Middle Lake, offshore on Middle Lake (tailrace channel outlet), Camp Grayling, the community of Black Lake, offshore of the water intake at Black Lake, and the proposed location of the submerged weir in the Fond du Lac River. After adding the MOE values for background CACs (see Table 8.3-2), the maximum concentrations for all CACs at all receptor locations were below the SAAQS or the Canada Wide Standard (see Table 8.5-9). Based on the results of the air quality modelling, minor changes to air quality are predicted; however, concentrations of CACs remain below criteria. As such, residual effects on human health from changes in air quality are expected to be negligible.

- **Changes in existing ambient sound levels and vibrations can affect the human population and health.**

A noise assessment was completed to evaluate the potential changes in noise levels from existing or proposed sound emission sources (see Section 8.5.4). The focus of the noise assessment was on public exposure, including receptors at the permanent resident's cabin on Middle Lake, at Camp Grayling, near the Project intake on Black Lake, and at the bridge location on the Fond du Lac River. Project-generated construction noises are anticipated to include vehicle and heavy equipment traffic, activities associated with the construction of access roads, the construction camp, and bridge across the Fond du Lac River, as well as blasting and drilling at the tailrace channel location and construction of the powerhouse on the east side of the Fond du Lac River. Noise associated with the operation of the Project will be mostly limited to the powerhouse and is predicted to be perceived as a low indistinctive hum. Noise from vehicles (up to 10 vehicles per day) will be associated with operation of the Project.

Health Canada's (2011) *Draft Guidance for Evaluation Human Health Impacts in Environmental Assessment: Noise* provides a suggested approach for assessing the health impacts of noise. Although Health Canada does not have specific noise guidelines or enforceable noise thresholds or standards, this approach to the noise assessment does consider a variety of internationally recognized standards for acoustics, such as United States Environmental Protection Agency (US EPA) standards. "Health Canada considers the following noise-induced endpoints as health effects: noise-induced hearing loss, sleep disturbance, interference with speech comprehension, complaints, and change in percent highly annoyed" (Health Canada 2010; Health Canada 2011).

Results of the noise assessment predict that noise levels at all three receptors will be below Health Canada's guidelines for noise-induced hearing loss, sleep disturbance, interference with speech comprehension, complaints, and change in percent highly annoyed. Therefore, it is anticipated that the construction noise will not result in nuisance for the people living in the area. Construction traffic will however be audible, especially activities resulting in a noise peak, such as passing traffic, back up alarms, and dropping of hard material in empty trucks. It is assumed that initial closure of the Project would be completed at a slower rate relative to construction, generating less traffic volume per year than during construction. Assuming that vehicles and equipment used during construction are also used for closure, changes to ambient sound levels (ASLs) from the Project during closure are predicted to be lower than during construction.

Blasting activity of Project construction was assessed based on the following estimates for the maximum weight of explosive (kg) detonated per delay period (Section 8.5.5.3). The Project construction activities, that require blasting, include tailrace channel excavation, water intake and powerhouse excavation, and power tunnel and surge shaft. The blasting at the tailrace channel will be above ground while the blasting in the tunnel will be underground. Results of the noise assessment indicate that the limits for ground vibration peak particle velocity (PPV) from blasting operations is 30 mm/s. The PPV limit is 50 mm/s, therefore, the Project blasting activity are below the limits at each of the receptors and the ground vibrations attenuation distances are much closer to the Project site than each of the receptors (Section 8.5.5.3). The blasting charge will also result in air vibration. The air vibration levels are measured in dBL, which attenuate with distance from the blasting site, similar to airborne noise. Results indicate that the maximum air vibration levels at each receptor are below the 128 dBL limit and that the receptors are located at a much larger the distance than the air vibration attenuation distances (Section 8.5.5.3).

During operations, most of the incremental daytime and nighttime noise levels from the Project are predicted to be confined to the powerhouse. Based on the results of the noise assessment, the nighttime sound contributions from the Project on local receptors during operations are predicted to be below the PSLs for the nighttime (Section 8.5.5.3). The predicted total noise levels due to the Project operation at 1.5 km Buffer are also below the daytime PSL.

The cabin owner who is a year around resident at Middle Lake places a high value on the serenity of the LSA. While the noise assessment indicates that noise and vibrations associated with construction, traffic, excavation, blasting, and operations are anticipated to remain below limits at each receptor, these noises and vibrations may periodically become notable. The Proponent is committed to working with the contractor to limit Project-related disruption to local stakeholders. The Proponent will provide effective and timely communication about Project activities and whether any restrictions to activities will be applied (e.g., for safety concerns). Finally, the Proponent will consider compensation for demonstrated losses resulting from the Project.

Overall, changes to noise levels from the Project during construction and operations are predicted to be below guideline limits (i.e., Health Canada and Rule 012). Therefore, the residual effects from changes in noise levels from the Project on the local human population and health are expected to be negligible.

- **Changes to surface water quality can affect the health of resource users who collect or drink water while pursuing traditional activities on the land.**

Potential changes to surface water quality are primarily related to the discharge of water collected in the settling ponds from the management of groundwater from tunneling activities, in combination with runoff from waste rock piles. The results of the surface water quality modelling (Section 11.5.2.2) indicate that minor, short-term changes are predicted in the Fond du Lac River during the construction phase because of discharge from the settling ponds. However, these changes would not involve exceedences of applicable water quality guidelines under fully mixed conditions, or at the edge of the applicable mixing zone in the river. As such, the residual effects from changes to surface water quality on the local human health are expected to be negligible.

- **Changes to water and ice regime on the Fond du Lac River and in proximity to the water intake on Black Lake may affect public safety during open water and ice travel among local residents.**

No risks have been identified aside from the existing navigation hazards with respect to travel in open water. Although parts of the Fond du Lac River between Black Lake and Middle Lake can be accessed by boat (often using land based trails), the river is dangerous to navigate. Most notably, Elizabeth Falls itself is impassable by boat. Changes to water-based travel will not result from the Project.

During the winter, there could be changes to how ice forms in proximity to the intake on Black Lake and in proximity to the tailrace channel as it enters Middle Lake. This may affect the ability of people to travel safely on ice by snow mobile. Under existing conditions, the ice on Middle Lake near the Fond du Lac River is generally considered unsafe and is avoided during the winter months. This trend is expected to continue with the operation of the Project. On Black Lake, the snow mobile route that extends between the shoreline and island near the water intake. Practices implemented to improve the safety of ice travel include establishing and marking safe travel routes during the ice covered season, lighting the intake to act as a beacon for travel after dark, and communicating with the local communities regarding potential changes associated with travel. Overall, the residual effects from the Project on the local human population and health are expected to be negligible.

- **Project construction and operation will result in income opportunities, including income associated with employment in addition to equity income resulting from BLFN participation as a partner in the Project.**

Personal income related to Project construction and operations can affect community health and well-being by increasing individual and community income. This may contribute both positively and negatively to health and well-being, depending on how income is used. Increased personal income may allow for greater purchasing power, as well as an improved range of economic activities for employees and their households. For example, increased income often is associated with better health and longer life expectancy, allowing people to purchase higher quality foods or to pay for advanced education opportunities. On the other hand, increased personal income might contribute negatively to health and well-being if additional income results in misspending of income on substances such as alcohol and drugs. These activities, in turn, may have spinoff effects on the broader community including the potential for family instability. Higher levels of disposable income have been linked to drinking and drug use in other resource projects in Canada (Goldenberg et al. 2010). Research suggests that after one or two years communities can adjust to increased income levels through an increase in social stability and improved services (National Aboriginal Health Organization [NAHO] 2008). This suggests that while construction may represent an opportunity for misspending, operation employment income is more likely to contribute to overall improvements to individual health and well-being.

Mitigation practices may reduce some of the negative effects associated with sudden increases in disposable income. These include the recruitment of an employment counsellor during the construction phase of the Project who would provide support to local workers, connecting them with employment opportunities, as well as providing on-site counselling services and coordination for those who may encounter problems at work or home. In addition, the Proponent and educational institutions will provide training designed to ready the local workforce, including providing training in life skills, money management, and addictions counselling. The Tazi Twé Employment and Training Charter identifies support systems for trainees and employees through BLFN's engagement of a National Child Benefit Reinvestment (NCBR) representative, who will help support those local residents attending employment and training programs for the Project. Supports provided through the NCBR include home-to-work transition and parental support programs. The AANDC also provides funding for the delivery of key social development programs in the community, including Income Assistance, First Nations Child and Family Services and Family Violence Prevention. Coordination with support and social services, such as local health service providers, can also help improve outcomes related to addictions in the context of increase disposable income. Furthermore, as BLFN is a dry reserve, several mitigation practices will be introduced to prevent the introduction of drugs and alcohol at the construction camp, and as a result, in the community. These are addressed in detail in Section 20.5.1.

Similar to the potential effects of increased personal income, increases in equity income to BLFN related to Project operation may affect community health and well-being. Equity income to BLFN will increase the First Nation's annual revenues and will empower the First Nation with resources to address community needs. Community equity income is discussed in Section 18.0.

Employment counselling and training should help to limit effects on the local human population and health because of increased personal income related to the Project. The increase in community equity to BLFN is expected to have a positive effect on local human population and health Through access to increased community revenues, the equity income that is anticipated from the Project will empower BLFN to address community needs and improve local well-being. Overall, the residual effects from the Project on the local human population and health are expected to be negligible.

- **The Project may affect the ability to access country foods, which could affect health and well-being.**

The construction and operation of the Project will result in minor changes to resource use and traditional activities, which have links to health and well-being. One of the main factors that could affect well-being is changes to the ability to access country food, or domestic resource use. Country foods are rich in nutrients and provide for the maintenance of good health, while traditional resource use activities, such as hunting, fishing, and gathering, contribute to increased physical activity and health (Assembly of First Nations [AFN] 2007).

As discussed in Section 17.0, the presence of the Project, as well as the presence of the construction and operations' workforces, may result in reduced ability for some members of the communities to pursue traditional resource use activities. As a result, local resource users, particularly those who currently live and harvest within or near the Project footprint could experience a reduction to their consumption of country foods and a reduction in activities associated with this lifestyle, both of which have implications for personal health. The reduction of access to country foods could result in increased food purchases. As noted in Annex VI, the cost of purchasing food in the north is much higher than in other areas of the Province, and northern residents often have less access to fresh and healthy food choices at affordable prices. Purchased food reduces the money available for other activities or household and personal expenses, which could cause negative effects on human health.

Although there is potential for health effects related to reduced access to land and resource use, the small number of current resource users in the LSA means that very few local resource users are likely to be affected. Most local resource users will be able to access and harvest in other nearby areas for the duration of Project construction and will be provided access through Project areas where there are no risks to public safety. During operation, the area is likely to become more accessible for resource use purposes than during the construction phase. The Proponent is committed to working with local resource users to mitigate the loss of their regular resource use areas to providing access through areas that are otherwise restricted to the public during construction (assuming there is no risk to public safety. This could include compensation where appropriate. Although there might be minor changes to resource use and traditional activities, effects on the local human population and health are expected to be negligible.

- **The presence of short-term workers at the construction camp increases the potential risk for the spread of communicable diseases.**

An influx of non-local workers into the LSA presents an increased risk for the spread of communicable diseases through exposure or contact with local residents at the construction camp (i.e., with local resident workers) or through interactions with residents in the LSA communities. Although measures will be introduced to the limit the opportunities for interaction between local residents and non-local workers (see Section 20.5.1), there is still potential for the spread of communicable disease at the construction camp.

To reduce the potential for the spread of communicable diseases, the General Contractor will implement sanitary practices in camp, including the installation of hand wash stations and workplace sanitary practices signage. Prior to the start of construction, the Proponent will coordinate with local health service providers to determine if any education strategies are required or appropriate. Monitoring for an increase in the prevalence of communicable diseases will occur in the construction camp and adaptive management practices implemented should they be required.

The Proponent recognizes that one of the unique health considerations in northern Saskatchewan is tuberculosis (TB). Northern Saskatchewan has higher rates of TB than other parts of the province, at 159.1 cases per 100,000 residents compared to 1.7 cases per 100,000 residents of southern Saskatchewan in 2010 (AHA 2011). The Proponent will coordinate efforts with the provincial workplace guidelines for TB, currently under review by the province and local TB Prevention and Control Program to develop appropriate TB prevention education strategies for the construction camp. Appropriate medical screening for workers may be considered if determined necessary from consultation with health service providers.

20.4.3 Accidents, Malfunctions, and Unplanned Events

Accidents, malfunctions, and unplanned events occurring on-site have the potential to adversely affect human population and health. The following event was identified as having a potential interaction with human population and health.

- **Release or spills of hazardous materials (e.g., fuel, oil) can cause changes in the environment that could affect human health.**

Spills during construction, operations, or closure activities have the potential to change surface water and soil quality, which can adversely affect vegetation, wildlife, wildlife habitat, and subsequently, human health. Spills that occur in high enough concentrations could contaminate surface water and soils and cause direct toxicity to aquatic organisms, soil organisms, and vegetation. The effects of these spills could also affect human health should local residents and resource users consume contaminated water, vegetation, or wildlife.

Spills are generally preventable and local in nature. Environmental design features and mitigation practices will also be implemented as part of the Environmental Protection Plan (EnvPP) to reduce the likelihood and extent of spills and leaks at the Project site. Spill containment supplies will be available in designated areas on the Project site and within Project vehicles. An Emergency Response and Contingency Plan will be developed and will include instruction for the rapid response control and management of spills or release of hazardous substances. All spills will be isolated and immediately cleaned up. Spills will be reported to the appropriate agency if the spill exceeds reportable volumes for the material spilled as outlined in the provincial *Environmental Spill Control Regulations*. In the unlikely event of a spill, disposal of all contaminated soil will be handled by a licensed contractor and will be hauled off-site to an approved facility.

Storage facilities for hazardous wastes will meet regulatory requirements. All fuel storage tanks will be designed and constructed based on the requirements of the Canadian Council of Ministers of the Environment (CCME) Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products (CCME 2003), the National Fire Code of Canada, and any other standards that are required. The containment area will be sized to hold 110% of the volume of the largest storage tank and will include a gravel base with a continuous high-density polyethylene liner sheet installed under the tanks and the internal sides of the berm. The storage containers will be regularly inspected for leaks or damage and replaced when necessary. Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled and located in lined and bermed containment areas. Reagents and fuel Enviro-Tanks (if applicable) will be located in larger, double-walled containers.

