LABRADOR – ISLAND TRANSMISSION LINK ENVIRONMENTAL ASSESSMENT

Freshwater Environment: Fish and Fish Habitat, Water Resources Component Study

May 2011

nalcor energy
LOWER CHURCHILL PROJECT

LABRADOR – ISLAND TRANSMISSION LINK ENVIRONMENTAL ASSESSMENT
Environmental Component Studies: Introduction and Overview

Nalcor Energy is proposing to develop the *Labrador – Island Transmission Link* (the Project), a High Voltage Direct Current (HVdc) electrical transmission system extending from Central Labrador to the Avalon Peninsula on the Island of Newfoundland.

The Project was registered under the Newfoundland and Labrador *Environmental Protection Act* (*NLEPA*) and the *Canadian Environmental Assessment Act* (*CEAA*) in January 2009 (with subsequent amendments and updates), in order to initiate the provincial and federal environmental assessment (EA) processes. Following public and governmental review of that submission, an Environmental Impact Statement (EIS) was required for the Project. The EIS is being developed by Nalcor Energy, in accordance with the requirements of both *NLEPA* and *CEAA* and the *EIS Guidelines and Scoping Document* issued by the provincial and federal governments.

In support of the Project's EIS, Nalcor Energy has undertaken a series of environmental studies to collect and/or compile information on the existing biophysical and socioeconomic environments and to identify and assess potential Project-environment interactions. This environmental study program has included field surveys, associated mapping and analysis, environmental modeling, and the compilation and analysis of existing and available information and datasets on key environmental components. This report comprises one of these supporting environmental studies.

A general guide to these Environmental Component Studies, some of which are comprised of multiple associated reports, is provided on the opposite page.

The information reported herein will be incorporated into the Project's EIS, along with any additional available information, to describe the existing (baseline) environmental conditions and/or for use in the assessment and evaluation of the Project's potential environmental effects and in the identification and development of mitigation.

This study focuses on the relevant aspects of the proposed Project – including the proposed and alternative HVdc transmission corridors, marine cable crossings, and/or other Project components and activities – as known and defined at the time that the EA process was initiated and/or when the study commenced. Project planning and design are ongoing, and as is the case for any proposed development, the Project description has and will continue to evolve as engineering and EA work continue. The EIS itself will describe and assess the specific Project components and activities for which EA approval is being sought, and will also identify and evaluate other, alternative means of carrying out the Project that are technically and economically feasible as is required by EA legislation.

The EIS and these Component Studies will be subject to review by governments, Aboriginal and stakeholder groups and the public as part of the EA process.

Nalcor Energy – Lower Churchill Project

LABRADOR-ISLAND TRANSMISSION LINK: ENVIRONMENTAL COMPONENT STUDIES (CSs)

Component Study	Reports	
1) Vegetation CS	**Report 1a** Ecological Land Classification	**Report 1b** Wetlands Inventory & Classification
	Report 1c Regionally Uncommon Plants Model	**Report 1d** Timber Resources
	Report 1e Vegetation Supplementary Report	
2) Avifauna CS		
3) Caribou & Other Large Mammals CS	**Report 3a** Caribou & Their Predators	**Report 3b** Moose & Black Bear
4) Furbearers & Small Mammals CS		
5) Marine Environment: Fish & Fish Habitat, Water Resources CS	**Report 5a** Marine Fish: Information Review	**Report 5b** Marine Flora, Fauna & Habitat Survey
	Report 5c Marine Habitats (Geophysical) Survey	**Report 5d** Water, Sediment & Benthic Surveys
	Report 5e Marine Surveys: Electrode Sites	**Report 5f** Marine Surveys: Supplementary
6) Freshwater Environment: Fish & Fish Habitat, Water Resources CS		
7) Marine Environment: Marine Mammals, Sea Turtles & Seabirds CS	**Report 7a** Marine Mammals, Sea Turtles & Seabirds: Information Review	**Report 7b** Marine Mammal & Seabird Surveys
	Report 7c Ambient Noise & Marine Mammal Surveys	
8) Species of Special Conservation Concern CS		
9) Marine Environment & Effects Modelling CS	**Report 9a** Strait of Belle Isle: Oceanographic Environment & Sediment Modelling	**Report 9b** Strait of Belle Isle: Marine Sound Modelling - Cable Construction
	Report 9c Electrodes: Environmental Modelling	
10) Historic & Heritage Resources CS		
11) Socioeconomic Environment: Communities, Land & Resource Use, Tourism & Recreation CS	**Report 11a** Communities, Land & Resource Use, Tourism & Recreation	**Report 11b** Current Levels of Accessibility Along the Transmission Corridor
12) Socioeconomic Environment: Aboriginal Communities & Land Use CS		
13) Socioeconomic Environment: Marine Fisheries in the Strait of Belle Isle CS		
14) Viewscapes CS		

Environmental Component Study Required Under the EIS Guidelines: Comprising Reports (Shaded cells above)	
Avifauna: 2, 7a, 7b	Furbearers: 4
Caribou (and Predators): 3a	Timber Resources: 1d
Water (Quality and Quantity): 5a, 5d, 5e, 5f, 6	Marine and Freshwater Fish and Fish Habitat: 5, 6, 7, 13
Species at Risk: 8	Historic Resources: 10
Viewscapes: 14	Socioeconomics: 11, 12, 13
Environmental study reports submitted as additional background information: 1a, 1b, 1c, 1e, 3b, 9	

Labrador – Island Transmission Link

Freshwater Environment: Fish and Fish Habitat, Water Resources Component Study

Preface

This *Freshwater Environment: Fish and Fish Habitat, Water Resources Component Study* has been prepared and submitted as part of the Environmental Assessment (EA) of the proposed **Labrador-Island Transmission Link** (the Project).

The study provides information on freshwater fish and fish habitat and water quality and quantity within the transmission corridor (proposed and alternative corridor segments) and adjacent areas, through an analysis of spatial imagery, field surveys, and the compilation of existing and available datasets and information from the literature.

The main report (November 2010) presents information on the freshwater environment for the originally defined transmission corridors from Gull Island (Labrador) to Soldiers Pond (Newfoundland), with an attached supplement (March 2011) also providing similar information for an additional transmission corridor option from Muskrat Falls in Labrador.

The environmental information presented in this *Component Study* will be incorporated and used in the Project's eventual Environmental Impact Statement (EIS), which will provide a summary description of the existing environment and an environmental effects assessment for the Project.

Labrador – Island Transmission Link

Freshwater Environment:
Fish and Fish Habitat, Water Resources

Prepared for:

Nalcor Energy
Hydro Place, 500 Columbus Drive, PO Box 12800
St. John's, Newfoundland and Labrador
Canada A1B 0C9

WTO TBR0050, WO 659826

Prepared by:

AMEC Earth & Environmental
A division of AMEC Americas Limited
133 Crosbie Road
St. John's, Newfoundland and Labrador
Canada A1B 4A5

AMEC Project # TF8154113

November 17, 2010

EXECUTIVE SUMMARY

Nalcor Energy is proposing to develop the *Labrador – Island Transmission Link*, a High Voltage Direct Current (HVdc) transmission system extending from Central Labrador to the Island of Newfoundland's Avalon Peninsula. The environmental assessment process for the Project was initiated in January 2009 and an Environmental Impact Statement (EIS) is being prepared by Nalcor Energy.

In anticipation and support of the Project's environmental assessment, Nalcor Energy contracted AMEC Earth and Environmental to conduct this *Freshwater Environment: Fish and Fish Habitat, Water Resources Study*. The objective was to obtain and present information on freshwater fish and fish habitat and water resources in and near the Project area, and specifically, to identify and describe those watercourses that may be crossed by the transmission corridor for use in the environmental assessment and on-going Project design and planning.

Air Photo Interpretation and GIS Analysis

For the purposes of this study, the Project area (transmission corridor) was sub-divided into the following four general regions based on geography and possible differences in fish presence and habitat:

1) *Southeastern Labrador* (Gull Island to the Strait of Belle Isle),

2) *Northern Peninsula* (Strait of Belle Isle to approximately the Hampden area),

3) *Central and Eastern Newfoundland* (Hampden area to the Clarenville area), and the

4) *Avalon Peninsula* (approximately the Clarenville area to Soldiers Pond).

Through the study, freshwater fish habitat at each watercourse crossing along the proposed transmission corridor and various identified alternative corridor segments was identified and assessed through the analysis and interpretation of digital air photos and/or satellite imagery in a Geographic Information System (GIS).

Interpretation of each crossing included an assessment of various relevant physical and/or biological features and characteristics. The information was then used to describe and characterize each watercourse crossed by the centreline of the transmission corridor. The survey was completed using an approach and methods that are similar to previous successful linear surveys / assessments conducted by the study team and approved by Fisheries and Oceans Canada (DFO).

Air photo interpretation was completed for all 656 identified watercourse crossings within the transmission corridor (proposed and alternative segments). Streams were classified by identifying and describing both their flow morphology and dominant substrate. To further understand the features and characteristics of a stream, additional data were collected regarding stream morphology, namely the stream wetted width and channel width and the riparian vegetation adjacent to the stream. Relevant GIS applications and software such as the Spatial Analyst extension in ArcMap were applied to derive additional information, including the gradient of the stream and the watershed area of each stream. The stream gradient provided morphological information that assisted in the classification of stream habitat types.

Each watercourse crossing was then classified based upon the size of the respective watershed based on the following size categories: intermittent (N) (<2.6 km^2), small (S1) (2.6 to 50 km^2), small (S2) (50 to 200 km^2), small (S3) (200 to 500 km^2), intermediate (I1) (500 to 1,000 km^2), intermediate (I2) (1,000 to 10,000 km^2) and large

(>10,000 km^2). The watershed size of the eightieth percentile of all intermittent streams identified on 1:50,000 mapping was chosen as the watershed size below which all would be classed as intermittent.

The accuracy of the data produced through air photo interpretation was evaluated for quality assurance and quality control by surveying a representative number of watercourses on the ground (groundtruthing). The accuracy of air photo interpretation was then assessed using Kappa analysis, a discrete multivariate technique used to assess accuracy for statistical determination.

A total of 656 potential watercourse crossings were identified within the transmission corridor through air photo analysis within a GIS system. In particular, interpreters assessed and classified potential fish habitat within a total of 196 streams in the Southeastern Labrador region, 173 in the Northern Peninsula region, 184 in the Central and Eastern Newfoundland region and 103 in the Avalon Peninsula region. All regions had riverine fish habitat which consisted of rapid, riffle, flat or discontinuous habitat types. Overall the most common flow morphology throughout the Project area was riffle type flow at 43 percent. The most common dominant substrate material overall was fine substrate at 61 percent.

Freshwater Field Survey

All potential stream crossings along the centreline of the proposed and alternative transmission corridors were identified and characterized through the above described GIS analysis. The subsequent and associated freshwater field program was designed to collect additional information related to an appropriate and representative sub-set of these identified watercourse crossings. Representative sample sites throughout the transmission corridor were selected for field surveys based on the number of watercourse crossings within each watershed size interval.

Through the above noted GIS analysis, stream crossings identified in the Southeastern Labrador, Northern Peninsula, Central and Eastern Newfoundland, and the Avalon Peninsula regions were classified by estimating the watershed drainage area (defined as the watershed area upgradient of the crossing location). Each watercourse crossing was then assigned to a size category, and the planned distribution of the field survey sampling effort was derived to provide the following "coverage": 0 percent of intermittent, 10 percent of S1, 25 percent of S2, 50 percent of S3, 50 percent of I1, 50 percent of I2 and 100 percent of large.

Based on this, the number of watercourse crossing sites surveyed for each study area region was as follows: 15 in Southeastern Labrador, 13 on the Northern Peninsula, 20 in Central and Eastern Newfoundland, and five on the Avalon Peninsula, for a total of 53 watercourse crossing sites field surveyed across the Project area during the summer field season of 2008.

Field sampling provided additional data on freshwater fish and their habitats within these select and representative regional watercourses, as well as facilitating a general evaluation of the overall accuracy of the air photo interpretation. Field sampling also included the collection of baseline water and sediment samples, the collection of data on physical characteristics (stream morphology) of watercourse crossings and fish species presence. In particular, field sampling consisted of the collection of stream morphology data including water depth, water velocity and fish habitat characterization (e.g., riffle, run, steady or cascade) fish species presence, invertebrate sampling, water and sediment quality analyses.

Fish Habitat Types and Fish Species

The three dominant habitat types of the field surveyed watercourses were riffle (34 percent), steady (26 percent) and run (25 percent). The least common habitat type observed was riffle/run (15 percent).

The most abundant fish species captured during field surveys via electrofishing were brook trout (*Salvelinus fontinalis*) and Atlantic salmon (*Salmo salar*). Brown trout (*Salmo trutta*) were only captured in the Avalon Peninsula region and American eel (*Anguilla rostrata*) were only captured in the Northern Peninsula region.

Fish were present at all field surveyed watercourses except P369 (Central and Eastern Newfoundland) in South Brook (Halls Bay) watershed, P270 (Northern Peninsula) in the Sop's Arm watershed and P204 (Northern Peninsula) in the Castors River watershed.

Water and Sediment Sampling

During the field program water and sediment samples were collected from a number of select watercourse crossings. A total of 44 water samples were collected and analyzed for general chemistry (e.g., Total Organic Carbon {TOC}; Total Inorganic Carbon {TIC}; Dissolved Organic Carbon {DOC}; Dissolved Inorganic Carbon {DIC}; Volatile Organic Hydrocarbons {VOCs}; Benzene, Toluene, Ethylene and Xylene {BTEX}; Total Petroleum Hydrocarbons {TPH}, anions, cations, and sulphates) and a full metals suite. A total of 13 sediment samples were collected and analyzed for general chemistry and full metals suite.

The analysis of water samples for metals and hydrides collected during the 2008 field program resulted in all but one sample (P533 – Avalon Peninsula) having at least one metal at a concentration above Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Aquatic Life (PAL). Metals which were found within water samples to exceed CCME guidelines included aluminium, cadmium, copper, iron, lead, mercury, and selenium. In addition, general chemistry analysis results indicated that the pH at 18 of the 44 sites sampled was outside of CCME guidelines.

Analysis of water samples for VOC and BTEX indicated that no sample exceeded CCME guidelines. However, while there is no CCME guideline value for TPH, a hydrocarbon identification of heavy oil at site P541, located in Avalon Peninsula region was recorded.

The analysis of sediment samples collected during the 2008 field program indicated that no sample had any parameter above CCME guidelines.

Freshwater Environment: Literature Review

A literature review was conducted to supplement the information obtained through air photo analysis and field survey, in order to further expand upon the knowledge of the current freshwater environment within and adjacent to the Project area.

The literature review initially focussed upon identifying those fish species that are known to occur within specific watersheds. This information was compared against the observations collected during the field survey.

Within the more fish diverse Southeastern Labrador region the literature review identified Atlantic sturgeon (*Acipenser oxyrhynchus*), American eel, Atlantic salmon, brook trout, burbot (*Lota lota*), lake chub (*Couesius plumbeus*), fourspine stickleback (*Apeltes quadracus*), lake whitefish (*Coregonus clupeaformis*), longnose dace (*Rhinichthys cataractae*), longnose sucker (*Catostomus catostomus*), mottled sculpin (*Cottus bairdi*), northern redhorse (*Moxostoma aureolum*), round whitefish (*Prosopium cylindraceum*), slimy sculpin (*Cottus cognatus*), rainbow smelt (*Osmerus mordax*), threespine stickleback (*Gasterosteus aculeatus*) and white sucker (*Catostomus commersoni*) as species which are known to occur in the region. Atlantic salmon, brook trout, burbot, longnose dace, mottled sculpin, pearl dace (*Margariscus margarita*), and white sucker were captured during the field program.

The literature review of the Northern Peninsula region identified nine species which are known to occur in this area: alewife (*Alosa pseudoharengus*), American eel, Arctic charr (*Salvelinus alpinus*), Atlantic salmon, brook trout, ouananiche (landlocked form of *Salmo salar*), rainbow smelt, threespine stickleback, and tomcod (*Microgadus tomcod*). Of the nine fish species identified during the literature review only American eel, Atlantic salmon, brook trout, and threespine stickleback were caught during the field program.

The literature review of the Central and Eastern Newfoundland region identified American eel, Arctic charr, Atlantic salmon, brook trout, ninespine stickleback (*Pungitius pungitius*), ouananiche, rainbow smelt, and threespine stickleback as species which occur within this area. Of the eight species identified during the literature review only Atlantic salmon, brook trout, and threespine stickleback were caught during the field program.

The literature review of the Avalon Peninsula region identified Atlantic salmon, brook trout, brown trout, fourspine stickleback, threespine stickleback and rainbow trout (*Oncorhynchus mykiss*) as species which occurred in the area. All of these species were caught during the field program with the exception of fourspine stickleback.

Municipal drinking water supplies identified as being crossed by the transmission line corridor were considered and available water quality data for these sites were collected from a provincial data portal (NL DEC 2010) and assessed for current conditions. All regions consisted of sites that exceeded colour parameter guidelines for Canadian Drinking Water Quality (CDWQ) (aesthetics parameter). Central and Eastern Newfoundland region also exceeded the manganese value for CCME PAL guidelines (Steve's Pond water supply, Arnold's Cove) and pH values for both the CDQW and CCME PAL guidelines (all sites except Brigades Pond, Southern Harbour).

Table of Contents

List of Figures

List of Tables

List of Appendices

1.0 INTRODUCTION

Nalcor Energy is proposing to develop the *Labrador - Island Transmission Link* (the Project), a High Voltage Direct Current (HVdc) transmission system extending from Central Labrador to the Island of Newfoundland's Avalon Peninsula. The Environmental Assessment (EA) of the Project is ongoing, with an Environmental Impact Statement (EIS) being prepared by Nalcor Energy.

In preparation for and in support of the Project's EA, this *Freshwater Environment: Fish and Fish Habitat, Water Resources* Study was completed in order to obtain and present information on the existing freshwater environment in the area of, and which may interact with, the proposed Project, as environmental baseline information for use in the EIS and in on-going Project design and planning.

1.1 Project Overview

The proposed Project involves the construction and operation of transmission infrastructure within and between Labrador and the Island of Newfoundland (Figure 1.1).

The proposed HVdc transmission system, as currently planned, includes the following key components:

- an alternating current to direct current (ac to dc) converter station at Gull Island in Central Labrador, on the north side of the Churchill River adjacent to the switchyard for the Lower Churchill Hydroelectric Generation Project;
- an HVdc transmission line extending from Gull Island across Southeastern Labrador to the Strait of Belle Isle. This overhead transmission line will be approximately 400 km in length with a cleared right of way averaging approximately 60 m wide, and consisting of single galvanized steel lattice towers;
- cable crossings of the Strait of Belle Isle with associated infrastructure, including cables placed under the seafloor through various means to provide the required cable protection;
- an HVdc transmission line (similar to that described above) extending from the Strait of Belle Isle across the Island of Newfoundland to the Avalon Peninsula, for a distance of approximately 700 km;
- a direct current to alternating current (dc to ac) converter station at Soldiers Pond on Newfoundland's Avalon Peninsula; and
- electrodes in Labrador and Newfoundland, with overhead wood pole lines connecting them to their respective converter stations.

Project planning and design activities to date have identified a 2 km wide corridor for the on - land portions of the proposed transmission line and two 500 m wide corridors for the proposed Strait of Belle Isle cable crossings, as well as various corridor segments in particular areas.

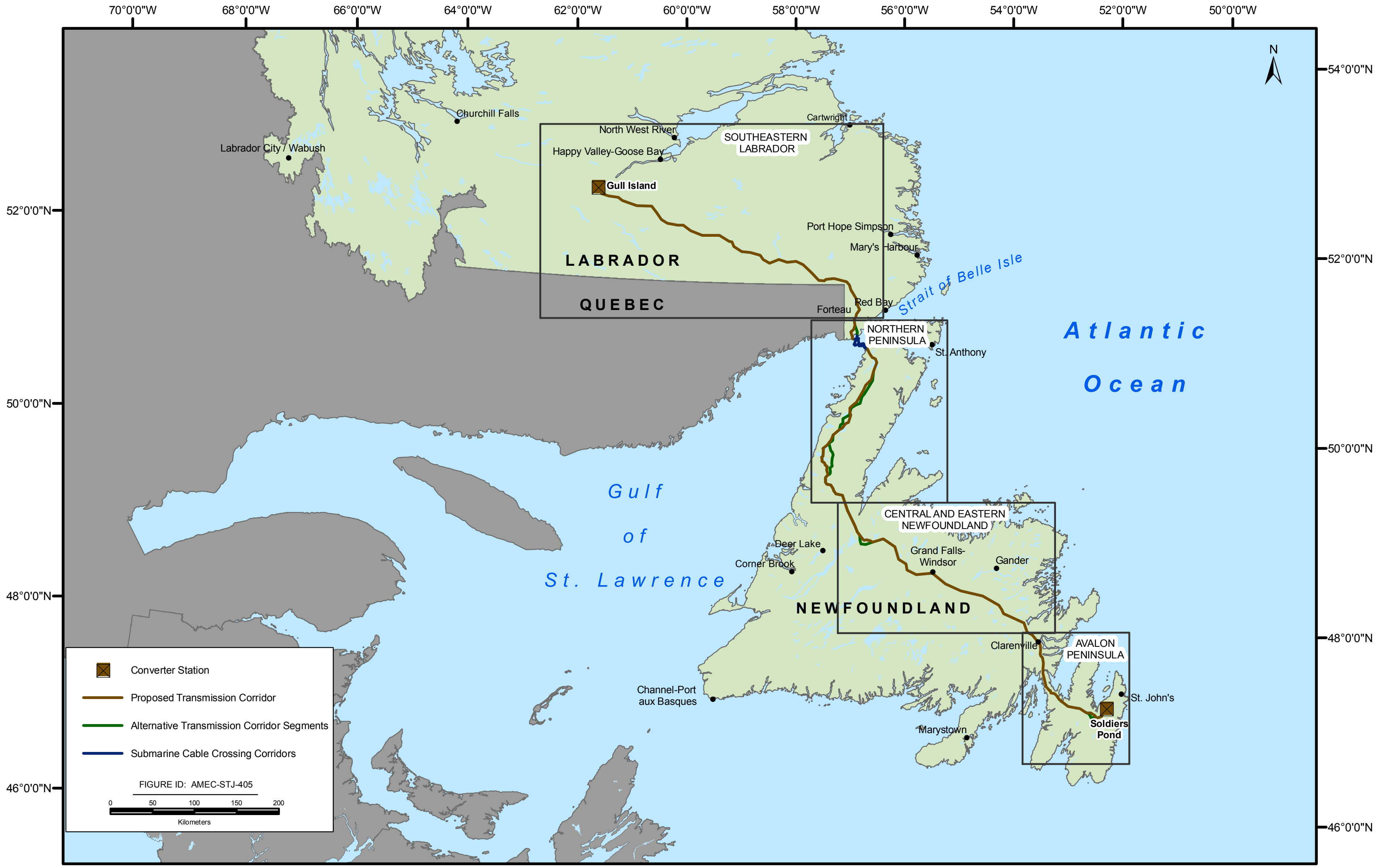

Figure 1.1 The Proposed Labrador - Island Transmission Link

It is these transmission corridors that were the subject of Nalcor Energy's environmental baseline study program. Project planning is ongoing, and it is anticipated that the Project description will continue to evolve as engineering and design work and the EA continue.

In conjunction and concurrent with the EA process, Nalcor Energy will be continuing with its technical and environmental analyses of the corridors, in order to eventually identify and select a specific routing for the transmission line from within these larger corridors. The transmission line will have an on - land right of way that will average approximately 60 m in width. The eventual transmission routes and locations will be selected with consideration of technical, environmental and socioeconomic factors.

1.2 Study Purpose and Objectives

As indicated above, the purpose of this *Freshwater Environment: Fish and Fish Habitat, Water Resources Study* was to obtain and present information on the existing freshwater environment in the area of, and which may interact with, the proposed Project, as environmental baseline information for use in the EA and in on-going Project design and planning.

The key objective of the study was to provide an appropriate and useful understanding of the existing (baseline) freshwater environment for these purposes, with due consideration of the nature and geographic scale of the Project and its potential interactions with the freshwater environment. The study approach therefore utilized a range of methods, including GIS / air photo analysis to identify and characterize all of the watercourses potentially crossed by the transmission corridor, a field survey of a select and representative sample of these watercourse crossings to obtain additional information on their key physical and biological characteristics, and an extensive review of existing and available information and datasets to supplement this primary data collection. The freshwater study was designed and carried out using techniques similar to previous successful linear surveys / assessments conducted by the study team and approved by Fisheries and Oceans Canada (DFO). The nature, and appropriateness, of this study approach and methodology was discussed with relevant government agencies and stakeholders as part of the planning and design of the Project's environmental study program in 2008, and at various times upon completion of the associated fieldwork and analysis and report preparation.

The specific study objectives and deliverables were as follows:

1. Identify all of the potential watercourses that may be crossed by the transmission corridor (proposed and alternative segments), as well as determine the size of their associated watersheds;

2. Assess and characterize the existing freshwater fish habitats within these identified watercourse crossings through air photo interpretation (e.g., flow morphology, dominant substrate, slope, width, riparian vegetation);

3. Determine, based on the above noted calculation of watershed size, the specific watercourses to be field sampled for fish species presence, habitats, water and sediment characteristics; and to conduct a field survey of these identified watercourse crossings across the transmission corridor; and

4. Identify, compile, review and summarize other existing and available information and datasets on the freshwater environment in the general Project area, in order to supplement the above information collection and analysis.

Through the air photo interpretation, field survey and literature review, the study identifies each of the various watercourse crossings across the transmission corridors and describes the associated fish and fish habitat characteristics of these watercourse crossings.

The study also provides information on water resources in these watercourses, including the collection and analysis of water samples (water quality) and the calculation of watershed size, water depths and flow velocity (water quantity).

1.3 Study Team

Study team members for this Freshwater Environment Study have been conducting freshwater surveys and fish habitat classification for many years in Newfoundland and Labrador and elsewhere. Members of this team were selected based on their experience and knowledge of aquatic environments, fish and fish habitat, GIS applications and air photo interpretation and/or associated field work.

Key team members included: **James H. McCarthy, M.Sc.**, a senior biologist and project manager with AMEC St. John's. Mr. McCarthy held the position of project manager and senior biologist. Mr. McCarthy also led various tasks associated with the field program and coordinated the air photo interpretation. Quality assurance and review was provided by **David Robbins, M.Env.Sc.,** a senior biologist and corporate sponsor for this work. **Suzanne Mullowney, B.Enviro. Studies & Forest Conservation (Honours)** is a lead field biologist with AMEC St. John's. Mrs. Mullowney performed as a team lead during the field study, participated in air photo interpretation, and assisted with writing the draft and final report. **Dermot Kenny**, **Natural Resources Technician,** is an AMEC fisheries / field technician with over ten years of field experience. Mr. Kenny performed as a team lead in the field portion of the project and assisted with data entry and writing of the draft and final reports. **Michael Teasdale, M.Sc.** is a lead biologist with AMEC St. John's. Mr. Teasdale assisted with the air photo interpretation.

The freshwater field program required the assistance of knowledgeable and experienced field technicians. As such, the field crews included **Jesse Noel,** a field technician who has assisted on numerous aquatic studies throughout Newfoundland and Labrador, and **Matthew Gosse, 4th year B.Sc. student,** a junior environmental scientist with three years field experience with AMEC. Mr. Noel acted as a field team member under the direction of Mr. Kenny and/or Mrs. Mullowney. Mr. Gosse performed as team member, under the direction of Mrs. Mullowney and/or Mr. Kenny during the field study and assisted with data entry and air photo interpretation.

GIS data entry and analysis were completed by **Juanita Abbott**, **B.A.**, **Neala Griffin**, **B.A. GISB** and **Karl Keough B.Comm, CGA, B.Sc., M.E.S**. This team generated and reviewed drainage basin and slope analysis, input datasets from air photo interpretation and maintained the database and mapping for the study.

2.0 APPROACH AND METHODS

The following sections provide an overview of the design and conduct of this *Freshwater Environment Study*, including the development and use of the watercourse GIS database, literature reviews and the associated 2008 freshwater field survey program.

2.1 Watercourse Database

Data collected during previous studies of the transmission corridor and data collected through air photograph interpretation, satellite imagery, topographic mapping and GIS applications were used to generate an information database which was used to identify and characterize each watercourse crossing along the transmission corridor.

The methods used for the interpretation of these data and the criteria used to classify the identified watercourses are described below.

2.1.1 Spatial Imagery Utilized

Several sources of spatial imagery were used in the identification and classification of potential watercourse crossings within the transmission corridor, including topographic mapping, aerial photographs and satellite imagery. Topographic mapping was utilized as the primary source of spatial imagery for the identification of potential crossings within the Project corridor whereas aerial photographs and satellite imagery provided a means of assessing a large area more efficiently and accurately than through the use of topographic maps alone.

Topographic maps (1:50,000) were available for the entire transmission corridor and were primarily used in the identification of streams/rivers which the transmission corridor may potentially cross.

Aerial photography (1:30,000), with a spatial resolution of 60 cm, was provided by the Government of Newfoundland and Labrador – Department of Environment and Conservation – Lands Branch, Surveys and Mapping Division. Total coverage included a 15 km wide corridor from near Hampden, east to the Isthmus of Avalon, but was unavailable for the Northern Peninsula and Labrador regions. The vintage of the digital aerial photography obtained and used ranged from 1999 to 2006.

To supplement the available air photos and fill in the above noted spatial gaps, SPOT 5 satellite imagery was purchased through the Canadian distributor- Lunctus Geomatics Corporation. Satellite imagery, with a spatial resolution of 2.5 m (panchromatic) and 5 m (multispectral), was acquired to cover an area that encompassed the proposed transmission corridor and adjacent areas. The 2.5 m panchromatic (greyscale) imagery was coloured using both SPOT 5 multispectral (colour) imagery and Landsat 7 (colour) imagery, and all products were ortho-corrected. The most recent imagery that met the criteria of less than 10 percent cloud cover and acquisition during snow free conditions (between the months of June and October) was used. The vintage of the imagery ranged from 2005 to 2008.

2.1.2 Water Crossing Identification

For the identification of potential stream crossings, a watercourse was defined as any stream which could be discerned on a 1:50,000 topographic map. This definition is consistent with that used in Newfoundland and Labrador for identification of watercourses requiring buffer zones for protection of fish and fish habitat (Scruton et al. 1997).

GIS applications were used to identify and label all watercourses intersecting the centreline of the 2 km wide transmission corridor (proposed corridor and identified alternative segments), each of which were given a unique identification number.

Identified watercourse crossings were originally labelled with a prefix of either a P (proposed corridor) or an A (alternative corridor segment) followed by a unique identification number (e.g., P29), which was incorporated into the GIS database. Since the initiation of the study, however, various changes to the Project (e.g., the removal of several previously identified corridor segments for technical reasons) and the fact that the initial labelling of the watercourses did not in all cases use this “P” or “A” labelling system consistently, has resulted in these label prefixes being rather arbitrary in the final mapping product and report. However, it has been maintained herein in order to avoid the potential for data transcription errors.

2.1.3 Water Crossing Delineation and Drainage Area

Watershed drainage area and slope are typically very good indicators of freshwater fish habitat type within a section of stream, and preliminary interpretation can therefore be used to categorize similar streams in terms of habitat type at each crossing.

As in past similar linear assessments, watercourse crossings within the transmission corridor have been classified based upon the estimated watershed drainage area (where drainage area is defined as that watershed area upgradient of the crossing). Each watercourse crossing was then assigned to watershed size intervals: intermittent (N), small (S1, S2, S3), intermediate (I1, I2) and large (L) (Table 2.1).

Table 2.1 Size Categories of Potential Watercourse Crossings

Watercourse Type	Watershed Size (km^2)
Intermittent (N)	<2.6
Small (S1)	2.6 to 50
Small (S2)	50 to 200
Small (S3)	200 to 500
Intermediate (I1)	500 to 1,000
Intermediate (I2)	1,000 to 10,000
Large (L)	>10,000

A total of 656 potential watercourse crossings were identified within the corridors through the use of the GIS database (1:50,000 mapping). As a conservative approach, all potential stream crossing locations near the centreline of all transmission corridors were included. In order to remain conservative, all crossings with watershed areas less than 2.6 km^2 were assumed to be intermittent.

The use of this assumption is consistent with that of past watershed surveys conducted within the Voisey’s Bay area of Labrador and the Schefferville area of Western Labrador, where smaller watershed sizes were shown to be intermittent. Specifically, 80 percent of the streams surveyed in the Voisey's Bay and Schefferville areas with watershed areas less than 2.6 km^2 were intermittent (AMEC 2004; AMEC 2005).

Digital Elevation Modelling (DEM) files (Canadian Digital Elevation Data (CDED)) were used to generate stream catchment networks throughout the corridor at each identified crossing. DEM files provide ground elevation data at a scale of 1:50,000 resolution from the National Topographic System Data Base (NTSDB) or from individual provinces. The files are organized into geographically referenced, regularly spaced intervals (grid) of elevation data that can be overlain onto GIS mapping. The upriver catchment area of each crossing was estimated using Argos 9.2 with the Arc Hydro tool within the Spatial Analyst extension. Where DEM files could not accurately discriminate catchment areas, editing was completed using contours from the basemaps. Each drainage area was then mapped using GIS and categorized into size classes. This classification of upriver catchment area was used to select the number and type of crossings that were field surveyed. This acted as a means of generally checking the photo interpretation data against data collected in the field, as well as providing additional baseline data on the stream crossings.

Calculated Stream Gradients

The stream gradient (or slope) of each watercourse crossing that intersected the centreline of the transmission corridor was generated using GIS and DEM files. The DEM information was queried based on watercourse location and slopes were calculated with the Spatial Analyst extension in ArcMap.

The length of stream used in the slope determination was defined by the characterization of the stream within the transmission corridor. Specifically, slope was generated from the stream segment that crossed the centreline out to the corridor edges or until the segment reached another tributary (i.e., where two stream reaches intersect). This ensured that the slope more accurately represented the habitat present near the centreline of the corridor and did not include potentially different stream reaches and/or stream characteristics.

The Zonal Statistics tool in the Spatial Analyst extension of ArcGIS was used to determine the DEM elevation data required to calculate stream slope for each stream segment (the stream segment being the "zone of interest" within the Zonal tool). The output for each stream segment included the elevation range between the upper and lower points of the stream segment (i.e., the total change in elevation) as well as the overall segment length (i.e., the length of stream where the total change in elevation occurred). These values were used to generate the overall slope of the stream segment, expressed as a slope percentage.

2.1.4 Air Photo Interpretation

Using the GIS database, air photo interpretation was completed for all identified watercourse crossings. Each stream within the transmission corridor was examined to determine potential fish habitat type. Characterization of watercourse crossings followed the DFO riverine methodology prescribed for coarse level assessments as outlined in McCarthy et al. (2007). Descriptions of the parameters (flow morphology, dominant substrate, wetted width, channel width and riparian vegetation) and the classifications included in the interpretation and database for each crossing are provided below. The next chapter of this report presents a summary / description of all classifications. These habitat characteristics provide information on the various habitat types which can be utilized during various life stages of fish.

All aerial photos of the Project area were scanned and georeferenced enabling GIS applications and information to be applied to the digital air photos. This allowed for more efficient interpretation of the images through the use of GIS applications that defined the physical space of the image, establishing locations as coordinate systems. Once the digital image was linked to georeferenced real-world coordinates the location of features such as the corridor and identification of streams within the proposed transmission corridor could be displayed. Interpreters could then work with a segment of stream within the corridor. Figure 2.1 provides an example of an aerial photograph used to interpret fish habitat at stream crossings within the transmission corridor. The yellow lines depict the corridor boundaries, whereas the black dashed line represents the corridor centreline and the red dots identify the stream crossings within the corridor.

Digital air photos were analyzed using ArcGIS Explorer software, which provides additional measuring utilities over simple image viewer software. For example, quantitative measurements of channel and wetted widths were recorded directly from digital air photos and input to spreadsheets. ArcGIS Explorer software also allowed study team members to import and display additional ArcGIS shapefiles (layers) such as the proposed transmission corridor, location and identification of each stream crossing and 1:50,000 topographic NTS map data to aid in interpretation. These features were overlaid on the digital image and could be displayed or 'turned off' individually within the software. The ability to turn various layers on and off allowed interpreters to better identify stream crossing locations and habitat characteristics within the transmission corridor.