Vehicles will be regularly maintained and will carry fire extinguishers and standard emergency clean-up kits. Construction machinery, equipment, and vehicles will not be stored, refuelled, or repaired near waterbodies. Vehicle fuelling stations will be located on a constructed pad sloping toward a drain connected to a sump. Any spills on the fueling stations would flow to the sump, which would be pumped to a container for shipment off-site. Implementation of the above environmental design features are expected to reduce the likelihood and extent of the release or spills of hazardous materials occurring on-site. Therefore, this interaction is determined to have no linkage to effects on human health.

- **Fire**

Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response and Contingency Plan. Fire safety measures and response will be reviewed with the communities of Black Lake and Stony Rapids. On-site personnel will be trained in established fire prevention and response procedures and appropriate firefighting equipment will be available on-site so that trained personnel will be able to respond promptly. The fire protection water system will be comprised of two electric motor driven pumps, each powered by separate electrical sources, and a by-pass to allow flow to pass in the event that both pumps fail.

Each pump will be sized to meet the full demand of the largest component of the system with the addition of 31.5 litres per second (L/s) for hose demand. Distribution pumps located in the water treatment plant will provide the fire protection flows through pipelines to the Project buildings. Storage tanks will provide the necessary storage capacity to meet fire-protection requirements stipulated by the National Fire Protection Association 851 (i.e., two hours of available water at 750 US gallons per minute). The implementation of the abovementioned mitigation is anticipated to result in no linkage to effects to human population and health.

20.4.4 Primary Interactions

The following interaction was determined to be primary for socio-economic effects on human population and health:

- During the construction phase of the Project, the presence of short-term workers and their interaction with local residents has the potential to affect local health and well-being.
- Increased traffic and degradation of transportation infrastructure can increase the potential for vehicle-to-vehicle collisions, which can cause injury or mortality to people.

20.5 Residual Effects Analysis

Project-related changes to human population and health may result from primary Project interactions. The first is the potential for adverse interactions between the non-local construction workforce and residents in the LSA, which has the potential to affect individual and community well-being. The second interaction relates to changes to traffic volumes during the construction phase, which presents the potential risks for increased traffic accidents.

20.5.1 Influx of Workers

Section 18.0 describes the Project workforce, including peak construction workforce, operations workforce, and the anticipated local and non-local workforce requirements. The total construction workforce will be substantial relative to the size of the communities of Black Lake and Stony Rapids, with a sizeable proportion of the workforce coming from outside the LSA. Table 18.5-2 describes the peak for the construction workforce, with peaks expected to be the highest during the second and third quarters (i.e., April through to September) of 2015 to 2017. Although parts of the workforce are expected to be hired from the LSA, at the peak as much as 77% to 90% of the workforce may be from the RSA and beyond.

There is a potential for negative interactions between the non-local workforce and local residents. Such negative interactions have occurred during construction of resource development projects located near small northern communities (Vanclay 2002; Goldenberg et al. 2007; Goldenberg et al. 2010) including incidents involving alcohol and drug use, violent and aggressive behaviour, verbal and physical abuse, unplanned pregnancies, and increased rates of STIs. Although the vast majority of visits by non-local workers to a community near a major development have no adverse interactions, a very small number of incidents can be problematic, particularly in small close-knit communities such as those in the LSA.

The assessment of effects associated with an influx of workers for the Project takes into account the size of the workforce, workforce timing, peaks, and rotations, as well as the location of the construction camp and camp amenities, camp regulations, and the transportation of workers. To reduce the potential for negative interactions between non-local workers and residents of the communities of Black Lake and Stony Rapids, a number of policies and procedures will be put in place. Mitigation to limit the opportunities for negative interactions to occur include educating residents and local service providers about the potential risks associated with a non-local workforce and developing response measures to address issues as they arise.

During the construction phase, non-local workers will be flown into and out of Stony Rapids airport with shuttle service provided from the airport to the construction camp and Project site. It is anticipated that the work rotation will be 14 days on, with seven days off between shifts. Non-local workers will return to their home communities for their days off rather than remaining on-site or in the communities of Black Lake or Stony Rapids. The non-local construction workers will be provided with accommodation at the construction camp during their work rotation, while local construction workers will be given the option to reside at home or at the construction camp. The construction camp population is estimated to be up to 250 workers throughout the course of construction.

The construction camp will be located on the west side of the Fond du Lac River, approximately 7 km by road from the community of Black Lake and 22 km by road from the Northern Hamlet of Stony Rapids. The construction camp will be designated as a dry construction camp (i.e., no alcohol or illegal drugs will be permitted on-site) following regulations currently enforced on BLFN reserve land. For overall safety, and to dissuade the potential for drugs to infiltrate the construction camp, the proponent will have a drug-testing program in place to screen workers prior to being employed as well as test workers if there is reason to believe they are under the influence of a banned substance. Drug testing may also take place if a safety incident has occurred. This is in keeping with SaskPower requirements that construction contractors meet or exceed SaskPower Drug and Alcohol policy and the Construction Opportunities Development Council (CODC) Drug and Alcohol program.

Although non-local workers will leave the region during their days off according to the work rotation schedule, the short distance between the construction camp and the communities of Black Lake and Stony Rapids may serve as an incentive for non-local workers to travel to the communities during their time off. Both communities have limited recreational amenities and services. In the Northern Hamlet of Stony Rapids, one local hotel/restaurant sells liquor. The owner of the restaurant serving alcohol has a long-standing policy restricting alcohol sales (i.e., drinks may only be purchased with food) and a limitation to four drinks is enforced by the proprietor. While there are no other public locations in the Northern Hamlet of Stony Rapids, where alcohol is permitted; alcohol is available for purchase for guests staying at Camp Grayling.

To reduce the incidence of non-local workers visiting the communities of Black Lake and Stony Rapids during their non-working hours, the construction camp will implement a number of measures that encourage workers to stay on-site. The construction camp will provide recreational facilities for workers, including a canteen and cable/internet services. The construction camp will be fenced and access will be controlled by a security gate. In addition, casual visitors to the construction camp will not be permitted. As most non-local workers will fly into Stony Rapids airport and be transported directly to and from the airport by shuttle van, few personal vehicles are expected to access the site. Finally, with 10- to 12-hour work shifts, workers will have few available hours for pursuing off-site activities following their daily shifts.

In addition to reducing opportunities for negative interactions between local residents and non-local workers, several other measures will be implemented to increase awareness at the construction camp and within the communities. In the construction camp, these measures will include cross-cultural training for all staff. The training will incorporate an overview of the community of BLFN, a review of policies and procedures with respect to resource use activities, and discussion of the expectations of BLFN in terms of interactions with the community and its members. In the community, awareness programs such as workshops will be developed to identify the risks associated with the presence of a construction camp and non-local workers, focusing on sensitive populations such as women and children.

The Proponent will also coordinate with local service providers, such as the RCMP, health, and social services, in order to understand the potential strains that an influx of non-local workers could place on the communities. This coordination will include the identification of appropriate local supports and counselling should an incident occur. Mechanisms for monitoring potential occurrences of negative interactions, including the potential for an increase in the prevalence of communicable diseases, will be developed, so that if negative situations arise, the effects can be quickly identified, tracked, and adaptive management can be used to address the situation.

These mitigation practices and policies, along with the living and working conditions for construction workers and limited access to alcohol in the Northern Hamlet of Stony Rapids, are expected to reduce greatly the number of trips construction workers will make to the communities Black Lake and Stony Rapids, as well as diminish the occurrence of negative interactions associated with the visits that do occur. It will not eliminate the possibility of negative interactions but it will avoid them to the maximum extent possible, as well as providing a mechanism for alleviating the outcomes of negative incidents if they do occur.

Project effects on community well-being are limited to the construction phase of the Project because the required workforce for operations will be very small compared to the construction workforce, with between six and eight permanent positions expected. The Proponent has identified mechanisms to recruit, train, and retain the operations workforce from the LSA, and as such, there is limited risk of worker-interaction issues beyond construction.

20.5.2 Changes to Traffic Volumes

During construction and operation of the Project, changes to traffic patterns and volume related to the Project may affect travel safety among local residents. The risk to public safety associated with travel is the potential for increased traffic accidents.

According to the traffic analysis discussed in Section 19.0, the potential for effects from traffic volume associated with the Project only exist for Control Section 905-07 of Highway 905 – the section of Highway 905 between Stony Rapids and Black Lake – as well as the proposed new access road to the Project site. Collision or accident occurrences are discussed in terms of accidents per million vehicle kilometres (accidents per Mvkm). This rate is calculated by multiplying the ADT (average vehicles per day) by 365 to arrive at the average number of vehicles per year, then multiplying this number by the length of the road section in kilometres (km) and dividing the total by 1,000,000.

During construction of the Project, the southern portion of Control Section 905-07 connecting Black Lake to the proposed site access road is anticipated to experience increased truck traffic, resulting in a 19% increase in Mvkm, from 3.74 to 4.35 Mvkm. This detectable increase could increase the current collision frequency on this section of the highway from four to five accidents per year. During the operations of the Project, a conservative increase of 10 small vehicles is assumed to be travelling from Black Lake to the Project site. This increase in traffic would result in an increase of approximately 8% from the current Mvkm of 3.74 to 4.02 Mvkm; however, this is not anticipated to increase the vehicle collision frequency on the highway during operations.

The northern portion of Control Section 905-07 connecting Stony Rapids to the proposed site access road is anticipated to experience the bulk of daily small vehicle traffic (40 small vehicles) during construction, with a 30% increase in traffic, from 3.74 to 4.87 Mvkm. This is a detectable increase and could increase the current collision frequency from four to five accidents per year. During the operations of the Project, a conservative increase of 10 small vehicles is assumed to be travelling daily from the Northern Hamlet of Stony Rapids to the Project site. This increase in traffic would result in an increase in Mvkm of approximately 8%, from 3.74 to 4.02; however, this is not anticipated to increase the vehicle collision frequency on the highway during operations.

The anticipated Mvkm for the proposed site access road is 0.13 (45 ADT x 365 days x 8.5 km / 1,000,000) during the construction phase of the Project, with an anticipated Mvkm of 0.03 (10 ADT x 365 x 8.5 km / 1,000,000) during Project operations. These are relatively low Mvkm; however, low Mvkm does not always mean a low collision rate.

Many factors may contribute to road collisions; an increase in traffic volumes is not the only metric used in determining the risk of collisions. Saskatchewan Government Insurance (SGI) reports that in 2010, human conditions were a more prevalent factor in fatal collisions (42.7%) than in all collisions (33.3%). Driver inattention or distraction accounted for approximately 23% of reported factors leading to collision (SGI 2012). Overall, human condition and actions, including alcohol, inattention, disregard for traffic controls, and driving too fast for road conditions, accounted for 65.9% of all factors leading to collisions, and 82.3% when considering factors leading to collision resulting in death. Environmental conditions, mainly animal actions, are important factors for rural and highway collisions. On other roads (i.e., not urban streets, provincial highways, or rural roads), such as Highway 905, environmental conditions accounted for 48.9% of collisions in 2010, compared to 23.8% of collisions caused by human conditions, 24.3% of collisions caused by human action factors, and 3.0% of collisions caused by vehicle factors.

Mitigation to reduce traffic and traffic collisions during the construction and operations of the Project will include a number of practices and policies. As noted above, driver actions in terms of both skill and attitude play a critical role in roadway safety and the avoidance of vehicle collisions. All employees, including construction contract workers and operations employees of SaskPower, who will be driving as part of Project activities, will be required to adhere to all driving rules and regulations, with particular attention to the Saskatchewan distracted driver legislation. Employees will be directed to respond appropriately to changing road and weather conditions and to identify and avoid potential driving hazards. Restrictions will also be placed on the use of company vehicles during the construction of the Project, with the non-local construction workforce shuttled between the Stony Rapids airport and the construction camp.

In addition to mitigation associated with driver actions, all roads will have posted speed limits, signs, and other warnings to alert traffic to trail and road crossings. Unpaved roads will be regularly graded and maintained to avoid washboarding and rutting, and vegetation along roadsides will be maintained to increase visibility of roadsides and ditches. The general contractor will be charged with monitoring traffic on the local access road for the duration of the construction phase of the Project, as well as working with the Proponent to coordinate with local RCMP, health, and emergency services providers regarding traffic increases and possible issues affecting public health and safety. The access road will be controlled with signage, fences, and other security features to limit access to the area during both the construction and operations phases. Similar mitigation, such as permanent fencing, will restrict access to the water intake and powerhouse structure, as well as the tailrace channel and any storage buildings on the east side of the Fond du Lac River.

20.5.3 Management of Uncertainty

Like all scientific results and inference, residual effects predictions for the socio-economic environment will have uncertainty associated with the data and current knowledge of the system. The confidence in residual effect predictions is related to the following:

- adequacy of baseline data for understanding conditions in the local and regional study areas;
- the understanding of Project-related residual effects on the system; and
- knowledge of the effectiveness of environmental design features and mitigation at limiting effects on VCs.

For risks to local residents associated with potential adverse interactions with non-local workers, a qualitative analysis was applied. Satisfactory methods to estimate quantitatively these risks do not exist. As such, uncertainty is inherent in the analysis. Sources of uncertainty include:

- what is precise numbers of construction workers on-site at various times during construction;
- how interested workers will be in going to local communities during their off-hours;
- how difficult it will be for workers to travel between the camp and local communities;
- how interactions between workers and community members might take place; and
- how local businesses and residents will respond to the presence of construction workers.

The communities in the LSA have relatively limited experience with major project construction nearby. As such, the approach adopted to identify and understand potential risks associated with worker interaction rely heavily on examples from other jurisdictions, including a review of relevant literature and experience in other projects. Conservative assumptions were used in the evaluation of potential effects, and the evaluation considered that social impacts tend to be more prominent in northern remote communities (Lawrence 2004).

Uncertainty exists with respect to the magnitude and duration of non-local construction workers and local residents interaction effects, as each of these is dependent not only on the type of incident that occurs, but also on the individual and community's resilience and ability to manage the outcomes of the effect. The analysis recognizes that even a single incident could have a significant effect on the individual and to the communities at large. The assessment took into consideration the importance of early engagement with local residents and service providers so that potential risks could be identified prior to the on-set of construction, and strategies can be devised to address issues as they arise. Implementation of adaptive management practices during construction is important to respond to non-local construction workers and local resident interaction issues as they arise, as well as help reduce the potential for future interactions.

With respect to traffic, some uncertainty exists with respect to the total increase and timing of traffic volumes, which will be refined as Project engineering is finalized. Furthermore, as described in Section 20.5.2, many factors may contribute to road collisions; and an increase in traffic volumes is not the only metric used in determining the risk of collisions. Overall, human condition and actions, including alcohol, inattention, disregard for traffic controls, and driving too fast for road conditions were factored into the analysis of potential effects. Mitigation practices and policies are anticipated to limit the risk to local human population and health from the increase in Project-related vehicle traffic.

20.6 Determination of Significance

The changes in measurement endpoints associated with primary interactions provide the foundation for determining significance from the Project on human population and health. Direction, magnitude, duration, and geographic extent are the main factors of consideration used to predict significance. For human population and health, the assessment of significance considers the scale of these factors, in addition to professional opinion based upon the context of the Project in combination with other relevant experience. The assessment of significance also considers the efficacy of the proposed mitigation and enhancement measures to limit residual adverse effects and enhance potential benefits to human population and health. The determination of significance assessment considers all primary interactions that are expected to result in residual effects on human population and health.

Frequency is not considered in evaluating the significance of residual socio-economic effects on human population and health. For socio-economic changes, the residual effects are generally continuous; therefore, criterion frequency is typically not used. Similarly, reversibility is not used in determining effects on the socio-economic environment as effects associated with a project are typically part of an ongoing process of interdependent economic and social change extending into the future. In general, these processes cannot be reversed to return to pre-project development conditions.

20.6.1 Residual Effects Criteria

Table 20.6-1 describes the criteria used when evaluating effects on human population and health.

Direction – Direction refers to the overall nature of the effect. A negative effect would be one where there is an adverse effect on the VC relative to the existing environment. A positive rating anticipates that the socio-economic effect will be of benefit to the VC relative to the existing environment.

Magnitude - Magnitude refers to the degree of change in a measurement endpoint and the resulting residual effect on human population and health. Magnitude may be low, moderate, or high. Low magnitude predicts a small, but hardly discernible effect on natural, cultural, and social features of the environment. A moderate rating anticipates that the effect on a VC is likely to result in a noticeable change relative to the existing environment. High magnitude suggests that the change will be large, and a meaningful change will occur relative to the existing environment.

Duration - Duration is defined as the amount of time that human population and health is exposed to Project activities or phases. Short-term effects are anticipated to occur over the course of construction only. Medium-term effects can occur within the first 10 years of operations of the Project, or for one human generation relative to human population and health. Long-term effects are those effects that are likely to persist beyond 10 years into operations of the Project, or for more than one generation relative to human population and health.

Geographic Extent - Geographic extent considers the location in which effects are likely to be measurable relative to the existing environment. For human population and health, these include local and regional areas. A local rating anticipates that effects will be measurable in the communities of Black Lake and Stony Rapids, or the LSA. A regional rating anticipates that changes would extend beyond the local area, and be measurable within the Athabasca region or the province of Saskatchewan as a whole.

Table 20.6-1: Residual Effects Criteria for Human Population and Health

Direction	Magnitude	Duration	Geographic Extent
Negative: An adverse effect relative to the existing environment. **Positive:** A beneficial effect relative to the existing environment.	**Low:** Effects are likely to result in a small, hardly discernible change relative to the existing environment. **Moderate:** Effects are likely to result in a noticeable or detectable change relative to the existing environment. **High:** Effects are would be likely to result in a large, meaningful, and readily detectable change relative to the existing environment.	**Short-term:** Changes will only occur during the construction phase. **Medium-term:** Changes will extend to the first 10 years of operation of the Project, or for one generation relative to human population and health. **Long-term:** Changes will last for more than 10 years, or for more than one generation relative to human population and health.	**Local:** Changes would affect communities in the LSA including the communities of Black Lake and Stony Rapids. **Regional:** Changes would extend to the Athabasca region and to Saskatchewan as a whole.

20.6.2 Project-specific Residual Effects

The analysis of residual effects on human population and health considers two factors: potential effects associated with non-local construction workers and local resident interactions, and potential effects associated with traffic accidents. For both of these factors, mitigation practices will be implemented to reduce the potential for effects to occur. In the case of non-local construction workers and local resident interaction, adaptive management practices have also been identified to address issues as they arise. Effects on human population and health related to non-local construction workers and local resident interactions are expected to result in negative residual effects that are primarily related to construction activities. Residual effects are predicted to be noticeable or detectable change relative to the existing conditions and local in geographic extent. However, the consequences of a negative effect (e.g., an altercation resulting in injury) could be longer lasting. No significant adverse effect of the Project on human population and health are expected because of non-local construction workers and local resident interactions, however, it is recognized that even a single incident could have a significant effect on the individual and local communities. Early engagement with local residents and service providers will be completed so that potential risks can be identified prior to the on-set of construction, and strategies can be devised to address issues as they arise.

Effects related to traffic accidents are expected to remain with the LSA (with traffic accidents extending to Highway 905). The increased traffic volume is expected to be noticeable or detectable change relative to the existing conditions and have a negative residual effect that is primarily related to the construction phase. Mitigation practices and policies are anticipated to limit the risk to local human population and health from the increase in Project-related vehicle traffic. It is acknowledged that any vehicle collision resulting in the death of an individual would have a significant effect on the immediate family and local community.

20.6.3 Cumulative Residual Effects

Cumulative effects are those effects from the Project, combined with the effects from prior development, existing activities, and reasonably foreseeable future developments that are sufficiently certain to proceed. Reasonably foreseeable developments or designated projects that would be included in the EIS are activities or projects that:

- would be developed in the spatial and temporal boundaries of the Project;
- have been proposed and scoped to a reasonable level of detail;
- may be induced by the Project;
- are currently undergoing regulatory review; and
- have the potential to change the Project or the effects predictions.

For human population and health, one additional development was identified as having potential spatial overlap for the RSA: the Highway 968 All-weather Road Project, a proposed 88.5 km road from highway 905 near Stony Rapids to the community of Fond du Lac. The proposed roadway would extend from approximately 3.5 km south of the Stony Rapids airport at its intersection with Highway 905, and generally following the existing winter road location west for 31.9 km toward Fond du Lac. The remaining 56.6 km of roadway would be entirely new, terminating on the south shore of Lake Athabasca near Fond du Lac. The project would take approximately three years to construct, and would result in an estimated 300 person years of employment (MHI 2010). With respect to human population and health, this could result in both additional people and traffic coming through the RSA. Increased traffic volumes could present additional risks to public safety with respect to traffic accidents.

Additional workers accessing businesses and services in the communities in the region presents further opportunity for adverse interactions between non-local construction workers and local residents.

At present, there is no evidence to suggest that there would also be a temporal overlap with construction activities for the Project and the development of the proposed roadway. Although the duration of the Project has the potential to last over 90 years, it is only overlap during the construction phase that presents potential changes to the evaluation of cumulative effects. Saskatchewan Highways and Infrastructure budget announcements for 2013 to 2014 do not include the proposed road and the environmental assessment process has not moved beyond the submission of a Project Description in 2010 (MHI 2010; Government of Saskatchewan 2013). Based on the assumption that construction phases for the Project and the road development are not likely to overlap, no significant adverse effects from the Project, combined with existing and reasonably foreseeable developments on human population and health, are predicted.

20.7 On-going Engagement

A Project Advisory Committee, including equal representation from the EFHLP and SaskPower will meet at least monthly or as otherwise agreed to by the Committee, and will review the status of the Project including environmental, engineering and construction activities including community matters that relate to the completion of the Project. It is anticipated that this committee will discussion on-going concerns about socio-economic effects, and that the EFHLP and SaskPower will work together collaboratively on measures to address any community concerns.

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20.9 Glossary

Term	Description
Communicable Diseases	An infectious disease transmissible (as from person to person) by direct contact with an affected individual or the individual's discharges or by indirect means (as by a vector).
Crude Rate	The total number of events occurring in an entire population over a period of time, without reference to any of the individuals or subgroups within the population.
Chronic Disease	A disease that persists for a long time and cannot generally be prevented by vaccines or cured by medication. Chronic diseases tend to become more common with age. Examples include arthritis, cardiovascular disease, cancer, and diabetes.
Environmental Impact Statement	A report that documents the information required to evaluate the environmental effect of a project.
Infant Mortality Rate	The ratio of the number of deaths in one year of children less than one year of age to the number of live births in that year.
Life Expectancy	The expected number of years of life remaining at a given age, in the statistical sense.
Mortality Rate	A measure of the number of deaths (in general, or due to a specific cause) in a population, scaled to the size of that population, per unit of time. Mortality rate is typically expressed in units of deaths per 1000 individuals per year.
Premature Mortality Rate	The rate of deaths of residents aged 0-74 years, per 1,000 residents aged 0 to 74 years. The values are standardized to account for age/sex differences in populations.
Residual Effect	An environmental effect that remains, or is predicted to remain, even after mitigation measures have been applied.
Supplementary Factors	When an individual with a diagnosed disease or injury is hospitalized for a specific treatment of that disease or injury or when an individual is hospitalized with a problem that is not itself an illness or injury.

20.10 List of Acronyms

Term	Definition
AFN	Assembly of First Nations
AHA	Athabasca Health Authority
AANDC	Aboriginal Affairs and Northern Development Canada (formerly known as Indian and Northern Affairs Canada [INAC])
BLFN	Black Lake First Nation
CAC	Criteria Air Contaminant
CCME	Canadian Council of Ministers of the Environment
CDC	Centers for Disease Control and Prevention
CODC	Construction Opportunities Development Council
EFHLP	Elizabeth Falls Hydroelectric Limited Partnership
EIS	Environmental Impact Statement
EnvPP	Environmental Protection Plan
GHG	Greenhouse Gas
IPHRC	Indigenous Peoples' Health Research Centre
KPI	Key Person Interview
KYRHA	Keewatin Yatthé Regional Health Authority
LSA	Local Study Area
MSRA	Methicillin-resistant Staphylococcus Aureus
MOE	Saskatchewan Ministry of Environment
NAHO	National Aboriginal Health Organization
NCBR	National Child Benefit Reinvestment
NPRI	National Pollutant Release Inventory
PPV	Peak Particle Velocity
RCMP	Royal Canadian Mounted Police
RSA	Regional Study Area
the Project	Tazi Twé Hydroelectric Project
TSP	Total Suspended Particulates
SAAQS	Saskatchewan Ambient Air Quality Standards
SGI	Saskatchewan Government Insurance
STI	Sexually Transmitted Infection
VC	Valued Component
WHO	World Health Organization

20.11 List of Units

Term	Definition
accidents/Mvkm	accidents per million vehicle kilometres
km	kilometre
Mvkm	million vehicle kilometres
%	percent

21.0 ENVIRONMENTAL MANAGEMENT, MONITORING, AND FOLLOW-UP

This section provides a summary of the monitoring and follow-up programs proposed to verify the accuracy of the effects assessment and to determine the effectiveness of mitigation and environmental design features. Monitoring programs will be designed to incorporate baseline data, compliance data (e.g., regulatory documents, standards, or guidelines), and real time data. These programs will also include any contingency procedures/plans or other adaptive management provisions as a means of addressing unforeseen effects or correcting exceedances, as required, complying or conforming to benchmarks, regulatory standards or guidelines.

21.1 Environmental Protection Plans

An Environmental Protection Plan (EnvPP) provides detailed site-specific environmental protection procedures to be implemented by the construction team or operational personnel during various phases of the Tazi Twé Hydroelectric Project (Project). For the Project, the EnvPP is designed for use as a reference document providing the framework for the delivery, management, and monitoring of environmental and socio-economic protection practices to meet or exceed regulatory requirements. The purpose of EnvPPs is to guide construction and operational activities to reduce potential effects on the environment, and to satisfy corporate policies and commitments, regulatory requirements.

The EnvPP describes how the proponent is organized and functions to deliver timely, effective, and comprehensive solutions and mitigation practices to address potential environmental effects. Roles and responsibilities for employees and contractors are defined, and management, communication, and reporting structures are outlined. The EnvPP describes how the environment will be protected during the construction, operation, and closure phases of the Project.

The EnvPP will be used for the following purposes:

- identify Environment Health and Safety (EHS) concerns and develop appropriate protection practices and procedures for these concerns;
- list all required permits and approvals and their associated terms and conditions;
- provide concise and clear instructions for procedures that protect the environment;
- provide a reference document for personnel when planning or completing specific activities;
- communicate changes in the program through the revision process; and
- provide a reference to applicable legislative requirements.

Reducing environmental effects of the Project is a key design and operational component of the Project. Applicable environmental (federal and provincial) regulations, permits, and standards will be adhered to throughout all Project phases. The proponent's existing procedures and codes of practice will cover environmental management and workplace safety for the Project. Best Management Practices (BMP) will be adopted to provide practical guidance in meeting permitting requirements, completing contract documents, and constructing the Project.

21.2 Environmental Management Plans

Environmental management plans focus on limiting effects on environmental components. They outline specific actions that must be taken during construction and operation to mitigate Project effects. Many of the management plans include monitoring to determine success of the actions taken and to determine if additional actions need to be taken (i.e., adaptive management). The following plans will be prepared prior to the construction of the Project:

- Blasting Plan;
- Erosion and Sediment Control Plan;
- Site Water Management Plan;
- Waste Management Plan;
- Waste Rock Management Plan; and
- Weed Management Plan.