Streams were principally classified by identifying both *flow morphology* and *dominant substrate*. Flow morphology is a habitat feature that depends upon the volume of water flowing in a stream and the slope of the stream segment. Substrate is the material that forms the bottom of the stream (e.g., bedrock, cobble, gravel) and is also significant in characterizing fish habitat. The dominant substrate was identified from the air photos as the most commonly occurring substrate type within a specific stream segment.

In an effort to further characterize the features of stream crossings, additional morphometric features were also measured. For example, stream water levels fluctuate depending on recent weather conditions, season and/or development of the surrounding land. Measurement of the wetted width and channel width provided the water level at the time the image was taken and an estimate of the maximum high water level of the stream respectively.

The strip of land adjacent to both sides of the stream is referred to as the riparian zone and is typically comprised of assemblages of vegetation species which are characteristically different from upland vegetation. Riparian vegetation provides cover for fish against predators, regulates water temperature in the summer and assists in stabilizing stream banks.

Figure 2.1 Sample Aerial Photograph used to Interpret Fish Habitat at Potential Stream Crossings within the Transmission Corridor.

In some cases streams which were present on the 1:50,000 topographic maps were not visible in the air photo/satellite imaging. The specific reasons for this discrepancy may stem from a number of factors, such as: 1) the stream was small and heavily covered by riparian vegetation, 2) the stream was dry at the time the image was taken or 3) cloud cover obscured the stream. Any crossing where visibility was obscured enough to limit interpretation was classified as discontinuous and all quantitative and qualitative parameters were not measured.

Flow Morphology

Flow morphology was classified using slope, dominant substrate and surface water conditions as well as the imaging itself. Morphology classifications included rapids, riffle/run, flat/steady or discontinuous (Table 2.2).

Calm water, such as that associated with a flat/steady is typically dark in colour and smooth in appearance. As water velocity and/or the gradient increases, the surface of the water appears dark with white "spots" where larger substrate or standing waves are present, suggesting a riffle/run. Progressively increasing water velocity and gradient causes the water surface to appear textured with increasingly larger amounts of white on the image, suggesting rapids.

Table 2.2 Flow Morphology Descriptions

Category	Code	Name	Description
Flow Morphology	RA	rapid	Large amount of white water
	RI	riffle/run	Some white water visible – little areas of white mixed with black (calmer water)
	FL	flat/steady	No white water – black and calm
	DS	discontinuous	Discontinuous stream – unable to follow entire stream, disappears within vegetation

Dominant Stream Substrate

Dominant stream substrate was characterized using the available air photos/imagery. A total of three classifications were utilized; 1) coarse, 2) medium and 3) fine, all within the littoral zone (depth of water penetrable by light) (Table 2.3).

Table 2.3 Dominant Substrate Classifications

Category	Code	Name	Description
Dominant Substrate	LC	littoral coarse	>50 percent boulder
	LM	littoral medium	>50 percent rubble/cobble
	LF	littoral fine	>50 percent gravel/sand/silt/mud

The classification of each stream reach was based on the substrate size class that constituted greater than 50 percent of the total visible substrate coverage. Coarse substrate consisted of substrate greater than rubble in size (boulder and bedrock). This substrate type was distinguishable/visible on imagery as broken water that moves around boulders and breaks the surface. White water may also be visible around the substrate, which provides a method of measuring the width of the substrate. Medium substrate consists of rubble and cobble size classes. This class can also generally be distinguished on imaging but will have limited white/visible water (unless the slopes are quite large). Generally, it is difficult to distinguish between the finer substrate classes (e.g., gravels, sand, silt etc.) since these finer substrates often appear uniform. Typically finer substrates will not break the water's surface; therefore white water is not present.

Wetted Width

The wetted width of each crossing was measured using the measuring tool within the software, and was defined as the perpendicular distance (m) between the shoreline at each crossing, as described by McCarthy et al. (2007).

Channel Width

The channel width of each crossing was taken as the measured, perpendicular distance (m) between the visible riparian vegetation (again, by means of the measuring tool within the software) at each crossing, as described by McCarthy et al. (2007).

Riparian Vegetation

The riparian area is the area of land adjacent to the stream. It is a transition zone between the aquatic and upland areas, and is typically comprised of distinct vegetation types such as smaller and thicker deciduous shrubs and trees.

The vegetation within the riparian area was classified by distinguishable vegetation types: conifer tree, conifer shrub, deciduous tree, deciduous shrub, grass, lichen, bog and treed bog (Table 2.4). Riparian vegetation was characterized for both sides of each watercourse crossing.

Table 2.4 Riparian Vegetation Classifications

Category	Code	Name	Description
Riparian Vegetation	CT	conifer tree	White or black spruce, balsam fir, tamarack – usually darker in contrast
	CS	conifer shrub	Dwarf spruce/balsam fir/tamarack – shorter shadows and/or little shadow, darker in contrast
	DT	deciduous tree	Yellow or white birch, aspen – lighter in contrast
	DS	deciduous shrub	Alder, Labrador tea, sweet gale, dogwoods, etc. – fine detail, short/stocky vegetation usually associated with bog areas.
	GR	grass	Grasses or sedges – fine detail, lighter in contrast.
	LI	lichen	Reindeer or other lichens – white patches or speckles on the ground between trees or larger patches in more open areas.
	BO	bog	Saturated areas with shrubs, mosses, lichens and/or grass/sedges – open areas with little to no mature (tall) trees, open water seen as black areas (ponds) or white “reflections”.
	TB	treed bog	Bog with trees

A number of streams were not visible in the aerial photographs due to either heavy vegetation cover, cloud cover, poor image quality / resolution / scale, or the stream bed was dry. These were classified as discontinuous - either permanently or seasonally. In the corresponding tables within Appendix A these sites were referred to as ”unavailable to be interpreted”.

Parameter Calibration

As various study team members were involved in air photo interpretation, checks were performed for consistency. Each interpreter initially reviewed a series of stream crossings (P430 through P440 inclusive) within ArcGIS Explorer and completed independent interpretations/measurements of dominant substrate, channel width, wetted width, dominant riparian habitat and incidental observations. Flow morphology (habitat classification) was also determined based on all habitat measurements including slope (provided from GIS prior to interpretation). Upon completion of individual interpretations, all team members went through a calibration exercise. The exercise included a review of all interpretations as well as a presentation by each as to how they measured and determined each parameter. Consensus and calibration between all team members occurred regarding the measurement of parameters as well as determinations of habitat characteristics. A list of the collaborative categories for each parameter was then provided to each interpreter describing the quantitative and qualitative data that would be collected prior to interpretation.

Air Photo Interpretation Assessment of Accuracy

Accuracy assessment determines the quality of the information derived from remotely sensed data (Congalton 1991; Congalton and Green 1999). The consistency and correctness of photo interpretation is determined by both the nature and quality of the image and the interpreter's experience and skill (Congalton and Mead 1983). Accuracy assessment can be qualitative or quantitative. The purpose of quantitative accuracy assessment is the identification and measurement of map errors and typically involves the comparison of interpreted sites against reference information for the same sites. In an accuracy assessment, the reference data is assumed to be correct (Congalton and Green 1999).

An assessment of the accuracy of photo interpretation was determined to ensure that the database is a reasonable reflection of habitat classifications. For the freshwater air photo interpretation database, flow morphology was used to compare the accuracy of interpretation in the present study. This was chosen as it represents one of the more important habitat estimations for characterizing habitat by air photo. Other parameters, such as dominant substrate type can be somewhat more limited by aerial image resolution, as well as differences in distinguishing features recorded between air photo and field-based surveys and differences in the specific site / spatial area that is the focus of the GIS analyses vs the site survey (See later for a discussion of this).

Congalton and Mead's (1983) method for assessing the accuracy of remote sensed data was applied using error matrices to compare the interpreted data against reference data. Error matrices can be analyzed statistically for accuracy with *Kappa*, a discrete multivariate analysis technique which results with a KHAT ($\hat{K}$) statistic, a measure of the actual agreement between interpretation and field reference data as shown in the equation below (Congalton 1991; Congalton and Green 1999; Congalton and Mead 1983):

$$\hat{K} = \frac{\sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r} \left(X_{i+} * X_{+i} \right)}{\mathrm{N}^2 - \sum_{i=1}^{r} \left(X_{i+} * X_{+i} \right)}$$

where;

r = number of rows and columns in error matrix,

X_{ii} = number of objects in row *i* and column *i*,

X_{i+} = marginal total of row *i*,

X_{+i} = marginal total of column *i*, and

N = total number of objects.

This method was applied to the paired data (interpreted and reference) as a means for testing the significance of the KHAT statistic for the error matrix (flow morphology) to determine if the agreement between remotely sensed classifications and the reference data was significantly greater than zero (i.e., better than a random classification) (Congalton and Green 1999).

In addition, the accuracy of the interpretations was also calculated using this error matrix.

2.2 Literature Review

Prior to the commencement of the 2008 freshwater field work, initial desktop work was undertaken which included a literature search, review and analysis of available information pertaining to fish species presence and fish habitat within the watersheds with which the transmission corridor may potentially cross. This existing and available information was used to guide the fieldwork, as well as to eventually supplement the information gathered through the GIS analysis and field survey, and thus, to provide a more extensive understanding of freshwater fish habitat and fish species presence within and adjacent to the Project area.

All information located during the literature review was consolidated, categorized, and catalogued by stream names representing major watersheds intersecting the corridor. The search for relevant literature included searches of government databases, academic and reference libraries as well the review of previous studies conducted by Nalcor Energy.

Upon completion of the field surveys, additional literature searches were conducted to gather existing water quality data. Databases included drinking water quality sampling and water samples collected at various years and season by both provincial and federal agencies.

2.3 Field Program

The field program was designed to sample a representative subset of crossings analyzed during the air photo/imaging interpretation and GIS analysis. It was also used to identify fish species present and to collect baseline water, sediment and macroinvertebrate samples as well as additional regional habitat detail not distinguishable from air photos.

Prior to the deployment of the field crews, potential crossings were preselected and identified on field maps for surveying. While field crews attempted to survey the preselected sites, coordination of helicopter logistics dictated that the sites surveyed were altered at times to increase efficiencies between survey crews. However, the effort with respect to watershed size was maintained (e.g., a selected watercourse within the Small (S3) category would be changed with another watercourse within the same category).

2.3.1 Field Survey Site Selection

In order to ensure that the overall study effort and the particular sites surveyed were appropriate and sufficient, the survey design was completed similar to past successful linear surveys/assessments conducted by the study team and approved by DFO. Prior to the field survey of stream crossings, the Project area was subdivided into four regions (see earlier Figure 1.1) as follows:

- *Southeastern Labrador* – The transmission corridor from Gull Island to the Strait of Belle Isle.
- *Northern Peninsula* – The transmission corridor from the Strait of Belle Isle southwards to the Hampden area.
- *Central and Eastern Newfoundland* – The transmission corridor from approximately the Hampden area to the Clarenville area.
- *Avalon Peninsula* – The transmission corridor from the Clarenville area to Soldiers Pond.

Representative sites throughout each region were then selected for sampling based on a sampling frequency that was determined by watershed size (Table 2.5).

Table 2.5 Transmission Corridor Field Survey Sample Size for Each Classification[1]

Watercourse Type	Watershed Size Interval (km^2)	Estimated Sampling Effort (percent of watercourses)
Intermittent (N)	<2.6	0
Small (S1)	2.6 to 50	10
Small (S2)	50 to 200	25
Small (S3)	200 to 500	50
Intermediate (I1)	500 to 1,000	50
Intermediate (I2)	1,000 to 10,000	50
Large (L)	>10,000	100

[1](AMEC 2003; AMEC 2004; AMEC 2005)

It should be noted that as a result of the above described evolution of the Project (transmission corridor) since the freshwater study was initiated, the specific corridor segments - and thus the overall number and location of watercourse crossings – has changed since the initial planning and conduct of the summer 2008 field program. As a result, the percentage of field survey sites by watershed size interval may have varied slightly from the general distribution of the sampling effort presented above.

Overall, however, the freshwater field survey work included an adequate and appropriate type, size and range of representative watercourses across the Project area.

2.3.2 Data Collection

During the freshwater field surveys, information was collected on key physical, biological and chemical parameters. The surveys were completed utilizing AMEC *Standard Operating Procedures* (SOPs) as well as general standard methods accepted by DFO (e.g., McCarthy et al. 2007, Scruton et al. 1992, and Sooley et al. 1998). All field work was conducted under DFO *Experimental Licence NL-596-08.*

Two field teams were organized and mobilized to complete the freshwater surveys. On August 12, 2008 Team 1, which consisted of Dermot Kenny and Jesse Noel, commenced work in the Southeastern Labrador portion of the study area. Access to all survey locations was obtained by helicopter, with surveys being completed during the period of August 12 to 18, 2008. Team 2, consisting of Suzanne Mullowney and Matthew Gosse, completed surveys on four streams in the Avalon Peninsula region between August 14 and 17, 2008 which were accessible by road.

On August 20, 2008 both teams relocated to Deer Lake to begin the fieldwork in the Northern Peninsula and Central and Eastern Newfoundland regions of the study area. On August 21, 2008 Mr. Kenny left the field program and Mr. Noel transferred to Team 2. The remaining streams within the Northern Peninsula and Central and Eastern Newfoundland regions were all accessed by helicopter. Sampling of streams in the Northern Peninsula region occurred between August 21 to 27, 2008. The Central and Eastern Newfoundland portion of the fieldwork occurred between August 28 and September 1, 2008. On September 1, 2008 the team relocated to Grand Falls-Windsor to complete the field surveys in Central and Eastern Newfoundland region from September 1 to 6, 2008. The remaining field surveys in the Avalon Peninsula region were completed on September 10, 2008.

Physical Parameters

During the freshwater field surveys a variety of physical parameters were recorded including general notes on the weather at the time of the survey and recording the Universal Transverse Mercator (UTM) coordinates of each stream survey location using the World Geodetic Survey 1984 (WGS84) map datum.

The team also recorded measurements of:

- channel dimensions (channel width, wetted width, ice scour height),
- substrate composition (percentage of each class of substrate found within the stream bed, e.g., cobble, gravel),
- stream slope,
- instream features (discharge, water depths and velocity),
- riparian vegetation (dominant species, percent cover, instream woody debris) , and
- upstream and downstream photos of each transect.

A general habitat description was also developed (i.e., pool, riffle, run and the quantity of each in the surveyed section of stream).

The field habitat descriptors were clearly able to be more detailed than those used and obtained through the air photo interpretation exercise. Measurements were generally completed throughout the stream at 300 m intervals which included the crossing location based on GPS and mapping (Figure 2.2).

Information collected during the field surveys described the freshwater fish habitat at the time of survey. However, additional survey data collected can allow modelling of stream conditions under a variety of stream flows if required. In particular additional information collected included measuring the bank height from the surface of the water to the top of the river bank at full channel width. This provided a full cross section of the streambed and its banks. In this regard, additional surveys under "high", "medium" and "low" flow events are not initially required since the collected data could be used to model changes in stream flow. Stream surveys completed during the 2008 field program were conducted to coincide with "typical low flows" such that accurate habitat quantification could be determined at each site and that typical fish numbers and habitat utilization under low flow conditions could be recorded.

Figure 2.2 Example of Recording Instream Features (Water Velocity)

Biological Parameters

Index electrofishing for fish species presence and composition was conducted at each survey location (Figure 2.3). Stream survey sites were selected so as to be as close as possible to the centreline of the transmission corridor.

Survey sites were either accessed by helicopter, road or on foot. Upon arrival at each stream an electrofishing station was selected where water depth and velocity allowed the team to safely complete the electrofishing (i.e., water velocities were not excessive and water depths allowed electrofishing to be completed without immersing any part of the electrofisher in water).

The electrofishing team consisted of two or three individuals with one operating the electrofisher while the remaining crew collected the shocked fish with dip nets. Index electrofishing started at the downstream end of the station and worked upstream, sweeping the entire width of the stream. This ensured that any disturbed sediment or debris would flow away from the fishing area maintaining instream visibility. The dip netter(s) collected the shocked fish downstream of the electrofisher and placed them in approximately 8 to 10 litres of water in a bucket. The entire area of the station was fished until 300 seconds was reached, as described by Scruton and Gibson (1995).

Once electrofish sampling was completed the fish were processed. First, the fish were transferred to another 10 L bucket of water with a battery operated aerator to keep the water oxygenated. From the holding bucket, 15 to 20 fish were transferred at a time to a second container containing 2 mL of anaesthetic (1:10 clove oil to ethanol) in 5.5 L of water. The use of an anaesthetic made it easier to process fish and reduced handling time.

Processing of the captured fish involved the identification, weighing (g), measuring (mm), and identification of any deformities, erosion, lesions, or tumours on each fish by one team member while another member recorded the information. This was repeated until all fish were processed.

All fish were given time to recover from the anaesthetic in a 20 L bucket of freshwater and then released back into slow moving water within the stream from where the fish were captured, as per Scruton and Gibson (1995).

Figure 2.3 Index Electrofishing

Benthic macroinvertebrates, which can be indicators of stream health, were also quantitatively sampled and collected from each stream sampled. Two replicate samples were collected from each site using a standard Surber Sampler. The Surber Sampler is made up of two metal frames that support a net (Figure 2.4).

One of the metal frames was set on the stream bottom, defining the area to be sampled, while the other supported the net. The sampler was used for shallow flowing waters and was pegged into the substrate for additional support in faster flowing water. The sampler was placed in an area of uniform substrate and positioned so that it was parallel to water flow with the net pointing downstream. This ensured that any invertebrates present in the substrate drifted into the net from the flow of water when the substrate was disturbed. Only the substrate occurring inside of the metal frame resting on the stream bottom was disturbed. Rocks and stones were picked up and cleaned in the water with a stiff brush ensuring that any invertebrates clinging to the rocks were deposited into the net. Once a rock was cleaned, it was discarded outside the sampling area. Once all the substrate inside the frame was disturbed and cleaned of any invertebrates, the contents of the net were emptied into a jar containing 70 percent ethanol. Samples were labelled with a time, date, stream, location and sample number. The Surber Sampler was removed, rinsed after use and moved to a random location upstream and the sampling method was repeated.

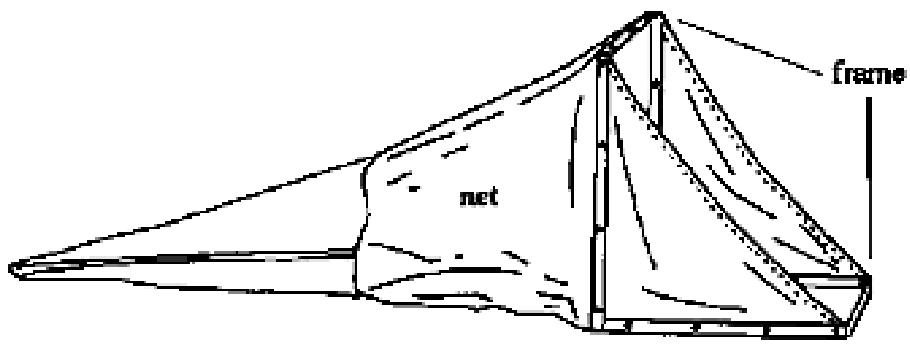

Figure 2.4 Diagram of a Surber Sampler

While macroinvertebrates were not required for habitat characterization, they were preserved and available for analysis (e.g., identification, density, diversity and numbers) if required and appropriate in the future.

Given the nature of the Project, its potential interaction with the freshwater environment, and the associated regulatory requirements, analysis of benthic macroinvertebrate has not been completed.

Chemical Parameters

In-situ physico-chemical attributes were recorded at each survey crossing using a Hydrolab water sensor. In-situ records included parameters such as water and air temperature, dissolved oxygen (mg/L and percent saturation), pH, and conductivity (Figure 2.5).

Water samples were also collected from a representative number of sites and sent for analysis for standard water quality parameters such as general chemistry and metals.

Where suitable substrate was present (i.e., high proportion of fine sediment), sediment samples were also collected and analyzed for metals and standard sediment quality as part of the baseline data sampling.

All water and sediment samples were analyzed at a Canadian Association for Environmental Analytical Laboratories (CAEAL) certified laboratory. Standard field duplicates of 10 percent of all samples were collected and sent to the laboratory for Quality Assurance/Quality Control (QA/QC). In addition, laboratory results also identified in-laboratory QA/QC measures (blanks and calibrations) as part of standard reporting. Water and sediment samples were analyzed in accordance with Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Aquatic Life (PAL) (CCME 2007).

.

Figure 2.5 In-situ Water Quality Testing with Hydrolab Water Sensor

3.0 RESULTS

As described in the preceding chapter, this *Freshwater Environment Study* utilized a variety of techniques to describe the existing freshwater environment along the transmission corridor. These included watershed and fish habitat classification using air photo interpretation; a literature review of known fish presence and water quality within the Project area; and the collection of additional data through a 2008 field survey program.

The results for each of these components and activities are summarized below, with additional, detailed information provided in the Appendices.

3.1 Watercourse Database

The watercourse database was developed through analysis of 1:50,000 scale NTS basemaps to identify potential stream crossings within the transmission corridor. The watercourse database combines all data for each watercourse within a GIS database.

3.1.1 Mapping Analysis

A series of topographic maps, located in Appendix A, were produced to illustrate stream location in relation to the transmission corridor as well as to provide a visual summary of the watershed size classification of each potential crossing. Adjacent to the stream location are the stream numbers identifying each individual stream. The map series also identifies field sampled sites. The pages adjacent to each map contain tables summarizing the results of both the air photo interpretation and field survey data along with photographs of each of the survey sites. An overview of the location of the sites is provided in Figures 3.1 to 3.3.

3.1.2 Air Photo Interpretation Accuracy and Reclassification

An error matrix was produced for the study's flow morphology interpretations (Table 3.1). Table 3.2 presents a summary of the accuracy calculations.

Two separate types of accuracy were calculated; producer and user. Producer accuracy reflects how accurate the interpreter was in determining the proper categories within a classification based on the imaging. For example, the producer accuracy for flow morphology categorized as Riffle in Table 3.1 is 29 out of 36 (81 percent), meaning 81 percent of the Riffle habitat identified in field surveys was correctly classified by the interpreter. User accuracy for the same flow morphology is 29 out of 33 (88 percent), meaning that the user of the mapping would find that 88 percent of the time that the map indicates Riffle, it would be Riffle on the ground.

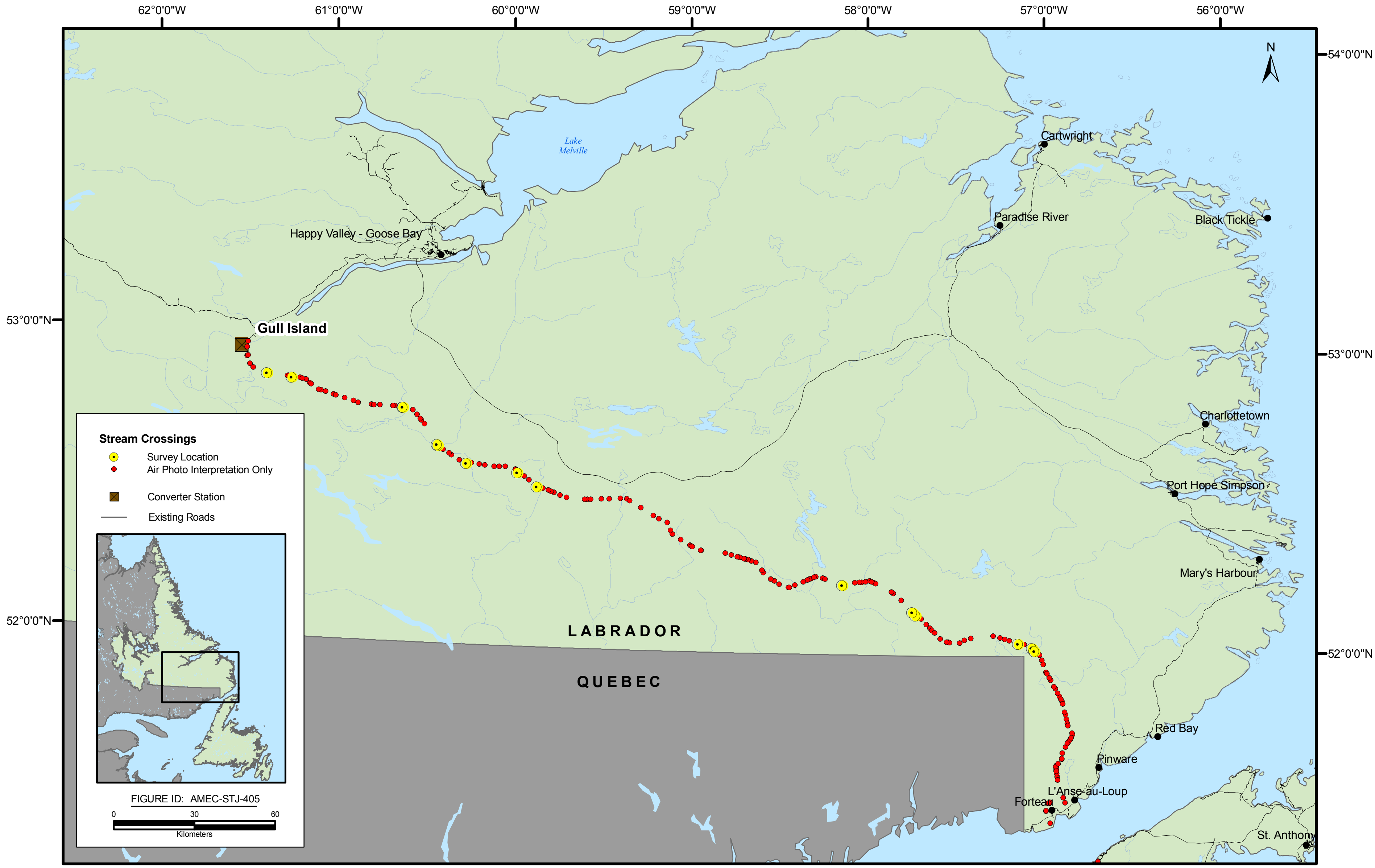

Figure 3.1 Identified and Surveyed Watercourse Crossings within the Southeastern Labrador Region

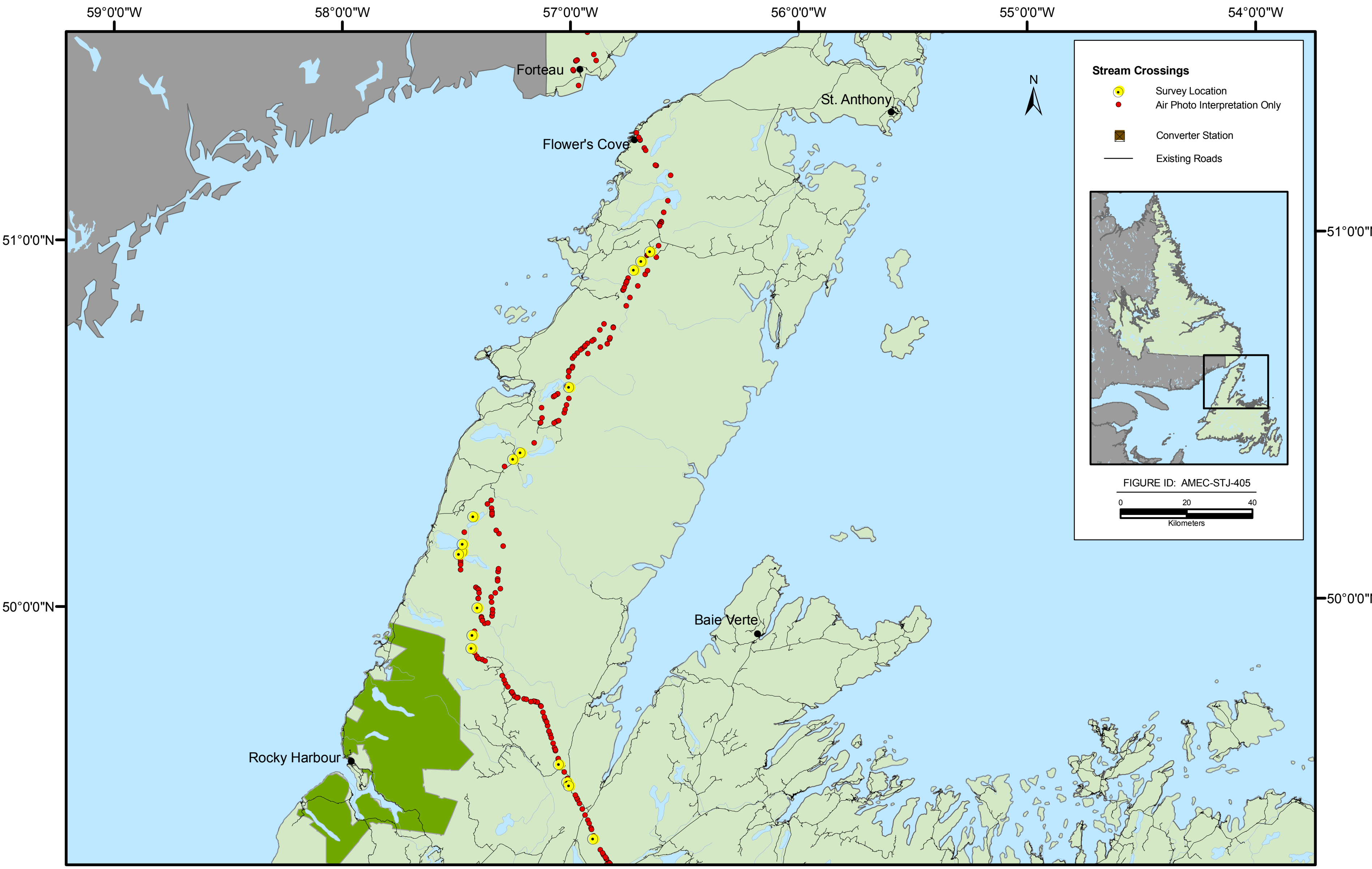

Figure 3.2 Identified and Surveyed Watercourse Crossings within the Northern Peninsula Region

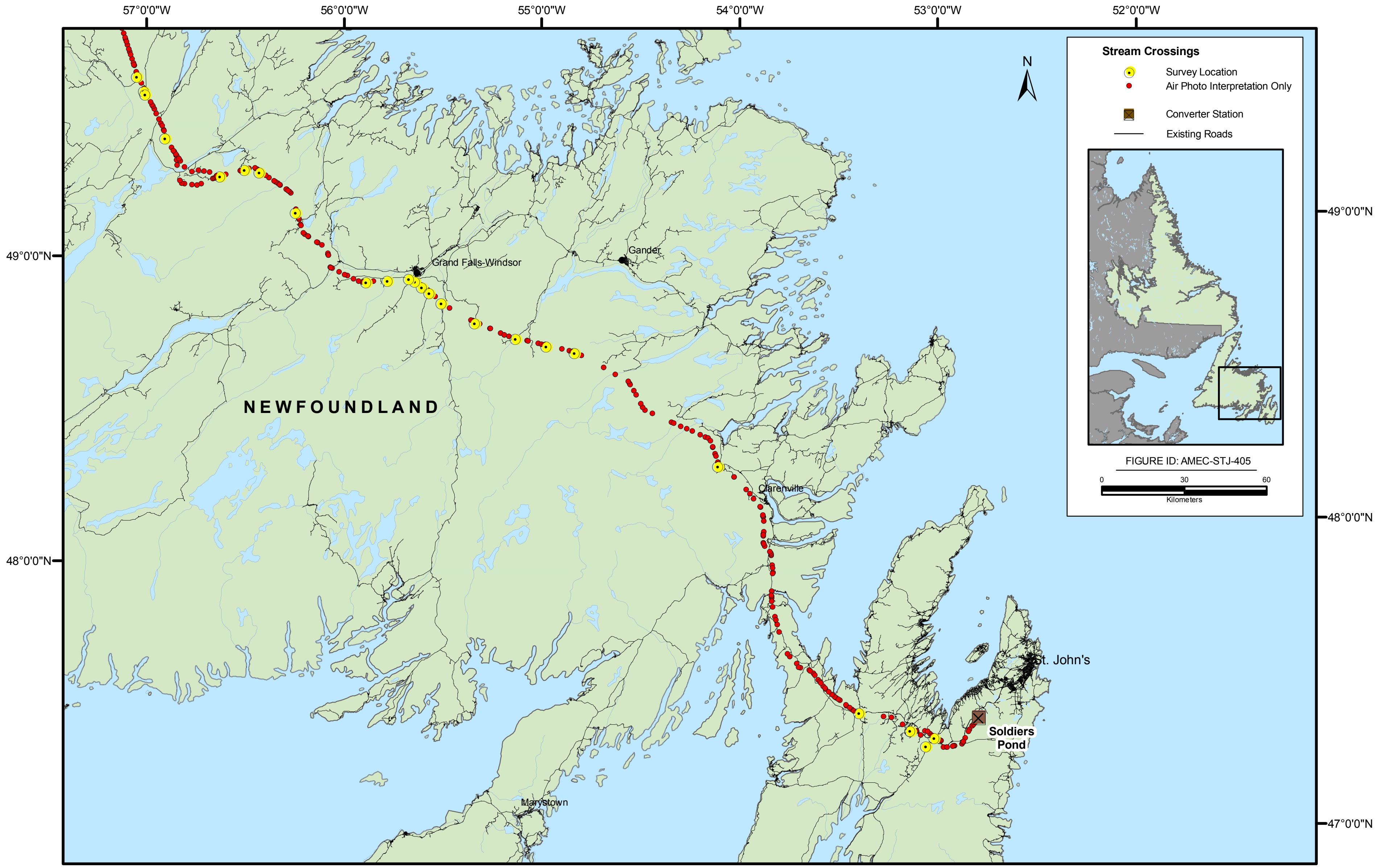

Figure 3.3 Identified and Surveyed Watercourse Crossings within the Central and Eastern Newfoundland and Avalon Peninsula Regions

Table 3.1 Error Matrix Table for Flow Morphology

		Reference Data			
Air Photo Interpretation		RI	FL	RA	*Row Total*
	RI	**29**	2	2	33
	FL	6	**10**	0	16
	RA	1	0	**0**	1
	Column Total	36	12	2	50

RI – Riffle, FL - Flat, RA – Rapids

The accuracy associated with flow morphology characterization was derived by summing the results in the bolded boxes on the diagonal (39), divided by the total number of streams interpreted (50). The overall accuracy is relatively high at 78 percent, and indicates a good ability to distinguish between the categories used. However, the two stream crossings classified as Rapids through air photo interpretation were actually both classified as Riffle during field surveys. This could have been due to a lack of sufficient resolution in the imaging to allow differentiation between the two categories, but may also be attributed to potential differences between water levels depicted in the aerial photographs and levels when the field surveys were completed. In addition, the infrequent occurrence of the Rapid flow morphology in the field could also lead to an overestimation of the error for this category due to the small sample size.

Table 3.2 Summary of Accuracy Calculations

Interpretation Category	Accuracy Category	Classification	Ratio (from matrix)	Accuracy (%)
Flow Morphology	Overall		39/50	78
	Producer	RI	29/36	81
		FL	10/12	83
		RA	0/2	0
	User	RI	29/33	88
		FL	10/16	63
		RA	0/1	0

It should also be noted that the analysis of accuracy conducted above is typically used in assessing the accuracy of larger map classifications such as forest types, agriculture and development. As such, verification should be considered conservative as sample sizes indicated in the method outlined by Congalton and Mead (1983) are considerably larger than those applied here.

Analysis of initial dominant substrate classifications between the air photo interpretation and the field survey findings indicated a degree of variability between these results. In some cases this may have been due to imaging resolution and quality, and/or other potential issues which may have influenced the ability to accurately identify and characterize stream crossing substrates in this manner. It is also important to remember that the air photo interpretation focussed solely on the visible portion of the substrate (such as nearshore and/or substrates protruding from the water's surface), whereas the field surveys focussed on the entire wetted width substrate. This would likely affect the ability to make direct comparisons between the air photo interpretation results and the field survey work for all of the sampled watercourse crossings.