21.3 Environmental Monitoring and Follow-up Plans

Environmental monitoring plans are designed to measure the actual effects of the Project, test predictions, or identify unanticipated effects. The proponent's monitoring and follow-up plans will be developed prior to the start of construction and will include recommendations made by regulatory agencies and stakeholders, as appropriate, during the Environmental Impact Statement (EIS) review process. Monitoring and follow-up plans will be developed by the proponent to comply with regulatory requirements, permits, and corporate commitments. Typically, monitoring includes one or more of the following categories, which may be applied during the Project:

- **Compliance Monitoring -** confirms compliance to regulatory requirements, company commitments, and implementation of approved design standards and mitigation. Compliance inspections will be undertaken as part of a comprehensive EnvPP.
- **Environmental Monitoring -** tracks conditions or issues during the Project lifespan and is a key component of adaptive management (e.g., monitoring for soil erosion and rare plant species during construction or monitoring water quality and discharge volumes), and for continuous improvement of the EnvPP. Information obtained during environmental monitoring programs can be used to implement further mitigation as required.
- **Follow-up Monitoring -** designed to verify the accuracy of effects predictions, reduce uncertainty, determine the effectiveness of environmental design features and mitigation, and to provide feedback to operations for modifying or adopting new mitigation designs, policies, and practices.

The goal of a monitoring program is to confirm that proper practices and controls are in place in order to reduce the potential for environmental effects during all phases of Project development, and to provide clearly defined action plans and emergency response procedures to account for human and environmental health and safety. If monitoring detects effects that are different from the predicted effects, or detects the need for improved or modified design features, then adaptive management will be implemented. This may include increased monitoring, changes in monitoring plans, or additional mitigation.

The monitoring programs will be designed to maintain the continued compliance of the Project with the environmental requirements set out in this document and applicable legislation during construction and operation. The detailed monitoring programs will be finalized with input from federal and provincial government agencies, Aboriginal groups, the public, and other stakeholders. This may occur after the environmental assessment but will be consistent with the information presented in the EIS. Pertinent legislation, regulations, industry standards, documents, and legislative guides will be used in the development of the monitoring program. Additional monitoring may be identified as part of the permits and applications, which will be obtained for the Project prior to construction.

The environmental monitoring and follow-up identified for each VC chapter are summarized in Table 21.1-1. This table will be continuously updated during operations.

Table 21.1-1: Summary of Monitoring and Follow-up Activities

Valued Component	Environmental Monitoring and Follow up
Atmospheric Environment	■ The results of the air quality assessment indicate that no additional monitoring or follow-up programs are required. ■ The results of the noise assessment indicate that no additional monitoring or follow-up programs are required.
Hydrogeology	■ The rate of groundwater inflow will be monitored as power tunnel construction progresses so there is advanced warning if flow volumes increased faster than expected. ■ Groundwater quality will be monitoring during construction and operation of the Project, and following closure. Results from this monitoring program will be used to support development and adjustments to the Decommissioning and Reclamation Plan.
Hydrology	■ Continuous water level sensors can be installed on Black Lake to monitor predicted effects on these waterbodies. These sensors can be regularly surveyed using an engineer's rod and level to correct for potential movement. ■ Continuous flow records can be maintained in the bypassed section of the Fond du Lac River to verify environmental effects predictions. ■ Some of the streamflow and water level data collected during the monitoring and follow-up programs can be used in the hydrological models applied to this assessment allowing for verification and validation of model results. These data also can be used to verify the hydrologic function of the weir at the outflow of Black Lake.
Fish and Fish Habitat	■ It is anticipated that monitoring of fisheries offsetting activities, as defined in the Fisheries Offsetting Plan, will be required during the Project operation. The objectives and methods used to offset serious harm to fish within the LSA will be determined with input from regulators and local communities.

Table 21.1-1: Summary of Monitoring and Follow-up Activities (continued)

Valued Component	Environmental Monitoring and Follow up
Surface Water Quality	■ A program will be established to verify predicted changes in water quality in the Fond du Lac River given the discharges from the settling ponds. ■ A program will be established to monitor potential changes in water quality in Black Lake, Middle Lake, and several small lakes near the Project to verify the prediction of no effects on water quality due to acid deposition from the Project. If monitoring detects effects that are different from predicted effects, or the need for improved or modified design features, then adaptive management will be implemented.
Soils	■ Soil conditions will be monitored to estimate reclamation success, and soil quality issues such as erosion, admixing, and compaction will be assessed as part of this task.
Vegetation	■ Monitoring of re-vegetation techniques and success. ■ Environmental monitoring for weed species during construction and operation and the implementation of a Weed Management Plan
Wildlife	■ Prior to construction, detailed site assessments will be completed to identify listed wildlife species that may be present in the areas to be disturbed, which were not identified during previous surveys. ■ Additional wildlife surveys will be completed prior to construction if construction activities are to take place during the breeding season.
Heritage	■ An additional Heritage Resource Impact Assessment is required for portions of the access road that traverse native boreal forest located 250 metres from unnamed creeks that drain into Middle Lake prior to construction activities.
Land use	■ Monitoring and follow-up programs associated with fish and fish habitat, vegetation, and wildlife also relevant to land and resource use. ■ Community concerns on resource use will be monitored and managed by a Project Advisory Committee consisting of SaskPower and the Project.
Economy	■ Community concerns on the economy will be monitored and managed by a Project Advisory Committee consisting of SaskPower and the Project. ■ With respect to the longer-term effects associated with Project operation, BLFN may want to consider monitoring how their equity is invested and what the associated outcomes for the community would be.
Infrastructure and Community Services	■ Community concerns on infrastructure and community services will be monitored and managed by a Project Advisory Committee consisting of SaskPower and the Project. ■ With respect to the longer-term effects associated with Project operation, the BLFN may want to consider monitoring the investment of their equity and the associated outcomes for the community.
Population and Health	■ Community concerns on population and health will be monitored and managed by a Project Advisory Committee consisting of SaskPower and the Project.

BLFN = Black Lake First Nation; LSA = local study area; Project = Tazi Twé Hydroelectric Project

21.4 List of Acronyms

Acronym	Definition
BLFN	Black Lake First Nation
BMP	Best Management Practices
EHS	Environmental Health and Safety
EIS	Environmental Health and Safety
EnvPP	Environmental Protection Plan
LSA	local study area
Project	Tazi Twé Hydroelectric Project

22.0 CORPORATE COMMITMENTS

This section summarizes the proponent's corporate commitments made within this Environmental Impact Statement (EIS). This commitments register table will be the proposed structure for on-going reporting to the Saskatchewan Ministry of Environment (MOE) and other federal and provincial government and regulatory agencies. Table 22.0-1 outlines the commitments made in the EIS to prevent or mitigate effects from the Project, to meet regulatory requirements, and for monitoring and follow-up activities. Commitments documented in Table 22.0-1 are measureable, achievable, and reportable.

Table 22.0-1: Summary of Corporate Commitments

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
1	5.5.1, 5.9.1, 7.2.7, 8.4, 9.4, 11.4, 12.4, 13.4, 14.4, 15.4, 16.4, 17.4 19.4, 20.4	TBD	*Indian Act R.S.C. 1985, c.I-5*	Lease of Land (Section 53-1)	TBD	Aboriginal Affairs and Northern Development Canada	An Environmental Protection Plan (EnvPP) will be developed and implemented for the Project.	Regular inspections and monitoring during construction to confirm compliance to the EnvPP.	Prior to construction	TBD	TBD	TBD	
2	5.3.1, 5.3.6, 5.3.9, 5.11, 11.4.1, 11.7, 12.4.1, 13.4.2, 21.2	TBD	*Indian Act R.S.C. 1985, c.I-5*	No Specific Permit	TBD	Aboriginal Affairs and Northern Development Canada	An Erosion and Sediment Control Plan will be developed and implemented for the Project.	Regular inspections and monitoring during construction to confirm compliance to the plan.	Prior to construction	TBD	TBD	TBD	
3	5.9.1, , 12.3, 14.4, 14.7, 21.2	TBD	*Indian Act R.S.C. 1985, c.I-5* *The Weed Control Act*	Lease of Land (Section 53-1) No Specific Permit	TBD	Aboriginal Affairs and Northern Development Canada Ministry of Environment - Environmental Protection Branch	A detailed Weed Management Plan will be developed and implemented for the Project.	Regular inspections for weeds during construction will occur.	Prior to construction	TBD	TBD	TBD	
4	5.3.1, 16.4.2, 16.4.3	TBD	*The Heritage Property Act, 1980*	No Specific Permit	TBD	Ministry of Parks, Culture and Sport	Construction activities will be stopped and the Heritage Conservation Branch will be contacted should unanticipated archaeological materials or features be discovered during construction activities.	Regular inspections and monitoring during construction.	Prior to construction	TBD	TBD	TBD	

Table 22.0-1: Summary of Corporate Commitments (continued)

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
5	5.3.7,5.10, 8.4, 9.4.1, 11.4, 11.5.1.2, 12.4.1, 12.4.2, , 13.4.2, 14.4.2, 15.4.2, 17.4.3, 21.2	TBD	*Indian Act R.S.C. 1985, c.1-5* *The Fisheries Act, R.S.C., 1985, C.F-14 (amended 2012)*	Blasting Permit	TBD	Aboriginal Affairs and Northern Development Canada Fisheries and Oceans Canada	A Blasting Plan will be developed and implemented for the Project.	Regular inspections and monitoring during construction to confirm compliance to the plan.	Prior to construction	TBD	TBD	TBD	
6	5.3.10, 5.5.1, 9.4.1, 10.4.1, 11.4.1, 11.5.1.2, 11.7, 12.4.1, 12.4.2, 13.4.1, 13.4.2, 14.4.1, 14.4.2, 15.4.1, 15.4.2, 20.4, 21.2	TBD	*Indian Act R.S.C. 1985, c.1-5* *Environmental Management and Protection Act* *The Water Regulations, 2002, R.R.S.,c.E-10.21 Reg 1*	Lease of Land (Section 53-1) No Specific Permit	TBD	Aboriginal Affairs and Northern Development Canada Water Security Agency	A Site Water Management Plan will be developed and implemented for the Project; this will include site drainage, settling ponds, and water treatment areas.	Regular inspections and monitoring during construction and operation to confirm compliance to the plan.	Prior to construction	TBD	TBD	TBD	
7	5.6.1.3, 9.4.2, 10.4.1, 11.4.1, 11.5.2, 11.6.2, 12.4.1, 17.4.2, 19.4.1,	TBD	*Indian Act R.S.C. 1985, c. 1-5* *Environmental Management and Protection Act, R.R.S. 2010, c. E-10.22* *The Water Regulations, 2002, R.R.S. c.E-10.21 Reg 2*	A waterworks licence for construction and operations will be acquired from the federal or provincial government as determined to be applicable by them	TBD	Aboriginal Affairs and Northern Development Canada Water Security Agency Ministry of Environment - Environmental Protection Branch	A potable water treatment facility will be required to meet the expected peak water consumption rate during peak construction periods and treat water to meet provincial drinking water quality and safety standards.	Regular inspections and monitoring during construction.	Prior to construction	TBD	TBD	TBD	

Table 22.0-1: Summary of Corporate Commitments (continued)

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
8	5.3.10, 5.5.1, 9.4.1, 10.4, 11.5.2, 13.4.1, 14.4.1, 15.4.2,	TBD	*Indian Act R.S.C. 1985, c. 1-5* *Environmental Management and Protection Act, R.R.S. 2010, c. E-10.22* *The Water Regulations, 2002, R.R.S. c.E-10.21 Reg 2*	A licence will be acquired from the federal or provincial government as determined to be applicable by them	TBD	Aboriginal Affairs and Northern Development Canada Water Security Agency	Dewatering activities for the water intake, power tunnel, and tailrace channel will be directed to settling ponds prior to discharge to watercourses.	Regular inspections and monitoring during construction.	Prior to construction	TBD	TBD	TBD	
9	5.5.2, 9.4.1, 11.4, 11.7, 12.4.1, 12.4.2, 14.4.1, 14.4.2, 15.4.1, 21.2	TBD	*Indian Act R.S.C. 1985, c.1-5* *Environmental Management and Protection Act*	Waste Disposal Permit	TBD	Aboriginal Affairs and Northern Development Canada Ministry of Environment - Environmental Protection Branch	A Waste Rock Management Plan will be developed for the Project to assess and manage various waste rock types (including rock with ARD potential, elevated concentrations of various metals, or containing uranium mineralization).	Regular testing and monitoring during construction to characterize the waste rock and confirm compliance to the plan.	Prior to construction	TBD	TBD	TBD	
10	5.9.1, 15.4.2, 19.4.2, 21.2	TBD	*Indian Act R.S.C. 1985, c.I-5*	Waste Disposal Permit	TBD	Aboriginal Affairs and Northern Development Canada	A Waste Management Plan for the construction camp and worksite will be developed for construction and operations.	Regular inspections and monitoring during construction to confirm compliance to the plan.	Prior to construction	TBD	TBD	TBD	
11	5.5.4, 5.10, 9.4.3, 11.4.3, 12.4.3, 13.4.3, 14.4.3, 15.4.3, 17.4.3, 20.4.3	TBD	*Canadian Environmental Protection Act, 1999, C-15.1* *Environmental Management and Protection Act* *Hazardous Substance and Waste Dangerous Goods Regulations*	Approval to Construct (Section 10) - Hazardous Substance and Waste Dangerous Goods	TBD	Environment Canada Ministry of Environment - Environmental Protection Branch	Appropriate storage areas will be constructed, maintained, and monitored for all hazardous substances and waste dangerous goods.	Routine inspections and compliance audits.	Prior to construction	TBD	TBD	TBD	

Table 22.0-1: Summary of Corporate Commitments (continued)

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
12	5.10, 9.4.3, 11.4.3, 12.4.3, 13.4.3, 14.4.3, 15.4.2, 17.4.3, 20.4.3	TBD	*Canadian Environmental Protection Act, 1999, C-15.1* *Environmental Management and Protection Act* *Hazardous Substance and Waste Dangerous Goods Regulations*	Approval to Store (Section 9) - Hazardous Substance and Waste Dangerous Goods	TBD	Environment Canada Ministry of Environment - Environmental Protection Branch	Procedures will be put in place to handle spills of hazardous substances. Spill response materials will be maintained at locations where hazardous materials are stored and will be located around the Project site.	Routine inspections and compliance audits.	Prior to construction	TBD	TBD	TBD	
13	5.10, 9.4.3, 11.4.3, 12.4.3, 13.4.3, 14.4.3, 15.4.3, 17.4	TBD	*Canadian Environmental Protection Act, 1999, C-15.1*	Federal Above Ground Storage Tank Technical Guidelines, P.C. 1996-1234	TBD	Environment Canada	Appropriate storage areas will be constructed, maintained, and monitored for all hazardous substances and waste dangerous goods.	Regular inspections and compliance audits during construction.	Prior to construction	TBD	TBD	TBD	Refer to Environmental Code of Practice for Above and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products at: http://www.ec.gc.ca/rs-st/default.asp?lang=En&n=06EF27CF-1.
14	5.3.4, 5.5.4, 5.10, 9.4, 13.4, 14.4, 15.4, 17.4,	TBD	*Transportation of Dangerous Goods Act, 1996*	No Specific Permit.	TBD	Transport Canada	All hazardous materials and waste will be transported, stored, handled, and disposed of in accordance with all regulatory requirements.	Transportation of Dangerous Goods Manifests/Bill of Lading.	Prior to construction	TBD	TBD	TBD	As required, some dangerous goods require the preparation of, and inclusion on the shipping documents, an Emergency Response Assistance Plan (ERAP).
15	5.3.2	TBD	*Indian Act R.S.C. 1985, c. 1-5*	Lease of Land (Section 53-1)	TBD	Aboriginal Affairs and Northern Development Canada	Permanent roads will be designed to meet current provincial road design standards. Site drainage, erosion, and sedimentation management will be in accordance with the applicable provincial and federal regulations and guidelines.	Regular inspections and monitoring during construction.	Prior to construction	TBD	TBD	TBD	

Table 22.0-1: Summary of Corporate Commitments (continued)

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
16	5.9.1, 5.9.2, 5.10, 9.4.3, 11.4.3, 11.7, 12.4.3, 13.4.3, 14.4.3, 15.4.3, 16.4.3, 17.4.3, 19.4.3, 20.4	TBD	*Indian Act R.S.C. 1985, c. 1-6*	No Specific Permit Lease of Land (Section 53-1)	TBD	Aboriginal Affairs and Northern Development Canada	An Emergency Response Plan will be developed for the Project.	Regular inspections and compliance audits during construction and operation.	Prior to construction	TBD	TBD	TBD	
17	5.3.1, 13.4, 14.4, 14.5.1.3, 15.4.2,	TBD	*Indian Act R.S.C. 1985, c.I-5*	Licence to cut timber on surrendered lands or on reserve land	TBD	Aboriginal Affairs and Northern Development Canada	Clearing of vegetation will be limited to the extent possible and only removed in areas that may pose a hazard or interfere with construction activities. Merchantable timber will be available to the local community.	Regular inspections and monitoring during construction.	Prior to construction	TBD	TBD	TBD	
18	13.4.2, 13.6	TBD	*Environmental Management and Protection Act*	No Specific Permit	TBD	Ministry of Environment - Environmental Protection Branch	A site-specific assessment will be completed prior to soil salvage to identify surficial stripping depths and develop a site-specific soil salvage plan.	Inspections during construction and closure.	Prior to construction	TBD	TBD	TBD	
19	5.3.1, 14.4, 15.4	TBD	*Migratory Birds Convention Act, S.C., 1994, c. 22* *Species at Risk Act, S.C. 2002, c. 29* *Environmental Management and Protection Act* *Wildlife Act*	No Specific Permit	TBD	Environment Canada Ministry of Environment - Environmental Protection Branch Ministry of Environment - Fish and Wildlife Branch	An appropriate pre-construction survey will be completed and if federal or provincial tracked species are discovered activity setback guidelines will be applied if construction occurs during sensitive nesting, breeding, and rearing periods for wildlife species.	Regular inspections and monitoring during construction.	Prior to construction	TBD	TBD	TBD	No specific permit; however, may affect timing of construction activities or mitigation may have to be identified should species at risk be identified in the Project area. Surveys may be completed prior to construction to determine if species at risk are in the area. If species are identified then mitigation (e.g., MOE activity restriction guidelines) may be required.

Table 22.0-1: Summary of Corporate Commitments (continued)

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
20	5.3.6, 5.3.9, 5.4.3, 11.4.2, 12.4.2, 12.5.2, 17.4	TBD	*The Fisheries Act, R.S.C., 1985, c. F-14 (amended 2012)*	Fisheries Act Authorization (Section 35)	TBD	Fisheries and Oceans Canada	In-water works (e.g., water intake, submerged weir, and tailrace channel) will be constructed and operated in accordance with conditions outlined in the *Fisheries Act* Authorization.	Regular inspections and monitoring during construction to confirm compliance to DFO requirements.	Prior to construction	TBD	TBD	TBD	
21	5.3.6, 5.3.9, 11.4.2, 12.4.2	TBD	*The Fisheries Act, R.S.C., 1985, c. F-14 (amended 2012)*	Fisheries Act Authorization (Section 35)	TBD	Fisheries and Oceans Canada	A Turbidity Monitoring Program will be implemented during construction of the bridge piers, submerged weir, and water intake and tailrace outlet connections to Black Lake and the Fond du Lac River, respectively.	Regular inspection and monitoring during the in-water work components of construction to confirm compliance to the Authorization.	Prior to construction	TBD	TBD	TBD	
22	5.6.1.3, 12.4.1, 19.4.1	TBD	*The Fisheries Act, R.S.C., 1985, c.F-14 (amended 2012)*	No Specific Permit	TBD	Fisheries and Oceans Canada	Water pump intakes will be screened as per Fisheries and Oceans' "Freshwater Intake End-of-Pipe Fish Screen Guideline" to prevent entrainment of fish (DFO 1995).	Water intake structures will be regularly monitored and inspected through compliance audits.	Prior to construction	TBD	TBD	TBD	
23	12.2, 12.7, 17.5.1, 23.1.1, Appendix 12.2	TBD	*The Fisheries Act, R.S.C., 1985, c.F-14 (amended 2012)*	Fisheries Act Authorization (Section 35)	TBD	Fisheries and Oceans Canada	A Fish Habitat Offsetting Plan will be developed for the Project.	Approval of the Plan by DFO through the *Fisheries Act* Authorization, and follow-up monitoring as required by the Authorization.	Prior to construction	TBD	TBD	TBD	
24	5.6.1.3, 19.4.1	TBD	*The Water Security Agency Act, S.S. 2006, W-8.1th*	A water rights licence will be acquired from the provincial government	TBD	Water Security Agency	The appropriate water rights licence will be obtained prior to diverting water from Black Lake through the power tunnel or pumping water from the Fond du Lac River to use for potable and industrial purposes (operations).	Acquisition and compliance with the water rights licence.	Prior to construction	TBD	TBD	TBD	

Table 22.0-1: Summary of Corporate Commitments (continued)

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
26	2.1.4	TBD	*The Water Power Act, R.S.S. 1978, c. W-6* and/or *The Dominion Water Act R.C.S., 1985 c. W-4*	A water power licence will be acquired from the federal or provincial regulator as determined to be applicable	TBD	Water Security Agency or Aboriginal Affairs and Northern Development Canada	The Proponent will comply with all regulatory requirements as applicable.	Acquisition and compliance with the water power licence.	Prior to construction	TBD	TBD	TBD	
27	11.4, 11.5.2, 12.4, , 15.4.2, 17.4	TBD	*The Fisheries Act, R.S.C., 1985, c.F-14 (amended 2012)*	No Specific Permit	TBD	Fisheries and Oceans Canada	DFO guidelines for the Use of Explosives in or Near Canadian Fisheries Waters will be used for this Project.	Regular inspections and monitoring during construction to confirm compliance with the guidelines.	Prior to construction	TBD	TBD	TBD	
28	5.3.7	TBD	*Occupational Health and Safety Act, S.S. 1993, O-1.1*	No Specific Permit	TBD	Ministry of Labour and Workplace Safety	The underground works will be performed in accordance with requirements of the *Occupational Health and Safety Act* of the Province of Saskatchewan.	Regular inspections and monitoring during construction to confirm compliance with safety practices.	Prior to construction	TBD	TBD	TBD	
29	5.5.1, 9.4.1, 11.4, 12.4.2, 13.4.1, 14.4.1, 15.4.1, 20.4	TBD	*Canadian Environmental Protection Act, 1999, c-15.1*	No Specific Permit	TBD	Environment Canada	A Water Quality Monitoring Program will be implemented.	Regular inspections and monitoring during construction and operation.	Prior to operation	TBD	TBD	TBD	
30	5.6.1.6, 12.41, 15.4.2, 17.4.2	TBD	*Canada Labour Code R.S.C., 1985, C.L-2* *Indian Act R.S.C., 1985, c.I-5*	No Specific Permit.	TBD	Aboriginal Affairs and Northern Development Canada Health Canada	An Access Management Plan will be developed for the construction camp and worksite.	Security will prevent public access to the work site.	Prior to construction	TBD	TBD	TBD	

Table 22.0-1: Summary of Corporate Commitments (continued)

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
31	5.5.2, 5.7.2, 9.4.1, 11.4.1, 12.4.1, 13.4.1	TBD	*Canadian Nuclear Safety Act*	Licence - Canadian Nuclear Safety Commission	TBD	Canadian Nuclear Safety Commission	Excavated rock and aggregate materials will be tested to confirm whether this material requires special management (ARD potential radioactivity). Any wasterock that is found to be ARD generating or radioactive will be disposed of as per provincial and federal guidelines.	Regular testing during construction to characterize the waste rock.	Prior to construction	TBD	TBD	TBD	
32	5.6.1.3, 9.4.1, 10.4.1, 11.4.1, 12.4.1, 13.4.1, 14.4.1, 20.4.1	TBD	*The Oil and Gas Conservation Act* *Indian Act R.S.C., 1985, c.I-5*	Well Licence	TBD	Ministry of Economy Indian Oil and Gas Canada Aboriginal Affairs and Northern Development Canada	Potable water for the construction camp is anticipated to be sourced from one or more new wells located near the camp and will be treated on-site.	Licence will be available on-site during drilling.	Prior to construction	TBD	TBD	TBD	
33	5.6.1.4, 9.4.1, 10.4.1, 11.4.1, 12.4.1, 12.4.2, 13.4.1, 14.4.1, 15.4.1, 19.4.2,	TBD	*Environmental Management and Protection Act,, R.R.S. 2010, c.E-10.22* *The Water Regulations, 2002, R.R.S. c.E10.21 Reg 1* *Indian Act R.S.C., 1985, c.I-5*	An approval to construct and operate sewage works will be acquired from the federal or provincial government as determined to be applicable by them. Permit to Transport and Dispose of Liquid Domestic Waste Waste Disposal Permit	TBD	Water Security Agency Aboriginal Affairs and Northern Development Canada	Sewage and grey water from the Project will be transported to the Black Lake Lagoon for disposal.	Regular inspection and monitoring during construction.	Prior to construction	TBD	TBD	TBD	

Table 22.0-1: Summary of Corporate Commitments (continued)

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
34	5.5.3, 9.4.1, 10.4.1, 11.4.1, 12.4.1, 13.4.1, 14.4.1, 15.4.1, 20.4	TBD	*Environmental Management and Protection Act,, R.R.S. 2010, c.E-10.22* *The Water Regulations, 2002, R.R.S. c.E10.21 Reg 1* *Indian Act R.S.C., 1985, c.I-5*	Permit to Transport and Dispose of Liquid Domestic Waste Waste Disposal Permit	TBD	Aboriginal Affairs and Northern Development Canada Water Security Agency	A Site Water Management Plan will be developed for the site during operations.	Regular inspections and compliance audits.	Prior to operation	TBD	TBD	TBD	
35	5.6.1.3, 5.10, 10.4.1, 11.4.1, 12.4.1, 13.4.3, 14.4.3, 15.4.3, 17.4.3, 19.4.3, 20.4.3	TBD	*National Fire Code*	No Specific Permit	TBD	National Fire Protection Association	Water required for fire protection will be provided for the site to meet requirements.	Regular inspections and compliance audits.	Prior to operation	TBD	TBD	TBD	
36	5.7, 5.7.1, , 9.4.1, 10.4.1, 11.4, 11.4.2, 12.4, 15.4, 15.4.1	TBD	*Indian Act R.S.C. 1985, c. 1-5*	No Specific Permit Lease of Land (Section 53-1)	TBD	Aboriginal Affairs and Northern Development Canada	A Decommissioning and Reclamation Plan will be developed for the Project.	Plan is created and continually updated during Project operation.	Prior to operation	TBD	TBD	TBD	
37	2.1.4, 5.10, 8.5.1, 11.5.1, 13.4.2, 14.4.2, 15.4.2, 17.4.2, 20.4.2	TBD	*Indian Act R.S.C. 1985, c. 1-6* *The Clean Air Act*	No Specific Permit Lease of Land (Section 53-1)	TBD	Aboriginal Affairs and Northern Development Canada Ministry of Environment - Environmental Protection Branch	Equipment will be regularly maintained for compliance with provincial and federal air emission standards. Facilities generating air emissions will be compliant with provincial and federal air emission standards.	Regular inspections and compliance audits during construction and operation.	Prior to construction	TBD	TBD	TBD	

Table 22.0-1: Summary of Corporate Commitments (continued)

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
38	2.1.4, 12.4	TBD	*Environmental Management and Protection Act,* R.R.S. 2010, c. E-10.22	Aquatic Habitat Protection Permit	TBD	Water Security Agency	Construction of the water intake in Black Lake will comply with conditions outlined in the Aquatic Habitat Protection Permit	Regular inspections and monitoring during construction to confirm compliance with the requirements of the Aquatic Habitat Protection Permit	Prior to Construction	TBD	TBD	TBD	
39	2.1.4	TBD	*Navigable Waters Protection Act, R.S., 1985, c. N-22* [(a)]	An Approval to construct a work (i.e., water intake) in Black Lake	TBD	Transport Canada	Construction of the water intake in Black Lake will comply with conditions of the *Navigable Waters Protection Act* Approval and marker buoys will be used during open water season. In winter unsafe ice conditions marked by other means.	Regular inspections and compliance audits.	Prior to Construction	TBD	TBD	TBD	
40	5.3.4	TBD	*Explosives Act,* R.S.C., 1985, c.E-17	A certificate to carry out activities relating to the storage of explosives will be obtained from the federal government as determined to be applicable by them	TBD	Department of Natural Resources	On-site storage of explosives will be performed in accordance with requirements of the federal *Explosives Act*	Regular inspections and monitoring during construction to confirm compliance with the requirements of the *Act*	Prior to Construction	TBD	TBD	TBD	