In any event, whereas dominant substrates were initially classified into three types according to size category Coarse (25 cm to 100 cm), Medium (6 cm to 25 cm) and Fine (< 6 cm) - as a result of the above considerations this parameter was re-classified and re-assessed for the final report. Specifically, the substrate categories were revised to include two classes only (Coarse and Fine), with Fine defined as a dominant substrate composition of material less than 25 cm in size. All crossings initially classified as Medium were re-interpreted according to these revised categories, resulting in a total of 331 streams that were initially classified as Medium being re-interpreted and re-classified as either Coarse or Fine.

3.1.3 Air Photo Interpretation Results

A total of 656 potential watercourse crossings were identified through mapping analysis and had digital imagery interpreted by team members. In particular, interpreters assessed and classified potential fish habitat within a total of 196 streams in the Southeastern Labrador region, 173 in the Northern Peninsula region, 184 in the Central and Eastern Newfoundland region and 103 in the Avalon Peninsula region. All regions had riverine fish habitat which consisted of various proportions of rapid, riffle and flat habitat types.

The following sections provide an overview of the identified watercourse crossings within the proposed transmission corridor (and alternative corridor segments) by region, including their associated characteristics, as determined by the air photo interpretation component of the study. This includes an initial summary table, which is followed by a table which provides more detailed information for each watercourse crossing within the region in question. Further information is provided in the appendices to this report.

Classified riparian vegetation was also recorded as a conservative approach to better understand the possible overhang and canopy cover available at the sampled sites. Results of preliminary identification of riparian vegetation are located in Tables 3.4, 3.6, 3.8, and 3.10 Watercourse Crossings (Air Photo Interpretation Results) for each region.

Southeastern Labrador

The Southeastern Labrador region contained 196 watercourse crossings (or 30 percent of the total within the transmission corridor). The most common occurring flow morphologies within this region were flats (63.8 percent), followed by riffle habitat (20.9 percent). Of the remaining, 8.7 percent were unable to be interpreted, 2.6 percent were comprised of rapids and 4.1 percent were discontinuous habitat. Within this region 70.9 percent of the identified stream crossings were dominated by fine substrate material, 20.4 percent by coarse substrate material with the remaining 8.7 percent unable to be interpreted (Table 3.3). Channel width and wetted width for the region averaged 31.11 m and 13.62 m respectively (Table 3.3).

Table 3.3 Summary of Watercourse Crossing Characteristics as Determined by Air Photo Interpretation: Southeastern Labrador

Watercourse Crossing Characteristics Identified (Proposed and Alternative Corridors)	Number of Observations
Watershed Size Category	
< 2.6 km^2	105 (53.5%)
2.6 - 50 km^2	73 (37.2%)
50 - 200 km^2	8 (4.1 %)
200 - 500 km^2	6 (3.1 %)
500 - 1,000 km^2	2 (1.0 %)
1,000 - 10,000 km^2	2 (1.0 %)
Total	196
Dominant Substrate	
Fine	139 (70.9 %)
Coarse	40 (20.4 %)
Unclassified*	17 (8.7%)
Total	196
Flow Morphology	
Rapid	5 (2.6 %)
Riffle	41 (20.9 %)
Flat	125 (63.8 %)
Discontinuous	8 (4.1 %)
Unclassified*	17 (8.7 %)
Total	196
Channel Width (m): Average / Range	31.11 / 1.00 – 304.0
Wetted Width (m): Average / Range	13.62 / 1.00 – 221.0
* Unclassified refers to data not classified during air photo interpretation. Reasons include: cloud cover, no visible stream, air photo unavailable.	

Further and more detailed information on the identified characteristics of each watercourse crossing within the region is provided below in Table 3.4 (Please see Appendix A for further information, including the location of each watercourse crossing point / stream ID).

Table 3.4 Watercourse Crossings (Air Photo Interpretation Results): Southeastern Labrador

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
Proposed Transmission Corridor							
1	P1	2.6 - 50	4.59	304 / 221	Fine	Flat	CT
2	P2	2.6 - 50	1.99	28.1 / 28.1	Coarse	Riffle	CT
3	P1003	2.6 - 50	2.84	46.6 / 31.1	Fine	Flat	CS
4	P3	< 2.6	1.90	-	-	-	CT
5	P4	< 2.6	2.00	59.4 / 34.0	Coarse	Flat	CT
6	P5	< 2.6	2.67	10.6 / 10.6	Coarse	Riffle	CT

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
7	P6	< 2.6	1.26	48.6 / 13.9	Coarse	Flat	DT
8	P7	50 - 200	0.25	57.8 / 28.3	Coarse	Flat	DT
9	P8	< 2.6	1.80	13.6 / 13.6	Fine	Flat	DT
10	P9	< 2.6	2.47	5.3 / 5.3	Fine	Riffle	DT
11	P10	2.6 - 50	0.76	36.2 / 12.8	Coarse	Flat	DT
12	P11	< 2.6	3.79	28.1 / 11.7	Fine	Riffle	DT
13	P12	< 2.6	2.61	19.9 / 13.3	Fine	Riffle	DT
14	P1017	2.6 - 50	0.44	34.5 / 19.8	Fine	Flat	BA
15	P13	< 2.6	0.75	29.5 / 11.8	Coarse	Riffle	CT
16	P14	2.6 - 50	1.38	14.0 / 14.0	Coarse	Riffle	CT
17	P15	< 2.6	0.84	8.2 / 8.2	Fine	Riffle	CT
18	P1004	2.6 - 50	0.83	-	-	-	-
19	P16	< 2.6	1.38	-	-	-	DS
20	P17	< 2.6	2.91	21.6 / 9.7	Coarse	Riffle	DS
21	P18	< 2.6	1.56	133.0 / 105.0	Coarse	Riffle	DT
22	P19	< 2.6	1.66	45.0 / 3.8	Fine	Discontinuous	BO
23	P20	2.6 - 50	0.57	28.1 / 5.3	Fine	Flat	TB
24	P21	2.6 - 50	0.74	13.9 / 6.5	Fine	Flat	DS
25	P22	< 2.6	1.67	20.1 / 6.2	Fine	Flat	TB
26	P23	< 2.6	3.03	-	-	-	-
27	P24	2.6 - 50	4.26	35.2 / 25.5	Fine	Riffle	BO
28	P25	2.6 - 50	0.48	9.4 / 4.7	Coarse	Riffle	CS
29	P26	2.6 - 50	2.31	45.0 / 4.8	Fine	Flat	BO
30	P27	< 2.6	2.14	13.7 / 2.7	Fine	Flat	BO
31	P28	2.6 - 50	0.80	21.1 / 5.3	Fine	Flat	TB
32	P29	200 - 500	0.07	64.9 / 54.9	Coarse	Flat	CS
33	P30	2.6 - 50	0.51	3.6 / 3.6	Fine	Flat	CS
34	P31	< 2.6	0.56	73.4 / 3.3	Fine	Flat	TB
35	P32	2.6 - 50	0.46	45.9 / 5.4	Fine	Flat	TB
36	P33	< 2.6	1.13	71.4 / 3.2	Fine	Flat	BO
37	P34	2.6 - 50	0.64	10.9 / 5.0	Fine	Flat	BO
38	P35	2.6 - 50	0.41	10.4 / 4.3	Coarse	Flat	DS
39	P36	1,000 - 10,000	0.52	71.4 / 63.1	Coarse	Riffle	BO
40	P37	500 - 1000	0.63	24.7 / 8.9	Coarse	Riffle	BO
41	P38	< 2.6	0.99	11.9 / 7.8	Fine	Flat	BO
42	P39	2.6 - 50	2.55	12.1 / 9.1	Fine	Flat	DS
43	P40	50 - 200	2.82	18.9 / 7.1	Coarse	Riffle	DS
44	P41	< 2.6	4.51	15.4 / 5.7	Fine	Flat	CS
45	P42	< 2.6	2.22	3.6 / 3.6	Fine	Riffle	CT
46	P43	2.6 - 50	2.22	21.2 / 5.9	Fine	Flat	BO
47	P44	< 2.6	1.57	11.3 / 11.3	Coarse	Riffle	BO
48	P45	50 - 200	0.68	29.9 / 21.2	Coarse	Flat	BO
49	P46	< 2.6	3.23	3.7 / 3.7	Fine	Riffle	CT
50	P47	2.6 - 50	1.23	4.1 / 4.1	Fine	Flat	CS
51	P48	2.6 - 50	0.95	3.4 / 3.4	Fine	Riffle	CT
52	P49	< 2.6	5.29	3.3 / 3.3	Fine	Riffle	CT
53	P50	2.6 - 50	0.91	49.6 / 3.3	Fine	Flat	CS
54	P51	< 2.6	1.66	8.2 / 8.2	Fine	Flat	CT
55	P52	2.6 - 50	0.71	42.1 / 4.5	Fine	Flat	CS

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
56	P53	< 2.6	0.46	1.0 / 1.0	Fine	Flat	TB
57	P54	2.6 - 50	0.61	2.6 / 2.6	Fine	Flat	CS
58	P55	200 - 500	0.10	122.9 / 42.6	Fine	Flat	TB
59	P56	< 2.6	2.35	23.0 / 8.4	Coarse	Riffle	BO
60	P57	< 2.6	2.58	21.6 / 3.1	Fine	Flat	CS
61	P58	< 2.6	2.36	4.8 / 4.8	Fine	Flat	CS
62	P59	2.6 - 50	0.86	39.5 / 18.5	Fine	Flat	DS
63	P60	< 2.6	2.36	1.0 / 1.0	Fine	Flat	DS
64	P61	2.6 - 50	0.42	48.2 / 31.4	Coarse	Riffle	DS
65	P62	2.6 - 50	0.63	17.7 / 7.3	Fine	Flat	CS
66	P63	2.6 - 50	0.64	22.5 / 17.1	Fine	Flat	BO
67	P64	2.6 - 50	0.52	36.7 / 5.1	Fine	Flat	CS
68	P65	2.6 - 50	0.58	27.4/13.8	Fine	Flat	TB
69	P66	2.6 - 50	1.78	3.5/3.5	Fine	Discontinuous	TB
70	P67	50 - 200	0.14	69.6/44.1	Fine	Flat	TB
71	P68	< 2.6	1.04	4.9/4.9	Fine	Flat	TB
72	P69	50 - 200	0.70	30.9/23.4	Coarse	Flat	CS
73	P70	2.6 - 50	0.61	294.3/12.6	Fine	Flat	BO
74	P71	< 2.6	0.81	11.2 / 5.1	Fine	Flat	BO
75	P72	< 2.6	1.26	11.2 / 7.0	Fine	Flat	TB
76	P73	< 2.6	0.92	15.2 / 9.1	Fine	Flat	TB
77	P74	2.6 - 50	1.09	8.8 / 3.4	Fine	Flat	BO
78	P75	< 2.6	2.01	14.0 / 4.0	Fine	Discontinuous	DS
79	P76	50 - 200	1.00	66.3 / 36.6	Coarse	Riffle	TB
80	P77	2.6 - 50	1.39	18.9 / 3.6	Fine	Riffle	TB
81	P78	2.6 - 50	1.20	1.0 / 1.0	Fine	Flat	TB
82	P79	< 2.6	0.72	5.2 / 4.0	Fine	Flat	TB
83	P80	< 2.6	1.38	9.3 / 4.3	Fine	Flat	BO
84	P81	50 - 200	0.19	33.8 / 27.2	Fine	Flat	BO
85	P82	< 2.6	1.13	11.9 / -	-	Discontinuous	BO
86	P83	2.6 - 50	1.77	7.7 / 3.2	Fine	Flat	CS
87	P84	2.6 - 50	2.04	21.0 / 6.4	Coarse	Flat	CT
88	P85	2.6 - 50	1.59	19.5 / 6.8	Fine	Flat	CT
89	P86	< 2.6	0.88	63.4 / 1.0	Fine	Flat	BO
90	P87	< 2.6	0.71	10.8 / 6.1	Fine	Flat	DS
91	P88	< 2.6	0.82	42.1 / 2.1	Fine	Flat	BO
92	P89	< 2.6	0.94	53.1 / 6.7	Fine	Flat	BO
93	P90	< 2.6	0.76	30.2 / 8.9	Fine	Flat	TB
94	P91	< 2.6	0.67	17.2 / 3.9	Fine	Flat	DS
95	P92	2.6 - 50	0.76	65.1 / 28.8	Fine	Flat	BO
96	P93	2.6 - 50	0.30	21.2 / 3.6	Fine	Flat	BO
97	P94	< 2.6	1.04	45.1 / 1.3	Fine	Flat	DS
98	P95	2.6 - 50	0.32	1.7 / 1.7	Fine	Flat	DS
99	P96	< 2.6	2.39	17.1 / 2.2	Fine	Flat	DS
100	P97	2.6 - 50	0.69	28.5 / 5.3	Fine	Flat	TB
101	P98	2.6 - 50	0.07	49.5 / 5.0	Fine	Flat	TB
102	P99	500 - 1,000	0.40	60.6 / 32.8	Fine	Flat	TB
103	P100	< 2.6	1.11	22.5 / 12.4	Fine	Flat	DS
104	P101	2.6 - 50	0.74	20.3 / 10.1	Fine	Flat	DT

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
105	P102	< 2.6	1.12	22.2 / 7.6	Fine	Flat	TB
106	P103	< 2.6	0.90	34.6 / 15.1	Fine	Riffle	TB
107	P104	1,000 - 10,000	0.31	78.6 / 61.2	Coarse	Flat	CT
108	P105	2.6 - 50	0.32	7.2 / 3.8	Fine	Flat	CS
109	P106	2.6 - 50	1.03	31.0 / 4.8	Fine	Flat	BO
110	P107	< 2.6	0.92	27.4 / 3.2	Fine	Flat	BO
111	P108	2.6 - 50	0.16	18.3 / 2.8	Coarse	Riffle	CS
112	P109	2.6 - 50	1.75	32.1 / 9.9	Coarse	Riffle	TB
113	P110	2.6 - 50	1.86	63.2 / 20.0	Fine	Flat	BO
114	P111	< 2.6	0.58	69.8 / 43.6	Fine	Flat	BO
115	P112	200 - 500	0.56	64.8 / 27.6	Coarse	Flat	BO
116	P113	< 2.6	0.39	33.3 / 33.3	Fine	Flat	BO
117	P114	< 2.6	0.73	31.7 / 8.5	Fine	Flat	CS
118	P115	< 2.6	0.91	31.3 / 16.6	Fine	Flat	CT
119	P116	2.6 - 50	0.58	5.9 / 1.7	Fine	Flat	CT
120	P117	< 2.6	2.15	47.7 / 25.7	Coarse	Riffle	CT
121	P118	2.6 - 50	1.89	32.4 / 17.5	Coarse	Riffle	CT
122	P119	< 2.6	0.34	30.8 / 30.8	Fine	Flat	BO
123	P120	2.6 - 50	0.77	41.3 / 41.3	Fine	Flat	TB
124	P121	200 - 500	0.56	63.1 / 22.2	Coarse	Flat	CT
125	P122	2.6 - 50	0.58	198.1 / 31.6	Coarse	Rapid	CT
126	P123	2.6 - 50	1.52	140.1 / 28.2	Fine	Riffle	CT
127	P124	2.6 - 50	0.78	18.6 / 7.4	Fine	Flat	CT
128	P125	< 2.6	1.18	73.0 / 25.6	Fine	Flat	TB
129	P126	2.6 - 50	1.36	50.6 / 19.1	Fine	Riffle	CT
130	P127	2.6 - 50	0.83	87.9 / 56.6	Fine	Riffle	CT
131	P128	2.6 - 50	0.54	29.5 / 8.7	Coarse	Rapid	CS
132	P129	2.6 - 50	0.22	31.8 / 13.9	Fine	Flat	CS
133	P130	< 2.6	0.47	20.9 / 20.9	Fine	Flat	DS
134	P131	< 2.6	0.89	23.2 / 8.9	Fine	Flat	BO
135	P132	2.6 - 50	0.36	34.7 / 23.9	Coarse	Rapid	CT
136	P133	< 2.6	0.51	18.6 / 4.5	Fine	Flat	TB
137	P134	< 2.6	1.01	23.7 / 5.8	Coarse	Rapid	CT
138	P135	2.6 - 50	0.08	19.1 / 7.2	Fine	Flat	BO
139	P136	2.6 - 50	0.07	171.1 / 29.4	Fine	Flat	BO
140	P137	< 2.6	1.07	61.8 / 61.8	Coarse	Riffle	CT
141	P138	2.6 - 50	0.32	5.4 / 5.4	Fine	Discontinuous	BO
142	P139	2.6 - 50	0.53	7.5 / 7.5	Fine	Discontinuous	BO
143	P140	2.6 - 50	0.28	7.5 / 7.5	Fine	Discontinuous	BO
144	P141	2.6 - 50	0.86	19.4 / 4.1	Fine	Flat	DS
145	P142	2.6 - 50	2.30	14.0 / 14.0	Coarse	Riffle	CS
146	P143	50 - 200	0.39	23.1 / 10.2	Coarse	Rapid	DS
147	P144	< 2.6	1.13	1.0 / 1.0	Fine	Flat	TB
148	P145	< 2.6	1.06	1.9 / 1.9	Fine	Flat	TB
149	P146	2.6 - 50	0.46	2.8 / 2.8	Fine	Flat	TB
150	P147	< 2.6	0.56	7.4 / 7.4	Fine	Flat	TB
151	P148	< 2.6	1.57	-	-	-	-
152	P149	< 2.6	3.27	-	-	-	-
153	P150	< 2.6	2.12	-	-	-	-

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
154	P151	< 2.6	2.29	-	-	-	-
155	P152	2.6 - 50	1.75	-	-	-	-
156	P153	< 2.6	8.48	-	-	-	-
157	P154	< 2.6	2.29	-	-	-	-
158	P155	< 2.6	4.25	1.2 / 1.2	Fine	Flat	TB
159	P156	< 2.6	3.47	5.5 / 5.5	Fine	Flat	TB
160	P157	< 2.6	3.04	1.9 / 1.9	Coarse	Flat	TB
161	P158	2.6 - 50	2.69	4.3 / 4.3	Fine	Flat	DT
162	P159	< 2.6	6.37	9.8 / 9.8	Coarse	Riffle	DT
163	P160	< 2.6	2.11	3.5 / 3.5	Fine	Flat	TB
164	P161	< 2.6	6.96	3.7 / 3.7	Fine	Riffle	DS
165	P162	< 2.6	6.62	5.2 / 5.2	Fine	Riffle	TB
166	P163	< 2.6	3.31	2.6 / 2.6	Fine	Flat	TB
167	P164	< 2.6	3.12	1.5 / 1.5	Fine	Flat	TB
168	P165	2.6 - 50	2.7	1.7/1.7	Fine	Flat	DS
169	P166	2.6 - 50	0.47	2.5/2.5	Fine	Flat	TB
170	P167	200 - 500	1.20	2.7/2.7	Fine	Riffle	DT
171	P168	< 2.6	8.35	2.2/2.2	Fine	Riffle	DT
172	P169	< 2.6	2.67	1.5/1.5	Fine	Flat	DT
173	P170	< 2.6	4.32	-	-	-	-
174	P171	< 2.6	4.16	-	-	-	-
175	P172	< 2.6	3.38	1.5 / 1.5	Fine	Flat	BO
176	P1018	< 2.6	0.00	15.0 / 4.7	Fine	Flat	BA
177	P173	< 2.6	6.82	6.8 / 6.8	Fine	Flat	TB
178	P174	< 2.6	1.38	8.4 / 8.4	Fine	Flat	BO
179	P1019	< 2.6	4.95	9.4 / 6.2	Fine	Flat	BA
180	P175	< 2.6	1.76	54 / 40	Coarse	Riffle	TB
181	P176	< 2.6	3.43	2.0 / 2.0	Fine	Flat	BO
182	P177	< 2.6	5.20	3.7 / 3.7	Fine	Flat	DS
183	P178	< 2.6	2.27	1.5 / 1.5	Fine	Flat	DS
184	P179	< 2.6	2.45	3.2 / 3.2	Fine	Flat	BO
185	P180	< 2.6	2.76	1.8 / 1.8	Fine	Flat	DS
186	P181	< 2.6	5.83	1.5 / 1.5	Fine	Flat	CT
187	P182	< 2.6	6.68	3.8 / 3.8	Fine	Flat	TB
188	P1020	< 2.6	8.12	128.6 / 14.7	Fine	Flat	BA
189	A1	< 2.6	3.05	34.2 / -	Fine	-	BO
190	A2	200 - 500	0.57	42.1 / 22.9	Fine	Flat	BO
191	A3	< 2.6	7.50	33.6 / -	Fine	-	BO
192	A9	< 2.6	5.75	-	-	-	-
193	A10	< 2.6	7.03	-	-	-	-
194	A11	2.6 - 50	0.73	36.5/17.5	Fine	Riffle	BO
Alternative Transmission Corridor Segment(s)							
195	P183	< 2.6	6.22	3.8 / 3.8	Fine	Discontinuous	CT
196	P184	< 2.6	1.02	8.1 / 8.1	Fine	Flat	TB
Note: See Map Atlas (Appendix A) for information on watercourse crossing numbers / IDs and locations, and definitions.							

Northern Peninsula

The Northern Peninsula region includes 173 watercourse crossings (or 26 percent of the total within the transmission corridor), of which 42.8 percent were assessed as flats and 33.5 percent riffles in terms of flow morphology. Of the remaining, 6.9 percent were unable to be interpreted 8.1 percent were comprised of rapids and 8.7 percent were discontinuous habitat. The most commonly occurring substrates were fine material (61.3 percent), followed by coarse substrate material (30.6 percent), with the remaining 8.1 percent unable to be interpreted (Table 3.5). Channel width and wetted width for the region averaged 11.83 m and 7.99 m respectively (Table 3.5).

Table 3.5 Summary of Watercourse Crossing Characteristics as Determined by Air Photo Interpretation: Northern Peninsula

Watercourse Crossing Characteristics Identified (Proposed and Alternative Corridor)	Number of Observations
Watershed Size Category	
< 2.6 km^2	100 (57.8 %)
2.6 - 50 km^2	59 (34.1 %)
50 - 200 km^2	7 (4.1 %)
200 - 500 km^2	7 (4.1 %)
500 - 1,000 km^2	0
1,000 - 10,000 km^2	0
Total	173
Dominant Substrate	
Fine	106 (61.3 %)
Coarse	53 (30.6 %)
Unclassified*	14 (8.1 %)
Total	173
Flow Morphology	
Rapid	14 (8.1 %)
Riffle	58 (33.5 %)
Flat	74 (42.8 %)
Discontinuous	15 (8.7 %)
Unclassified*	12 (6.9 %)
Total	173
Channel Width (m): Average / Range	11.83 / 0.9 – 104.7
Wetted Width (m): Average / Range	7.99 / 0.9 – 61.9
* Unclassified refers to data not classified during air photo interpretation. Reasons include: cloud cover, no visible stream, air photo unavailable.	

Further and more detailed information on the identified characteristics of each watercourse crossing within the region is provided below in Table 3.6 (Please see Appendix A for further information, including the location of each watercourse crossing point / stream ID).

Table 3.6 Watercourse Crossings (Air Photo Interpretation Results): Northern Peninsula

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
Proposed Transmission Corridor							
197	P185	< 2.6	1.38	-	-	-	-
198	P186	< 2.6	0.00	-	-	-	-
199	P187	< 2.6	0.00	2.8 / 2.8	Fine	Flat	BO
200	P188	2.6 - 50	1.08	4.8 / 4.8	Fine	Flat	BO
201	P189	< 2.6	0.87	1.0 / 1.0	Fine	Discontinuous	BO
202	P190	< 2.6	1.07	2.4 / 2.4	Fine	Discontinuous	BO
203	P191	< 2.6	1.54	4.6 / 4.6	Fine	Discontinuous	BO
204	P192	< 2.6	1.00	2.4 / 2.4	Fine	Discontinuous	BO
205	P193	50 - 200	0.47	15.7 / 9.1	Fine	Flat	BO
206	P194	< 2.6	1.37	3.8 / 3.8	Fine	Discontinuous	BO
207	P195	< 2.6	1.66	2.9 / 2.9	Fine	Discontinuous	BO
208	P196	< 2.6	1.68	3.4 / 3.4	Fine	Flat	BO
209	P197	< 2.6	1.68	-	Fine	Flat	BO
210	P198	< 2.6	1.68	4.9 / 4.9	Fine	Discontinuous	BO
211	P199	< 2.6	1.68	4.9 / 4.9	Fine	Discontinuous	BO
212	P200	2.6 - 50	4.90	1.0 / 1.0	Fine	Riffle	BO
213	P201	2.6 - 50	0.83	10.5 / 7.1	Fine	Flat	BO
214	P202	< 2.6	0.31	18.1 / 6.4	Fine	Flat	BO
215	P203	< 2.6	1.68	4.3 / 4.3	Fine	Flat	BO
216	P204	2.6 - 50	2.98	5.8 / 5.8	Fine	Discontinuous	BO
217	P205	50 - 200	0.70	13.2 / 4.4	Fine	Flat	BO
218	P206	2.6 - 50	4.89	4.6 / 4.6	Fine	Flat	BO
219	P207	2.6 - 50	8.63	-	-	-	-
220	P208	< 2.6	10.48	20.4 / 11.4	Coarse	Riffle	CS
221	P209	< 2.6	8.62	3.1 / 3.1	Fine	Riffle	BO
222	P210	< 2.6	1.76	3.1 / 3.1	Fine	Riffle	DS
223	P211	2.6 - 50	1.33	39.2 / 12.4	Coarse	Riffle	CT
224	P212	2.6 - 50	4.88	8.3 / 3.1	Fine	Riffle	DS
225	P213	2.6 - 50	4.46	35.8 / 26.0	Coarse	Rapid	DT
226	P214	< 2.6	9.06	14.8 / 3.5	Coarse	Rapid	DS
227	P215	2.6 - 50	7.13	11.8 / -	Fine	Discontinuous	TB
228	P216	< 2.6	10.54	0.9 / 0.9	Fine	Riffle	CS
229	P217	< 2.6	5.76	2.8 / 2.8	Fine	Riffle	CS
230	P218	2.6 - 50	1.06	104.7 / 20.8	Coarse	Riffle	DS
231	P219	< 2.6	5.60	2.2 / 2.2	Fine	Flat	DS
232	P220	< 2.6	7.54	3.9 / 3.9	Coarse	Riffle	CS
233	P221	< 2.6	6.56	1.4 / 1.4	Fine	Riffle	DS
234	P222	< 2.6	7.82	1.5 / 1.5	Fine	Riffle	CT
235	P223	< 2.6	5.39	2.6 / 2.6	Fine	Flat	CT
236	P224	< 2.6	5.77	1.9 / 1.9	Coarse	Riffle	CS
237	P225	< 2.6	2.84	2.6 / 2.6	Fine	Riffle	CS
238	P226	2.6 - 50	3.51	1.8 / 1.8	Fine	Riffle	CT
239	P227	< 2.6	1.87	3.7 / 3.7	Fine	Flat	CS
240	P228	200 - 500	0.66	9.4 / 9.4	Fine	Flat	BO
241	P229	2.6 - 50	1.80	4.0 / 4.0	Fine	Flat	TB
242	P230	2.6 - 50	1.93	5.7 / 5.7	Coarse	Riffle	TB

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
243	P231	< 2.6	4.67	3.8 / 3.8	Fine	Flat	TB
244	P232	2.6 - 50	0.81	2.5 / 2.5	Fine	Flat	TB
245	P233	< 2.6	1.49	6.7 / 6.7	Fine	Flat	TB
246	P234	< 2.6	1.87	3.7 / 3.7	Fine	Flat	TB
247	P235	< 2.6	1.33	2.5 / 2.5	Fine	Flat	TB
248	P236	2.6 - 50	0.54	2.4 / 2.4	Fine	Riffle	CS
249	P237	2.6 - 50	0.68	3.1 / 3.1	Fine	Flat	LI
250	P238	200 - 500	1.6	46 / 37.3	Coarse	Riffle	CS
251	P239	200 - 500	1.44	45.3 / 39.4	Coarse	Riffle	DS
252	P240	2.6 - 50	2.27	3.1 / 3.1	Fine	Flat	BO
253	P241	50 - 200	0.85	16.2 / 10.6	Coarse	Rapid	CT
254	P242	50 - 200	0.54	46 / 46	Coarse	Riffle	CS
255	P243	2.6 - 50	1.28	5.5 / 5.5	Fine	Flat	TB
256	P244	< 2.6	0.56	2.4 / 2.4	Fine	Flat	TB
257	P245	200 - 500	3.17	27.7 / 21.7	Coarse	Riffle	CT
258	P246	2.6 - 50	5.09	2.6 /2.6	Fine	Flat	TB
259	P1005	200 - 500	0.17	50.6 / 35.6	Coarse	Riffle	TB
260	P247	2.6 - 50	18.68	4.5 / 4.5	Coarse	Rapid	CS
261	P248	< 2.6	15.44	24 / 24	Fine	Flat	BO
262	P249	< 2.6	15.44	-	-	-	-
263	P250	< 2.6	15.44	-	-	Riffle	CS
264	P251	< 2.6	8.50	3.3 / 3.3	Fine	Riffle	CS
265	P252	< 2.6	3.80	1.3 / 1.3	Fine	Flat	BO
266	P253	< 2.6	8.43	2.8 / 2.8	Fine	Riffle	CS
267	P254	2.6 - 50	6.44	37.2 / 22.7	Fine	Flat	TB
268	P255	< 2.6	3.85	12.2 / 12.2	Coarse	Riffle	TB
269	P257	< 2.6	0.81	24 / 24	Fine	Flat	BO
270	P258	2.6 - 50	1.33	6.3 / 6.3	Fine	Flat	TB
271	P259	2.6 - 50	0.36	1.8 / 1.8	Fine	Flat	TB
272	P260	< 2.6	5.59	2.5 / 2.5	Fine	Flat	TB
273	P261	< 2.6	0.00	-	-	-	-
274	P262	< 2.6	2.28	-	-	-	-
275	P263	< 2.6	2.82	1.0 / 1.0	Fine	Flat	BO
276	P264	< 2.6	9.27	10.6 / 4.8	Coarse	Rapid	DT
277	P265	2.6 - 50	6.29	3.6 / 1.2	Coarse	Riffle	BO
278	P266	< 2.6	7.19	1.5 / 1.5	Fine	Flat	BO
279	P267	2.6 - 50	4.91	18.5 / 9.3	Coarse	Riffle	TB
280	P268	< 2.6	4.59	8.5 / 8.5	Fine	Flat	TB
281	P269	< 2.6	1.86	4.3 / 1.3	Fine	Riffle	TB
282	P270	2.6 - 50	4.07	31.7 / 13.5	Coarse	Riffle	TB
283	P271	< 2.6	9.49	8.2 / 8.2	Coarse	Rapid	DT
284	P272	< 2.6	9.26	3.8 / 3.8	Coarse	Riffle	CT
285	P273	2.6 - 50	4.89	22.1 / 22.1	Coarse	Riffle	CT
286	P274	< 2.6	2.55	5.3 / 5.3	Fine	Riffle	CT
287	P275	< 2.6	7.66	-	-	-	-
288	P276	< 2.6	6.21	2.5 / -	-	Discontinuous	CT
289	P277	< 2.6	7.30	1.0 / 1.0	Coarse	Riffle	CS
290	P278	< 2.6	7.77	1.8 / 1.8	Coarse	Riffle	CS

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
291	P1009	2.6 - 50	3.63	34.4 / 9.3	Coarse	Riffle	DS
292	P279	2.6 - 50	3.44	27.7 / 21.7	Coarse	Riffle	CT
293	P280	50 - 200	0.90	42.1 / 29.3	Coarse	Rapid	CT
294	P281	< 2.6	6.35	3.1 / 3.1	Fine	Riffle	CT
295	P282	< 2.6	5.53	1.2 / 1.2	Coarse	Riffle	CT
296	P283	< 2.6	4.46	2.3 / 2.3	Fine	Flat	CT
297	P284	< 2.6	4.79	2.7 / 2.7	Fine	Flat	TB
298	P1010	< 2.6	2.71	16.6 / 6.4	Fine	Flat	CS
299	P285	< 2.6	9.14	1.5 / 1.5	Coarse	Rapid	CT
300	P1011	2.6 - 50	3.60	14.9 / 9.8	Coarse	Flat	CT
301	P1012	< 2.6	1.49	29.9 / 13.0	Coarse	Flat	CT
302	P286	2.6 - 50	6.97	2.0 / 2.0	Fine	Flat	TB
303	P287	< 2.6	4.41	2.0 / 2.0	Fine	Flat	TB
304	P288	< 2.6	2.08	3.7 / 3.7	Fine	Flat	CS
305	P1013	2.6 - 50	1.24	11.3 / 7.3	Fine	Flat	CS
306	P289	< 2.6	2.24	2.9 / 2.9	Fine	Flat	TB
307	P290	< 2.6	0.00	1.9 / 1.9	Fine	Flat	BO
308	P291	< 2.6	0.00	1.9 / 1.9	Fine	Flat	BO
309	P292	< 2.6	9.70	-	Fine	Flat	BO
310	P1014	2.6 - 50	5.15	21.7 / 9.1	Fine	Flat	DS
311	P293	< 2.6	3.41	-	Fine	Flat	CT
312	P294	2.6 - 50	0.55	2.1 / 2.1	Fine	Flat	TB
313	P295	2.6 - 50	1.08	3.0 / 3.0	Fine	Flat	CT
314	P296	< 2.6	2.70	2.3 / 2.3	Fine	Flat	TB
315	P1015	2.6 - 50	1.17	5.6 / 5.6	Fine	Flat	BO
316	P297	< 2.6	7.31	2.1 / 2.1	Coarse	Riffle	CS
317	P298	< 2.6	6.36	2.1 / 2.1	Coarse	Riffle	CT
318	P299	< 2.6	6.49	2.1 / 2.1	Coarse	Riffle	CT
319	P300	< 2.6	7.57	-	Coarse	Riffle	CT
Alternative Transmission Corridor Segment(s)							
320	A12	< 2.6	1.27	-	-	-	-
321	A13	< 2.6	1.49	-	-	-	-
322	A14	2.6 - 50	1.04	-	-	-	-
323	A15	2.6 - 50	2.43	11.2 / 11.2	Fine	Flat	BO
324	A16	< 2.6	2.49	11.7 / 11.7	Fine	Flat	BO
325	A17	2.6 - 50	0.97	12.0 / 12.0	Fine	Riffle	BO
326	A18	2.6 - 50	1.74	3.3 / 3.3	Fine	Discontinuous	BO
327	A19	2.6 - 50	2.97	16.0 / 14.5	Coarse	Riffle	BO
328	A20	< 2.6	5.28	3.2 / 3.2	Coarse	Rapid	DT
329	A21	< 2.6	2.84	18.3 / 1.9	Fine	Discontinuous	BO
330	A22	< 2.6	4.63	2.7 / 2.7	Fine	Riffle	BO
331	A23	2.6 - 50	1.98	32.4 / 16.3	Coarse	Riffle	BO
332	A24	2.6 - 50	1.41	4.3 / 4.3	Fine	Flat	BO
333	A25	2.6 - 50	1.86	12.4 / 5.6	Fine	Flat	BO
334	A26	< 2.6	4.84	19.6 / 8.1	Fine	Flat	BO
335	A27	2.6 - 50	2.48	28.8 / 14.7	Coarse	Rapid	BO
336	A37	< 2.6	4.47	43.6 / 17.6	Fine	Riffle	BO
337	A38	2.6 - 50	2.36	32.3 / 6.1	Fine	Riffle	CS

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
338	A39	2.6 - 50	3.51	23.7 / 3.6	Coarse	Flat	DS
339	A40	200 - 500	0.66	80.9 / 61.9	Coarse	Rapid	CT
340	A41	< 2.6	5.68	17.4 / 9.6	Coarse	Riffle	CT
341	A42	50 - 200	3.18	22.0 / 15.7	Coarse	Riffle	CT
342	A43	< 2.6	0.37	4.4 / 4.4	Fine	Flat	BO
343	A44	< 2.6	0.27	2.3 / 2.3	Fine	Flat	CT
344	A45	2.6 - 50	0.54	14.9 / 6.7	Fine	Riffle	TB
345	A46	2.6 - 50	2.23	9.7 / 3.2	Coarse	Riffle	DS
346	A47	< 2.6	2.1	3.7 / 3.7	Fine	Flat	DS
347	A48	< 2.6	1.27	8.7 / -	-	-	BO
348	A50	200 - 500	1	10.3 / 10.3	Fine	Flat	BO
349	A51	< 2.6	0.99	6.7 / 6.7	Fine	Flat	BO
350	A52	< 2.6	0.48	4.9 / 4.9	Fine	Flat	BO
351	A53	< 2.6	0.34	8.8 / 8.8	Fine	Flat	BO
352	A54	2.6 - 50	1.36	24.5/19.5	Coarse	Rapid	DS
353	A55	2.6 - 50	9.27	22.8/19.4	Coarse	Riffle	DS
354	A56	2.6 - 50	6.07	16.7/12.7	Coarse	Flat	DS
355	P1006	2.6 - 50	4.36	18.7 / 11.2	Coarse	Riffle	DS
356	P1007	50 - 200	5.74	19.0 / 9.7	Coarse	Riffle	DS
357	P1008	< 2.6	5	-	-	-	-
358	A57	< 2.6	2.33	6.7 / 6.7	Fine	Flat	TB
359	A58	< 2.6	3.85	3.5 / 3.5	Fine	Flat	TB
360	A59	2.6 - 50	2.07	17.9 / 9.3	Coarse	Rapid	CS
361	A60	2.6 - 50	7.2	30.4 / 23.3	Coarse	Rapid	CS
362	A61	2.6 - 50	5.01	27.4 / 21.9	Fine	Riffle	DS
363	A62	< 2.6	4.87	8.3 / 8.3	Coarse	Riffle	DS
364	A63	2.6 - 50	2.06	17.9 / 13.2	Fine	Flat	TB
365	A64	< 2.6	4.55	5.0 / 5.0	Fine	Flat	TB
366	A65	2.6 - 50	2.93	4.8 / 4.8	Fine	Discontinuous	TB
367	A66	< 2.6	2.61	3.5 / 3.5	Fine	Discontinuous	TB
368	A67	< 2.6	9.25	2.3 / 2.3	Coarse	Riffle	TB
369	A68	< 2.6	4.09	4.2 / 4.2	Fine	Flat	TB
Note: See Map Atlas (Appendix A) for information on watercourse crossing numbers / IDs and locations, and definitions.							