Table 22.0-1: Summary of Corporate Commitments (continued)

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
41	17.7, 18.7, 19.7, 20.7	TBD	N/A	N/A	TBD	N/A	A Project Advisory Committee, including equal representation from the EFHLP and SaskPower will meet at least monthly or as otherwise agreed to by the Committee, and will review the status of the Project including environmental, engineering and construction activities including community matters that relate to the completion of the Project. It is anticipated that this committee will discussion on-going concerns about socio-economic effects, and that the EFHLP and SaskPower will work together collaboratively on measures to address any community concerns.	Documentation of meetings and collaboration efforts to address any community concerns.	Throughout the life of the Project	TBD	TBD	TBD	
42	17.5.1.1, 17.5.2	TBD	N/A	N/A	TBD	N/A	The Proponent is committed to working with the contractor to limit Project-related disruption to the principle resource user and Camp Grayling. The Proponent will provide effective and timely communication about Project activities and whether any restrictions to activities will be applied (e.g., for safety concerns). Finally, the Proponent will consider compensation for demonstrated losses resulting from the Project.	Documentation of communication with the principle resource user and Camp Grayling and efforts to address concerns, if applicable. Documentation of compensation, if applicable.	Throughout the life of the Project	TBD	TBD	TBD	

Table 22.0-1: Summary of Corporate Commitments (continued)

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
43	17.5.1.2	TBD	N/A	N/A	TBD	N/A	In addition to road alignment that avoids cultural campsites and protects public safety, the Proponent is committed to timely and effective communication with local resource users about construction and operation activities, including providing information about any restrictions that may be put in place to limit risks to public safety.	Documentation of meetings and collaboration efforts to address any community concerns.	Throughout the life of the Project	TBD	TBD	TBD	
44	18.5.1.1	TBD	N/A	N/A	TBD	N/A	Contractors will be required to support apprenticeship-training programs and implement a craft-mentoring program that pairs trainees and apprentices with experienced craftsmen and foremen.	Implementation of a craft-mentoring program	Prior to construction	TBD	TBD	TBD	
45	18.5.1.2	TBD	N/A	N/A	TBD	N/A	SaskPower will advertise several operations positions through SaskPower Human Resources and hire the most qualified individuals, with a preference for BLFN and Athabasca Region applicants.	N/A	Prior to initiation of each phase of the Project	TBD	TBD	TBD	

[(a)] Act is currently being revised. Changes to the Act had not come into force at the time this table was generated. Changes to the Act will have to be reviewed in context of the Project once additional information is available.
TBD = To be determined; EnvPP = Environmental Protection Plan; DFO = Fisheries and Oceans Canada; ARD = Acid Rock Drainage; ERAP = Emergency Response Assistance Plan; MOE = Ministry of Environment; EIS = Environmental Impact Statement; N/A = not applicable

22.1 List of Acronyms

Term	Definition
ARD	Acid Rock Drainage
BLFN	Black Lake First Nation
BMP	Best Management Practices
CCME	Canadian Council of Ministers of the Environment
DFO	Fisheries and Oceans Canada
EIS	Environmental Impact Statement
EnvPP	Environmental Protection Plan
ERAP	Emergency Response Assistance Plan
MOE	Saskatchewan Ministry of Environment
Project	Tazi Twé Hydroelectric Project

23.0 SUMMARY OF CANADIAN ENVIRONMENTAL ASSESSMENT ACT SECTION 5 REQUIREMENTS

Section 5 of the *Canadian Environmental Assessment Act* (*CEAA* 2012) outlines the environmental effects that should be considered for a designated project. This section will provide a summary of the changes to components of the environment that are listed under Section 5.

23.1 Changes to Components of the Environment with Federal Jurisdiction

The Environmental Impact Statement (EIS) evaluates all potential Tazi Twé Hydroelectric Project (Project)-environment interactions, with the intent to focus the effects assessment on those interactions with the greatest potential to result in significant residual effects on valued components (VCs) of the biophysical and socio-economic environments. Section 5(1)(a) of *CEAA 2012* outlines the categories of direct and indirect environmental effects that are to be considered in an environmental assessment of a designated project, and include:

- fish and fish habitat;
- aquatic species; and
- migratory birds.

The effects analysis for these components is summarized in the sections below.

23.1.1 Fish and Fish Habitat and Aquatic Species

The fish and fish habitat assessment was completed to identify and evaluate potential effects from the Project on fish and fish habitat and to provide recommendations on best practices and mitigation. The assessment endpoint for fish and fish habitat is focused on the maintenance of fish populations that have been identified as important to the Black Lake First Nation (BLFN) or the outfitter at Camp Grayling; fish species that have been identified as potentially sensitive are included.

Water withdrawal from Black Lake for power generation is expected to cause some injury and mortality to fish because of impingement or entrainment at the water intake. Fish injuries and mortalities that are expected to occur because of impingement or entrainment of fish in the water intake during Project operations are predicted to have residual effects that will be moderate in magnitude. Some fish currently drift downstream out of Black Lake into the Fond du Lac River via the Black Lake outflow. During Project operation, fish are expected to drift downstream through the natural river outflow and the water intake. However, the total number of fish leaving the Black Lake fish community is not expected to change from the current level of out-migration because overall Black Lake outflow rates and volumes will not change with the development of the Project. Out-migration of fish from Black Lake once the Project is operating is expected to be similar to current levels and therefore within the resilience limits of Black Lake fish populations. Selection of a shallow-water (i.e., 5 metres [m] deep) water intake design is thought to be protective of deep-water species, such as lake trout, whitefish, and cisco, during specific periods of the annual cycle. Black Lake cisco have some features characteristic of common cisco and shortjaw cisco; shortjaw cisco are listed as a potentially threatened species under Schedule 2 of the *Species at Risk Act (SARA)*, and are identified as a threatened species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Although the number of fish moving downstream out of Black Lake is not expected to change because of Project development, a higher rate of injury and mortality is expected for fish that are impinged at or entrained by the water intake structure versus fish that pass downstream through the natural Black Lake outflow. Fish that drift into the Fond du Lac River through the natural Black Lake outflow could become integrated into downstream populations of the same species, assuming they are not harmed or killed during passage down the turbulent river, and could therefore have the opportunity to spawn and pass on their genetic material. Fish that are entrained with water flows into the power tunnel could be more likely to be killed or injured; injured fish could become easier prey for birds and piscivorous fish downstream of the tailrace channel outlet. Therefore, fish that pass through the power tunnel and powerhouse turbines could be less likely to survive and reproduce. The frequency of residual effects for injury and mortality of impinged or entrained Black Lake fish is expected to be continuous and permanent; however, the potential for future effects will cease immediately following the cessation of power generation.

Loss and alteration of fish habitat is expected due to the Project footprint. Although appropriate and applicable mitigation practices will be used and sensitive habitats will be avoided to the greatest extent possible, construction and operation of the Project is expected to result in some harmful alteration, disruption, or destruction (HADD) of fish habitat. However, with successful design and implementation of the Fish Habitat Offsetting Plan, it is not expected that there will be a net loss of fish habitat resulting from the Project footprint or construction of Project components. Therefore, the magnitude of residual effects from the Project footprint will be negligible. Following closure, Project infrastructure will be decommissioned and reclaimed. Design and implementation of the Fish Habitat Offsetting Plan early in the Project development will compensate for habitat loses, therefore, the effects are considered reversible in the short-term.

The loss and alteration of fish habitat that is expected because of changes to hydrology in the Fond du Lac River between Black Lake and Middle Lake during Project operations is predicted to have residual effects that will be moderate in magnitude. The quantity of suitable overwintering habitat available to Arctic grayling in the bypassed section of the Fond du Lac River during Project operation is expected to be greater than that available under historically normal flow conditions (i.e., without the Project in place). Under average to below-average spring flow conditions, Project operation is expected to result in a net decrease in the quantity of suitable spawning habitat available to Arctic grayling. Foraging habitat is expected to improve under reduced riparian flows proposed for the Project. It is anticipated that hydrological changes in the Fond du Lac River will alter the relative abundance of prey items available to Arctic grayling and other fish species; however, this change is not expected to extend beyond the resilience limits of fish populations in the Fond du Lac River. The frequency of residual effects for loss and alteration of fish habitat in the Fond du Lac River because of Project operation and changes to hydrology is expected to be continuous. Effects will cease within a few years following the cessation of power generation, and therefore are considered reversible over the long-term.

The residual effects from the Project are not predicted to be large enough to alter the state of fish health, abundance, distribution, or habitat, and therefore, influence the maintenance of self-sustaining fish populations. The scale of residual effects from the Project interactions, independently or combined, should not be large enough to cause irreversible changes at the population level and decrease the resilience of fish communities within the local or regional study areas. Overall, the residual effects from the Project as a whole on maintenance of self-sustaining fish populations are not significant.

23.1.2 Migratory Birds

Upland breeding birds, waterbirds, and the bald eagle have been identified as valued components species to represent the broader category of migratory birds.

23.1.2.1 Habitat Loss and Fragmentation

Development of the Project is expected to change the abundance, distribution, and spatial arrangement of habitat in the regional study area (RSA). Habitat loss includes the direct removal or alteration of habitat due to the Project and other developments. Changes to habitat were assessed to the maximum predicted point of development of the Project footprint (disturbance assessment area), which should have the largest geographic extent of residual effects on wildlife. Thus, the analysis overestimates the changes to habitat loss and fragmentation from the Project, and the predicted effects on the abundance and distribution of migratory birds.

Decreases in habitat area can directly influence migratory bird populations by reducing the carrying capacity of the environment. A species with very specific habitat requirements and low dispersal ability (or ability to move) is more likely to be negatively affected by habitat fragmentation than a generalist or highly mobile species.

Upland breeding bird populations are anticipated to adapt to the changes in habitat loss and fragmentation from the Project. Most upland breeding bird species have high reproductive capability (BNA 2013) and have long effective dispersal distances (i.e., are highly mobile). Fragmentation effects have less influence than habitat loss when there is a large proportion of natural habitat on the landscape (Fahrig 1997, 2003; Andrén 1999; Flather and Bevers 2002; Swift and Hannon 2010), which is the predicted state and condition of habitat in the RSA with the Project. Changes to the loss and fragmentation of habitat from the Project are anticipated to have a negligible influence on the abundance, distribution, and connectivity of upland breeding bird populations.

The RSA is located in the Western Boreal Forest of North America, which is considered an important breeding area for waterfowl (Slattery 2013). However, there was a low abundance of waterbirds recorded during baseline surveys (Section 15.3.8.1) and no important breeding or staging areas are present in the RSA (Poston et al. 1990; SKCDC 2013). The small and local changes in habitat loss and fragmentation from the Project are expected to be within the resilience limits of waterbirds and result in a negligible influence on the abundance, distribution, and connectivity of populations.

Bald eagles generally nest in forested areas adjacent to large, fish-bearing bodies of water (Blood and Anweiler 1994; Buehler 2000). Fourteen bald eagle individuals and two bald eagle nests were observed during baseline surveys. Bald eagles are anticipated to adapt to the minor and local changes in habitat loss and fragmentation from the Project. Bald eagles have high reproductive capability (Buehler 2000) and it is likely that food supply, not habitat quantity, is the limiting factor for bald eagles currently breeding in the RSA. Changes to habitat loss and fragmentation from the Project in the RSA are anticipated to have a negligible influence on the abundance, distribution, and connectivity of the bald eagle population.

23.1.2.2 Habitat Quality

Project development could generate sensory disturbances including increased noise levels and visual disturbances from moving vehicles and humans during construction and operations. Factors that seem to influence the magnitude of effects include the type of disturbance, the frequency and intensity of the disturbance, and the level of habituation to disturbance (Fortin and Andruskiw 2003; Bayne et al. 2008; Fahrig and Rytwinksi 2009). Few studies have focused on the effects of noise and disturbance to upland bird behaviour and movement. Behaviours most likely to be affected are nest site selection, territory selection, mate attraction, and foraging. Noise could inhibit predator detection and interfere with mate/chick communication (Habib et al. 2007). Similar to habitat loss and fragmentation, changes to habitat quality were assessed for the maximum predicted point of development of the Project footprint (disturbance assessment area), which should have the largest geographic extent of residual effects on migratory birds.

Indirect effects on upland breeding bird communities from sensory disturbance associated with the Project were assessed by calculating changes in density using data from baseline studies. A 1 kilometre (km) zone of influence was used in the upland breeding bird habitat quality analysis as scientific literature suggests that most sensory disturbance to upland breeding birds are limited to within 1 km of infrastructure.

Decrease in upland breeding bird habitat quality from the Project is predicted to be within or slightly exceed baseline values for most habitats. However, changes in habitat quality from the Project are expected to be within the resilience limits of affected bird populations. Although the analysis has assumed that indirect habitat effects result in a decrease in bird abundance, changes in habitat quality from sensory disturbance, do not necessarily result in demographic consequences to populations (Gill et al. 2001). Most of the effects from indirect changes in habitat quality could be related to a local shift in distribution with little influence on survival and reproduction rates. Most upland breeding bird species have high reproductive capability (BNA 2013). Changes to habitat quality from sensory disturbance effects associated with the Project are anticipated to have a negligible to minor influence on the abundance and distribution of upland breeding bird populations.

Few studies have focused on the effects of noise and disturbance to waterbird behaviour and movement. However, some studies (Korschgren et al. 1985; Ward and Stein 1989; Dahlgren and Korschgren 1992) have found that noise and motion disturbances originating from man-made sources can negatively affect waterbird behaviour. Disturbance effects on waterbirds could include displacement, nest abandonment, reduced nest success, or reduced foraging efficiency (Hockin et al. 1992; Dahlgren and Korschgren 1992).

Decreases in waterbird habitat quality from the Project are predicted to be within or slightly exceed baseline values; however, waterbird species are anticipated to adapt to changes in habitat quality from the Project. Most waterbird species have high reproductive capability (BNA 2013). Construction activities could result in local changes to the movement and behaviour of individuals, but effects from sensory disturbance should disappear at the end of construction. There were low numbers of waterbirds recorded in the LSA (Section 15.5.1.7), which is likely due to natural limited availability of quality breeding habitat near the Project. Changes to habitat quality from sensory disturbance effects associated with the Project are anticipated to have a negligible influence on the abundance and distribution of waterbird populations in the RSA.

Studies on responses of bald eagles to human disturbance are limited, so effects on bald eagle from Project-related sensory disturbance were qualitatively assessed using scientific literature on bald eagles and other raptor species. Decreases in bald eagle habitat quality from the Project are predicted to be within or slightly exceed baseline values. Construction activities could result in local changes to the movement and behaviour of individuals, but effects from sensory disturbance should disappear early in operations. Bald eagles have high reproductive capability (Buehler 2000) and populations for most raptor species are considered ‘very common’ in Saskatchewan (SKCDC 2012a). As discussed above, bald eagles are likely able to habituate to human disturbance. In addition, the abundance of bald eagles observed near the Project during baseline surveys was low, which is likely due to natural limited availability of quality breeding habitat near the Project. Changes to habitat quality from the Project are anticipated to have a negligible effect on the abundance and distribution of the bald eagle population.

Residual effects from habitat loss, alteration, and fragmentation on migratory birds could be reversible or irreversible. The reversibility of residual effects is expected to vary among species, and could depend on factors such as habitat and food preferences. For example, some ground-nesting species of upland breeding birds could use the reclaimed areas soon after vegetation is established (effect is reversible in the medium-term). The establishment of mature forest could occur within the temporal bounds of the assessment (effect is reversible in the long-term) or could occur outside of the temporal boundary of the assessment (effect could be permanent). Natural succession processes in the RSA are slow and plant community trajectories can be altered by a number of factors (e.g., climate change, fire, and unforeseeable human development). The effect from direct habitat loss and fragmentation on wildlife is continuous over the life of the Project; however, the main sources of residual effects are related to the construction of the Project.

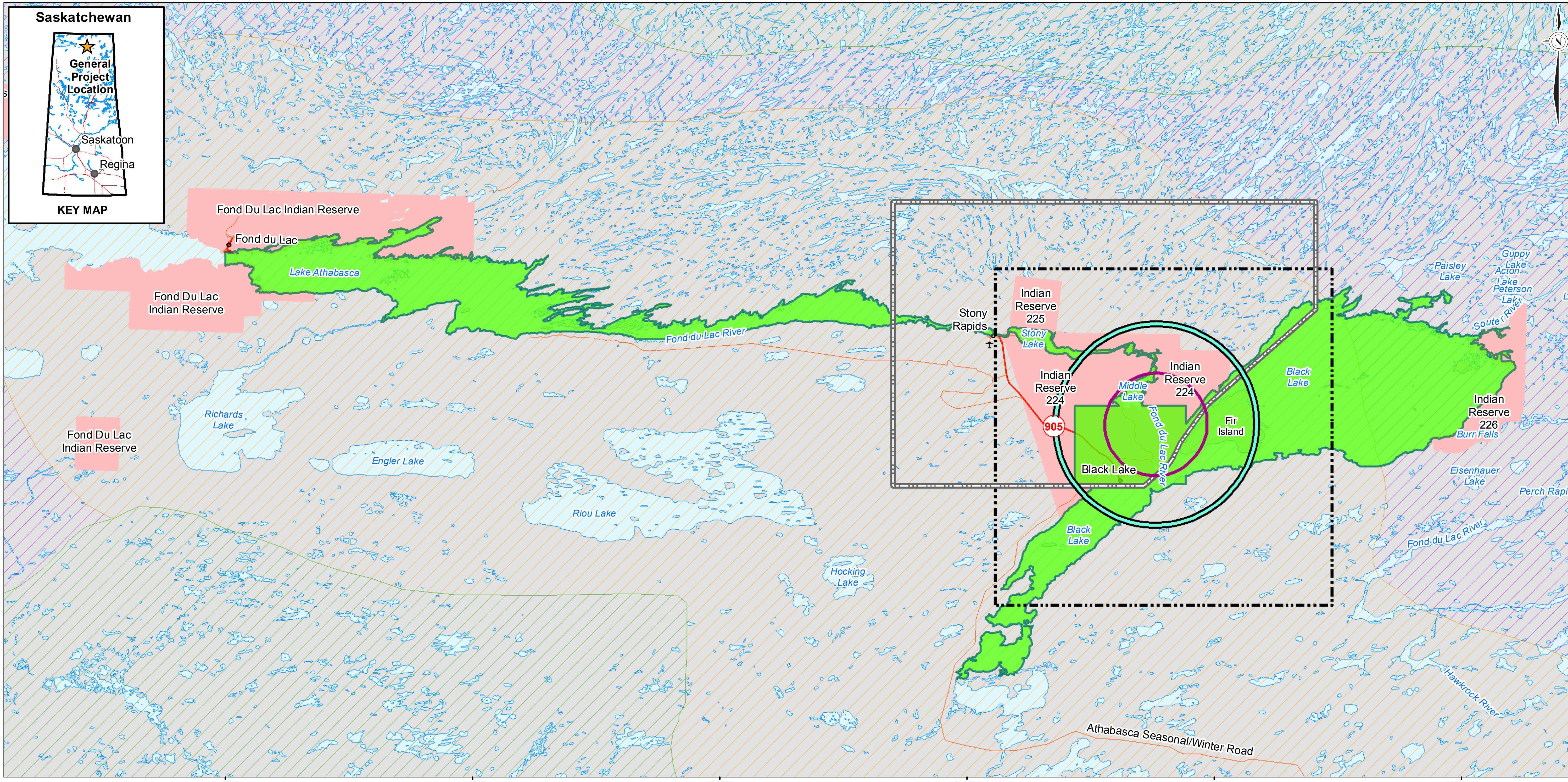
In summary, the incremental and cumulative effects from the Project and previous and existing developments are not predicted to be large enough to alter the state of migratory bird populations and adversely influence self-sustaining populations. The scale of residual effects from the Project interactions, independently or combined, should not be large enough to cause irreversible changes at the population level and decrease the resilience of migratory bird populations. Overall, the cumulative effects from the Project and previous and existing on migratory bird populations are predicted to be not significant.

23.2 Changes to Components of the Environment That Would Occur on Federal or Trans-boundary Lands

Under Section 5(1)(b) of *CEAA 2012*, a designated project is required to describe the potential changes that can occur to the environment that would occur on federal lands, in another province, or outside of Canada. This section summarizes the potential changes to the environment from the Project that may occur on federal lands or on trans-boundary lands.

The Project itself is located on the Chicken Indian Reserve (No.224); this land is set aside for the exclusive use and benefit of the members of the BLFN, and is designated as federal land. In 2009, an Order in Council (P.C.2009-305) was approved by the Governor General in Council, pursuant to paragraph 39(1)(c), and Section 40 of the *Indian Act* (Government of Canada, 1985), designating portions of the Chicken Indian Reserve No. 224, 225, and 226 for exploration and development of minerals, development of a hydroelectric facility, and commercial leasing purposes.

The RSA boundaries for each VC were designed to quantify baseline conditions at a scale that is large enough to assess the maximum predicted geographic extent (i.e., maximum zone of influence) of direct and indirect effects from the Project on VCs. The RSA for each VC is shown in Figure 23.2-1. Potential changes to VCs of the biophysical and socio-economic environments resulting from the Project will occur on the Chicken Indian Reserve (e.g., federal land) within Saskatchewan. No other federal lands within Saskatchewan will be affected by the Project. The RSAs for each VC do not include other provinces or territories. Therefore, the environmental assessment completed for the Project has determined that there will be no trans-boundary effects because of the Project.



LEGEND

HAMLET OR COMMUNITY	NORTHERN ADMINISTRATION DISTRICT
RUNWAY	ATHABASCA LAND USE PLAN - STAGE 1
HIGHWAY	ATHABASCA LAND USE PLAN - STAGE 2
ROAD	ATHABASCA LAND USE PLAN - STAGE 3
INDIAN RESERVE	
WATERBODY	

HYDROLOGY & AQUATICS REGIONAL STUDY AREA
AIR QUALITY STUDY AREA
NOISE STUDY AREA
GEOTECHNICAL REGIONAL STUDY AREA
TERRESTRIAL REGIONAL STUDY AREA

10 0 10
SCALE 1:400,000 KILOMETRES

REFERENCE

DMTI HIGHWAYS AND ROADS
NTS MAPSHEET 74I, 74J, 74O, 74P
NAD 83 UTM ZONE 13

PROJECT

TAZI TWÉ HYDROELECTRIC PROJECT

TITLE

TAZI TWÉ REGIONAL STUDY AREAS

Tazi Twé Hydroelectric Project

PROJECT	10-1365-0004	FILE No.	
DESIGN		SCALE AS SHOWN	REV. 1
GIS	SM	18/11/13	
CHECK	BC	18/11/13	
REVIEW	MM	18/11/13	

FIGURE: 23.2-1

23.3 Effects of Changes to the Environment on Aboriginal Peoples

The Project is located within the Chicken Indian Reserve No. 224. The Chicken Indian Reserve No. 224 was created under the Order in Council (OIC) 1978-1647; that is the land is set aside for the exclusive use and benefit of the members of the BLFN. The area surrounding the Chicken Indian Reserve No. 224 is provincial crown land and accessible to all aboriginal people for the pursuit of traditional and cultural activities. The BLFN has three registered reserve locations; two are unpopulated. The reserve parcels that have permanent, seasonal, or historical ties to the community and include the following:

- Chicken 224 – populated – 25,819.4 hectares (ha);
- Chicken 225 – no resident population – 2,193.4 ha; and
- Chicken 226 – no resident population – 4,216.9 ha (Aboriginal Affairs and Northern Development Canada [AANDC] 2012a).

The Chicken 224 reserve parcel includes an earlier settlement at Stony Lake, as well as the current community of Black Lake. The reserve extends to an area just east of Stony Rapids, where several BLFN homes are located.

As described in Section 23.2, the RSA for each VC is designed to quantify the maximum geographic extent of potential effects resulting from the Project. While no other First Nations Reserves will be directly affected, the Project's potential effects may extend outside of the reserve land, and may affect the traditional territory of the following communities:

- Fond du Lac Denesuline First Nation;
- Hatchet lake Denesuline First Nation;
- Métis Nation Saskatchewan Camsell Portage Local 79;
- Métis Nation Saskatchewan Stony Rapids Local 80; and
- Métis Nation Saskatchewan Uranium City Local 50.

This section will describe the effects of any changes the Project may cause to the environment on Aboriginal peoples as described in Section 5(1)(c) of *CEAA* 2012; this includes the effects of any changes:

- to health and socio-economic conditions;
- to physical and cultural heritage;
- to the current use of lands and resources for traditional purposes; and
- to any structure, site, or thing that is of historical, archaeological, paleontological, or architectural significance.

23.3.1 Health and Socio-economic Conditions

The analysis of residual effects on human population and health considers two factors: potential effects associated with non-local construction workers and local resident interactions and potential effects associated with traffic accidents. For both of these factors, mitigation practices will be implemented to reduce the potential for effects to occur.

In the case of non-local construction workers and local resident interaction, adaptive management practices have also been identified to address issues as they arise. Effects on human population and health related to non-local construction workers and local resident interactions are expected to be negative in direction, moderate in magnitude, short term in nature (i.e., primarily during construction activities), and local in geographic extent; however the consequences of a negative effect (e.g., an altercation resulting in injury) could be longer lasting. No significant adverse effect of the Project on human population and health are expected because of non-local construction workers and local resident interactions, however, it is recognized that even a single incident could have a significant effect on the individual and local communities. Early engagement with local residents and service providers will be completed so that potential risks can be identified prior to the on-set of construction, and strategies can be devised to address issues as they arise.

Effects related to traffic accidents are expected to remain within the LSA (with traffic accidents extending to Highway 905). The increased traffic volume is expected to be negative in direction, moderate in magnitude, and short term in nature (i.e., primarily during construction activities). Mitigation practices and policies are anticipated to limit the risk to local human population and health from the increase in Project-related vehicle traffic. However, it is acknowledged that in the event that a traffic accident results in human injury or fatality, the effect would be considered high magnitude. Any vehicle collision resulting in the death of an individual would have a significant effect on the immediate family and local community.

The socio-economic environment is divided into two main components including economy, and infrastructure and community services. The potential effects on the local economy and infrastructure and community services are described in this EIS in Section 18.6 and Section 19.6, respectively.

The analysis of residual effects on economy considers several relevant indicators including potential changes to education and training, employment, contracting and businesses, and to income (i.e., individual and community). In most instances, the overall magnitude of effects is expected to be most discernible during the construction phase, when training and employment opportunities will be the greatest. However, the effects from operation are most likely to produce meaningful outcomes for the community, be it through long-term permanent employment opportunities, or through the equity associated with BLFN's partnership in the Project.

Based on the analysis of effects described in Section 18.5 of this EIS, effects on economy are expected to be positive in direction, moderate in magnitude, long-term in duration, and regional in geographic extent. Depending upon how equity and other Project income is spent by the BLFN, the magnitude of these effects may even be higher, and is likely to represent a significant source of improvement to various measurement endpoints for economy. Overall, there is no significant adverse effect of the Project on economy.

For economy, numerous existing and potential projects have the potential to overlap with the Project, particularly given that the geographic extent of the RSA extends to the entire province of Saskatchewan. A complete list of potential projects has not been examined, however would include projects such as northern uranium mining operations, and proposed mines in northern Saskatchewan. Conceptually, the issues in relation to economy, particularly the local economy, result from the fact that additional projects or developments represent opportunity and competition for local resources (e.g., employment or contracting). Cumulative effects on the economy would translate into higher levels of local and regional employment and business opportunities. These higher levels of economic activity, while beneficial overall, could place additional demands on the local and regional workforce and businesses, and could lead to capacity challenges, particularly in the LSA. However, this could result in additional benefits in the RSA. Given the overall positive nature of effects on economy, no significant adverse effects from the Project, combined with existing and reasonably foreseeable developments on economy are predicted.

The analysis of residual effects on infrastructure and community services considers potential changes to health care, childcare, and education services and facilities, traffic volumes, and quality and development of infrastructure income resulting from BLFN's partnership in the Project. Effects on infrastructure and community services are expected to be positive in direction, moderate in magnitude, long-term in duration, and local in geographic extent. Depending upon how equity and other Project income is spent by the BLFN, the magnitude of these effects may even be higher, which, could result in meaningful changes to BLFN infrastructure and community services, given the positive rating of the effect. Overall, there is no significant adverse effect from the Project on infrastructure and community services.