Central and Eastern Newfoundland

The Central and Eastern Newfoundland region of the Project contained 184 watercourse crossings (or 28 percent of those within the transmission corridor). The most commonly observed flow morphologies in this region were riffles (61.4 percent) and flats (22.8 percent). Of the remaining, 11.4 percent were unable to be interpreted and the remaining 4 percent were comprised of a mixture of rapids (3.3 percent) and discontinuous (1.1 percent) habitat. Streams within this region consisted of 47.3 percent fine dominant substrate material, 40.8 percent coarse dominant substrate material and 12.0 percent unable to be interpreted (Table 3.7). Channel and wetted width for the region averaged 13.25 m and 10.56 m respectively (Table 3.7).

Table 3.7 Summary of Watercourse Crossing Characteristics as Determined by Air Photo Interpretation: Central and Eastern Newfoundland

Watercourse Crossing Characteristics Identified (Proposed and Alternative Corridor)	Number of Observations
Watershed Size Category	
< 2.6 km^2	94 (51.1 %)
2.6 - 50 km^2	64 (34.8 %)
50 - 200 km^2	17 (9.2 %)
200 - 500 km^2	2 (1.1 %)
500 - 1,000 km^2	5 (2.7 %)
1,000 - 10,000 km^2	2 (1.1 %)
Total	184
Dominant Substrate	
Fine	87 (47.3 %)
Coarse	75 (40.8 %)
Unclassified*	22 (12.0 %)
Total	184
Flow Morphology	
Rapid	6 (3.3 %)
Riffle	113 (61.4 %)
Flat	42 (22.8 %)
Discontinuous	2 (1.1 %)
Unclassified*	21 (11.4 %)
Total	184
Channel Width (m): Average / Range	13.25 / 0.3 – 294.0
Wetted Width (m): Average / Range	10.56 / 0.3 – 285.1
* Unclassified refers to data not classified during air photo interpretation. Reasons include: cloud cover, no visible stream, air photo unavailable.	

Further and more detailed information on the identified characteristics of each watercourse crossing within the region is provided below in Table 3.8 (Please see Appendix A for further information, including the location of each watercourse crossing point / stream ID).

Table 3.8 Watercourse Crossings (Air Photo Interpretation Results): Central and Eastern Newfoundland

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
Proposed Transmission Corridor							
370	P301	2.6 - 50	2.30	4.3 / 4.3	Fine	Flat	TB
371	P302	< 2.6	4.16	-	-	-	-
372	P303	2.6 – 50	1.82	-	-	-	-
373	P1016	< 2.6	2.20	9.8 / 9.8	Fine	Flat	CS
374	P304	< 2.6	2.06	-	-	-	-
375	P305	2.6 – 50	1.22	-	-	-	-
376	P306	< 2.6	7.50	50.4 / 26.8	Coarse	Riffle	BO

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
377	P307	< 2.6	4.24	-	-	-	-
378	P308	50-200	1.84	21.1 / 13.4	Fine	Riffle	CT
379	P309	< 2.6	3.07	-	-	-	-
380	P310	< 2.6	1.27	-	-	-	-
381	P311	50-200	1.30	22.9 / 17.6	Coarse	Riffle	CS
382	P312	< 2.6	2.09	-	-	-	-
383	P313	2.6 – 50	1.38	-	-	-	-
384	P314	< 2.6	3.40	8.7 / 8.1	Fine	Riffle	CT
385	P315	2.6 - 50	2.98	21.9 / 12.5	Fine	Riffle	CT
386	P316	< 2.6	3.84	-	-	-	-
387	P317	2.6 – 50	2.87	-	-	-	-
388	P318	< 2.6	3.38	1.6 / 1.6	Fine	Riffle	CT
389	P319	< 2.6	1.21	1.7 / 1.7	Coarse	Discontinuous	DS
390	P320	2.6 – 50	0.91	1.7 / 1.7	Coarse	Riffle	CT
391	P321	< 2.6	0.88	2.1 / 2.1	Fine	Riffle	CT
392	P322	2.6 – 50	1.44	2.2 / 2.2	Coarse	Riffle	TB
393	P323	< 2.6	2.30	1.2 / 1.2	Fine	Flat	CT
394	P324	2.6 – 50	1.87	1.9 / 1.9	Coarse	Riffle	CT
395	P325	< 2.6	1.84	2.1 / 2.1	Coarse	Riffle	DS
396	P326	2.6 – 50	2.50	3.8 / 3.8	Coarse	Riffle	CT
397	P327	2.6 – 50	1.96	3.7 / 3.7	Coarse	Riffle	CT
398	P328	< 2.6	1.42	1.0 / 1.0	Fine	Riffle	BO
399	P329	2.6 - 50	1.63	1.0 / 1.0	Fine	Flat	CT
400	P330	2.6 – 50	1.24	2.6 / 2.6	Fine	Riffle	CT
401	P331	2.6 – 50	1.64	1.0 / 1.0	Fine	Riffle	TB
402	P332	2.6 – 50	2.44	3.8 / 3.8	Fine	Riffle	TB
403	P333	< 2.6	1.72	2.0 / 2.0	Coarse	Riffle	CT
404	P334	2.6 – 50	2.04	1.0 / 1.0	-	Riffle	CT
405	P335	< 2.6	2.12	2.8 / 2.8	Fine	Riffle	CT
406	P336	< 2.6	3.14	0.9 / 0.9	Fine	Riffle	BO
407	P337	2.6 – 50	3.60	3.1 / 3.1	Coarse	Riffle	TB
408	P338	2.6 – 50	10.32	1.0 / 1.0	Coarse	Riffle	DS
409	P339	< 2.6	6.61	0.8 / 0.8	Fine	Riffle	TB
410	P340	< 2.6	3.10	2.2 / 1.6	Fine	Flat	TB
411	P341	2.6 – 50	2.87	11.5 / 11.5	Coarse	Rapid	CT
412	P342	< 2.6	2.65	1.0 / 1.0	Fine	Riffle	TB
413	P343	50-200	2.01	0.9 / 1.3	Coarse	Riffle	TB
414	P344	< 2.6	3.14	2.1 / 2.1	Fine	Riffle	TB
415	P345	< 2.6	4.76	0.5 / 0.5	Fine	Riffle	DS
416	P346	2.6 – 50	3.80	1.5 / 1.5	Coarse	Riffle	CT
417	P347	< 2.6	4.45	1.1 / 1.2	Coarse	Riffle	TB
418	P348	< 2.6	3.61	0.4 / 0.4	Fine	Riffle	TB
419	P349	< 2.6	2.70	2.8 / 2.8	Fine	Flat	TB
420	P350	< 2.6	3.76	1.6 / 1.6	Fine	Riffle	TB
421	P351	< 2.6	2.93	0.8 / 0.8	Fine	Riffle	TB
422	P352	2.6 – 50	2.36	8.2 / 5.5	Coarse	Riffle	CT
423	P353	< 2.6	2.20	2.1 / 1.8	Fine	Riffle	TB
424	P354	< 2.6	2.25	2.2 / 2.2	Fine	Riffle	TB

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
425	P355	2.6 – 50	1.43	5.1 / 4.8	Coarse	Riffle	TB
426	P356	2.6 – 50	1.43	3.9 / 3.9	Coarse	Riffle	CT
427	P357	< 2.6	3.18	1.5 / 1.5	Fine	Riffle	TB
428	P358	< 2.6	1.51	8.3 / 6.0	Fine	Flat	BO
429	P359	< 2.6	1.58	1.7 / 1.7	Fine	Riffle	CT
430	P360	50-200	0.21	37.8 / 25.0	Coarse	Riffle	TB
431	P361	< 2.6	0.46	9.7 / 8.3	Fine	Flat	BO
432	P362	< 2.6	1.49	3.0 / 3.0	Fine	Riffle	TB
433	P363	< 2.6	1.74	1.7 / 1.3	Fine	Riffle	TB
434	P364	< 2.6	1.50	1.4 / 1.4	Fine	Flat	TB
435	P365	2.6 – 50	1.07	11.1 / 8.6	Coarse	Riffle	TB
436	P366	< 2.6	2.00	0.8 / 0.8	Coarse	Riffle	TB
437	P367	< 2.6	1.17	7.7 / 4.6	Fine	Flat	TB
438	P368	2.6 – 50	0.29	12.8 / 8.9	Coarse	Flat	TB
439	P369	200- 500	0.35	86.2 / 53.3	Coarse	Riffle	DS
440	P370	< 2.6	2.01	1.9 / 1.9	Coarse	Flat	DS
441	P371	< 2.6	0.98	2.0 / 0.7	Fine	Riffle	BO
442	P372	2.6 – 50	0.89	3.0 / 3.0	Fine	Riffle	TB
443	P373	2.6 – 50	3.12	2.6 / 2.6	Coarse	Riffle	CT
444	P374	< 2.6	3.23	23.8 / 0.7	Fine	Riffle	TB
445	P375	2.6 – 50	4.26	1.5 / 1.5	Coarse	Riffle	CT
446	P376	2.6 – 50	4.13	1.2 / 1.2	Coarse	Riffle	CT
447	P377	< 2.6	2.76	2.0 / 2.0	Fine	Riffle	CT
448	P378	50-200	1.09	5.4 / 4.5	Coarse	Riffle	CT
449	P379	< 2.6	1.47	0.9 / 0.9	Fine	Flat	BO
450	P380	< 2.6	0.00	1.3 / 1.3	Fine	Flat	CT
451	P381	2.6 – 50	0.29	68.9 / 63.6	Coarse	Riffle	CT
452	P382	< 2.6	2.73	1.0 / 1.0	Fine	Riffle	TB
453	P383	< 2.6	1.28	1.2 / 1.2	Coarse	Riffle	CT
454	P384	< 2.6	1.26	0.9 / 0.9	Fine	Flat	TB
455	P385	< 2.6	0.24	1.8 / 1.8	Fine	Riffle	TB
456	P386	2.6 – 50	0.84	3.0 / 1.3	Fine	Riffle	TB
457	P387	2.6 – 50	2.20	1.1 / 1.1	Fine	Riffle	LI
458	P388	50-200	0.51	32.1 / 29.1	Coarse	Riffle	BO
459	P389	500 – 1,000	0.34	294.0 / 285.1	Coarse	Riffle	CT
460	P390	2.6 – 50	1.24	10.1 / 7.1	Coarse	Riffle	TB
461	P391	2.6 – 50	1.52	1.7 / 1.7	Fine	Riffle	TB
462	P392	2.6 – 50	2.37	3.3 / 3.3	Fine	Riffle	BO
463	P393	50-200	0.56	12.7 / 10.1	Coarse	Riffle	TB
464	P394	2.6 – 50	0.82	2.1 / 2.1	Coarse	Riffle	TB
465	P395	2.6 – 50	1.06	13.6 / 3.1	Coarse	Riffle	TB
466	P396	< 2.6	2.34	5.1 / 5.1	Fine	Riffle	TB
467	P397	2.6 – 50	2.80	9.0 / 5.6	Coarse	Riffle	CT
468	P398	< 2.6	2.25	1.8 / 1.8	Coarse	Riffle	CT
469	P399	500 – 1,000	0.35	74.8 / 59.8	Coarse	Riffle	CT
470	P400	< 2.6	3.10	1.0 / 1.0	Coarse	Riffle	CT
471	P401	50-200	0.53	33.7 / 27.6	Coarse	Riffle	TB
472	P402	2.6 – 50	1.37	19.3 / 12.6	Fine	Riffle	TB

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
473	P403	2.6 – 50	1.63	2.4 / 2.4	Fine	Riffle	TB
474	P404	< 2.6	1.91	1.8 / 1.8	Coarse	Riffle	CT
475	P405	2.6 – 50	2.03	26.0 / 17.8	Coarse	Riffle	TB
476	P406	< 2.6	0.83	1.0 / 1.0	Coarse	Riffle	TB
477	P407	< 2.6	0.55	0.9 / 0.9	Fine	Flat	TB
478	P408	50-200	0.17	37.5 / 28.8	Coarse	Riffle	TB
479	P409	< 2.6	1.45	0.7 / 0.7	Fine	Riffle	TB
480	P410	< 2.6	1.38	0.5 / 0.5	Fine	Riffle	TB
481	P411	< 2.6	0.76	10.4 / 10.4	Coarse	Flat	TB
482	P412	< 2.6	0.79	1.8 / 1.8	Fine	Riffle	BO
483	P413	2.6 – 50	0.62	1.0 / 1.0	Coarse	Riffle	CT
484	P414	50-200	0.14	12.2 / 6.5	Fine	Flat	CT
485	P415	< 2.6	0.68	0.7 / 0.7	Fine	Riffle	BO
486	P416	500-1000	0.63	81.8 / 65.0	Coarse	Riffle	CT
487	P417	< 2.6	0.27	75.9 / 44.7	Coarse	Rapid	CT
488	P418	50-200	1.44	4.8 / 2.0	Coarse	Riffle	CT
489	P419	< 2.6	0.97	2.2 / 2.2	Fine	Flat	TB
490	P420	< 2.6	1.16	3.3 / 3.3	Fine	Flat	TB
491	P421	2.6 – 50	1.76	2.2 / 2.2	Fine	Riffle	TB
492	P422	2.6 – 50	4.35	1.4 / 1.4	Fine	Riffle	TB
493	P423	< 2.6	1.34	2.1 / 2.1	Fine	Flat	TB
494	P424	2.6 – 50	1.96	0.4 / 0.4	Fine	Flat	TB
495	P425	< 2.6	3.89	13.6 / 8.2	Coarse	Riffle	CT
496	P426	< 2.6	3.65	0.3 / 0.3	Fine	Flat	TB
497	P427	< 2.6	3.63	0.7 / 0.7	Fine	Flat	TB
498	P428	< 2.6	4.44	2.0 / 2.0	Fine	Riffle	CT
499	P429	< 2.6	5.60	1.9 / 1.9	Coarse	Riffle	TB
500	P430	1000-10,000	0.00	115.5 / 106.4	Coarse	Riffle	DS
501	P431	50-200	1.37	24.5 / 17.0	Fine	Flat	DS
502	P432	< 2.6	1.58	1.4 / 1.4	Coarse	Riffle	DS
503	P433	< 2.6	1.27	5.0 / 1.4	Fine	Riffle	DS
504	P434	< 2.6	1.76	1.3 / 1.3	Fine	Flat	TB
505	P435	< 2.6	1.75	7.3 / 2.1	Coarse	Flat	CT
506	P436	< 2.6	2.17	1.0 / 1.0	Fine	Flat	BO
507	P437	500-1000	0.56	79.6 / 77.0	Coarse	Rapid	CT
508	P438	50-200	0.94	51.8 / 46.9	Coarse	Riffle	CT
509	P439	< 2.6	5.31	2.5 / 2.5	Coarse	Riffle	CT
510	P440	< 2.6	2.10	1.7 / 1.7	Fine	Riffle	CT
511	P441	50-200	1.60	12.0 / 22.1	Coarse	Riffle	CT
512	P442	2.6 – 50	1.86	7.8 / 3.7	Coarse	Riffle	CT
513	P443	2.6 – 50	0.77	13.0 / 10.1	Coarse	Flat	TB
514	P444	50-200	0.39	37.1 / 17.9	Coarse	Flat	CT
515	P445	2.6 – 50	1.93	37.1 / 57.0	Fine	Flat	BO
516	P446	< 2.6	1.81	1.9 / 1.9	Fine	Flat	CT
517	P447	2.6 – 50	1.20	20.7 / 5.7	Coarse	Riffle	CT
518	P448	< 2.6	2.83	8.4 / 1.4	Fine	Riffle	TB
519	P449	2.6 – 50	3.37	13.4 / 7.0	Coarse	Riffle	TB
520	P450	2.6 – 50	1.63	4.9 / 1.6	Fine	Flat	TB

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
521	P451	< 2.6	3.87	2.3 / 1.2	Fine	Flat	BO
522	P452	50-200	1.15	37.1 / 28.1	Coarse	Riffle	CT
523	P453	2.6 – 50	2.87	7.3 / 5.6	Coarse	Riffle	CT
524	P454	< 2.6	0.55	13.5 / 7.3	Coarse	Riffle	TB
525	P455	1000-10,000	0.16	43.3 / 36.2	Fine	Flat	DS
526	P456	2.6 – 50	0.68	4.3 / 1.7	Fine	Flat	TB
527	P457	500-1000	0.36	28.3 / 28.3	Coarse	Rapid	CT
528	P458	2.6 – 50	1.94	1.9 / 1.9	Fine	Flat	TB
529	P459	2.6 – 50	5.38	4.9 / 1.4	Fine	Flat	TB
530	P460	50-200	1.88	36.5 / 19.7	Coarse	Rapid	TB
531	P461	2.6 – 50	1.62	1.1 / 1.1	Fine	Riffle	TB
532	P462	< 2.6	2.63	1.0 / 1.0	Coarse	Riffle	CT
533	P463	< 2.6	4.30	1.0 / 1.0	Fine	Riffle	CT
534	P464	2.6 – 50	0.40	90.8 / 43.3	Coarse	Riffle	BO
535	P465	< 2.6	2.27	1.0 / 1.0	Fine	Flat	CT
536	P466	2.6 – 50	2.87	0.7 / 0.7	Fine	Riffle	TB
537	P467	2.6 – 50	3.98	1.6 / 1.6	Fine	Flat	CT
538	P468	< 2.6	7.96	1.9 / 1.9	Coarse	Riffle	CT
539	P469	200-500	1.78	29.2 / 26.4	Coarse	Riffle	CT
Alternative Transmission Corridor Segment(s)							
540	A94	2.6 - 50	1.64	-	-	-	-
541	A95	< 2.6	0.00	2.9 / 2.9	Fine	Flat	BO
542	A96	< 2.6	1.35	5.1 / 4.5	Fine	Flat	BO
543	A97	< 2.6	5.62	1.0 / 1.0	Fine	Discontinuous	DT
544	A98	2.6 – 50	7.49	-	-	-	-
545	A99	< 2.6	3.02	-	-	-	-
546	A100	2.6 – 50	2.97	-	-	-	-
547	A101	< 2.6	3.85	-	-	-	-
548	A102	< 2.6	3.88	-	-	-	-
549	A103	2.6 – 50	5.54	-	-	-	-
550	A104	2.6 – 50	2.86	-	-	-	-
551	A105	< 2.6	2.71	-	-	-	-
552	A106	< 2.6	2.86	-	-	-	-
553	A107	< 2.6	2.18	54.9/54.9	Coarse	Rapid	DS
Note: See Map Atlas (Appendix A) for information on watercourse crossing numbers / IDs and locations, and definitions.							

Avalon Peninsula

The Avalon Peninsula region contained 103 watercourse crossings (or 16 percent of those within the transmission corridor). The two most commonly occurring flow morphologies were riffles (67.0 percent) and flats (26.2 percent). The remaining 7 percent were comprised of a mixture of rapids (2 percent) and discontinuous (4.9 percent) habitat. Streams within the area were dominated by fine substrate materials (68.0 percent) whereas the remaining streams had substrates dominated by coarse materials (32.0 percent). Channel and wetted width for the region averaged 7.91 m and 6.24 m respectively (Table 3.9).

Table 3.9 Summary of Watercourse Crossing Characteristics as Determined by Air Photo Interpretation: Avalon Peninsula

Watercourse Crossing Characteristics Identified (Proposed and Alternative Corridor)	Number of Observations
Watershed Size Category	
< 2.6 km^2	67 (65.0%)
2.6 - 50 km^2	34 (33.0 %)
50 - 200 km^2	2 (2.0%)
200 - 500 km^2	0
500 - 1,000 km^2	0
1,000 - 10,000 km^2	0
Total	103
Dominant Substrate	
Fine	70 (68.0 %)
Coarse	33 (32.0 %)
Unclassified*	0
Total	103
Flow Morphology	
Rapid	2 (2.0 %)
Riffle	69 (67.0 %)
Flat	27 (26.2 %)
Discontinuous	5 (4.9 %)
Unclassified*	0
Total	103
Channel Width (m): Average / Range	7.91/ 0.7 – 234.0
Wetted Width (m): Average / Range	6.24 / 0.5 – 234.0
* Unclassified refers to data not classified during air photo interpretation. Reasons include: cloud cover, no visible stream, air photo unavailable.	

Further and more detailed information on the identified characteristics of each watercourse crossing within the region is provided below in Table 3.10 (Please see Appendix A for further information, including the location of each watercourse crossing point / stream ID).

Table 3.10 Watercourse Crossings (Air Photo Interpretation Results): Avalon Peninsula

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
Proposed Transmission Corridor							
554	P470	< 2.6	3.08	4.8 / 4.8	Fine	Riffle	BT
555	P471	50 - 200	0.98	29.5 / 15.1	Coarse	Riffle	BT
556	P472	< 2.6	2.64	0.8 / 0.8	Fine	Flat	BO
557	P473	2.6 - 50	6.52	1.7 / 1.7	Coarse	Riffle	TB
558	P474	2.6 - 50	3.68	1.6 / 1.6	Fine	Riffle	CT
559	P475	< 2.6	3.75	5.3 / 3.1	Coarse	Riffle	CT

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
560	P476	2.6 - 50	18.67	4.0 / 4.0	Coarse	Riffle	CT
561	P477	2.6 - 50	3.55	4.9 / 4.9	Coarse	Riffle	CT
562	P478	< 2.6	5.37	1.0 / 1.0	Fine	Discontinuous	TB
563	P479	2.6 - 50	5.23	1.0 / 1.0	Fine	Discontinuous	CT
564	P480	2.6 - 50	2.89	1.7 / 1.7	Coarse	Discontinuous	TB
565	P481	< 2.6	5.26	10.4 / 8.3	Fine	Riffle	CT
566	P482	< 2.6	8.17	11.3 / 6.7	Fine	Rapid	TB
567	P483	< 2.6	0.45	5.7 / 3.6	Fine	Riffle	DS
568	P484	2.6 - 50	0.45	18.2 / 16.1	Coarse	Riffle	DS
569	P485	2.6 - 50	0	11.7 / 8.2	Fine	Flat	DS
570	P486	< 2.6	0.89	3.9 / 1.8	Fine	Flat	DS
571	P487	< 2.6	4.44	1.0 / 1.0	Fine	Discontinuous	CT
572	P488	< 2.6	7.1	3.1 / 3.1	Coarse	Riffle	CT
573	P489	< 2.6	7.49	1.0 / 1.0	Fine	Riffle	TB
574	P1022	< 2.6	4.33	1.7 / 1.7	Fine	Flat	BO
575	P490	< 2.6	3.01	1.0 / 0.5	Coarse	Riffle	DS
576	P491	< 2.6	1.73	0.7 / 0.7	Fine	Riffle	BO
577	P492	< 2.6	2.08	11.5 / 11.5	Fine	Riffle	BO
578	P493	< 2.6	1.08	3.5 / 3.5	Fine	Flat	BO
579	P494	< 2.6	3.54	1.0 / 1.0	Coarse	Riffle	TB
580	P495	2.6 - 50	2.84	2.3 / 2.3	Coarse	Rapid	CT
581	P496	< 2.6	4.06	2.7 / 2.3	Coarse	Riffle	CT
582	P497	< 2.6	2.9	2.5 / 2.5	Coarse	Riffle	TB
583	P1023	< 2.6	3.49	9.7 / 5.9	Coarse	Flat	CS
584	P498	< 2.6	3.28	2.2 / 1.0	Fine	Flat	BO
585	P499	< 2.6	6.53	8.8 / 4.5	Fine	Riffle	DS
586	P500	< 2.6	5.6	55.1 / 1.0	Fine	Discontinuous	BO
587	P501	2.6 - 50	1.01	13.8 / 10.1	Coarse	Riffle	DS
588	P502	2.6 - 50	2.7	9.8 / 4.6	Coarse	Flat	DS
589	P503	< 2.6	4.51	1.0 / 0.9	Fine	Flat	BO
590	P504	2.6 - 50	1.65	3.0 / 3.0	Fine	Riffle	CT
591	P505	< 2.6	3.77	1.0 / 1.0	Coarse	Riffle	CT
592	P1001	< 2.6	5.5	3.4 / 3.4	Fine	Flat	BO
593	P506	< 2.6	1.84	2.7 / 2.7	Coarse	Riffle	CT
594	P507	< 2.6	5.04	1.0 / 1.0	Coarse	Flat	CT
595	P1000	< 2.6	2.34	3.3 / 3.3	Fine	Flat	BO
596	P508	< 2.6	3.6	1.0 / 1.0	Coarse	Riffle	CT
597	P509	2.6 - 50	3.81	3.5 / 3.5	Coarse	Riffle	DS
598	P510	< 2.6	4.43	1.0 / 1.0	Fine	Riffle	DS
599	P511	2.6 - 50	2.81	3.3 / 3.3	Coarse	Riffle	DS
600	P512	2.6 - 50	2.05	3.0 / 3.0	Coarse	Riffle	DS

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
601	P513	< 2.6	4.01	2.0 / 2.0	Fine	Riffle	DS
602	P514	< 2.6	3.4	2.8 / 2.8	Fine	Riffle	DS
603	P515	2.6 - 50	2.97	5.2 / 5.2	Coarse	Riffle	DS
604	P516	< 2.6	2.61	3.3 / 3.3	Fine	Riffle	CT
605	P517	< 2.6	3.77	2.9 / 2.9	Fine	Riffle	DS
606	P518	2.6 - 50	1.12	2.3 / 2.3	Coarse	Riffle	DS
607	P519	< 2.6	3.92	2.5 / 2.5	Fine	Riffle	DS
608	P520	2.6 - 50	1.77	9.6 / 8.8	Coarse	Riffle	CT
609	P521	2.6 - 50	0.71	4.1 / 4.1	Fine	Riffle	CT
610	P522	< 2.6	0.57	3.3 / 3.3	Coarse	Riffle	DS
611	P1002	2.6 - 50	3.99	24.5 / 13.2	Fine	Flat	BO
612	P523	< 2.6	1.66	7.6 / 7.6	Fine	Flat	TB
613	P524	< 2.6	0.73	3.7 / 3.7	Fine	Riffle	DS
614	P525	2.6 - 50	0.89	4.3 / 4.3	Fine	Flat	TB
615	P526	2.6 - 50	0.3	14.9 / 9.4	Fine	Flat	TB
616	P527	< 2.6	2.28	4.2 / 4.2	Coarse	Riffle	DS
617	P528	< 2.6	1.98	2.0 / 2.0	Fine	Flat	DS
618	P1021	2.6 - 50	0.56	29.9 / 22.5	Fine	Flat	BO
619	P529	2.6 - 50	0.64	9.2 / 7.2	Fine	Riffle	CT
620	P530	< 2.6	1.27	1.0 / 1.0	Fine	Flat	CS
621	P531	< 2.6	2.26	2.5 / 2.5	Fine	Riffle	DS
622	P532	< 2.6	0.8	2.8 / 2.8	Fine	Riffle	TB
623	P533	2.6 - 50	4.38	3.5 / 3.5	Fine	Riffle	TB
624	P534	2.6 - 50	4.87	3.3 / 3.3	Fine	Riffle	TB
625	P535	< 2.6	1.25	4.0 / 4.0	Fine	Flat	DS
626	P536	2.6 - 50	1.64	12.8 / 9.5	Coarse	Riffle	CT
627	P537	< 2.6	2.57	5.6 / 5.6	Fine	Riffle	TB
628	P538	< 2.6	2.76	3.0 / 3.0	Fine	Riffle	DS
629	P539	< 2.6	2.61	1.3 /1.3	Fine	Riffle	TB
630	P540	< 2.6	3.31	4.2 / 4.2	Fine	Riffle	TS
631	P541	50 - 200	2.3	7.8 / 7.8	Coarse	Riffle	TB
632	P542	2.6 - 50	0.73	9.0 / 8.1	Coarse	Riffle	CT
633	P543	< 2.6	1.78	1.1 / 1.1	Fine	Riffle	TB
634	P544	< 2.6	3.06	1.1 / 1.1	Fine	Riffle	CT
635	P545	< 2.6	3.54	2.0 / 2.0	Fine	Riffle	TB
636	P546	< 2.6	5.77	1.8 / 1.8	Fine	Riffle	TB
637	P547	2.6 - 50	1.86	2.1 / 2.1	Fine	Flat	CT
638	P548	< 2.6	4.19	1.1 / 1.1	Fine	Riffle	CT
639	P549	< 2.6	6.91	1.4 / 1.4	Fine	Riffle	TB
640	P550	< 2.6	4.03	0.8 / 0.8	Fine	Riffle	BO
641	P551	< 2.6	3.06	1.7 / 1.7	Fine	Flat	BO

#	Stream ID	Watershed Size Category (km^2)	Slope (%)	Channel / Wetted Width (m)	Dominant Substrate	Flow Morphology	Riparian Vegetation
642	P552	< 2.6	1.73	2.6 / 2.6	Fine	Riffle	CT
643	P553	< 2.6	4.35	1.0 / 1.0	Fine	Riffle	CT
644	P554	< 2.6	13.95	15.0 / 15.0	Fine	Flat	BO
645	P555	< 2.6	3.46	1.1 / 1.1	Fine	Riffle	TB
646	P556	2.6 - 50	5.67	6.5 / 4.9	Coarse	Riffle	TB
647	P557	< 2.6	6.43	2.0 / 2.0	Fine	Riffle	CT
648	P558	< 2.6	4.78	2.0 / 2.0	Fine	Riffle	CT
649	P559	< 2.6	3.53	4.8 / 4.8	Fine	Riffle	BO
650	P560	< 2.6	2.19	2.2 / 2.2	Fine	Flat	TB
651	P561	2.6 - 50	2.11	2.1 / 2.1	Coarse	Riffle	TB
652	P562	2.6 - 50	2.93	3.9 / 3.9	Coarse	Riffle	TB
Alternative Transmission Corridor Segment(s)							
653	A108	< 2.6	1.25	7.5 / 3.4	Fine	Riffle	CS
654	A109	2.6 - 50	13.29	40.6 / 11.6	Fine	Flat	TB
655	A110	2.6 - 50	5.28	234.0 / 234.0	Fine	Flat	DS
656	A111	< 2.6	6.1	1.0 / 1.0	Fine	Flat	BO
Note: See Map Atlas (Appendix A) for information on watercourse crossing numbers / IDs and locations, and definitions.							

Overall the most common flow morphology throughout the transmission corridor area was riffle at 43 percent followed closely by flats at 41 percent whereas the most common dominant substrate was fine at 61 percent.

3.2 Literature Review

The sections below provide results of literature reviews for both fish species presence and water quality.

3.2.1 Fish Species Presence

Table 3.11 presents a summary of the fish species presence information reported in the existing literature. It only presents findings recorded in the literature and not of general range distribution descriptions. A brief summary of each region is provided below.

Within the Southeastern Labrador region Atlantic sturgeon (*Acipenser oxyrhynchus*), American eel (*Anguilla rostrata*), Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*), burbot (*Lota lota*), fourspine stickleback (*Apeltes quadracus*), lake whitefish (*Coregonus clupeaformis*), longnose sucker (*Catostomus catostomus*), northern redhorse (*Moxostoma aureolum*), round whitefish (*Prosopium cylindraceum*), rainbow smelt (*Osmerus mordax*), threespine stickleback (*Gasterosteus aculeatus*) and white sucker (*Catostomus commersoni*) have been reported in the literature (Anderson 1985; Atlantic Biological Services Limited 1980; Department of Fisheries and Aquaculture 2002; Reddin et al. 2008; Riche 1965).

Within the Northern Peninsula region alewife (*Alosa pseudoharengus*), American eel, Arctic charr (*Salvelinus alpinus*), Atlantic salmon, brook trout, ouananiche (landlocked form of *Salmo salar*), rainbow smelt, threespine stickleback, and tomcod (*Microgadus tomcod*) were documented (Acres Consulting Services Limited 1979; AMEC 2003; DFO 2007; Mercer 1962; Porter et al. 1974).