For infrastructure and community services, one additional development was identified as having potential spatial overlap with the RSA: the Highway 968 All-weather Road Project, a proposed 88.5 km road from Highway 905 near Stony Rapids to the community of Fond du Lac. The proposed roadway would extend from approximately 3.5 km south of the Stony Rapids airport at its intersection with Highway 905 and generally follow the existing winter road location west for 31.9 km toward Fond du Lac. The remaining 56.6 km of roadway would be entirely new, terminating on the south shore of Lake Athabasca near Fond du Lac. The project would take approximately three years to construct and would result in an estimated 300 person years of employment. With respect to infrastructure and community services, this could result in additional workers accessing services in communities in the region, in addition to additional air and road traffic associated with transporting personnel and equipment to the site (Ministry of Highways and Infrastructure 2010). These higher levels of activity, while beneficial overall, could place additional demands on the local infrastructure and community services and could lead to capacity challenges, particularly in the LSA. However, this could result in additional benefits in the RSA.

At present, there is no evidence to suggest that there would be a temporal overlap with construction activities for the Project and the development of the proposed roadway. The Ministry of Highways and Infrastructure budget announcements for 2013-2014 do not include the proposed road, and the environmental assessment process has not moved beyond the submission of a Project Description in 2010 (Ministry of Highways and Infrastructure 2010; Government of Saskatchewan 2013). Based on the assumption that construction phase for the Project and the road development are unlikely to overlap, no significant adverse effects from the Project, combined with existing and reasonably foreseeable developments on infrastructure and community services are predicted.

A Project Advisory Committee, including equal representation from the Elizabeth Falls Hydroelectric Limited Partnership (EFHLP) and SaskPower will meet at least monthly or as otherwise agreed to by the Committee, and will review the status of the Project including environmental, engineering and construction activities including community matters that relate to the completion of the Project. It is anticipated that this committee will discussion on-going concerns about socio-economic effects, and that the EFHLP and SaskPower will work together collaboratively on measures to address any community concerns.

23.3.2 Physical and Cultural Heritage

Heritage resources in Saskatchewan include all archaeological, historical, and paleontological objects and sites, as well as any property deemed to be of interest for its architectural, historical, cultural, environmental, aesthetic, and scientific value (Government of Saskatchewan 1980). As such, potential effects that may cause changes to any structure, site, or thing that is of historical, archaeological, paleontological, or architectural significance are considered in this section.

Potential effects on heritage resources are limited to direct disturbance and loss of archaeological sites during Project construction activities. A database and literature search, Elder interviews, and a pre-construction field assessment was carried out as part of baseline studies to determine if heritage resources were present in heritage sensitive areas of the Project footprint (Annex V; Golder 2013). No heritage resources were identified in conflict. However, a historical Dené cemetery (IgNj 6) is within 60 m of an existing road extending north from Camp Grayling towards the weir structure. Appropriate mitigation (e.g., flagging off or barricading access) should be taken to avoid this cemetery in the event that any road upgrade activities are planned. In a letter dated July 17, 2013 (Appendix 16.1) the Heritage Conservation Branch agreed with the above findings and recommendations outlined in the baseline assessments and have no concerns with the Project proceeding. As such, here are no expected effects on heritage resources from the Project footprint (Section 16.4).

23.3.3 Use of Lands and Resources for Traditional Purposes

Resource use and associated activities is a way of life for individuals in northern Saskatchewan, particularly the communities in the Athabasca region. Renewable resource uses include traditional resource uses by Aboriginal people, such as domestic hunting and fishing, along with resource use for commercial purposes, such as commercial fishing, trapping, and outfitting. The assessment of effects on traditional and domestic resource use focuses on activities undertaken by members of the BLFN. By virtue of the Project's location on BLFN reserve land, domestic resource use by other communities is limited.

The potential effects on the use of lands and resources for traditional purposes are described in Section 17.5. The analysis of residual effects on use of lands and resources considers the potential changes to traditional and domestic resource use and potential changes to outfitting and lodge activities.The discussion of traditional and domestic resource use includes consideration of a principal resource user, who is most likely to experience effects related to Project construction and operation. Other community resource use is discussed; however, while effects on other community resource users is expected to be similar, the extent of effects on the broader community will be less than those experienced by the principal resource user.

According to Section 14.5.1.4 of this EIS, habitats with high or moderate potential to support traditional use plant species are expected to decrease by 6.3% and 6.2%, respectively, relative to existing conditions. Most of the reclamation activities are expected to occur during and immediately following construction, with some reclamation activities occurring during operations. For example, once an area has been decommissioned, salvaged topsoil will be placed on disturbed areas and re-vegetated to encourage endemic species to re-populate the area. Reclamation activities following construction will include the removal of portions of the temporary construction infrastructure not required during operation. Overall, the residual effects from the Project and previous and existing developments are not predicted to be large enough to alter the state of plant communities and significantly influence self-sustaining plant populations and communities.

There also will be habitat loss for important locally harvested species, including beaver, moose, marten and waterbirds (Section 15.5.1). Effects from direct loss, alteration, and fragmentation of habitats from the Project and previous and existing developments are expected to be of negligible to low magnitude. Overall, the Project was conservatively estimated to disturb 1.4% of the RSA during construction. These changes should have negligible effects on the movement of individuals and connectivity of wildlife populations (Section 15.6.2). Overall, the incremental and cumulative effects from the Project and previous and existing developments are not predicted to be large enough to alter the state of wildlife populations and adversely influence self-sustaining wildlife populations; effects are predicted to be not significant.

Some fish currently drift downstream out of Black Lake into the Fond du Lac River through the Black Lake outflow; during Project operation, fish are expected to drift downstream through the natural river outflow and the water intake. However, the total number of fish leaving the Black Lake fish community is not expected to change over the current level of out-migration because overall Black Lake outflow rates and volumes will not change with the development of the Project. Out-migration of fish from Black Lake once the Project is operating is expected to be similar to current levels (Section 12.6.2). It is anticipated that hydrological changes in the Fond du Lac River will alter the relative abundance of prey items available to Arctic grayling and other fish species; however, this change is not expected to extend beyond the resilience limits of fish populations in the Fond du Lac River. The successful design and implementation of a Fish Habitat Offsetting Plan is expected to result in a no net loss of fish habitat resulting from the Project footprint or construction of Project components.

Overall, the combined residual effects from the Project are not predicted to be large enough to alter the state of fish health, abundance, distribution, or habitat, and therefore, influence the maintentance of self-sustaining fish populations. Therefore, domestic fishing on Middle Lake is predicted to continue as it does presently. In addition, other local lakes, such as Stony Lake and Black Lake, will be unaffected by the Project and will continue to be accessible for domestic fishing.

Resource management strategies, including the prohibition of firearms, hunting, trapping, harvesting, and fishing for all employees will be implemented to reduce pressures on wildlife and fish populations. These strategies should also assist in limiting the number of people exploring the LSA, which will help to reduce any potential interactions between the cabin owner and the non-local workforce at Middle Lake.

The Proponent is committed to working with the principal resource user and the general community to mitigate for Project-related disruption occurring in regular resource use areas. The Proponent will provide effective and timely communication about Project activities and about any restrictions to activities that will be applied (e.g., for safety concerns). Finally, the Proponent will consider compensation for demonstrated losses resulting from the Project.

Other members of BLFN access areas in the LSA for resource harvesting purposes, though less frequently than the principal resource user. These local resource users typically access and harvest resources in nearby areas within the LSA and RSA. Although changes to vegetation, fish and wildlife have the potential to affect broader community resource use (i.e., similar to changes that will be experienced by the primary resource user), other community members tend to be active within the LSA, RSA and beyond; so suitable alternative locations for resource use will continue to be available for use.

As described in Section 17.3.2.3, there is one outfitter, Camp Grayling, operating a fishing lodge adjacent to the Project site on the Fond du Lac River. Camp Grayling facilities include a lodge and cabin buildings, as well as storage facilities. The camp offers sport-fishing activities on the Fond du Lac River, as well as on several lakes in the LSA and RSA, focusing on sport (rod) fishing for Arctic grayling on the Fond du Lac River near Elizabeth Falls and northern pike on Black Lake. Camp Grayling provides access through leases to 22 regional lakes including Middle Lake and receives half of the commercial fishery allocation on Black Lake.

As with the effects on domestic fishing for other resource users, Project effects on the majority of lakes used by Camp Grayling are expected to be negligible or not measurable. This includes Black Lake and Middle Lake. Effects of Project operations on Arctic grayling on the Fond du Lac River relate to changes in the quantity and quality of habitat, in addition to the potential for injury and mortality. It is anticipated that hydrological changes in the Fond du Lac River will alter the relative abundance of prey items available to Arctic grayling and other fish species; however, this change is not expected to extend beyond the resilience limits of fish populations in the Fond du Lac River. The overall size of the Arctic grayling population in the Fond du Lac River and Black Lake outlet near Grayling Island, as well as in the lower section of the Fond du Lac River near Middle Lake, is expected to remain similar to current levels. The Arctic grayling population in the middle, by-passed section of the Fond du Lac River is expected to persist, but may be reduced in numbers due to lower flows and volumes in the river. However, reduced flows on the Fond du Lac River because of Project operations may improve access for shoreline fishing.

It is difficult to predict with certainty the extent of potential effects on Camp Grayling, particularly with respect to the potential for demonstrable losses. This is due, in part, to the multiple factors that may influence a tourist's decision to visit a location, in addition to the fact that changes in visitor behaviour may or may not be directly or indirectly attributable to the Project. The Proponent is committed to working with the owner of Camp Grayling to discuss any potential Project effects and the mitigation or compensation that may be appropriate in the circumstances.

23.4 References

AANDC (Aboriginal Affairs and Northern Development Canada). 2012a. First Nation Profiles: Reserves/Settlements/Villages. Available from http://pse5-esd5.ainc-inac.gc.ca/FNP/Main/Search/FNReserves.aspx?BAND_NUMBER=359&lang=eng (accessed March 24, 2012).

Golder (Golder Associates Ltd.) 2013. Tazi Twé Hydroelectric Project. Heritage Baseline Study. Permit No. 12-162. Report on File with Heritage Conservation Branch, Regina, SK.

Government of Saskatchewan. 1980. *The Heritage Property Act*. Chapter H-2.2 of the Statutes of Saskatchewan. The Queen's Printer, Regina.

23.5 List of Acronyms

Term	Definition
BLFN	Black Lake First Nation
BMP	Best Management Practices
CCME	Canadian Council of Ministers of the Environment
CEAA	*Canadian Environmental Assessment Act*
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
EFHLP	Elizabeth Falls Hydroelectric Limited Partnership
EIS	Environmental Impact Statement
EnvPP	Environmental Protection Plan
HADD	harmful alteration, disruption or destruction
LSA	local study area
MOE	Saskatchewan Ministry of Environment
OIC	Order in Council
Project	Tazi Twé Hydroelectric Project
RSA	regional study area
SARA	*Species at Risk Act*
VC	valued component

23.6 List of Units

Term	Definition
%	percent
ha	hectares
km	kilometre
m	metre

24.0 CONCLUSION

Based on the analysis provide in this Environmental Impact Statement (EIS) and the engineered design features aimed at reducing negative effects, the Proponent believes that the Tazi Twé Hydroelectric Project (the Project), from construction through to closure, is not likely to cause significant adverse residual effects. The environmental assessment has also demonstrated there are likely benefits associated with the Project. Adverse effects on components of the environment are not predicted to be large enough to alter the:

- surface water quality for aquatic and terrestrial ecosystems, and for human use;
- maintenance of self-sustaining fish populations (including listed species);
- maintenance of a self-sustaining plant population and community (including listed species);
- maintenance of self-sustaining wildlife populations (including listed species);
- protection and preservation of heritage resources;
- continued opportunity for traditional and non-traditional activities such as hunting, fishing, trapping, and plant and berry gathering;
- continued opportunity for employment;
- continued access to health care, family services, education, and recreation; and
- protection of human health and maintenance of quality of life.

Both positive and negative socio-economic effects are anticipated as a result of the Project. It is recognized that there is potential for increased demand on local infrastructure and community services resulting from the Project; however, it is anticipated that the most recognizable positive effect to the economy will be seen during the construction phase when training and employment opportunities will be the greatest. The effects from operation are most likely to produce meaningful outcomes for the community, be it through long-term permanent employment opportunities or through the equity associated with Black Lake First Nation's (BLFN) partnership in the Project. Depending upon how equity and other Project income is spent by the BLFN, there is potential for positive changes to infrastructure and community services for the community.

The analysis of effects on human population and health indicates that, while there is potential for interactions between local residents and non-local construction workers, adaptive management practices have been identified to address issues should they arise. Mitigation practices and policies are anticipated to limit the risk to local human population and health from the increase in Project-related vehicle traffic. However, it is recognized that even a single incident could have a significant effect on the individual and local communities. Early engagement with local residents and service providers will be completed so that potential risks can be identified prior to the on-set of construction and strategies can be devised to address issues as they arise.

It is anticipated that current land and resource uses will persist in the area. Further to this, access created by the Project could make it easier for members from BLFN to access areas east of the Fond du Lac River, recognizing that access to the operation itself will be limited to protect public safety. The Proponent has committed to working with the land and resources users to mitigate for Project-related disruption occurring in regular resource use areas. The Proponent will provide effective and timely communication about the Project activities and whether any restrictions to activities will be applied (e.g., for safety concerns).

A Project Advisory Committee, including equal representation from the Elizabeth Falls Hydroelectric Limited Partnership and SaskPower, will meet at least monthly or as otherwise agreed to by the Committee and will review the status of the Project including environmental, engineering, and construction activities including community matters that relate to the completion of the project. It is anticipated that this committee will discuss on-going concerns about socio-economic effects and that the proponent will work on measures to address any community concerns.

Overall, it is the opinion of the Proponent that the Project is not likely to cause significant adverse residual effects on the biophysical and socio-economic environments.

24.1 List of Acronyms

Term	Definition
BLFN	Black Lake First Nation
EIS	Environmental Impact Statement
Project	Tazi Twé Hydroelectric Project