Table 3.11 Summary of Fish Presence from Literature Reviewed

Region	Stream Name Representing Watershed	River Ref Number	Map Index Number	Current Project Identified Stream Crossings	Fish Species: Tomcod	Burbot	American eel	Alewife	Arctic charr	Atlantic salmon	Ouananiche	Brook trout	Brown trout	Lake whitefish	Rainbow trout	Round whitefish	Rainbow smelt	Fourspine stickleback	Ninespine stickleback	Threespine stickleback	Atlantic sturgeon	Longnose sucker	White sucker	Northern redhorse	Reference
Southeastern Labrador	Kenamu			P17-P53		●[1]				●		●		●		●	●			●	●[1]	●	●	●	Anderson 1985; Riche 1965
	Joir River (PQ)			P54-P61																					
	St. Augustin			P62-P81																					
	St. Paul			P82-P146																					
	Pinware		12 -P	P147-P171			●			●		●										●			Anderson 1985; Atlantic Biological Services Limited 1980; Department of Fisheries and Aquaculture 2002
	Forteau Brook		12 -P	P172-P182, P1018-P1020, A1-A3 & A9-A10			●			●															Reddin et al. 2008; Department of Fisheries and Aquaculture 2002
	Overfall Brook			A11																					
	West River, St. Barbe			P193						●															DFO 2007
Northern Peninsula	St. Genevieve River			P194-P199 & A12-A13						●		●													DFO 2007; Mercer 1962
	Castors River			P200-P212 & A14-A21						●		●													DFO 2007; Mercer 1962
	East River, Hawkes Bay	W-47-0484	12 I/11	P213-P224						●		●													Porter et al. 1974; DFO 2007
	Torrent River	W-47-0480	12 I/11	A22-A27, A37-A48 & P225-235						●		●													Porter et al. 1974; DFO 2007
	River of Ponds	W-47-0474	12 I/11	P236-P240						●		●													Porter et al. 1974; DFO 2007; Mercer 1962
	Portland Creek	W-46-0462	12 I/4	P241-P251, P252-P260, P1006-P1008, A50-A56 & A57-A65						●		●					●								Porter et al. 1974; DFO 2007; Mercer 1962
	Sop's Arm River (Main River)			P261-P297 & P1009-P1015						●															DFO 2007; Acres Consulting Services Limited 1979
	Humber River	W-44-0243	12 A/13	P298-P300	●		●	●	●	●	●	●					●			●					Porter et al. 1974; DFO 2007; AMEC 2003
Central & Eastern Newfoundland	Humber River			P301-317	●		●	●	●	●	●	●					●			●					Porter et al. 1974; DFO 2007; AMEC 2003
	Hampden River			P318-P321						●															DFO 2007
	Grand Lake System			P322-P339					●		●	●													Scott & Crossman 1964
	Sheffield Lake			P340-P348 & A98 -A107																					
	South Brook, Halls Bay			P349-P379						●															DFO 2007
	Exploits River	E-07-0779	2 E/3	P380-P415			●		●	●	●	●								●					Porter et al. 1974; DFO 2007
	Rattling Brook			P416-P424							●														DFO 2007; Moores and Ash 1984
	Gander River	E-09-0861	2 E/8	P425-P442					●	●	●	●					●			●					Porter et al. 1974; DFO 2007
	Gambo River	E-11-0978	2 E/3	P443-P449						●	●	●					●		●						Porter et al. 1974; DFO 2007
	Terra Nova River	W-47-0480	12 I/11	P450-P456						●	●	●					●								Porter et al. 1974; DFO 2007; Scott & Crossman 1964; Moores and Ash 1984
	Northwest Brook	E-12-1088	2 D/8	P457 & 458						●	●	●													Porter et al. 1974; DFO 2007
	Salmon Brook			P459-461						●															DFO 2007
	Middle Brook			P462-464																					
	Mile Pond Brook			P465-P466																					
	Southwest Brook, Port Blandford			P467-P469			●			●							●								DFO 2007; Frontier Hydro Development Limited & Algonquin Power Corporation Incorporated 1997
Avalon Peninsula	Seal Cove River			P550-P562 & E141-E145									●												DFO 2007
	Mahers River			P545-P549																					
	Northern Arm River			P540-P544																					
	Maloneys River			P538-P539																					
	Lees Brook			P537																					
	Avondale River			P535P536									●												DFO 2007
	Witch Hazel Brook			P533-P534																					
	Coombs River			P532																					
	Hodge River			P531																					
	Spread Eagle River	E-17-1487	1 N/2	P523-P528						●		●	●												Porter et al. 1974
	Little Gut Brook			P522 & P1002																					
	Southern Cove Brook			P 521																					
	Western Cove Brook			P520																					
	Normans Cove Brook			P519																					
	Murphys Cove Brook			P517-P518																					
	Collier Bay Brook			P514-P516								●													DFO 2007
	Lemon Cove Brook			P513																					
	Trout Brook			P511-P512																					
	Unnamed Brook			P509-P510																					
	Big Gull Pond Brook			P507																					
	Little Jacks Pond			P503-P505																					
	Eastern Brook			P502																					
	Arnolds Cove Brook			P501																					
	Unknown Brook			P497																					
	Black Brook			P485-P489																					
	Northwest Brook			P481-P484																					
	Deep Bight River			P477-P480																					
	Dark Hole Brook			P474-P476																					
	Shoal Harbour River	E-16-1306	2 C/4	P470-P473						●		●	●		●					●					Porter et al. 1974; DFO 2007; AMEC 2003; Atlantic Biological Services Limited 1980
	Black Brook			P1023 & P498-P500																					
	Come by Chance			P1022 & P490 - P496						●			●					●							DFO 2007; Scott & Crossman 1964
	Hollis Cove Brook			P1001 & P506																					
	Fair Haven Brook (Long Pond)			P1000 & P508																					

[1] rare

Within the Central and Eastern Newfoundland region American eel, Arctic charr, Atlantic salmon, brook trout, ninespine stickleback (*Pungitius pungitius*), ouananiche, rainbow smelt, and threespine stickleback (DFO 2007; Frontier Hydro Development Limited & Algonquin Power Corporation Incorporated 1997; Moores and Ash 1984; Porter et al. 1974; Scott and Crossman 1964) have been reported.

Within the Avalon Peninsula region Atlantic salmon, brook trout, brown trout (*Salmo trutta*), fourspine stickleback, threespine stickleback, and rainbow trout (*Oncorhynchus mykiss*) were documented (Atlantic Biological Services Limited1980; DFO 2007; Porter et al. 1974; Scott and Crossman 1964).

Sections 3.2.1.1 to 3.2.1.28 provide a brief natural history of fish species found in Newfoundland and Labrador.

3.2.1.1 Atlantic tomcod (*Microgadus tomcod)*

The Atlantic tomcod is an inshore, bottom dwelling, shallow water marine species which regularly enters brackish and/or freshwater during the spawning migration (Scott and Scott 1988). Landlocked populations, where individuals remain within freshwater throughout their life, have also been infrequently reported (Scott and Scott 1988). The Atlantic tomcod is a short lived species which can attain an age of 4 years and typically reach a maximum length of 380 mm (Green and Chambers 2007). The species has a range which extends from the Hamilton Inlet/Lake Melville area of Labrador, throughout coastal Newfoundland, southward along the Canadian and United States coastal mainland to North Carolina (Scott and Scott 1988). Freshwater populations have been reported within Lake St. John, Quebec and within the Humber River system, Newfoundland (Scott and Scott 1988).

Spawning occurs during late fall to mid winter when adults move inshore and may occur in salt water but typically occurs in estuarine areas and at the mouths of rivers (Scott and Scott 1988). Spawning occurs over a sand, gravel or boulder substrate (Scott and Scott 1988). The 1.5 mm diameter, negatively buoyant eggs are deposited in masses, which adhere to the substrate, between November to February (Stewart and Auster 1987). Fertilization success is dependent upon salinity such that fertilization success is highest at low salinities (Stewart and Auster 1987). Unlike fertilization success, incubation time decreases with increasing salinity (up to 30 parts per thousand (ppt)) (Stewart and Auster 1987). Eggs exposed to salinities in excess of 30 ppt for extended periods of time experienced abnormal development (Stewart and Auster 1987).

Within 24 hours of hatching larvae become photosensitive and swim to the surface and gulp air to inflate their swim bladder (Stewart and Auster 1987). Once hatched in the spring larvae drift downstream with the higher freshwater flows of the spring freshet (Bradbury et al. 1999; Grant and Lee 2004; Scott and Scott 1988). Young-of-the-year (YOY) remain in estuarine waters throughout the summer and are restricted to areas with salinities near 10 ppt (Grant and Lee 2004) where they reach lengths between 60 to 90 mm (Scott and Scott 1988).

Adult Atlantic tomcod are found within a variety of habitats including eelgrass beds, salt marshes, mud flats, bays, estuaries, and coastal waters (Grant and Lee 2004). Atlantic tomcod can be found in waters up to 6 m deep within waters 1.6 km from shore (Grant and Lee 2004). Adults have been found to inhabit waters with temperatures between -1.2°C and 26°C (Grant and Lee 2004). Their ability to inhabit areas with sub-zero water temperature comes from the presence of a glycoprotein which depresses the freezing point of their blood (Grant and Lee 2004).

3.2.1.2 Burbot (*Lota lota*)

Burbot is the only member of the Gadidae family that resides in freshwater (Scott and Crossman 1998). They occur in continental Eurasia and North America, southward to about 40° N (Scott and Crossman 1998), where they frequent cool waters of large rivers, lower reaches of tributaries, and large lakes (Becker 1983). Burbot have been reported within the Churchill River (Beak Consultants Limited 1979; Black et al. 1986; Ryan 1980) and within the Atikonak Lake watershed (LGL Limited 1999) of southern Labrador. Anderson (1985) and Riche (1965) also reported Burbot in the Kenamu River in Labrador.

Burbot spawn in both lakes (Boag 1989; Bradbury et al. 1999; Ghan and Sprules 1991; Scott and Crossman 1998) or rivers (Arndt and Hutchinson 2000; Breeser et al. 1988; Cahn 1936; Chen 1969; Evenson 1993; Johnson 1981; McPhail and Lindsey 1970; Robbins and Deubler 1955; Scott and Crossman 1998; Sorokin 1971). Spawning usually takes place in mid-winter (January to March) under the ice in lakes or rivers (Grant and Lee 2004). Eggs typically hatch from late February to June (Grant and Lee 2004). Those that spawn in rivers reside in lakes but migrate into rivers to spawn (McPhail 1997). They tend to utilize areas with little accumulation of silt or detritus, usually at depths of 0.3 to 3.0 m, but have been reported at depths of 18 to 20 m (Boag 1989; Ford et al. 1995; McCrimmon and Devitt 1954; McPhail and Lindsey 1970; Morrow 1980; Scott and Crossman 1973; Sorokin 1971). The semi-buoyant eggs are broadcast into the water column well above the substrate (Fabricius 1954), then become demersal and settle into interstices in the substrate (Ford et al. 1995; Morrow 1980; Sorokin 1971).

Typically by early summer larval burbot attain a length of approximately 30 mm at which point they undergo a habitat shift from pelagic to a mainly benthic existence (McPhail 1997). YOY are typically found in the littoral regions of lakes over gravel, cobble or rubble bottoms (Faber 1970; Ford et al. 1995; Lawler 1963) where they have been observed in shallow water (0.5 to 3.0 m) during the day, sheltering under rocks and debris and are mainly active at night (Boag 1989; Lawler 1963). Juveniles have been shown to occupy essentially the same habitat as YOY and feed mainly on benthic invertebrates (McPhail 1997). In streams, young typically use undercut banks, submerged logs and vegetation for cover in sandy areas if rocky habitat is limited (Hanson and Qadri 1980; Scott and Crossman 1973). Throughout its geographical range in Canada, burbot generally reach sexual maturity between 2 to 8 years of age (Ford et al. 1995; McCrimmon and Devitt 1954; Ryan 1980; Scott and Crossman 1973).

Adults tend to congregate over gravel, rock, or cobble substrates (Ford et al. 1995) and often utilize undercut banks, roots of trees and dense vegetation as cover (Becker 1983). They have been observed inhabiting deep sections of rivers (McPhail and Lindsey 1970; Rawson 1942) and deep eddies in large northern rivers (Thornburgh 1986), mostly at depths greater than 1.5 m (Becker 1983). Adult burbot tend to move offshore to deeper waters (i.e., hypolimnion zone) and return to littoral regions during the autumnal decline in water temperatures (Bruce 1974; Carl 1992; Edsall et al. 1993; Ford et al. 1995; Kirillov 1988; Lawler 1963; Morrow 1980; Scott and Crossman 1973). In shallow water, especially where the bottom is brightly illuminated, burbot may seek overhead cover during the day and are sometimes found amongst aquatic plants (Edsall et al. 1993). The loft habitat provided by the tops of boulders is also a preferred resting area for adults (Edsall et al. 1993). Burbot feed on benthic invertebrates initially, moving to an exclusively fish diet once they reach a size greater than 500 mm (AGRA 1999).

3.2.1.3 American eel (*Anguilla rostrata*)

The American eel is distributed from south to western Greenland, southward from Hamilton Inlet, southward along the western coast of the Atlantic Ocean, throughout the Gulf of Mexico to the northern portion of the east coast of South America (Scott and Scott 1988). They have been reported throughout Newfoundland and along the south-eastern coast of Labrador as far north as Hamilton Inlet (Scott and Crossman 1998). The American eel is catadromous spending most of its life in freshwater and estuaries but migrating to sea to spawn. Eels typically begin their spawning migration between early summer and early fall depending upon location (COSEWIC 2006).

Eels spawn in the Sargasso Sea, with peak spawning occurring in mid-winter between February and July (Scott and Scott 1988). Although the depth at which spawning occurs is not known, evidence suggests that eels spawn in the upper few hundred metres of the water column (Kleckner et al. 1983). Adult eels presumably die after spawning (Scott and Crossman 1998).

During the freshwater phase of their life cycle, eels move into streams, rivers and muddy or silt-bottomed lakes (Scott and Scott 1988). Eels can be very mobile and may gain access to ponds and lakes, which appear unavailable to them, by using very small watercourses or by moving overland through wet grass (Scott and Scott 1988). Being nocturnal, they typically spend the day hiding under rocks and logs or buried in the mud. Investigations on diet composition of eels suggest that American eels rely heavily on benthic organisms and fishes as food sources (Scott and Crossman 1998). There are indications that a proportion of eels remain in brackish estuaries and do not enter freshwater (COSEWIC 2006). In Newfoundland, eels typically migrate to sea after spending 11 years in freshwater (Scott and Scott 1988).

Recent concern regarding population decreases in the Great Lakes has prompted the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to designate the American eel as a Species of Concern in 2006 (COSEWIC 2006). This designation is defined as a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats. Currently, the Species at Risk Act has not designated this species and therefore no legal protection for this species exists. The reason for the designation has been indicators of the status of the total Canadian component of this species are not available. Indices of abundance in the Upper St. Lawrence River and Lake Ontario have declined by approximately 99 percent since the 1970s (COSEWIC 2006). The only other data series of comparable length (no long-term indices are available for Scotia/Fundy, Newfoundland and Labrador) are from the lower St. Lawrence River and Gulf of St. Lawrence, where four out of five time series declined (COSEWIC 2006). Because the eel is panmictic (i.e., all spawners form a single breeding unit), recruitment of eels to Canadian waters would be affected by the status of the species in the United States as well as Canada (COSEWIC 2006). Prior to their declines, eels reared in Canada comprised a substantial portion of the breeding population of the species (COSEWIC 2006).

The collapse of the Lake Ontario and Upper St. Lawrence component may have significantly affected total reproductive output, but time series of elver abundance, although relatively short, do not show evidence of an ongoing decline (COSEWIC 2006). Recent data suggest that declines may have ceased in some areas; however, numbers in Lake Ontario and the Upper St. Lawrence remain drastically lower than former levels, and the positive trends in some indicators for the Gulf of St. Lawrence are too short to provide strong evidence that this component is increasing (COSEWIC 2006). Possible causes of the observed decline include habitat alteration, dams, fishery harvest, oscillations in ocean conditions, acid rain and contaminants (COSEWIC 2006).

3.2.1.4 Alewife (*Alosa pseudoharengus*)

Alewife can be found from southern Labrador to north-eastern Newfoundland (Scott and Scott 1988) southward to northern South Carolina (Berry 1964) possibly as far south as Florida (Rulifson and Huish 1982; Williams and Grey 1975).

They occur in both anadromous and landlocked forms. Anadromous alewives spend most of their adult lives at sea, only entering freshwater to spawn in lakes and quiet stretches of rivers above tidal influences (Grant and Lee 2004).

Spawning runs are typically dictated by temperature (water temperatures typically ranging from 12 to 16°C) and usually occur in mid-May or June (Grant and Lee 2004). Hatching can take as little as 2 days at 29°C (Edsall 1970), or as long as 15 days at 7.2°C (Grant and Lee 2004). After hatching YOY remain close to their spawning site until they migrate to the sea in late fall or early winter (Grant and Lee 2004).

Adults will only enter freshwater to spawn and will then return to coastal waters in the vicinity of their natal nurseries. Fish may require 4 to 10 years to reach maturity (Grant and Lee 2004).

3.2.1.5 Banded killifish (*Fundulus diaphanous*)

This killifish can be found along the eastern seaboard from South Carolina to the Maritimes and the west through southern Canada to the Red River, Manitoba and the Yellowstone River in Montana (Scott and Crossman 1998; Scott and Scott 1988). Although widely distributed in the Atlantic provinces it has only been reported in a few locations in Newfoundland, specifically in the vicinity of Stephenville Crossing, Freshwater Pond on the Burin Peninsula (Gibson et al. 1984; Scott and Crossman 1964; Scott and Crossman 1998; Scott and Scott 1988), and the Indian Bay watershed (Chippett 2003; Van Zyll de Jong et al. 1999) whereas the species has not been reported in Labrador.

It is considered a freshwater resident, even though it is euryhaline and salinity tolerant (Houston 1990; Scott and Scott 1998). Spawning typically takes place between April and May with a preferred temperature of 21°C (Carlander 1969; Richardson 1939; Scott and Crossman 1998). Gibson et al. (1984) reported females collected from Freshwater Pond in southeastern Newfoundland were in spawning condition in mid to late summer, indicating delayed spawning with respect to other localities in Newfoundland.

Spawning areas are selected by males and are typically located in shallow weedy pools (Scott and Crossman 1998) with males spawning individually with females (Grant and Lee 2004). The eggs, which are attached to the female by an adhesive thread, become detached after fertilization and stick to vegetation (Scott and Crossman 1998). Eggs hatch in 11 or 12 days with water temperatures between 22 and 27°C (Cooper 1936). Fry are 6 to 12 mm in length (Auer 1982) and will reach a length of 20 to 64 mm in their first year (Smith 1952; Trautman 1981).

Adults are usually found in schools and prefer shallow water with sand, gravel, or detritus covered bottoms near patches of submerged aquatic plants (Houston 1990; Keast et al. 1978; Killgore et al. 1991; Killgore et al. 1989; Page and Burr 1991; Rozas and Odum 1987; Scott and Crossman 1998). Although there is no information on seasonal movements, its distribution is thought to be related to salinity and temperature preferences as well as prey availability (Fritz and Garside 1974; Garside and Morrison 1977; Griffith 1974; Houston 1990; Weisberg 1986).

Banded killifish reach sexual maturity by end of their first year (Carlander 1969) or by age 2 (Keast and Eadie 1984; Portt et al. 1988).

It should be noted that the banded killifish, Newfoundland population, is listed as a species of special concern under the *Species at Risk Act* (SARA). The banded killifish is also listed under the *Newfoundland and Labrador Endangered Species Act* as a vulnerable species. During the literature review there were no records of banded killifish occurring within or near any watersheds which may potentially interact with the proposed transmission corridor.

3.2.1.6 Mummichog (*Fundulus heteroclitus*)

Mummichog can be found in Atlantic coastal and brackish waters from south western Newfoundland (Liem and Scott 1966) to north eastern Florida (Scott and Crossman 1998). They are most commonly found in salt marsh flats, estuaries, brackish water ponds, and tidal areas, particularly where there is submergent or emergent vegetation (Abraham 1985; Scott and Crossman 1998; Scott and Scott 1988). They can tolerate short exposures to freshwater whereas prolonged exposure can cause death (Nead and Buttner 1987).

Spawning usually begins in late spring and ends in late summer/early fall (Hardy 1978; Scott and Crossman 1988). Mummichog can spawn eight or more times in a single season, with each peak lasting five or more days (Taylor and DiMichele 1980). Spawning areas are selected by the female (Scott and Scott 1988) where eggs can be deposited on sand and mud substrates (Taylor 1986), algal mats (Pearcy and Richards 1962), or aquatic plants (Able and Castagna 1975; Day and Taylor 1981; Taylor 1986; Taylor et al. 1979). Northern populations prefer to spawn in sand while most southern populations utilize plants or mussel shells (Taylor 1986).

Eggs occur in clutches of 10 to 100 and are buried several centimetres below the surface, near the high water mark (Taylor 1986). Bigelow and Schroder (1953) reported that incubation usually takes 9 to 18 days depending on temperature. Incubation in the wild was reported to require 7 to 8 days at 22 to 34^{o}C (Taylor et al. 1977).

Larvae range from 4 to 7.7 mm in length (Hardy 1978) and remain in the intertidal zone for 6 to 8 weeks after hatching (Taylor et al. 1979). Information on the habitat requirements of juvenile mummichog is lacking however, within Newfoundland they have been found in a stagnant backwater area of an estuary at a depth of 1 m over mud substrate devoid of vegetation, and a small lagoon with a dense growth of eelgrass and soft mud substrate (Dickinson 1974). They typically reach sexual maturity at 2 years (Coad et al. 1995).

3.2.1.7 Lake chub (*Couesius plumbeus*)

Lake chub occur throughout the Churchill River system in Labrador (Backus 1951; Black et al. 1986). Specimens have been caught in the river's main stem (Ryan 1980) and in several of its tributaries including Lower Brook, Elizabeth River, Cache River, Pinus River and Dominion Lake (Beak 1980). They are apparently absent from rivers in southern Labrador and insular Newfoundland (Black et al. 1986). In north-western Canada and Alaska, the lake chub has been found in both clear and turbid waters of lakes and streams (McPhail and Lindsey 1970), while in Labrador they have been reported to occur mostly in streams and lake-like expansions of rivers (Backus 1951, 1957). In central Canada, lake chub appear to be common in tributary streams only during spring spawning migrations, returning to the lake once water temperatures exceed 16°C (Brown et al. 1970). They have been known to tolerate a wide variety of conditions, ranging from clear to turbid waters and from cool northern lakes to the outlets of hot springs (Becker 1983; McPhail and Lindsey 1970; Scott and Crossman 1998).

Lake chub usually undergo spawning migrations from lakes to tributary streams in May or June, shortly after ice-out (Brown et al. 1970; Bruce and Parsons 1976; Burgess 1978; McPhail and Lindsey 1970; Morrow 1980; Scott and Crossman 1973). In rivers and small streams, spawning has been observed in shallow water over rocky or gravel bottoms as well as amongst large rocks (McPhail and Lindsey 1970; Morrow 1980). In lakes, spawning typically takes place along shallow rocky shores and may be observed over a variety of substrates including silt, leaves, gravel, cobble and rubble (Brown et al. 1970). Fry have been observed utilizing submergent vegetation for cover (Brown et al. 1970), while YOY and juveniles are generally found over silty, sandy or gravel/cobble substrates (Mecum 1984).

Adults are commonly found in lakes in the southern portion of their range, with more northern populations preferring large lake-like expanses of rivers (Becker 1983; Scott and Crossman 1998). Within the Churchill River system, adults are more prevalent in the upper stretches of rivers with shallow gradients and more pools, lakes and ponds (AGRA 1999). Along shores, lake chub have been observed over a mainly sand bottom interspersed with large boulders (Becker 1983). Although it is essentially a shallow-water species (Becker 1983), lake chub have been reported to move into deeper and cooler regions of lakes during thermal summer stratification (Burgess 1978; Morrow 1980; Scott and Crossman 1973). In Labrador, lake chub were found to feed mainly on benthic invertebrates (Ryan 1980).

3.2.1.8 Longnose dace (*Rhinichthys cataractae*)

The longnose dace is widely distributed throughout north-central North America, yet in the Canadian Atlantic provinces, it has only been reported along the Churchill, Pinus and Naskaupi river systems in south-western Labrador (AGRA 1999; Beak 1980; Black et al. 1986; Scott and Crossman 1973). Although the longnose dace is typically a stream inhabitant in Labrador (Ryan 1980), it has also been reported in lakes throughout its geographical range (Scott and Crossman 1973).

Spawning normally occurs in riffles over a gravel substrate in spring (Bartnik 1970; Brown et al. 1970; McPhail and Lindsey 1970; Ryan 1980; Scott and Crossman 1973), but may also occur in lakes (Brazo et al. 1978; Gee and Machniak 1972). In lakes, spawning occurs along wave-swept inshore areas (Brazo et al. 1978) over a cobble/rubble/boulder substrate (Gee and Machniak 1972). Nests are not built however; territories are often established with one parent guarding the demersal and adhesive eggs which are deposited in groups among the substrate (Bartnik 1970, 1972; McPhail and Lindsey 1970). Young are pelagic upon hatching and occupy still, shallow waters close to shore with overhanging vegetation for approximately their first four months of life (Gee and Machniak 1972; McPhail and Lindsey 1970; Ryan 1980; Scott and Crossman 1973). They feed primarily on algae, diatoms, zooplankton and fish scales (Edwards et al. 1983). Gee and Machniak (1972) suggested that YOY move to deeper areas of rivers predominated by swift currents upon attaining a size of 30 mm (total length).

In streams, adults seem to prefer areas with aquatic vegetation and overhead cover (Hubert and Rahel 1989) and may exhibit similar preferences in lake habitats. However, field surveys by AGRA (1999) in the Churchill River found they generally inhabited clear, fast flowing, streams with limited cover. Adults have been found in turbulent, inshore regions of lakes over boulder or gravel bottoms throughout the summer (Brazo et al. 1978; Smith 1979), but generally move into deeper, cooler waters as water temperatures increase (Scott and Crossman 1973). Brazo et al. (1978) reported that adult longnose dace feed primarily on terrestrial insects that are presumably washed into the surge zone of the lake by wind and turbulent wave action, as well as benthic organisms and fish eggs.

3.2.1.9 Pearl dace (*Semotilus margarita*)

The pearl dace has been reported in Labrador in the Churchill River (Scott and Crossman 1973) although their distribution and population appears to be very limited in this area as several comprehensive fisheries surveys did not yield any specimens (Anderson 1985; Beak 1980; Ryan 1980). However, three specimens were caught by AGRA (1999) in the Cache River, a Churchill River tributary. There have been no reported occurrences in insular Newfoundland (Scott and Crossman 1973). In southern Canada, the pearl dace typically inhabits cool, clear headwater streams, while in northern areas it is also found in ponds, small lakes, bog drainage streams and stained, acid waters of beaver ponds (Scott and Crossman 1973; Tallman et al. 1984). Despite the reported abundance of pearl dace in most streams and lakes in northwestern Ontario (Tallman et al. 1984), they were rarely found in lakes containing northern pike (Beamish et al. 1986), suggesting that pearl dace represent an important forage species in lakes.

Spawning takes place in spring during ice-off in tributary streams or in vegetation on the periphery of lakes in early spring (Tallman et al. 1984). Spawning in beaver ponds and small lakes is typically over soft organic substrates, while stream spawning occurs at depths of about 60 cm over a sand or gravel bottom in wide ranging currents (McPhail and Lindsey 1970). Males do not build nests, but appear to defend territories (Scott and Crossman 1973). Investigations on diet composition suggest that pearl dace are omnivorous, consuming invertebrates, plant material and detritus (Carlander 1969; McPhail and Lindsey 1970; Tallman and Gee 1982; Tallman et al. 1984).

3.2.1.10 Northern pike (*Esox lucius)*

The northern pike has a circumpolar distribution in the northern hemisphere above 40° N latitude (Scott and Crossman 1998; Toner and Lawler 1969). Its native North American range includes Alaska, most of Canada south of the Arctic Circle, the drainages of the Missouri and Ohio Rivers, and the Great Lakes (Inskip 1982). In Labrador pike occur throughout the Churchill River system (Anderson 1985). Beak (1980) gill netted specimens on Minipi Lake and Dominion Lake and speculated that the species probably occurs on most lakes and ponds in headwater systems of the lower Churchill tributaries. Specimens were also angled at the mouths of tributaries where slow flowing deltas occur (Lower Brook and Elizabeth River) (AGRA 1999; Scruton 1984). Ryan (1980) found northern pike along the main stem of the lower Churchill River from Churchill Falls to Muskrat Falls, being especially abundant between Gull Island and Muskrat Falls, with specimens also collected below Muskrat Falls (AGRA 1999).

Northern pike are not adapted to strong currents and occur most frequently in lakes (Inskip 1982) where they inhabit backwaters and pools (Christenson and Smith 1965; Crossman 1978). In Canada, pike generally inhabit clear, cool to moderately warm, slow, meandering, heavily vegetated rivers or warm, weedy bays of lakes (Becker 1983; McPhail and Lindsey 1970; Scott and Crossman 1998). Pike inhabit areas containing aquatic vegetation throughout all stages of their life cycle (Ford et al. 1995; Inskip 1982) and have been found within a wide range of turbid waters, although they are much more common in clear and only slightly turbid water (Becker 1983).

Northern pike are early spring spawners, with males and females moving into flooded vegetated areas immediately after spring thawing. They generally spawn during daylight hours in shallow, heavily vegetated floodplains of rivers, marshes, and lakes (Bradbury et al. 1999; Clark 1950; Franklin and Smith 1963; McCarraher and Thomas 1972; Scott and Crossman 1998). Spawning occurs over a variety of substrates, but rubble beds covered with a layer of silt and decaying vegetation are commonly utilized (Ford et al. 1995). According to Casselman and Lewis (1996), the preferred spawning substrate is well oxygenated detritus and elaborate root systems of emergent vegetation, but spawning has also been reported to occur over sand and mud substrates (Holland and Huston 1984; Scott and Crossman 1998). Adhesive eggs are attached to vegetation where they incubate for only twelve to fourteen days (AMEC 2007). The newly hatched young (6 to 8 mm in length) remain attached to the vegetation and feed on the yolk sac (AMEC 2007). After 6 to 10 days, the yolk is absorbed and the free swimming young feed heavily on zooplankton and immature aquatic insects (AMEC 2007).

Within 7 to 10 days the juveniles begin to feed on small fish and by the time pike reach 50 mm in length, fish have become the primary diet (AMEC 2007). Juveniles are typically found over a mud or silt bottom at depths less than 2.0 m with abundant submerged vegetation (Ford et al. 1995; Inskip 1982). Adult pike require cover to enable their 'ambush' style of foraging, usually in the form of aquatic vegetation, tree stumps or fallen logs (Inskip 1982). However, complete vegetative cover is considered to be sub-optimal for adult pike foraging efficiency (Ford et al. 1995; Savino and Stein 1989; Wright 1990), with most adults preferring areas containing open water interspersed with moderately abundant vegetation (Casselman and Lewis 1996; Grimm and Backx 1990; Inskip 1982; Randall et al. 1996). Typically, large pike inhabit deeper unvegetated waters more often than smaller ones (Chapman and Mackay 1984; Grimm 1989). Outside of vegetation, the preferred habitat of large pike is a 'broken bottom' (Grimm 1989). Both juvenile and adult pike have been shown to avoid habitat predominated by sand (Eklov 1997).

3.2.1.11 Arctic charr (*Salvelinus alpinis*)

The Arctic charr has the most northerly distribution of all anadromous and freshwater salmonids. Although charr are found in streams, (and/or at sea) lacustrine populations are most common (Klemetsen et al. 2003). Spawning of anadromous Arctic charr in Newfoundland occurs from mid-October to mid-November but may occur two weeks earlier in Labrador (Scruton et al. 1997). Spawning substrates vary and can range from mud to boulders however, a gravel/cobble substrate with depths ranging from 0.3 to 120 m is usually utilized (Hindar and Jonsson 1982; Kircheis 1976; Rubin 1987, 1993; Rubin and Buttiker 1992). YOY are normally found in mid-water schools along the shores of lakes with individuals occasionally observed found hiding among stones (Moore 1975). Juveniles tend to inhabit the profundal zone (commonly at depths greater than six meters) of lakes (Halvorsen and Jorgensen 1996; Jorgensen et al. 2000; Klemetsen et al. 1989; Naesje 1995) with a structurally complex substrate (e.g., cobble, rubble, boulders) (L'Abee to Lund et al. 1993; Sandlund et al. 1987). At 3 to 4 years of age, juveniles undergo an ontogenetic habitat shift from benthic to pelagic areas (Johnson 1980; L'Abee to Lund et al. 1993; Naesje 1995; Sandlund et al. 1987), with adults performing seasonal benthic to pelagic movements to follow shifting food (i.e., crustaceans, to zooplankton) density (Hegge et al. 1989; Hindar and Jonsson 1982; L'Abee to Lund et al. 1993; L'Abee to Lund and Saegrov 1992; Naesje 1995).

3.2.1.12 Atlantic salmon *(Salmo salar*)

Atlantic salmon are distributed throughout the northern portion of the Atlantic Ocean from Portugal to Norway in the east, throughout southern Iceland and Greenland, and from Hudson Bay to the Connecticut River in the west (Scott and Scott 1988). In Canada, the anadromous form is distributed throughout eastern Quebec, the Maritimes and Newfoundland and Labrador (Scott and Scott 1988). Atlantic salmon are found throughout Newfoundland and southern Labrador (Scott and Crossman 1973; Scott and Scott 1988) and have been reported in coastal rivers as far north as the Fraser River (Black et al. 1986). Throughout Newfoundland and Labrador, Atlantic salmon occur in both anadromous and landlocked populations (Smith 1988). Anadromous salmon have been captured at sea up to the northern tip of Labrador (Power and Cressman 1975).

Landlocked salmon, commonly called ouananiche, are the dominant species in some Newfoundland lakes where they may exist as either normal or dwarf forms (Smith 1988). Ouananiche are the predominant form of the species which occupies the Churchill River watershed, although sea run are reported in small numbers in the lower Churchill River below Muskrat Falls, and in the Traverspine River (Beak 1980; Ryan 1980). Muskrat Falls is considered a physical barrier to the movement of the species (Bruce et al. 1975; Ryan 1980). They are found throughout the main stem of the Churchill River, being distributed from Churchill Falls to Gull Rapids as well as between Muskrat Falls and Gull Rapids (AGRA 1999; Beak 1980; Ryan 1980).

Ouananiche spawning typically occurs between late September and early November, depending on water temperature, with females ascending tributaries to prepare redds (nests) (Grant and Lee 2004). In Newfoundland, lake spawning has been reported to occur over a gravel substrate (Leggett 1965) at depths of 0.5 to 1.3 m (Cowan and Baggs 1988). Lake spawning has also been observed along shorelines (Leggett 1965) as well as near areas of moving water, usually above outlet streams and near the mouths of inlet streams (Einarsson et al. 1990; Harvey and Warner 1970; Leggett 1965). Milt and eggs (1,500 eggs per kg of female) are deposited in the redd and the female then covers the eggs, which range in size from 5 to 7 mm, with a layer of gravel (Scott and Scott 1988) When spawning is complete, the adults return to the lake. Incubation lasts for about 110 days (depending on temperature), with hatching generally occurring in April (Scott and Scott 1988). The larvae, or sac fry, remain in the redds until the yolk sac is absorbed, after which they emerge in May or June (Scott and Scott 1988).

For the next 2 or 3 years, the parr remain in stream habitat, preferring rapid water (Scruton et al. 1997). They then move to a lacustrine habitat and continue to grow rapidly (Harvey and Warner 1970; Leggett 1965; Leggett and Power 1969; Wiseman 1971). Jorgensen et al. (2000) found that juveniles utilized the littoral zone throughout the entire ice free season with smaller individuals occupying areas closer to the bottom than larger ones. Ouananiche mature at 2 to 3 years of age (Lee 1971; Leggett 1965; Leggett and Power 1969) and may live for up to 10 years in Newfoundland (Leggett 1965). Adults are generally pelagic and feed heavily on pelagic and surface organisms during June and July, but as water temperatures increase during the summer, they move to deeper, cooler water and appear to feed more on benthic organisms (Leggett 1965). Scruton et al. (1997) have shown that ouananiche will overwinter in deep warmer waters of reservoir systems as well as fast to flowing ice free waters of inlets, outlets and canals.

3.2.1.13 Brook trout (*Salvelinus fontinalis*)

The brook trout is widely distributed throughout Newfoundland and Labrador (Scott and Crossman 1973), at least as far north as the Hebron Fiord (Black et al. 1986), where they have been reported to make extensive use of clear, cool (less than 20°C) lake habitats (Ryan and Knoechel 1994). Brook trout are known to have both landlocked and anadromous populations throughout Newfoundland and Labrador (Scott and Crossman 1964, 1998). Anadromous populations may spend 1 or 2 months feeding at sea in relatively shallow water, close to their natal stream, while others spend their entire life in freshwater (Morrow 1980; Power 1980; Ryan 1988; Scott and Crossman 1964; Scott and Scott 1988).

Within Newfoundland and Labrador, lakes and ponds are utilized for spawning, overwintering and feeding (Cowan and Baggs 1988; Dempson and Green 1985; McCarthy 1996). Raleigh (1982) characterized optimal brook trout riverine habitat as clear, cold spring-fed streams with a silt-free rocky substrate in riffle to run areas; an approximate 1 to 1 pool to riffle ratio with areas of slow, deep water, well vegetated stream banks, abundant instream cover, and relatively stable water flow, temperature regimes and stream banks. Brook trout spawning has been observed in a variety of habitats and substrates, including: lake shorelines (Cowan and Baggs 1988; Dempson and Green 1985; Ford et al. 1995; Fraser 1982; Wiseman 1971; Wurtsbaugh et al. 1975), sandy and heavily silted substrates (Carline 1980; Chisholm et al. 1987; Webster 1962) and over aggregations of waterlogged sticks, woodchips and debris (Fraser 1982). This generalist spawning behaviour appears to be less dependent on substrate and more strongly correlated to the presence of groundwater upwelling (Morrow 1980), particularly for mainland populations. Groundwater upwelling is beneficial in that it protects eggs from freezing and carries dissolved oxygen to and metabolic wastes away from, developing embryos (Curry and Noakes 1995; Fraser 1982, 1985; Matthess 1982; Reiser and Wesche 1977).

Alevins remain in the nest until the yolk sac is absorbed (Ryan 1988; Scott and Scott 1988) and upon emergence disperse over gravel/cobble substrates in the shallow (less than 2 m) littoral zone, usually residing within 0.5 m of the bottom (Curry and Noakes 1995; Ford et al. 1995; Halvorsen and Jorgensen 1996; Hosn and Downing 1994; Pepper et al. 1985; Wurtsbaugh et al. 1975). Wesche (1980) reported that YOY and small juveniles (less than 15 cm in length) were associated more with instream cover (mostly rubble substrate) than overhead stream bank cover, and that an area of cover at least 15 percent of the total stream width is required. Boussu (1954) reported that aquatic vegetation is an important form of cover for young salmonids. Cunjak and Green (1983) observed in two Avalon Peninsula streams that YOY and juveniles showed a strong preference for cover (where available), but that the presence of competing species and/or lack of available cover can result in shifts of habitat utilization. In Newfoundland, juvenile brook trout typically move into lakes at 1 to 3 years of age (O'Connell and Dempson 1996; Ryan and Knoechel 1994) and move to deeper, cooler, waters during the warmer summer months (Venne and Magnan 1995).

Gibson et al. (1993) stated that in an Avalon Peninsula stream, brook trout biomass had a negative relationship to maximum flood height, indicating that habitats with more stable flows had higher production. Adults are often found in association with cover, which is sometimes considered a factor limiting to production (Boussu 1954; Cunjak and Power 1986; Fausch and White 1981; Hunt 1971; Lambert and Hanson 1989; Lewis 1969). Cover can be provided by overhanging vegetation, submerged vegetation, undercut banks, instream objects (woody debris, roots, and large boulders), rocky substrates, depth, and water surface turbidity (Becker 1983; Ford et al. 1995; Giger 1973; McPhail and Lindsey 1970; Raleigh 1982). Enk (1977) reported that in two Michigan streams, trout biomass and number of adults were significantly correlated with bank cover. Cunjak and Green (1983) reported that in two Avalon Peninsula streams, as brook trout increase in size they tend to move from shallow stream margins to deeper water (pools) with undercut banks and other forms of cover.

3.2.1.14 Brown trout (*Salmo trutta)*

The native range of the brown trout is European and Scandinavian based, including Germany, Denmark and into the Baltic Sea watershed (Scott and Scott 1988). Brown trout were first introduced to Newfoundland from Europe in the late 1800s on the Avalon Peninsula (Grant and Lee 2004). The species has both anadromous and non-anadromous forms (Grant and Lee 2004). They can spend two to four months or two or more years at sea before returning to spawn (Jensen 1968; Jonsson and Gravem 1985; Jonsson and Jonsson 2002; O'Connell 1982; Ryan 1988; Scott and Scott 1988; Went 1962). When they return to freshwater, brown trout do not always return to their place of origin (Ryan 1988). This cold-water species prefers clear, cool, well-oxygenated streams and lakes but is tolerant to somewhat warmer and more turbid water than other salmonids, such as brook trout (Bradbury et al. 1999). Spawning occurs between early October and early December (Bradbury et al. 1999). Brown trout spawn within shallow gravel sections of streams and have been noted to occasionally spawn along the rocky shorelines of lakes (Bradbury et al. 1999).

Eggs hatch between mid-April and mid-May and within a week have dispersed to suitable habitats (Grant and Lee 2004). During their first summer fry remain in their natal stream and tend to move from riffles to pools during winter (Elliot 1986). In Newfoundland they reach maturity at 2 to 6 years of age (Lee 1971; Liew 1969; MacKinnon 1998; O'Connell 1982).

3.2.1.15 Lake trout (*Salvelinus namaycush*)

Lake trout, the largest of the charr, are widely distributed in northern North America. They are found throughout southern Labrador, except for the south-eastern corner, but do not occur in insular Newfoundland (Black et al. 1986; Scott and Crossman 1973). In the south, lake trout prefer cool (less than 10°C), deep lakes, but in the north where temperatures are lower, they may inhabit shallow lakes and large rivers (McPhail and Lindsey 1970; Ryan 1988). In Labrador lake trout occur throughout the Churchill River watershed, but are more prevalent in the upper reaches (AGRA 1999; Anderson 1985). Beak (1980) reported the species present in the main stem only above Gull Island Rapids.

Lake trout usually spawn in shallow inshore areas of lakes, rarely in streams (Ford et al. 1995; Machniak 1975; Martin and Olver 1980). In most areas of Canada, spawning occurs in late summer to early fall (Ford et al. 1995; Scott and Crossman 1973), mainly in September or October in Labrador (Scruton et al. 1997). Lake trout have been reported to spawn over a great variety of depths, ranging from 0.1 to 5 m in shallower lakes (DeRoche 1969; Martin and Olver 1980; Normandeau 1969), to 5 to 10 m in larger lakes (Ford et al. 1995; Martin and Olver 1980; Thibodeau and Kelso 1990). There are also reports of spawning occurring at depths up to 100 m as well (Thibodeau and Kelso 1990). The spawning substrate is usually composed of large gravel (greater than 2 cm in diameter), cobble and rubble interspersed with boulders and is generally free of sand, mud, detritus and vegetation (DeRoche 1969; Ford et al. 1995; Marcus et al. 1984; Martin and Olver 1980; McPhail and Lindsey 1970; Normandeau 1969; Scott and Crossman 1973; Thibodeau and Kelso 1990).

Newly hatched larvae typically undergo early development within the protection of rocky substrate on the spawning grounds (Machniak 1975). Within a month of emergence, fry begin moving from the spawning area towards their nursery lake (Ford et al. 1995; Machniak 1975; Paterson 1968). In lake spawning populations, they may remain in shallow areas for several weeks to three months before moving to deeper water when temperatures exceed 15°C (Ford et al. 1995; Martin and Olver 1980; Morrow 1980; Peck 1982; Scott and Crossman 1998). Juveniles and adults generally have similar habitat, generally preferring boulders in shallower waters until temperatures exceed 10°C when they retreat to depth (DeRoche 1969). Diet consists primarily of fish, supplemented by insects and small mammals (AGRA 1999). Sexual maturity is thought to occur at a relatively old age. When Parsons (1975) sampled the Ossokmanuan Reservoir in western Labrador they found no sexually mature lake trout less than nine years of age, and Ryan (1980) concluded that lower Churchill River fish reach maturity at seven years of age.

3.2.1.16 Lake whitefish (*Coregonus clupeaformis*)

Lake whitefish are widely distributed throughout North America from the Atlantic coast, across Canada and the northern United States, to British Columbia, the Yukon Territory, and Alaska (Scott and Crossman 1998). They are distributed throughout southern Labrador (Beak Consultants Limited 1979; Black et al. 1986; Bruce 1974; LGL Limited 1999; Parsons 1975; Scott and Crossman 1998). There are normal and dwarf forms of lake whitefish within the lower Churchill River in Labrador. Although they are primarily found in lakes, they are relatively abundant in the main stem of the Churchill River, as well as the adjoining lakes and ponds within its watershed (Anderson 1985).

Lake whitefish undertake migrations to spawning grounds, ascending rivers or moving into the shallows of lakes when water temperatures cool to 4.5 to 10°C (Ford et al. 1995; MacKay 1963). Optimal growth and development occurs at 0.6°C, with 99 percent mortality at temperatures of 10°C and greater (AGRA 1999). There is some evidence that lake whitefish return to the same spawning grounds year after year (Ford et al. 1995; Machniak 1975). In Labrador, spawning migrations are reported from early September to mid-October (Scruton et al. 1997). River spawners generally utilize shallow (0.1 to 1.0 m), (Ford et al. 1995) riffles or rapids with a gravel/cobble substrate (Fenderson 1964; Machniak 1975), while lake spawners tend to utilize sandy substrates (Bidgood 1972; McCrimmon 1956). Spawning occurs in schools, with eggs being randomly deposited and remaining in the spawning area until hatching in mid May to mid June (Grant and Lee 2004). Scott and Crossman (1973) note that more northerly populations tend to produce fewer eggs. In the extreme northern limits of the range, individuals may only spawn once every two or three years (Grant and Lee 2004). Egg counts can vary greatly depending on a fish's size, with specimens from the Ossokmanuan Reservoir in western Labrador yielding anywhere from 967 to 20,963 eggs per fish (Bruce and Parsons 1976).

Upon hatching, whitefish larvae tend to aggregate along steep shorelines (Faber 1970), although they have been observed at depths of 0.3 to 1 m near aquatic vegetation (Reckahn 1970). Whitefish growth is relatively rapid, with the young feeding mainly on cladocerans and copepods (AGRA 1999). By early summer, young leave the shallow inshore waters and enter deeper lake waters (Scott and Crossman 1998). The diet of adult whitefish consist of aquatic insects and larvae, supplemented by other fish and even their own eggs (Scott and Crossman 1998). Outside of spawning, adult whitefish appear to have no preference for substrate type (Ford et al. 1995). In Labrador, the Churchill River watershed lake whitefish reach maturity over a range of 3 to 9 years old (Anderson 1985) and, as a species, tend to be long lived, with individuals reaching ages of 28 years (Grant and Lee 2004).

3.2.1.17 Rainbow trout (*Oncorhynchus mykiss*)

Rainbow trout were first introduced to Long Pond, Newfoundland in 1887 (Frost 1938; Scott and Crossman 1964). Stocking of other ponds in Newfoundland (Notre Dame Bay and Corner Brook areas) continued till the early 1900s (Andrews 1965; Chadwick and Bruce 1981; Porter 2000; Scott and Crossman 1964).

Raleigh and Duff (1980) stated that the most optimal rainbow trout habitat is clear cold water; a silt free rocky substrate in riffle to run areas; an approximately 1 to 1 pool-riffle ratio, with areas of slow deep water; well vegetated stream banks; abundant instream cover; and relatively stable water flow, temperature regimes, and stream banks.

Spawning occurs in spring from late March to mid May depending on location and weather conditions (Frost 1938; Frost 1940; Scruton et al. 1997). It can occur in tributary streams, larger streams, and lakes (Hartman et al.

1962; Lindsey et al. 1959; Scott and Crossman 1998) but is usually characterized by fine gravel in a riffle above a pool (Scott and Crossman 1998; Scott and Scott 1988). Depending on temperature, hatching occurs 45 to 75 days after fertilization (Calhoun 1944; Lea 1968). After emergence from the gravels the young move from spawning to rearing/riffle areas (Scott and Crossman 1998).

Sexual maturity is usually attained at 3 to 5 years, with males maturing a year earlier than females (Scott and Crossman 1998; Scott and Scott 1988). However in Newfoundland maturity is reached between 3 to 4 years of age (Lee 1971).

3.2.1.18 Round whitefish (*Prosopium cylindraceum*)

Round whitefish are widely distributed in lakes and ponds throughout their southern range, rivers in their northern range as well as brackish waters, from northern North America to eastern Asia (Becker 1983; McPhail and Lindsey 1970; Scott and Crossman 1998). Its range encompasses northern New Brunswick, Labrador, and Ungava west through Quebec, Ontario, and north westward from northern Manitoba through the Northwest Territories and northern British Columbia (Scott and Crossman 1998). Round whitefish have been reported in Labrador in the Churchill River system residing in cool ponds, streams and rivers (AGRA 1999; Beak Consultants Limited 1979; Ryan 1980). However, they are considered rare in this system (Anderson 1985). It is likely that round whitefish utilize the lower sections of some of the lower Churchill River tributaries for spawning and rearing habitat (AGRA 1999). In a recent study by AGRA (1999), they were captured in Lower Brook but were not captured in the main stem of the Churchill River downstream of Gull Rapids.

According to Scott and Crossman (1973), round whitefish are fall spawners (October to December). Spawning can take place in the inshore areas of lakes, at river mouths, or occasionally in rivers (Bradbury et al. 1999; McPhail and Lindsey 1970; Scott and Crossman 1998). Bryan (1973) reported that in Yukon Territory stream spawning occurred over a variety of substrates ranging from mud to gravel and boulders, with a preference for gravel substrates. In contrast to the lake whitefish, spawning is conducted in pairs, not in schools (Grant and Lee 2004). Normandeau (1969) indicated that females of the species can produce up to 20,000 eggs. The eggs remain in the spawning substrate until hatching occurs the following April (Bradbury et al. 1999).

Upon hatching the young remain on the bottom (Normandeau 1969) and disperse from the spawning area within 2 to 3 weeks (Morrow 1980). In Alaska, Suehanek et al. (1984) reported that young seek cobble or boulders, debris and overhanging vegetation at water depths ranging from 5 to 30 cm (optimal 5 to 15 cm) in relatively calm areas. Ryan (1980) reported that gillnet catches of mature specimens in the Churchill River system in Labrador were higher in fast-flowing sections than in steadies or backwaters. These distributions possibly indicate that juveniles prefer slow steadies and backwater habitat until they reach maturity, after which they prefer faster flowing sections of the main channel. According to Lee (1985), round whitefish tend to move into deeper and faster water as they grow. Suehanek et al. (1984) reported the optimal water velocity for adults was 0.6 to 0.9 m/s, with them utilizing the following cover types in order of most to least preferred: cobble and boulder, undercut banks, overhanging vegetation, debris/deadfall, submergent and emergent vegetation, rubble and large boulders.

Round whitefish are benthic and their diet consists mainly of benthic invertebrate larvae, insects and molluscs (Bradbury et al. 1999). The species has been noted to live up to 14 years (Grant and Lee 2004). Ryan (1980) indicates that the growth rates for round whitefish in the Churchill River are at an intermediate level when compared to results from other regions of North America.

3.2.1.19 Mottled sculpin (*Cottus bairdi*)

In eastern Canada, the mottled sculpin is confined to northern areas, occurring throughout the Churchill (AGRA 1999; Black et al. 1986) and Atikonak river systems (LGL Limited 1999) of Labrador, north through Ungava Bay, Quebec (Scott and Crossman 1998). Anderson (1985) reported that DFO surveys have identified sculpin from stomach contents of several species of fish (burbot, brook trout, lake whitefish, northern pike, lake trout) taken in the lower Churchill River main stem, as well as in the upper main stem of the river.

Mottled sculpin occur in cool, headwaters and, although typically a stream-dwelling species, they also inhabit large lakes (Becker 1983). Mottled sculpin are intolerant of high water temperatures and tend to occur in the coldest streams during the summer, usually with water temperatures between 11 and 16°C (Petrosky and Waters 1975). Spawning typically takes place in the spring, around April or mid-May (Scott and Crossman 1973), in the littoral zone (less than 1 m) of lakes under rocks and logs (Downhomer and Brown 1979; Lyons 1987; Ryan 1980; Savage 1963). Nesting is peculiar, with females depositing adhesive eggs on the ceilings of rocks, ledges or burrowed nesting sites (usually consists of small gravel) while in an inverted position (Downhomer and Brown 1979; Keenleyside 1979; Savage 1963; Scott and Crossman 1973), with the male subsequently guarding and aerating the eggs (Grant and Lee 2004).

Substrate preference tends to vary from study to study, possibly illustrating a generalistic or place-dependent, habitat utilization strategy. A study in the Mad River, Ontario, documents the occurrence of YOY on a mud bottom at depths of 5 to 25 cm (Scott and Crossman 1973). Studies in eastern Ontario and Wisconsin suggest that mottled sculpin prefer sandy substrates in both lakes and streams (Becker 1983; Emery 1973; Scott and Crossman 1973). Emery (1973) also reported mottled sculpin foraging at night in open, sandy areas. They may also utilize substrates comprised of a mixture of cobble, rubble and sand (Becker 1983; Greenberg 1991; Grossman and Freeman 1987; Scott and Crossman 1998; Van Snik-Gray and Stauffer 1999). Additional studies found that small sculpin were largely associated with cover, being located under rocks and logs (Becker 1983; Greenberg 1991; Lyons 1987).

3.2.1.20 Slimy sculpin (*Cottus cognatus*)

In eastern Canada, the slimy sculpin occurs in the Churchill and Fraser River systems of Labrador (Black et al. 1986; Scott and Crossman 1973) through most of Quebec and Ungava Bay (Scott and Crossman 1973). The species typically inhabits deep oligotrophic lakes, swift rocky-bottomed streams, areas of groundwater upwelling and headwater pools and riffles (Scott and Crossman 1998). In eastern Canada, the slimy sculpin frequents rocky or gravel streams and lake bottoms, and have been captured at depths ranging from 0.5 to 150 m (Brandt 1986; Mohr 1984, 1985; Scott and Crossman 1973; Wells 1980). However, the habitat utilized varies greatly depending upon on substrate and temperature (Scott and Crossman 1998). The slimy sculpin has been shown to have a very small home range and they do not migrate great distances (Morrow 1980).

Spawning occurs in May, shortly after ice-out over sand and gravel substrate in shallow sections of streams and lakes (Burgess 1978; McPhail and Lindsey 1970; Mohr 1984; Morrow 1980; Scott and Crossman 1973). The male selects the spawning site, which can be found under rocks, submerged logs, tree roots, or amongst large gravel or other foreign debris and is most common at depths less than 30 cm (Mohr 1985; Morrow 1980; Ryan 1980; Scott and Crossman 1973). In rivers, juveniles and adults are generally found in areas with cobble/rubble bottoms at velocities of less than 0.3 m/s (Van Snik-Gray and Stauffer 1999). In shallow lakes (0.5 to 1.5 m) they have been found over gravel and sand bottoms interspersed with rocks and boulders (Mohr 1984). Generally, as young slimy sculpin grow and mature, they shift from a shallow water habitat and nocturnal feeding to continuous activity in deeper water (Brandt 1986; Mohr 1985; Wells 1968). Diet mainly consists of benthic organisms (Mohr 1984; Wells 1980).

3.2.1.21 Rainbow smelt (*Osmerus mordax*)

Rainbow smelt are primarily an inshore anadromous species that occur within bays and estuaries from its northern limit in the Hamilton Inlet area of Labrador to New Jersey, but are rare in the Churchill River system (Anderson 1985). Landlocked smelt have been reported in many areas of insular Newfoundland (Grant and Lee 2004). Spawning has been reported in both lakes and rivers, with the female depositing adhesive eggs that become attached to the substrate which can be gravel (preferred), sand, mud, pebble, cobble, submerged logs and aquatic vegetation (Morrow 1980; Rupp 1965; Scott and Crossman 1998). Rainbow smelt are essentially a schooling, pelagic fish, inhabiting mid-water areas of inshore coastal waters (Leim and Scott 1966; Scott and Crossman 1998; Scott and Scott 1988). Smelt begin to school at about 19 mm in length, moving into shallow water during the night and returning to deeper channels during the day (Belyanina 1969).

3.2.1.22 Fourspine stickleback (*Apeltes quadracus*)

Fourspine sticklebacks are an euryhaline species only found on the east coast of North America, from the Gulf of St. Lawrence and Newfoundland south to Virginia (Scott and Crossman 1998; Scott and Scott 1988). In Newfoundland they have been found in the brackish and estuarine waters of the west coast (Scott and Crossman 1964; Van Vliet 1970), the western Avalon Peninsula (Garside 1970; Lewis 1978; Scott and Crossman 1964), and St. Mary’s Bay (Hanek and Threlfall 1970).

Spawning generally occurs in late spring or early summer in intertidal areas for anadromous species and along shorelines for freshwater dwellers (Scott and Crossman 1998; Scott and Scott 1988; Wootton 1976; Worgan and FitzGerald 1981). The males construct cup shaped nests out of branches or plant stems in which the female lays a clutch of 15 to 50 eggs which are then fertilized, aerated, and protected by the male (Grant and Lee 2004). The male may have more than one nest in the area or can be found placed on top of one another (Grant and Lee 2004).

Methven et al. (2001) found that YOY fourspine sticklebacks utilized shallow subtidal areas with small substrates as nursery grounds while Szedlmayer and Able (1996) observed them using eelgrass habitats within estuaries.

Little is known about the juvenile/adult stages of the fourspine stickleback but Scott and Scott (1998) reported that males have a one year lifespan while females may live to spawn the following spring.

3.2.1.23 Ninespine stickleback (*Pungitius pungitius*)

This is a circumpolar species which can be found in fresh and salt water habitats throughout the northern hemisphere, in North America, Europe, and Asia (Scott and Scott 1988). In coastal waters they are usually restricted to nearshore habitats (Scott and Scott 1988). In inland freshwater systems they can be found from the Arctic to the Mississippi River drainage and from Newfoundland in the east to Alaska in the west (Scott and Crossman 1998).

In summer, marine ninespine sticklebacks move to streams or brackish estuaries to spawn (Grant and Lee 2004). Spawning habitat is usually in shallow areas of low water velocity, dense aquatic vegetation with substrates consisting of mud and silt (McPhail and Lindsey 1970; Morrow 1980; Scott and Crossman 1998; Scott and Scott 1988; Wooton 1976), but can occur over sparsely vegetated areas with sand, gravel, or rocky substrates (McPhail and Lindsey 1970; Wooton 1976).

The tunnel shaped nest is constructed by the male from aquatic vegetation and suspended from vegetation 10 to 15 cm from the bottom or can be found directly on substrate in sparsely vegetated areas (Grant and Lee 2004). After the female lays 20 to 30 eggs in the nest the male fertilizes, guards, and aerates the nest (Scott and Scott 1988). Male sticklebacks may also construct additional other nests in the immediate area and mate with other females (Scott and Scott 1988). The male may provide care for the young up to two weeks after hatching then the young will make their way to the open water (Grant and Lee 2004). The young usually congregate in shallow sandy areas then move to deeper waters for overwintering (Grant and Lee 2004).

Ninespine sticklebacks seem to have a varying lifespan. Scott and Scott (1988) found it ranged from 3 to 3.5 years on the Atlantic Coast while Griswold and Smith (1973) reported a 5 year life span for females and a 3 year for males in Lake Superior.

3.2.1.24 Threespine stickleback (*Gasterosteus aculeatus*)

Threespine stickleback are almost circumpolar in distribution (it is absent from the cold Arctic, but have been observed in northern seas of Siberia and North America) and are widely distributed in the northern hemisphere (Scott and Crossman 1998; Scott and Scott 1988). It is an euryhaline species and exists as both freshwater resident and anadromous marine-dwelling form in Newfoundland and Labrador (Scott and Crossman 1998; Scott and Scott 1988). Its presence has been noted in Labrador in the Churchill River system (Anderson 1985; Scott and Crossman 1973). Beak (1980) also found the species at the mouth of the Elizabeth River and near Upper Brook. Whereas Ryan (1980) found the species within stomach contents of ouananiche, lake trout, burbot, brook trout and northern pike caught in the main stem of the lower Churchill River. The species has also been found within numerous Newfoundland lakes, rivers and coastal waters (Grant and Lee 2004).

Spawning generally occurs in the summer months, but timing can vary from April to September depending on local conditions (Scott and Crossman 1998). Freshwater resident populations spawn in both lakes and rivers, with anadromous populations spawning in brackish or fresh waters (Coad and Power 1973; Leim and Scott 1966; Morrow 1980; Wootton 1984). River spawning populations undergo a spring migration from lakes or larger rivers into smaller, slower tributaries and backwaters (Scott and Crossman 1998; Scott and Scott 1988). The males build nests over sandy/muddy substrates in areas of low flow and are usually found in the vicinity of submergent vegetation (Hagen 1967; Virgl and McPhail 1994). Lake spawning populations utilize two distinct habitat types, either open-water (Griswold and Smith 1972; Larson 1976; Lewis 1978; Wootton 1984) or in association with aquatic vegetation (Larson 1976; McPhail and Lindsey 1970; Morrow 1980; Sandlund et al. 1987). Anadromous populations spawning in marine or brackish water build nests in rock crevices, eelgrass beds, algal mats and sometimes over sand near vegetative cover (McPhail and Lindsey 1970; Morrow 1980). Nesting in the vicinity of aquatic vegetation or rock/boulder cover, whether in rivers, lakes or brackish water, is thought to increase the structural complexity of the habitat and reduce the risk of predation (AGRA 1999).

Males construct the nest from small twigs, algae or plant debris typically over a sandy or mud bottom (Griswold and Smith 1972; McPhail and Lindsey 1970; Ryan 1980; Scott and Crossman 1973; Scott and Scott 1988). However, nests have been found on a wide variety of substrates including silt, algal tufts and rock (Hagen 1967; Pepper 1976; Wootton 1976). Females deposit adhesive eggs in clusters in the nest (Morrow 1980). The males subsequently guard and fan the nests (Leim and Scott 1966; McPhail and Lindsey 1970; Scott and Crossman 1973; Scott and Scott 1988), protecting the young for up to 2 weeks after hatching or until they are able to fend for themselves (Scott and Scott 1988; Wootton 1976).

Outside the breeding season threespine sticklebacks return to the sea (anadromous) or into deeper waters or large rivers (freshwater resident) in the fall (Scott and Crossman 1998; Scott and Scott 1988; Wootton 1976). Threespine stickleback typically inhabit vegetated areas, usually over mud or sand (Page and Burr 1991). Threespine sticklebacks have been observed at a variety of depths (less than 1 m up to 17 m) in lakes along the Avalon Peninsula, Newfoundland (Campbell and Knoechel 1990) and have been shown to feed mainly on pelagic zooplankton (Campbell and Knoechel 1988, 1990; Ryan 1984) and benthic organisms (Campbell and Knoechel 1990; Ryan 1984). Newfoundland populations normally mature in their second or third year Ryan (1984) and generally have a life expectancy of 2.5 years or less (Fitzpatrick 1988; Ryan 1984).

3.2.1.25 Atlantic sturgeon (*Acipenser oxyrinchus*)

The range of Atlantic sturgeon is described as extending along the eastern seaboard of North America (Scott and Crossman 1973), with its true northern extent being uncertain. Scott and Crossman (1973) place its range as far north as Ungava Bay and Hamilton Inlet. The species is anadromous and is thought to spawn during the summer, probably yearly, with the young spending 3 to 4 years in freshwater before first migrating to sea (Scott and Crossman 1973). They are a very long lived species, reaching in excess of 60 years and maturing at approximately 22 to 28 years old (Scott and Crossman 1973). The record length was a 4.3 m long female which weighed 368 kg (Scott and Crossman 1973).

Anderson (1985) reported the capture of a 2.7 kg sturgeon at the mouth of the Kenamu River in the Southeastern Labrador region by Riche (1965). Backus (1957) also reported a specimen taken in “outer Hamilton Inlet”. Since these records, there have been no other captures documented.

3.2.1.26 Longnose sucker (*Catostomus catostomus*)

The longnose sucker can be found throughout northern North America from Alaska to western Labrador, and from the northern United States to the southern portion of the Northwest Territories (Scott and Crossman 1973). Longnose suckers are primarily bottom dwellers (McPhail and Lindsey 1970; Morrow 1980) and inhabit lakes, rivers and reservoirs. They have also been reported in brackish waters near the vicinity of river mouths (Walters 1955). They are abundant in Labrador in the Churchill River system and can be found in the main stem (AGRA 1999; Anderson 1985; Ryan 1980) and also throughout the adjoining lakes and tributaries (AGRA 1999; Anderson 1985; Ryan 1980). Beak (1980) reported this species as most abundant in the upper stretches of the lower Churchill watershed tributary systems, where gradients are gentler and where lakes and ponds are more common within river main stems. They have also been found in the Metchin River as well as Dominion Lake (AGRA 1999; Ryan 1980).

Longnose suckers which inhabit lacustrine habitats migrate into rivers to spawn (Harris 1962; Walton 1980). It is also possible that fish which inhabit the ponds and lakes of the Churchill River system may move into the main stem to spawn (AGRA 1999). Spawning generally occurs in the spring (mid April or May), however Ryan (1980) observed spawning in June in the Labrador region. During spawning, the female moves into the faster riffle or midstream waters of rivers and inlet streams, but may also utilize the outlet streams of lakes, or shallow lake margins (Becker 1983; Dion et al. 1994; Edwards 1983; Geen et al. 1966; McPhail and Lindsey 1970; Scott and

Crossman 1998; Smith 1979; Walton 1980). Longnose suckers are broadcast spawners, which repeatedly broadcast their adhesive eggs over a clean substrate comprised of cobble, or rubble in riffle areas where velocities range from 0.3 to 1.0 m/s and depth are between 15 and 60 cm (Becker 1983; Geen et al. 1966; Harris 1962; McPhail and Lindsey 1970; Scott and Crossman 1998; Walton 1980). The young spend 1 to 2 weeks in the spawning area and then move to lentic habitat (Bradbury et al. 1999).

YOY in Alaska were most abundant over silt and sand substrate in shallow (less than 0.2 m) backwaters having velocities less than 0.1 m/s (Mecum 1984). However, the same study found them to occur over gravel, cobble and rubble substrates at varying densities depending on depth and velocity. Juveniles (23 to 89 mm in length) live in lentic waters and are frequently found in shallow reedy areas (Edwards 1983). Juveniles have a preference for sand/gravel substrate but have also been found over silt, sand, gravel, cobble and rubble (Mecum 1984). Johnson (1971) observed that juveniles sought areas with some current, and may enter the lower reaches of streams. Adults were captured in tributaries of Atikonak Lake, south western Labrador, at temperatures ranging from 13.9 to 19.6°C and depths between 17 and 75 cm over a gravel, cobble, or boulder substrate (LGL Limited 1999). Adults are well adapted to high current velocities (Walton 1980) and are often found in swift rivers with stony bottoms (Edwards 1983; Nikolskii 1954).

The diet of the longnose sucker consists entirely of invertebrates and algae. Longnose suckers grow at a rate of approximately 15 to 20 mm per year and reach an average size of 305 to 356 mm in length, living for up to 19 years (Scott and Crossman 1973). In the Churchill River, longnose suckers exhibit linear growth at a rate near the lower limits exhibited by the species as a whole (Ryan 1980). Sexual maturity of the Churchill River system occurs at 6 to 7 years of age (Anderson 1985).

3.2.1.27 White sucker (*Catostomus commersoni*)

White suckers are restricted to North America, occurring from central Ungava, Labrador, south-western Georgia in the United States and west to Alberta, British Columbia and the Mackenzie River delta (Scott and Crossman 1998). They can be found in Nova Scotia and New Brunswick in the south, through to northern Labrador and northern Quebec, but are not found on the Island of Newfoundland (Scott and Crossman 1998). White suckers occur throughout the Churchill River system (Anderson 1985). Beak (1980) found white suckers present in some tributaries along the lower Churchill River, apparently restricted in the area of the Minipi River system, including Minipi Lake and its tributaries. Ryan (1980) reported that white suckers were relatively abundant throughout the main stem of the lower Churchill River, while AGRA (1999) only found them above Muskrat Falls.

Spawning, similar to the longnose sucker, takes place in the spring as stream temperatures rise, with females moving from the lakes into streams. Spawning generally takes place in pond/lake inlets and outlets, small creeks, and rivers with relatively swift, shallow waters running over gravel or coarse sand bottoms (Carlander 1969; Dence 1948; Forbes and Richardson 1920; McPhail and Lindsey 1970; Nelson 1968; Schneberger 1972; Twomey et al. 1984), but has been reported over boulder substrates as well (Dion et al. 1994). Demersal, adhesive, eggs are scattered over a period of 10 to 14 days and adhere to the immediate, or downstream, substrate (Scott and Crossman 1998). Adults which move into tributary streams to spawn, generally return to the lake after spawning is complete (Geen et al. 1966; Scott and Crossman 1998). The incubation period required is variable and has been linked with temperature and geographical location (Grant and Lee 2007).

YOY have been found over a range of substrates, including: sand/gravel substrate in areas with moderate currents (Thompson and Hunt 1930; Twomey et al. 1984), shallow-pool areas having velocities less than 0.3 m/s, depths less than 0.6 m, and along channel margins where boulders, vegetation, woody debris, undercut banks were the primary cover types (Aadland 1993). YOY school during the first year (Becker 1983); either remaining in their natal streams (Aadland 1993) or migrating from them approximately one month after spawning (Becker 1983; Bradbury et al. 1999; Geen et al. 1966; Scott and Crossman 1998). Juveniles (less than 150 mm in length) were reported in shallow backwaters and riffles with moderate water velocities (approximately 0.50 m/s) and a predominantly sand/rubble substrate (Propst 1982). Adults occur mainly over gravel, sand, silt and rubble substrates (Becker 1983; Twomey et al. 1984) and tend to be closely associated with riparian (overhanging trees, grass, shrubs, etc.) and instream cover such as submerged logs, roots, macrophytes, undercut banks and large boulders (Dence 1948; Minckley 1962; Propst 1982; Thompson and Hunt 1930). Adults are known to increasingly seek cover as water velocities increase (Symons 1976).

The diet of the white sucker consists mainly of aquatic insect larvae (Scott and Crossman 1998). While growth rates can vary widely, the growth rate for the Churchill River lies near the middle of the range described for the species as a whole (Ryan 1980). Growth may cease when sexual maturity is reached, which requires five to six years in the Churchill River system (Anderson 1985), with white suckers able to live up to 17 years (Grant and Lee 2004).

3.2.1.28 Northern redhorse (*Moxostoma aureolum*)

The northern redhorse is a sucker from the family Catostomidae which occurs widely across North America, reaching James Bay in the north and Texas in the south (Coad 2007; Page and Burr 1991). They, along with all redhorse, are characterized by having a three-chambered swim bladder and are distinguished from other suckers by its small head and bright red tail (Rook 1999). They inhabit both streams and lakes, preferring fast, clear to slightly turbid, water and are generally found in the deeper portions of channels over sand or gravel substrates (Coad 2007; Rook 1999). The species is not very tolerant of pollution and siltation but has been known to withstand water temperatures up to 37.2°C, and has been found in sluggish, shallow and unshaded rivers (McAllister and Coad 1974). Its preferred temperature is 26.0 to 27.5°C (Coad 2007).

The timing of spawning for this species ranges from early April to July, with spawning occurring primarily during May in Canadian rivers (Coad 2007). When water temperatures reach approximately 11°C males migrate upstream in large schools where they congregate and defend spawning territories that contain gravel riffles and rubble shoals (Coad 2007; Meyer 1962). The actual spawning ritual occurs when a female enters the gravel-lined troughs cleared by the males, with two males mating with a single female (Coad 2007; Meyer 1962). The semi-adhesive eggs are broadcast and left unattended, with hatching occurring within 4 or 5 days (Rook 1999).

They feed primarily on benthic insect larvae (e.g., chironomids, Ephemeroptera, and Trichoptera) and some algae (Coad 2007; Meyer 1962). Life span in Canadian waters is 14 years, longer than southern populations, with maturity being attained at 2 to 5 years depending on locality (Coad 2007; Meyer 1962).

The northern redhorse was recorded in the Kenamu River in the Labrador region by Riche (1965) but was not confirmed as this would be outside the eastern limit of its range (Anderson 1985).

3.2.2 Water Quality

Water quality monitoring of selected waterbodies in the province has been ongoing since 1986 under the Canada-Newfoundland Water Quality Monitoring Agreement (WQMA). Its purpose is to coordinate and integrate provincial and federal water monitoring. The WQMA provides for the regular monitoring of an index network of stations, as well as annual recurrent studies concentrating on water quality, sediment and biota in selected watersheds. Approximately 1,200 sites were identified throughout the province with twelve falling within the proposed transmission line corridor. Figures 3.4, 3.5 and 3.6 present the sites near/within the corridor. All water quality data from the WQMA can be accessed from the following website: http://www.env.gov.nl.ca/env/waterres/quality/background/agreement.html. Due to sporadic sampling effort and variation within the parameters sampled for each of the sites, this data was not found to be a useful source for presenting baseline water quality data across the Project corridor. Site locations are identified as a possible alternate source of data for particular parameters if required.

The province also collects and tests drinking water from various municipal water supplies. This is to ensure that water supplies comply with the Guidelines for Canadian Drinking Water Quality and to address any water quality issues that may arise. A total of fifteen water supply monitoring locations are within the study area of the proposed Project. Figures 3.4, 3.5 and 3.6 present the sites near/within the corridor. All water quality data from drinking water sampling can be accessed from the following: http://maps.gov.nl.ca/water.

Tables 3.12, 3.13, 3.14 3.15 summarize the most recent sampling data collected for source drinking water quality sites within the study area. This data ranges from 2008 to 2010 as the most recent data collected at these sites and in most cases are sampled more than once within the year. Those that were sampled only once within the year are also presented in the table. Data for these sites does exist beyond dates presented (on average data dates back between 10 to 18 years with the oldest ranging back 25 years) however, for relevancy to this study only the most recent sampling results have been presented.

Data was assessed by comparing results to the Canadian Council of Ministers of the Environment (CCME) (CCME 2007), Canadian Water Quality Guidelines for the Protection of Aquatic Life (PAL) (2007) and the Guidelines for Canadian Drinking Water Quality (CDWQ) (Health Canada 2007). General groupings of parameters were based on either aesthetics or contaminant Guidelines for the CDWQ. Aesthetic parameters are characteristics or substances which are usually not a threat to human health however, it can affect consumer's acceptance of the source based on such characteristics as smell or appearance. Contaminant parameters are those known or suspected of adversely affecting human health if present in concentrations equal to or greater than the guidelines. Although the guidelines for CDWQ apply to treated water (from consumer tap) and not untreated water sources, this guideline was compared to water quality results as a screening process by the Newfoundland and Labrador Department of Environment and Conservation, Water Resources Management Division and therefore are presented in this report.

All regions contained sites that exceeded colour parameter guidelines for CDWQ (aesthetics parameter). Central and Eastern Newfoundland region also had sites with exceeded manganese values for CCME PAL guidelines (Steve's Pond water supply, Arnold's Cove) and pH values exceeding both guidelines for CDQW and CCME PAL (all sites except Brigades Pond, Southern Harbour). Data from these sites reflect source water such as streams, ponds or wells prior to treatment or disinfection. Water quality monitoring assesses land use effects on the source water supplies thereby potentially affecting water quality. This water source is not only essential to the communities that depend on it for drinking water but also to the natural drainage basin and the ecosystem connected to it as a whole.

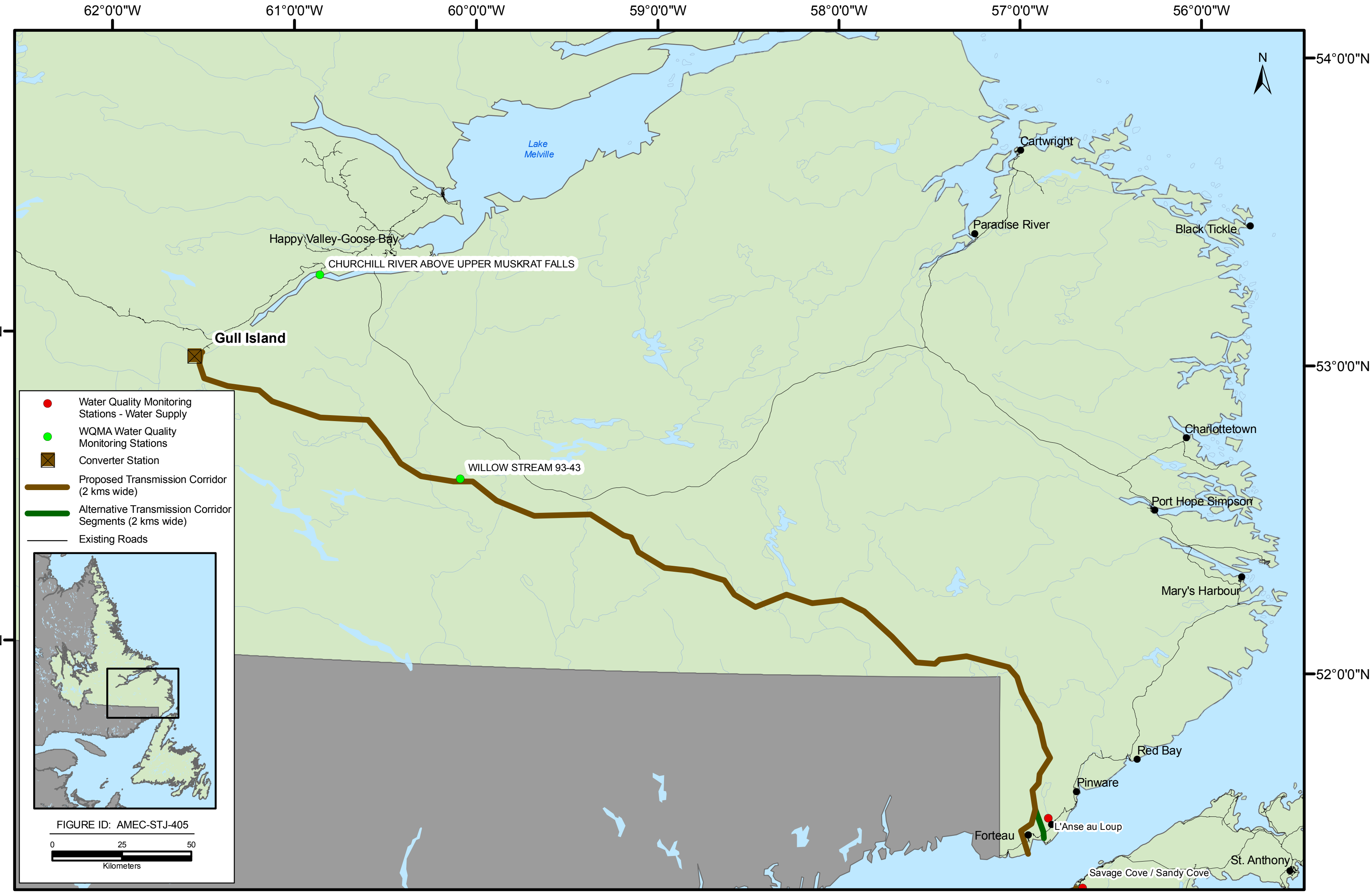

Figure 3.4 Identified Water Quality Monitoring Stations - Water Supply and WQMA Water Quality Monitoring Stations Within/Near the Transmission Corridor, Southeastern Labrador Region

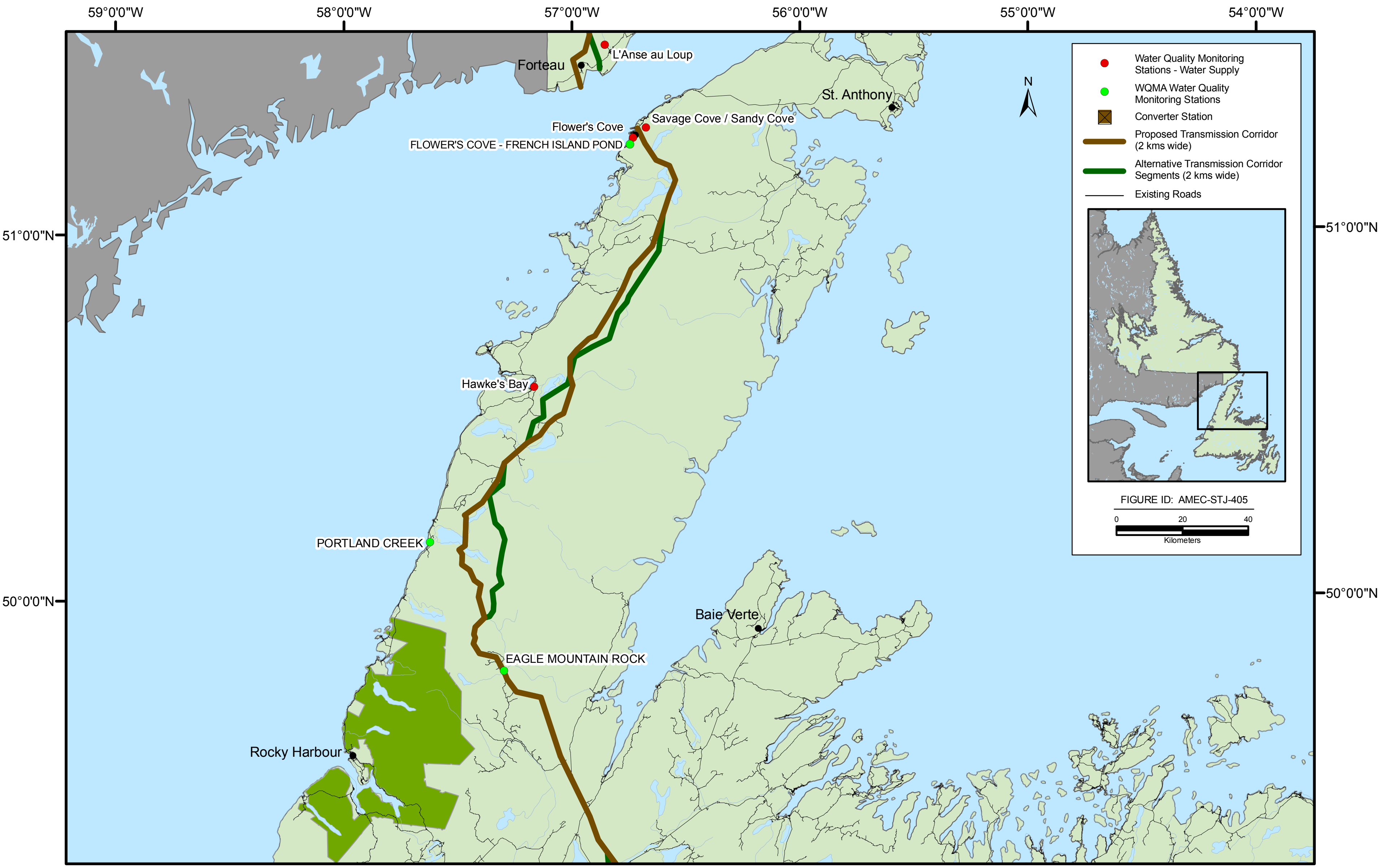

Figure 3.5 Identified Water Quality Monitoring Stations - Water Supply and WQMA Water Quality Monitoring Stations Within/Near the Transmission Corridor, Northern Peninsula Region

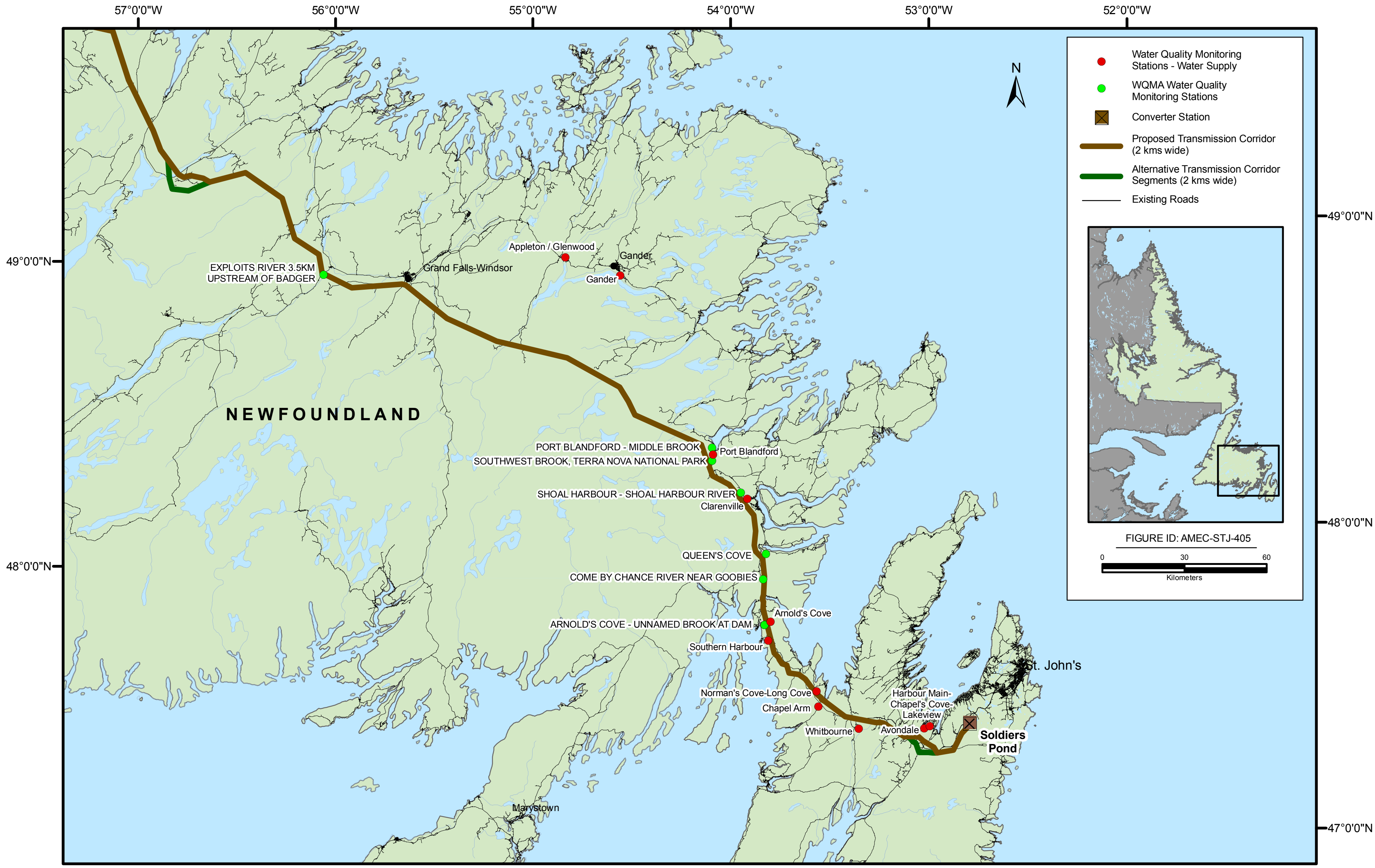

Figure 3.6 Identified Water Quality Monitoring Stations - Water Supply and WQMA Water Quality Monitoring Stations Within/Near the Transmission Corridor, Central and Eastern Newfoundland and Avalon Peninsula Regions

Table 3.12 Summarized Nutrients, Metals, Physical Parameter, and Major ions for Source Water Quality of Public Water Supplies crossed by the Project Corridor within the Southeastern Labrador Region

Community		L'Anse au Loup			CCME-CEQGs PAL (2007) Guidelines	CDWQ (2007) Guidelines	Aesthetic (A) Parameter or Contaminant (C)
Source Name		L'Anse au Loup River					
Year		2009					
	Units	Max	Min	Avg.			
Ammonia	mg/L	0.000	0.000	0.000	-		
Dissolved Organic Carbon	mg/L	3.7	3.5	3.6	-		
Nitrate(ite)	mg/L	0.160	0.000	0.080	-	10	C
Kjeldahl Nitrogen	mg/L	0.200	0.100	0.150			
Total Phosphorus	mg/L	0.000	0.000	0.000	-		
Aluminum	mg/L	0.050	0.040	0.045	0.005 - 0.1		
Antimony	mg/L	0.00000	0.00000	0.00000	-	0.006	C
Arsenic	mg/L	0.000	0.000	0.000	0.005	0.01	C
Barium	mg/L	0.028	0.028	0.028	-	1	C
Cadmium	mg/L	0.00000	0.00000	0.00000	0.000017	0.005	C
Chromium	mg/L	0.00000	0.00000	0.00000	0.001	0.05	C
Copper	mg/L	0.000	0.000	0.000	0.002 -0.004	1	A
Iron	mg/L	0.130	0.080	0.105	0.3	0.3	A
Lead	mg/L	0.000	0.000	0.000	0.001 - 0.007	0.01	C
Magnesium	mg/L	1.200	1.000	1.100	-		
Manganese	mg/L	0.005	0.003	0.004	-	0.05	A
Mercury	mg/L	0.00000	0.00000	0.00000	0.000026	0.001	C
Nickel	mg/L	0.000	0.000	0.000	0.025 - 0.150		
Selenium	mg/L	0.000	0.000	0.000	0.001	0.01	C
Uranium	mg/L	0.0002	0.0001	0.0002	-	0.02	C
Zinc	mg/L	0.008	0.000	0.004	0.03	5	A
Alkalinity	mg/L	14	14	14	-		
Colour	TCU	30	24	27	-	15	A
Conductivity	µg/cm	42	40	41	-		
Hardness	mg/L	16	14	15	-		
pH		7.28	7.22	7.25	6.5-9	6.5-8.5	A
Total Dissolved Solids	mg/L	21	20	20.5	-	500	A
Total Suspended Solids	mg/L	-	-	-			
Turbidity	NTU	0.6	0.4	0.5	-	1	C
Boron	mg/L	0.00	0.00	0.00	-	5	C
Bromide	mg/L	0	0	0			

Community		**L'Anse au Loup**			**CCME-CEQGs PAL (2007) Guidelines**	**CDWQ (2007) Guidelines**	**Aesthetic (A) Parameter or Contaminant (C)**
Source Name		**L'Anse au Loup River**					
Year		**2009**					
	Units	**Max**	**Min**	**Avg.**			
Calcium	mg/L	4.3	4	4.15	-		
Chloride	mg/L	3	3	3	-	250	A
Fluoride	mg/L	0	0	0		1.5	C
Potassium	mg/L	0.3	0.2	0.25	-		
Sodium	mg/L	1.8	1.8	1.8	-	200	A
Sulphate	mg/L	0	0	0	-	500	A

Notes:

Year- The most recent year of data for Source water (untreated) is presented in this table.

- : no value

Shaded data exceeds the Guidelines for Canadian Drinking Water Quality

Bolded data exceeds the CCME-CEQG's revised (2007) Protection of (Freshwater) Aquatic Life Criteria

CCME: Canadian Council of Ministers of the Environment

CEQGs: Canadian Environment Quality Guidelines

PAL: Protection of Aquatic Life

CDWQ: Canadian Drinking Water Quality

-: VALUE NOT ESTABLISHED

Aluminum Guideline = 5 µg/L-1 at pH <6.5;
= 100 µg/L-1 at pH ≥6.5

Lead Guideline = 1 µg/L at [CaCO3] = 0-60 mg/L
. = 2 µg/L at [CaCO3] = 60-120 mg/L
= 4 µg/L at [CaCO3] = 120-180 mg/L
= 7 µg/L at [CaCO3] = > 180 mg/L

Copper Guideline = 2 ug/L at [CaCO3] = 0-120 mg/L
= 3 ug/L at [CaCO3] = 120-180 mg/L
= 4 ug/L at [CaCO3] > 180 mg/L

Nickel Guideline = 25 ug/L at [CaCO3] = 0-60 mg/L
= 65 ug/L at [CaCO3] = 60-120 mg/L
= 110 ug/L at [CaCO3] = 120-180 mg/L
= 150 ug/L at [CaCO3] > 180 mg/L

Table 3.13 Summarized Nutrients, Metals, Physical Parameter, and Major ions for Source Water Quality for Public Water Supplies crossed by the Project Corridor within the Northern Peninsula Region

Community		Savage Cove / Sandy Cove	Flower's Cove			Hawke's Bay			CCME-CEQGs PAL (2007) Guidelines	CDWQ (2007) Guidelines	Aesthetic (A) Parameter or Contaminant (C)
Source Name		Big Pond	French Island Pond			Torrent River					
Year		2008[a]	2008			2008					
	Units		Max	Min	Avg.	Max	Min	Avg.			
Ammonia	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-
Dissolved Organic Carbon	mg/L	0.0	6.5	5.1	5.8	6.3	4.7	5.5	-	-	-
Nitrate(ite)	mg/L	0.350	0.000	0.000	0.000	0.000	0.000	0.000	-	10	C
Kjeldahl Nitrogen	mg/L	0.000	0.300	0.300	0.300	0.200	0.200	0.200	-	-	-
Total Phosphorus	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-
Aluminum	mg/L	0.000	0.020	0.010	0.015	**0.130**	**0.110**	**0.120**	0.005 - 0.1	-	-
Antimony	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-	0.006	C
Arsenic	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.01	C
Barium	mg/L	0.000	0.000	0.000	0.000	0.007	0.007	0.007	-	1	C
Cadmium	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.000017	0.005	C
Chromium	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.001	0.05	C
Copper	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002 -0.004	1	A
Iron	mg/L	0.000	0.070	0.060	0.065	0.130	0.120	0.125	0.3	0.3	A
Lead	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001 - 0.007	0.01	C
Magnesium	mg/L	1.400	12.000	9.600	10.800	1.800	1.200	1.500	-	-	-
Manganese	mg/L	0.000	0.008	0.005	0.007	0.010	0.009	0.010	-	0.05	A
Mercury	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.000026	0.001	C
Nickel	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025 - 0.150	-	-
Selenium	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.01	C
Uranium	mg/L	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	-	0.02	C
Zinc	mg/L	0.000	0.000	0.000	0.000	0.006	0.005	0.006	0.03	5	A
Alkalinity	mg/L	15	110	76	93	18	11	14.5	-	-	-
Colour	TCU	0	33	31	32	59	48	53.5	-	15	A
Conductivity	µg/cm	110	230	170	200	57	39	48	-	-	-
Hardness	mg/L	23	110	81	95.5	21	13	17	-	-	-
pH		6.56	7.98	7.86	7.92	7.20	7.17	7.19	6.5-9	6.5-8.5	A
Total Dissolved Solids	mg/L	78	119	83	101	30	20	25	-	500	A
Total Suspended Solids	mg/L	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	0	0.7	0.5	0.6	0.9	0.2	0.55	-	1	C

Community		Savage Cove / Sandy Cove	Flower's Cove			Hawke's Bay			CCME-CEQGs PAL (2007) Guidelines	CDWQ (2007) Guidelines	Aesthetic (A) Parameter or Contaminant (C)
Source Name		**Big Pond**	**French Island Pond**			**Torrent River**					
Year		**2008[a]**	**2008**			**2008**					
	Units		**Max**	**Min**	**Avg.**	**Max**	**Min**	**Avg.**			
Boron	mg/L	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-	5	C
Bromide	mg/L	0	0	0	0	0	0	0	-	-	-
Calcium	mg/L	7	22	17	19.5	5.5	3.4	4.45	-	-	-
Chloride	mg/L	28	10	5	7.5	4	4	4	-	250	A
Fluoride	mg/L	0	0	0	0	0	0	0	-	1.5	C
Potassium	mg/L	1.1	0.6	0.4	0.5	0.3	0.3	0.3	-	-	-
Sodium	mg/L	14	6.2	5.1	5.65	2.9	2.5	2.7	-	200	A
Sulphate	mg/L	4	2	0	1	3	0	1.5	-	500	A

Notes:

Year- The most recent year of data for Source water (untreated) is presented in this table.

- : no value

Shaded data exceeds the Guidelines for Canadian Drinking Water Quality

Bolded data exceeds the CCME-CEQG's revised (2007) Protection of (Freshwater) Aquatic Life Criteria

CCME: Canadian Council of Ministers of the Environment

CEQGs: Canadian Environment Quality Guidelines

PAL: Protection of Aquatic Life

CDWQ: Canadian Drinking Water Quality

-: VALUE NOT ESTABLISHED

Aluminum Guideline = 5 µg/L-1 at pH <6.5;
= 100 µg/L-1 at pH ≥6.5

Lead Guideline = 1 µg/L at [CaCO3] = 0-60 mg/L
. = 2 µg/L at [CaCO3] = 60-120 mg/L
= 4 µg/L at [CaCO3] = 120-180 mg/L
= 7 µg/L at [CaCO3] = > 180 mg/L

Copper Guideline = 2 ug/L at [CaCO3] = 0-120 mg/L
= 3 ug/L at [CaCO3] = 120-180 mg/L
= 4 ug/L at [CaCO3] > 180 mg/L

Nickel Guideline = 25 ug/L at [CaCO3] = 0-60 mg/L
= 65 ug/L at [CaCO3] = 60-120 mg/L
= 110 ug/L at [CaCO3] = 120-180 mg/L
= 150 ug/L at [CaCO3] > 180 mg/L

Table 3.14 Summarized Nutrients, Metals, Physical Parameter, and Major ions for Source Water Quality for Public Water Supplies crossed by the Project Corridor within the Central and Eastern Newfoundland Region

Community		Gander	Appleton / Glenwood			Port Blandford			Clarenville	Arnold's Cove			Southern Harbour			Normans's Cove-Long Cove			CCME-CEQGs PAL (2007) Guidelines	CDWQ (2007) Guidelines	Aesthetic (A) Parameter or Contaminant (C)
Source Name		Gander Lake	Gander Lake Outflow			Noseworthy's Pond			Shoal Harbour Brook	Steve's Pond			Brigades Pond			Normans's Cove-Long Cove					
Year		2010[a]	2008			2009			2010[a]	2009			2009			2008					
	Units		Max	Min	Avg.	Max	Min	Avg.		Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.			
Ammonia	mg/L	0.410	0.130	0.060	0.095	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.070	0.000	0.035	-	-	-
DOC	mg/L	6.2	6.4	5.8	6.1	7.9	4.5	6.2	5.7	5.9	5	5.45	6.5	3.4	4.95	4.8	3.6	4.2	-	-	-
Nitrate(ite)	mg/L	0.110	0.110	0.080	0.095	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	10	C
Kjeldahl Nitrogen	mg/L	0.100	0.200	0.100	0.150	0.300	0.300	0.300	0.200	0.300	0.200	0.250	0.200	0.000	0.100	0.200	0.100	0.150	-	-	-
Total Phosphorus	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-
Aluminum	mg/L	**0.090**	**0.120**	**0.110**	**0.115**	**0.090**	**0.040**	**0.065**	**0.110**	0.090	**0.090**	**0.090**	0.150	0.060	0.105	**0.120**	**0.070**	**0.095**	0.005 - 0.1	-	-
Antimony	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-	0.006	C
Arsenic	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.01	C
Barium	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.010	0.011	0.007	0.000	0.004	-	1	C
Cadmium	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.000017	0.005	C
Chromium	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.001	0.05	C
Copper	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.002 - 0.004	1	A
Iron	mg/L	0.070	0.170	0.130	0.150	0.190	0.000	0.095	0.190	0.090	0.060	0.075	0.110	0.000	0.055	0.090	0.070	0.080	0.3	0.3	A
Lead	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001 - 0.007	0.01	C
Magnesium	mg/L	0.600	0.700	0.700	0.700	0.600	0.500	0.550	0.500	0.500	0.500	0.500	0.700	0.600	0.650	0.600	0.500	0.550	-	-	-
Manganese	mg/L	0.010	0.032	0.012	0.022	0.011	0.007	0.009	0.019	0.053	0.028	0.041	0.024	0.017	0.021	0.047	0.018	0.033	-	0.05	A
Mercury	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.000026	0.001	C
Nickel	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025 - 0.150	-	-
Selenium	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.01	C
Uranium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-	0.02	C
Zinc	mg/L	0.000	0.009	0.006	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.005	0.03	5	A
Alkalinity	mg/L	5	0	0	0	6	0	3	0	5	0	2.5	7	7	7	0	0	0	-	-	-
Colour	TCU	43	64	55	59.5	45	18	31.5	63	42	21	31.5	57	14	35.5	31	25	28	-	15	A
Conductivity	µg/cm	26	27	22	24.5	110	86	98	48	31	30	30.5	43	40	41.5	29	29	29	-	-	-
Hardness	mg/L	7	7	7	7	8	8	8	8	7	6	6.5	10	10	10	6	5	5.5	-	-	-
pH		**6.20**	6.67	**6.47**	6.57	**6.46**	**6.34**	**6.40**	**6.46**	6.64	**6.21**	**6.43**	6.79	6.63	6.71	**6.21**	**6.02**	**6.12**	6.5-9	6.5-8.5	A
TDS	mg/L	15	13	11	12	45	45	45	23	16	13	14.5	22	21	21.5	14	12	13	-	500	A
TSS	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	0	0.4	0.3	0.35	0.6	0.5	0.55	0.3	0.6	0.5	0.55	0.9	0.9	0.9	0.5	0.4	0.45	-	1	C
Boron	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	-	5	C
Bromide	mg/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-
Calcium	mg/L	1.7	1.7	1.6	1.65	2.4	2.4	2.4	2.3	1.9	1.6	1.75	2.9	2.8	2.85	1.4	1	1.2	-	-	-
Chloride	mg/L	3	4	3	3.5	25	21	23	10	6	5	5.5	8	6	7	6	6	6	-	250	A
Fluoride	mg/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	1.5	C
Potassium	mg/L	0.2	0.4	0.2	0.3	0.3	0.2	0.25	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.3	0.35	-	-	-
Sodium	mg/L	2.6	2.6	2.3	2.45	16	15	15.5	6.3	3.5	3.5	3.5	4.6	4.4	4.5	4.9	3.7	4.3	-	200	A
Sulphate	mg/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	500	A

Notes:
Year- The most recent year of data for Source water (untreated) is presented in this table.
- : no value
Shaded data exceeds the Guidelines for Canadian Drinking Water Quality
Bolded data exceeds the CCME-CEQG's revised (2007) Protection of (Freshwater) Aquatic Life Criteria
CCME: Canadian Council of Ministers of the Environment
CEQGs: Canadian Environment Quality Guidelines
PAL: Protection of Aquatic Life
CDWQ: Canadian Drinking Water Quality
DOC: Dissolved Organic Carbon
TDS: Total Dissolved Solids
TSS: Total Suspended Solids
-: VALUE NOT ESTABLISHED
Aluminum Guideline = 5 µg/L-1 at pH <6.5;
= 100 µg/L-1 at pH ≥6.5
Lead Guideline = 1 µg/L at [CaCO3] = 0-60 mg/L
= 2 µg/L at [CaCO3] = 60-120 mg/L
= 4 µg/L at [CaCO3] = 120-180 mg/L
= 7 µg/L at [CaCO3] = > 180 mg/L
Copper Guideline = 2 ug/L at [CaCO3] = 0-120 mg/L
= 3 ug/L at [CaCO3] = 120-180 mg/L
= 4 ug/L at [CaCO3] > 180 mg/L
Nickel Guideline = 25 ug/L at [CaCO3] = 0-60 mg/L
= 65 ug/L at [CaCO3] = 60-120 mg/L
= 110 ug/L at [CaCO3] = 120-180 mg/L
= 150 ug/L at [CaCO3] > 180 mg/L

Table 3.15 Summarized Nutrients, Metals, Physical Parameter, and Major ions for Source Water Quality for Public Water Supplies crossed by the Project Corridor within the Avalon Peninsula Region

Community		Whitbourne			Avondale			Habour Main-Chapel's Cove-Lakeview			CCME-CEQGs PAL (2007) Guidelines	CDWQ (2007) Guidelines	Aesthetic (A) Parameter or Contaminant (C)
Source Name		Hodges River			Lee's Pond			Maloney's River					
Year		2009			2008			2008					
	Units	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.			
Ammonia	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-		
DOC	mg/L	5.2	5.1	5.15	7.1	2.5	4.3	3.3	3.3	3.3	-		
Nitrate(ite)	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	10	C
Kjeldahl Nitrogen	mg/L	0.200	0.200	0.200	0.300	0.100	0.194	0.200	0.200	0.200			
Total Phosphorus	mg/L	0.000	0.000	0.000	0.020	0.000	0.006	0.000	0.000	0.000	-		
Aluminum	mg/L	0.060	0.030	0.045	0.050	0.010	0.031	0.040	0.030	0.035	0.005 - 0.1		
Antimony	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-	0.006	C
Arsenic	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.01	C
Barium	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	1	C
Cadmium	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.000017	0.005	C
Chromium	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.001	0.05	C
Copper	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002 -0.004	1	A
Iron	mg/L	0.120	0.090	0.105	0.090	0.000	0.029	0.070	0.050	0.060	0.3	0.3	A
Lead	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001 - 0.007	0.01	C
Magnesium	mg/L	0.900	0.800	0.850	0.600	0.000	0.157	0.700	0.600	0.650	-		
Manganese	mg/L	0.037	0.014	0.026	0.006	0.000	0.002	0.019	0.015	0.017	-	0.05	A
Mercury	mg/L	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.000026	0.001	C
Nickel	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025 - 0.150		
Selenium	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.01	C
Uranium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-	0.02	C
Zinc	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.004	0.03	5	A
Alkalinity	mg/L	69	0	34.5	6	0	3	7	6	6.5	-		
Colour	TCU	55	0	27.5	17	12	14.5	24	15	19.5	-	15	A
Conductivity	µg/cm	88	62	75	42	37	39.5	65	61	63	-		
Hardness	mg/L	10	8	9	8	6	7	11	9	10	-		
pH		6.56	6.54	6.55	6.85	6.81	6.83	6.98	6.91	6.95	6.5-9	6.5-8.5	A
TDS	mg/L	88	25	56.5	22	17	19.5	32	30	31	-	500	A
TSS	mg/L	-	-	-	-	-	-	-	-	-			

Community		Whitbourne			Avondale			Habour Main-Chapel's Cove-Lakeview			CCME-CEQGs PAL (2007) Guidelines	CDWQ (2007) Guidelines	Aesthetic (A) Parameter or Contaminant (C)
Source Name		Hodges River			Lee's Pond			Maloney's River					
Year		2009			2008			2008					
	Units	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.			
Turbidity	NTU	0.5	0.4	0.45	0.2	0.2	0.2	0.2	0.2	0.2	-	1	C
Boron	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	-	5	C
Bromide	mg/L	0	0	0	0	0	0	0	0	0			
Calcium	mg/L	2.3	1.7	2	2	1.6	1.8	3.3	2.5	2.9	-		
Chloride	mg/L	23	12	17.5	8	7	7.5	14	13	13.5	-	250	A
Fluoride	mg/L	0	0	0	0	0	0	0	0	0		1.5	C
Potassium	mg/L	0.4	0.3	0.35	0.4	0.3	0.35	0.5	0.3	0.4	-		
Sodium	mg/L	13	8.7	10.85	5.2	5	5.1	8.8	8.5	8.65	-	200	A
Sulphate	mg/L	0	0	0	0	0	0	0	0	0	-	500	A

Notes:

Year- The most recent year of data for Source water (untreated) is presented in this table.

- : no value

Shaded data exceeds the Guidelines for Canadian Drinking Water Quality

Bolded data exceeds the CCME-CEQG's revised (2007) Protection of (Freshwater) Aquatic Life Criteria

CCME: Canadian Council of Ministers of the Environment

CEQGs: Canadian Environment Quality Guidelines

PAL: Protection of Aquatic Life

CDWQ: Canadian Drinking Water Quality

DOC: Dissolved Organic Carbon

TDS: Total Dissolved Solids

TSS: Total Suspended Solids

-: VALUE NOT ESTABLISHED

Aluminum Guideline = 5 µg/L-1 at pH <6.5;
= 100 µg/L-1 at pH ≥6.5

Lead Guideline = 1 µg/L at [CaCO3] = 0-60 mg/L
= 2 µg/L at [CaCO3] = 60-120 mg/L
= 4 µg/L at [CaCO3] = 120-180 mg/L
= 7 µg/L at [CaCO3] = > 180 mg/L

Copper Guideline = 2 ug/L at [CaCO3] = 0-120 mg/L
= 3 ug/L at [CaCO3] = 120-180 mg/L
= 4 ug/L at [CaCO3] > 180 mg/L

Nickel Guideline = 25 ug/L at [CaCO3] = 0-60 mg/L
= 65 ug/L at [CaCO3] = 60-120 mg/L
= 110 ug/L at [CaCO3] = 120-180 mg/L
= 150 ug/L at [CaCO3] > 180 mg/L

3.3 Freshwater Field Survey

As noted previously, a total of 53 watercourse crossings were field surveyed across the transmission corridor during the summer of 2008. Below is a summary of the results of the freshwater field program.

3.3.1 Field Survey Data

A summary of the results from the 2008 freshwater field survey are provided in Table 3.16 including the key physical and biological characteristics of each sampled watercourse crossing, by region (see Appendix A for further information, including the location of each watercourse crossing point / stream ID).

Table 3.16 Summary of Freshwater Field Survey Results (All Regions)

Stream ID	Stream / Watershed Name	Measured Watershed Size (km^2)	Channel / Wetted Width (m)	Average Measured Depth (m)	Average Measured Velocity (m/s)	Habitat Type	Dominant Substrate	Species Captured
Southeastern Labrador								
Proposed Transmission Corridor								
P7	Unknown / Unnamed, Churchill Tributary	88.8	23.50 / 20.60	0.25	0.14	Riffle / Run	Coarse	PD
P10	Unknown / Unnamed, Churchill Tributary	27.3	40.00 / 23.00	0.38*	0.00*	Steady	Fine	Bur, PD, WS
P29	Unknown / Kenamu	442.4	69.10 / 62.60	0.26	0.29	Riffle / Run	Medium	AS, BUR, PD, LND
P30	Unknown / Kenamu	6.2	14.00 / 4.10	0.13	0.04	Steady	Fine	AS, BT, LND
P36	Kenamu River/ Kenamu	1167.0	74.50 / 66.00	0.35	0.41	Riffle / Run	Coarse	AS, LND, PD
P37	Unknown / Kenamu	560.8	18.60 / 15.00	0.31	0.23	Riffle / Run	Coarse	AS, MS
P43	Unknown / Kenamu	6.1	9.1 / 1.5	0.31	0.28	Riffle / Run	Fine	BT
P52	Unknown / Kenamu	9.7	13.75 / 3.60	0.12	0.48	Steady	Coarse	BT
P55	Joir River/ Kenamu	217.6	43.70 / 28.10	0.29	0.25	Steady	Medium	BT, WS
P108	Unknown / St. Paul	26.7	29.70 / 22.50	0.27	0.15	Steady	Fine	BT, WS
P120	Unknown / St. Paul	6.3	49.60 / 4.10	0.59	0.00	Steady	Fine	BT
P121	St. Paul River/ St. Paul	489.5	62.00 / 41.2	0.53*	0.35*	Riffle / Run	Coarse	BT, Salamander
P139	Unknown / St. Paul	2.8	31.50 / 5.40	0.26	0	Steady	Fine	BT

Stream ID	Stream / Watershed Name	Measured Watershed Size (km^2)	Channel / Wetted Width (m)	Average Measured Depth (m)	Average Measured Velocity (m/s)	Habitat Type	Dominant Substrate	Species Captured
P142	Unknown / St. Paul	6.4	19.90 / 3.40	0.33	0.06	Riffle / Run	Coarse	BT
P143	Unknown / St. Paul	61.2	31.60 / 14.00	0.25	0.71	Riffle	Medium	BT, WS
Northern Peninsula								
Proposed Transmission Corridor								
P200	Toms Feeder / Castor River	7.5	13.10 / 4.30	0.15	0.08	Riffle	Medium	BT, AS
P204	Unknown / Castor River	2.8	24.6 0 / 8.40	0.13*	0.04*	Steady	Fine	None
P205	Unknown / Castor River	65.4	40.40 / 28.00	0.21	0.02	Steady	Coarse	AS
P228	Torrent River / Torrent River	393.0	37.80 / 18.40	0.17	0.38	Riffle	Medium	AS
P238	Torrent River / River of Ponds	330.1	52.40 / 37.90	0.17	0.2	Riffle	Coarse	AS, 3SB, A.Eel
P239	Unknown / River of Ponds	264.5	61.10 / 51.90	0.09	0.19	Run	Medium	AS, BT
P243	Unknown / Portland Creek	19.5	18.65 / 12.80	0.10	0.15	Riffle	Medium	BT, 3SB
P245	Unknown / Portland Creek	425.2	50.55 / 35.80	0.26	0.4	Run	Coarse	BT
P246	Unknown / Portland Creek	3.2	16.40 / 6.00	0.17	0.00	Steady	Fine	BT
P1005	Bowing Brook / Portland Creek	343.6	45.95 / 26.40	0.46*	0.32*	Steady	Medium	A. Eel
P259	Unknown / Portland Creek	15.8	20.53 / 14.90	0.31	0.13	Riffle	Fine	BT
P267	Unknown / Sop's Arm River (Main River)	6.0	26.75 / 15.20	0.09	0.04	Riffle	Medium	AS, BT
P270	Pond River/ Sop's Arm River (Main River)	7.5	21.60 / 17.00	0.05	0.07	Riffle	Medium	None
Central and Eastern Newfoundland								
Proposed Transmission Corridor								
P308	Taylor's Brook / Humber River	52.1	24.60 / 17.00	0.23*	0.47*	Run	Coarse	BT
P311	Gales Brook / Humber River	57.0	33.10 / 7.30	0.17	0.46	Riffle	Medium	BT, AS
P313	Gales Brook / Hampden River	12.0	7.65 / 2.90	0.19	0.17	Run	Medium	BT, AS, 3SB
P326	Main Brook / Grand Lake System	14.6	24.12 / 10.8	0.16	0.08	Steady	Coarse	BT

Stream ID	Stream / Watershed Name	Measured Watershed Size (km^2)	Channel / Wetted Width (m)	Average Measured Depth (m)	Average Measured Velocity (m/s)	Habitat Type	Dominant Substrate	Species Captured
P343	Upper Sheffield Brook / Sheffield Lake	127.2	51.32 / 23.20	0.36	0.51	Riffle	Coarse	BT
P346	Unknown / Sheffield Lake	10.8	15.48 / 4.60	0.2	0.19	Riffle	Coarse	BT
P352	Burnt Berry Brook / Sheffield Lake	35.0	30.67 / 9.90	0.19	0.37	Riffle / Run	Coarse	BT
P369	South Brook / South Brook Halls Bay	271.6	57.32 / 46.00	0.21	0.48	Steady	Medium	None
P397	Unknown /Exploits River	2.6	5.52 / 2.60	0.14	0.42	Run	Medium	AS, BT
P399	Sandy Brook / Exploits River	595.3	56.52 / 45.50	0.28	0.60	Run	Medium	AS, 3SB
P401	Stoney Brook / Exploits River	172.8	30.22 / 22.00	0.19*	0.32*	Riffle	Coarse	AS, 3SB
P403	Green Wood Brook / Exploits River	3.8	7.32 / 2.80	0.15	0.19	Riffle	Medium	AS, BT
P408	Little Rattling Brook / Exploits River	70.0	10.71 / 9.00	0.47	0.27	Riffle	Fine	AS, 3SB
P413	Unknown /Exploits River	21.8	12.97 / 7.70	0.39	0.13	Riffle	Medium	AS
P416	Rattling Brook / Rattling Brook	789.0	66.62 / 53.00	0.39*	0.29*	Run	Fine	AS, 3SB
P421	Unknown / Rattling Brook	4.6	13.60 / 3.80	0.09	0.20	Riffle	Medium	AS, BT
P430	Gander River / Gander River	2016.1	33.10 / 26.00	0.49	0.61	Run	Medium	AS, 3SB
P437	Southwest Gander River / Gander River	574.4	30.51 / 24.00	0.36	0.48	Run	Coarse	AS, BT
P441	Dead Wolf Brook / Gambo River	52.3	12.76 / 8.00	0.44	0.01	Steady	Coarse	BT
P469	Southwest River / Southwest Brook Port Blandford	404.9	45.10 / 31.00	0.33	0.42	Riffle	Coarse	AS
Avalon Peninsula								
Proposed Transmission Corridor								
P529	Unknown / Spread Eagle River	11.2	8.20 / 3.10	0.28	0.18	Riffle	Medium	AS, BT, Brn
P533	Unknown / Witch Hazel Brook	25.4	3.00 / 2.50	0.10	0.49	Run	Medium	AS, BT, 3SB

Stream ID	Stream / Watershed Name	Measured Watershed Size (km^2)	Channel / Wetted Width (m)	Average Measured Depth (m)	Average Measured Velocity (m/s)	Habitat Type	Dominant Substrate	Species Captured
P534	Unknown / Witch Hazel Brook	24.7	6.25 / 4.65	0.12	0.45	Run	Medium	AS, BT, 3SB
P541	Daniels River / Northern Arm River	51.0	5.80 / 5.20	0.28	0.11	Run	Medium	AS, 3SB
Alternative Transmission Corridor Segment(s)								
A110	Unknown / Northern Arm River	15.2	1.50 / 1.50	0.10	0.30	Run	Fine	AS, BT, Brn

Note: See Map Atlas (Appendix A) for information on watercourse crossing IDs, locations and definitions. Watershed Size is measured as the watershed area up gradient of the crossing site.
*Velocities and depths across a complete transect could not be measured due to stream conditions at the time of sampling.
Brn- Brown Trout, BT- Brook Trout, AS- Atlantic Salmon, 3SB- Threespine Stickleback, LND- Longnose dace, PD-Pearl Dace, Bur- Burbot, MS- Mottled Sculpin, A. Eel- American Eel, WS- White Sucker

Appendix A outlines the locations of all stream crossings and field survey locations along with a corresponding map sheet. In addition, Appendix A also includes tables with each map sheet presenting a summary of the air photo interpretation data and field survey data. A representative photograph is also presented with the data table on the opposite side of each map.

3.3.2 Stream Morphology Parameters

As indicated Table 3.16, the Southeastern Labrador region consisted of mostly steady and riffle/run habitat (each 47 percent), and to a lesser extent riffle (7 percent) habitat types. Within the Northern Peninsula region 54 percent of stream sections were riffle habitat, 31 percent were steady habitat and 15 percent were run habitat. Within the Central and Eastern Newfoundland region 45 percent were riffle habitat, 35 percent run habitat, 15 percent steady habitat, and 5 percent riffle/run habitat were observed. Site sections sampled within the Avalon Peninsula region were 80 percent run habitat and 20 percent riffle habitat. Overall, riffle habitat was the most common habitat type surveyed (34 percent) followed by steady habitat (26 percent) and run habitat (25 percent). The least common habitat type observed was riffle/run habitat (15 percent).

Mean, minimum and maximum depth and velocity measurements are summarized in Table 3.17 by region and habitat type.

Table 3.17 Water Depth and Velocity of Each Habitat Type by Region

Region and Habitat	Depth (m)			Velocity (m/s)		
	Mean	Min	Max	Mean	Min	Max
Southeastern Labrador						
Riffle	0.25	0.01	0.52	0.71	0.00	1.08
Riffle/Run	0.32	0.00	0.80	0.22	0.00	0.74
Steady	0.29	0.01	0.72	0.14	0.00	1.20
Northern Peninsula						
Riffle	0.15	0.00	0.67	0.18	0.00	1.01
Run	0.17	0.00	0.58	0.29	0.00	1.12
Steady	0.28	0.00	0.71	0.13	0.00	0.66
Central and Eastern Newfoundland						
Riffle	0.26	0.01	0.87	0.33	0.00	1.62
Riffle/Run	0.19	0.02	0.48	0.32	0.00	0.84
Run	0.32	0.01	0.66	0.44	0.00	1.21
Steady	0.25	0.03	0.79	0.27	0.00	0.89
Avalon Peninsula						
Riffle	0.28	0.02	0.53	0.18	0.00	0.65
Run	0.15	0.00	0.38	0.32	0.00	1.09

Habitats were classified based upon ranges of specific parameters (water velocity, substrate and depth) which define habitat types. The mean depth range was 0.15 to 0.28 m for riffle habitat, 0.19 to 0.32 m for riffle/run habitat, 0.25 to 0.29 m for steady habitat and 0.15 to 0.32 m for run habitat. Whereas the mean range of water velocities was 0.18 to 0.71 m/s for riffle habitat, 0.22 to 0.32 m/s for riffle/run, 0.13 to 0.27 m/s for steady habitat and 0.29 to 0.1 m/s for run habitat.

GPS coordinates, measured watershed size as well as watershed size category for all surveyed sites can be found in Appendix B.

3.3.3 Biological Parameters

Table 3.18 presents a summary of the total number of sites within each region where species were captured and the number of each species caught per region. The results of electrofishing surveys are presented in Table 3.19

All but three of the crossings surveyed had fish recorded; P369 in South Brook (Halls Bay) watershed, P270 in the Sop's Arm watershed and P204 in the Castors River watershed.

The majority of sites surveyed contained both brook trout and Atlantic salmon. Brown trout were only captured in the Avalon Peninsula region and American eel were only captured in the Northern Peninsula region. Appendix C presents all electrofishing data.

Table 3.18 Summary of Fish Species Captured During 2008 Freshwater Field Surveys by Region

Species Captured		Region			
		Southeastern Labrador (15)[1]	Northern Peninsula (16)[1]	Central and Eastern Newfoundland (16)[1]	Avalon Peninsula (6)[1]
American eel	Sites with species present[2]	0	2	0	0
	Number per Region[3]	0	9	0	0
Atlantic salmon	Sites with species present[2]	4	6	13	5
	Number per Region[3]	56	141	105	18
Brook trout	Sites with species present[2]	10	7	12	4
	Number per Region[3]	112	193	79	34
Brown trout	Sites with species present[2]	0	0	0	2
	Number per Region[3]	0	0	0	42
Burbot	Sites with species present[2]	2	0	0	0
	Number per Region[3]	6	0	0	0
Longnose dace	Sites with species present[2]	3	0	0	0
	Number per Region[3]	15	0	0	0
Mottled sculpin	Sites with species present[2]	1	0	0	0
	Number per Region[3]	1	0	0	0
Pearl dace	Sites with species present[2]	4	0	0	0
	Number per Region[3]	10	0	0	0
Threespine stickleback	Sites with species present[2]	0	2	6	3
	Number per Region[3]	0	8	13	6
White sucker	Sites with species present[2]	4	0	0	0
	Number per Region[3]	9	0	0	0

[1] Total number of sites electrofished
[2] Number of crossing locations where the species was captured
[3] Total number of individuals caught within each region

Table 3.19 Summary of 2008 Electrofishing Surveys

Region	Watershed Name	Stream Name[a]	Stream Crossing ID	Watershed Size Class (km^2)	Measured Watershed Size (km^2)[b]	Fish Species											Notes
						Burbot	American eel	Longnose dace	Pearl dace	Atlantic salmon	Ouananiche	Brook trout	Brown trout	Mottled sculpin	Threespine stickleback	White sucker	
Southeastern Labrador	Unnamed, Churchill Trib	Unknown	P7	50 - 200	88.8				●								
	Unnamed, Churchill Trib	Unknown	P10	2.6 - 50	15.2	●			●							●	
	Kenamu	Unknown	P29	200 - 500	436.3	●		●	●	●							
	Kenamu	Unknown	P30	2.6 - 50	6.2			●		●		●					
	Kenamu	Kenamu River	P36	1000 - 10000	1092.4			●	●	●							
	Kenamu	Unknown	P37	500 - 1000	574.5					●				●			
	Kenamu	Unknown	P43	2.6 - 50	6.1							●					
	Kenamu	Unknown	P52	2.6 - 50	9.7							●					
	Kenamu	Joir River	P55	2.6 - 50	221.6							●				●	
	St. Paul	Unknown	P108	2.6 - 50	27.7							●				●	
	St. Paul	Unknown	P120	2.6 - 50	6.3							●					
	St. Paul	St. Paul River	P121	200 - 500	491.5							●					Salamander
	St. Paul	Unknown	P139	2.6 - 50	2.8							●					
	St. Paul	Unknown	P142	2.6 - 50	6.4							●					
	St. Paul	Unknown	P143	50 - 200	61.2							●				●	
Northern Peninsula	Portland Creek	Bowing Brook	P1005	200 - 500	345.3		●										
	Castors River	Toms Feeder	P200	2.6 - 50	15.3					●		●					
	Castors River	Unknown	P204	2.6 - 50	2.8												No fish caught
	Castors River	Unknown	P205	50 - 200	65.6					●							
	Torrent River	Torrent River	P228	200 - 500	447.4					●							
	River of Ponds	River of Ponds	P238	200 - 500	331.6		●			●					●		
	River of Ponds	Unknown	P239	200 - 500	265.7					●		●					
	Portland Creek	Unknown	P243	2.6 - 50	19.6							●			●		
	Portland Creek	Unknown	P245	200 - 500	427.3							●					
	Portland Creek	Unknown	P246	2.6 - 50	3.2							●					
	Portland Creek	Unknown	P259	2.6 - 50	15.9							●					
	Sop's Arm River (Main	Unknown	P267	2.6 - 50	6.0					●		●					
	Sop's Arm River (Main	Pond River	P270	2.6 - 50	7.5												No fish caught
Central and Eastern Newfoundland	Humber River	Taylors Brook	P308	50 - 200	52.3							●					
	Humber River	Gales Brook	P311	50 - 200	57.2					●		●					
	Hampden River	Gales Brook	P313	2.6 - 50	12.1					●		●			●		
	Grand Lake System	Main Brook	P326	2.6 - 50	14.7							●					
	Sheffield Lake	Upper Sheffield	P343	50 - 200	194.1							●					
	Sheffield Lake	Unknown	P346	2.6 - 50	10.8							●					
	Sheffield Lake	Burnt Berry Brook	P352	2.6 - 50	35.2							●					
	South Brook, Halls Bay	South Brook	P369	200 - 500	272.6												No fish caught
	Exploits River	Unknown	P397	2.6 - 50	2.6					●		●					
	Exploits River	Sandy Brook	P399	500 - 1000	598.0					●					●		
	Exploits River	Stoney Brook	P401	50 - 200	161.2					●					●		
	Exploits River	Green Wood Brook	P403	2.6 - 50	3.8					●		●					
	Exploits River	Little Rattling	P408	50 - 200	79.8					●					●		
	Exploits River	Unknown	P413	2.6 - 50	21.8					●							
	Rattling Brook	Rattling Brook	P416	500 - 1000	605.9					●					●		
	Rattling Brook	Unknown	P421	2.6 - 50	3.7					●		●					
	Gander River	Gander River	P430	500 - 1000	989.4					●					●		
	Gander River	Gander River	P437	500 - 1000	989.4					●		●					
	Gambo River	Dead Wolf Brook	P441	50 - 200	53.3							●					
	Southwest Brook, Port	Southwest River	P469	200 - 500	405.1					●							
Avalon Peninsula	Northern Arm River	Unknown	A110	2.6 - 50	15.2					●		●	●				
	Spread Eagle River	Unknown	P529	2.6 - 50	11.2					●		●	●				
	Witch Hazel Brook	Unknown	P533	2.6 - 50	24.7					●		●			●		
	Witch Hazel Brook	Unknown	P534	2.6 - 50	24.7					●		●			●		
	Northern Arm River	Daniels River	P541	50 - 200	50.9					●					●		

[a] names were taken from 1:50000 topographic map

[b] Watershed size was calculated upstream of crossing

Species caught within the Southeastern Labrador region during the field program include Atlantic salmon, brook trout, burbot, longnose dace, mottled sculpin, pearl dace, and white sucker.

Species caught within the Northern Peninsula region during the field program include American eel, Atlantic salmon/ouananiche, brook trout, and threespine stickleback.

Species caught within the Central and Eastern Newfoundland region during the field program include Atlantic salmon/ouananiche, brook trout, and threespine stickleback.

Species caught within the Avalon Peninsula region during the field program include Atlantic salmon, brook trout, brown trout, and threespine stickleback.

The summary of the four regions indicates that some of fish documented during the literature review were not captured during the field program (and vice versa), however, each stream surveyed was a small portion of the entire watershed and locations noted in the literature were not the exact locations sampled. Therefore the electrofished area provides a sample of the species found in the immediate area and, at the time of the survey. Fish that were documented to be in the watershed may have been located elsewhere (e.g., in the headwaters or located in a more suitable habitat) than the habitat which was electrofished. For example, in the summary of fish presence from literature review it was documented that American eels were found in the Labrador, Northern Peninsula and Central and Eastern Newfoundland regions but during the field program they were only found in the Northern Peninsula region.

Ouananiche (land locked Atlantic salmon) and Atlantic salmon (anadromous form) were both documented in the Northern Peninsula and Central and Eastern Newfoundland regions during the literature review. However since they are the same species it was not possible to distinguish between the two forms during the field program. Therefore both forms have been included as Atlantic salmon.

3.3.4 Water and Sediment Quality Results

A summary of the survey locations where water and sediment samples were collected during the 2008 field program is provided in Table 3.20. Appendix D presents the laboratory results, summary tables of results with CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life and highlighted samples with concentrations exceeding these guidelines, as well as the in-situ measurements. It should be noted that most sites were not favourable for collection of sediment samples in that sedimentary materials were limited.

Water samples analyzed for metals and hydrides showed that all but one site (P533) had at least one parameter exceeding CCCME guidelines for the Protection of Aquatic Life. In particular, 39 of 44 samples collected showed levels of cadmium above CCME guidelines whereas 32 sample sites (15 in Southeastern Labardor, 5 in Northern Peninsula, 11 in Central and Eastern Newfoundland and, 1 in the Avalon Peninsula region) and 26 sample sites (9 in Southeastern Labardor, 7 in Northern Peninsula, 8 in Central and Eastern Newfoundland and, 2 in the Avalon Peninsula region) were above CCME guidelines for iron and aluminum respectively. In addition, eight of the 44 samples collected for metals were above CCME guidelines, these included three lead, two mercury (all in Southeastern Labrador for both parameters), two copper (1 in Southeastern Labrador and 1 in the Northern Peninsula) and one selenium (in Central and Eastern Newfoundland) which were above CCME guidelines. Table 3.21 summarizes the sites by region which had samples with metal concentrations above CCME guidelines.

In addition, tests conducted on water samples for Volatile Organic Carbons (VOC) and benzene, toluene, ethylbenzene, and xylene (BTEX) showed no concentrations which exceeded CCME guidelines. However, while there is no CCME guideline value for total petroleum hydrocarbons (TPH), a hydrocarbon identified as heavy oil was recorded at site P541, in the Avalon Peninsula region.

General chemistry analysis results showed an exceedance in pH at 18 of the 44 sites sampled (Table 3.21). Overall, pH values ranged from 5.49 to 8.04 for all the sampled sites and are typical of those found in the province.

A total of 13 sediment samples were collected and analyzed for general chemistry, metals and hydrides, and total organic carbon (TOC) (see Tables 3.20 and 3.21 for site and analysis summary). Of the 13 sediment samples 12 were adequate for general chemistry samples and only 1 sample was analyzed for metals and hydrides and TOC. There were no sediment samples which showed any exceedance of CCME guidelines for any parameter.

Table 3.20 Water and Sediment Samples Collected During the 2008 Field Program and Analysis Conducted

Region	Site ID	Water Quality				Sediment		
		General Chemistry	Metals	VOC	BTEX	General Chemistry	Metals	TOC
Southeastern Labrador	P7	●	●	●		●		
	P10	●	●	●	●	●		
	P29	●	●	●	●	●		
	P30	●	●	●		●		
	P36	●	●	●				
	P37	●	●	●		●		
	P43	●	●	●		●		
	P52	●	●	●		●		
	P55	●	●	●		●		
	P108	●	●	●		●		
	P120	●	●	●		●		
	P121	●	●	●				
	P139	●	●	●		●		
	P142	●	●	●				
	P143	●	●	●		●		
Northern Peninsula	P200	●	●		●			
	P204	●	●		●			
	P205	●	●		●			
	P228	●	●		●			
	P238	●	●		●			
	P239	●	●		●			
	P243	●	●		●			
	P245	●	●		●			
	P246	●	●		●			
	P259	●	●		●			
	P267	●	●		●			
	P270	●	●		●			
	P1005	●	●		●			

Region	Site ID	Water Quality: General Chemistry	Water Quality: Metals	Water Quality: VOC	Water Quality: BTEX	Sediment: General Chemistry	Sediment: Metals	Sediment: TOC
Central and Eastern Newfoundland	P308	●	●		●			
	P311	●	●		●			
	P313	●	●		●			
	P326	●	●		●			
	P343	●	●		●			
	P346	●	●		●			
	P352	●	●		●			
	P369	●	●		●			
	P397							
	P399							
	P401							
	P403							
	P408							
	P413					●	●	●
	P416	●	●		●			
	P421	●	●		●			
	P430	●	●		●			
	P437	●	●		●			
	P441							
	P469							
Avalon Peninsula	A110	●	●		●			
	P529							
	P533	●	●		●			
	P534	●	●		●			
	P541	●	●		●			

Table 3.21 Summary of Water Chemistry Results Exceeding CCME Guidelines

Region	Site ID	Metals: Aluminum	Metals: Cadmium	Metals: Copper	Metals: Iron	Metals: Lead	Metals: Mercury	Metals: Selenium	General Chemistry: pH
Southeastern Labrador	P7	●	●		●				
	P10	●	●		●				
	P29		●	●	●				
	P30	●	●		●	●			●
	P36				●				
	P37		●		●		●		
	P43		●		●				
	P52	●	●		●	●	●		
	P55		●		●				
	P108		●		●				
	P120	●	●		●				●
	P121	●	●		●				●
	P139	●	●		●	●			●
	P142	●	●		●				●

Region	Site ID	Metals							General Chemistry
		Aluminum	Cadmium	Copper	Iron	Lead	Mercury	Selenium	pH
	P143	●	●		●				●
Northern Peninsula	P200		●						
	P204	●	●		●				●
	P205	●	●		●				●
	P228		●						
	P238		●						
	P239		●						
	P243		●						
	P245		●						
	P246	●	●		●				
	P259	●	●	●	●				●
	P267	●	●		●				
	P270	●							●
	P1005	●	●						●
Central and Eastern Newfoundland	P308	●	●						
	P311		●		●				
	P313		●		●				
	P326	●	●		●				●
	P343	●	●		●			●	●
	P346	●	●		●				●
	P352	●	●		●				●
	P369		●		●				
	P416				●				
	P421	●	●		●				
	P430	●	●		●				
	P437	●	●		●				●
Avalon Peninsula	A110	●	●		●				●
	P534	●							●
	P541		●						

4.0 SUMMARY AND CONCLUSIONS

Nalcor Energy is proposing to develop the *Labrador – Island Transmission Link*, a High Voltage Direct Current (HVdc) transmission system extending from Central Labrador to the Island of Newfoundland's Avalon Peninsula. The EA process for the Project was initiated in January 2009 and an EIS is being prepared by Nalcor Energy.

In anticipation and support of that EA, Nalcor Energy contracted AMEC Earth and Environmental to conduct a Freshwater Environment study for the Project. The objective was to obtain and present information on freshwater fish and fish habitat and water resources in and adjacent to the Project Area, and specifically, to identify and characterize those watercourses that may be crossed by the transmission corridor. The Project will be undertaken in accordance with applicable permits and other regulatory requirements and guidance, as well as Nalcor Energy's standard mitigations, which will serve to avoid or reduce potential adverse effects on the freshwater environment.

An appropriate understanding of the freshwater environment along the proposed transmission corridor is beneficial, and has been obtained, for use in the EA and on-going Project design and planning.

Through the air photo interpretation, field survey and literature review, the study identifies each of the various watercourses crossed by the transmission corridors (proposed and alternatives) and describes their associated fish and fish habitat characteristics.

The study also provides information on water resources in these watercourses, including the collection and analysis of water samples (water quality) and the calculation of watershed sizes, water depths and flow velocity (water quantity), and a literature review of existing water quality in and near the Project area.

Air Photo Interpretation

A total of 656 potential watercourse crossings were identified within the transmission corridor through air photo analysis within a GIS system. Specifically, 586 of these watercourses crossings were within the proposed transmission corridor, and 70 were within the various alternative transmission corridor segments. In particular, interpreters assessed and classified potential fish habitat within a total of 196 streams in the Southeastern Labrador region, 173 in the Northern Peninsula region, 184 in the Central and Eastern Newfoundland region and 103 in the Avalon Peninsula region (Table 4.1). All regions had riverine fish habitat which consisted of rapid, riffle flat or discontinuous habitat types. Overall the most common flow morphology throughout the Project area was riffle type flow at 43 percent. The most common dominant substrate material overall was fine substrate at 61 percent.

Table 4.1 Labrador – Island Transmission Link: Identified Watercourse Crossings

Study Region	Watercourse Crossings		
	Proposed Transmission Corridor	**Alternative Transmission Corridor Segment(s)**	**Total**
Southeastern Labrador	194	2	**196**
Northern Peninsula	123	50	**173**
Central and Eastern Newfoundland	170	14	**184**
Avalon Peninsula	99	4	**103**
Total	**586**	**70**	**656**

Freshwater Field Program and Literature Review

A representative sample of 53 watercourse crossings were surveyed across the entire Project area during the summer of 2008. Stream morphological parameters including water depth, velocity measurements and habitat classification assessment (e.g., riffle, run or pool) were taken along survey transects. Water and sediment samples were also collected at representative sites for baseline data.

The analysis (general chemistry and metals) of water samples collected during the 2008 field program indicated that 43 of the 44 streams sampled had at least one parameter which exceeded CCME Canadian Water Quality Guidelines for the Protection of (Freshwater) Aquatic Life. The only stream which did not have any parameter which exceeded CCME guidelines was P533 located within the Avalon Peninsula region.

A total of 13 sediment samples were collected during the 2008 field program and subjected to chemical analysis. Of the 13 sediment samples, 12 were adequate for general chemistry analysis. The results indicated that neither sediment sample collected during the 2008 program had any parameter exceeding CCME guidelines.

Fish species recorded at each surveyed site were similar to that expected based on the literature review. The literature review was conducted to consolidate information regarding habitat descriptions and species compositions at each crossing location within the transmission corridor.

The literature identified a SARA designated fish species of special concern, the banded killifish (Newfoundland population) and a COSEWIC designated species the American eel listed as special concern. It is worth noting however that the banded killifish has not been found within the watersheds which the transmission corridor may interact, including during the fieldwork completed for this study.

Municipal drinking water supplies identified as being crossed by the transmission line corridor were considered and available water quality data for these sites were collected from a provincial data portal (NL DEC 2010) and assessed for current conditions. All regions consisted of sites that exceeded colour parameter guidelines for CDWQ (aesthetics parameter). Central and Eastern Newfoundland region also exceeded the manganese value for CCME PAL guidelines (Steve's Pond water supply, Arnold's Cove) and pH values exceeding both guidelines for CDQW and CCME PAL (all sites except Brigades Pond, Southern Harbour).

5.0 REFERENCES

Aadland, L.P. 1993. Stream habitat types: their fish assemblages and relationship to flow. North American Journal of Fisheries Management **13**: 790-806.

Able, K.W. and M. Castagna. 1975. Aspects of an undescribed reproductive behaviour in *Fundulus heteroclitus* (Pisces: Cyprinodontidae) from Virginia. Chesapeake Science **16**: 282-284.

Abraham, B.J. 1985. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (MidAtlantic)—mummichog and striped killifish. United States Fish and Wildlife Service, Biological Report Number 82 (11.40); United States Army Corps of Engineers Number TR EL824, 23p.

Acres Consulting Services Limited. 1979. Lower Churchill Transmission Line Project stream monitoring study, final report. Prepared for Newfoundland and Labrador Hydro St. John's, Newfoundland.

AGRA . 1999. Fish and fish habitat baseline study Churchill River Labrador. Prepared for Newfoundland and Labrador Hydro, St. John's, Newfoundland.

AMEC Earth and Environmental. 2003. Voisey's Bay Nickel Company Mine/Mill Project Fish Habitat Compensation Plan, Voisey's Bay Nickel Company, St. John's, Newfoundland.

AMEC Earth and Environmental. 2004. Victor Diamond Project Southwest Alternative Winter Road Aquatic Resources. DeBeers Canada Exploration Inc. Ontario, Canada.

AMEC Earth and Environmental. 2005. Potential Watercourse Crossings Desktop Data Review and Habitat Characterization. Lab Mag GP Incorporated, Montreal, Quebec.

AMEC Earth and Environmental. 2007. Lower Churchill Hydroelectric Generation Project Habitat Quantification. Prepared for Newfoundland and Labrador Hydro, St. John's, Newfoundland.

Anderson, T.C. 1985. The Rivers of Labrador. Canadian Special Publication of Fisheries and Aquatic Sciences Number 81, 389p.

Andrews, C.W. 1965. Early importation and distribution of exotic freshwater fish species in Newfoundland. Canadian Fish Culturist **36**: 35-36.

Arndt, S.K.A. and J. Hutchinson. 2000. Characteristics of burbot spawning in a tributary of Columbia Lake, British Columbia, over a four year period, p. 4860. *In* V.L. Paragamian and D.W. Willis (eds), Burbot: Biology, ecology, and management. American Fisheries Society, Fisheries Management Section Number 1.

Atlantic Biological Services Limited. 1980. Stream monitoring surveys, 1979. Aquatic monitoring of selected streams with respect to potential disturbance resulting from Lower Churchill Development transmission lines. Completed for Lower Churchill Development Corporation Limited, St. John's, Newfoundland.

Auer, N.A. 1982. Identification of larval fishes of the Great Lakes basin with emphasis on the Lake Michigan Drainage. Great Lakes Fishery Commission Special Publication Number 823, 744p.

Backus, R.H. 1951. New and rare records of fishes from Labrador. Copeia **4**: 288-294.

Backus, R.H. 1957. The fishes of Labrador. Bulletin of the American Museum of Natural Histiory **113**: 277-337.

Bartnik, V.G. 1970. Reproductive isolation between two sympatric dace, *Rhinichthys atratulus* and *R. cataractae,* in Manitoba. Journal of the Fisheries Research Board of Canada **27**: 2125-2141.

Bartnik, V.G. 1972. Comparison of the breeding habits of two subspecies of longnose dace, (*Rhinichythys cataractae).* Canadian Journal of Zoology **50**: 83-86.

Beak. 1980. Fisheries resources of tributaries of the Lower Churchill River. Prepared by Beak Consultants Limited for the Lower Churchill Development Corporation, St. John's, Newfoundland.

Beak Consultants Limited. 1979. Fisheries resources of selected tributaries of the Lower Churchill River. Prepared for Newfoundland and Labrador Hydro, St. John's, Newfoundland, 90p.

Beamish, F.W.H., P.J. Healy, and D. Griggs. 1986. Freshwater fishes in Canada: Report on phase 1 of a nation examination. Canadian Wildlife Federation, 155p.

Becker, G.C. 1983. Fishes of Wisconsin. University of Wisconsin Press, Madison, 1052p.

Belyanina, T.N. 1969. Synopsis of biological data on smelt, *Osmerus eperlanus* (Linnaeus) 1758. Food and Agriculture Organization of the United Nations Fisheries Synopsis Number 78, 57p.

Berry, F.H. 1964. Review and emendation of family Clupeidae. Copeia **1964 (4):** 720-730.

Bidgood, B.F. 1972. Divergent growth in lake whitefish populations from two eutrophic Alberta lakes. Alberta Fish and Willife Division, Edmonton, Alberta, Research Report Number 9, 120p.

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the western North Atlantic (sawfishes, guitarfishes, skates, rays, chimaeroids). Memoirs of the Sears Foundation for Marine Research **1:** 1588.

Black, G.A., J.B. Dempson, and W.J. Bruce. 1986. Distribution and postglacial dispersal of freshwater fishes of Labrador. Canadian Journal of Zoology **64**: 21-31.

Boag, T.D. 1989. Growth and fecundity of burbot, *Lota lota* L., in two Alberta lakes. M.Sc. thesis, University of Alberta, Edmonton.

Boussu, M.F. 1954. Relationship between trout and cover in a small stream. The Journal of Wildlife Management **18**: 229-239.

Bradbury, C., M.M. Roberge and C.K. Minns. 1999. Life history characteristics of freshwater fishes occurring in Newfoundland and Labrador, with major emphasis on lake habitat characteristics. Canadian Manuscript Report of Fisheries and Aquatic Sciences Number 2485, vii+150p.

Brandt, S.B. 1986. Ontogenetic shifts in habitat, diet and dielfeeding periodicity of slimy sculpin in Lake Ontario. Transactions of the American Fisheries Society **115**: 711-715.

Brazo, D.C., C.R. Liston and R.C. Anderson. 1978. Life history of the longnose dace, *Rhinichthys cataractae,* in the surge zone of eastern Lake Michigan near Ludington, Michigan. Transactions of the American Fisheries Society **107**: 550-556.

Breeser, S.W., F.D. Stearns, M.W. Smith, R.L. West, and J.B. Reynolds. 1988. Observations of movements and habitat preferences of the burbot in the Alaskan glacial river system. Transactions of the American Fisheries Society **117**: 506-509.

Brown, J.H., U.T. Hammer, and G.D. Koshinsky. 1970. Breeding biology of the lake chub *Couesius plumbeus,* at Lac la Ronge, Saskatchewan. Journal of the Fisheries Research Board of Canada **27**: 1005-1015.

Bruce, W.J. 1974. The limnology and fish populations of Jacopie Lake, west forebay, Smallwood Reservoir, Labrador. Canada Fisheries and Marine Service, Newfoundland Region, Resource Development Branch, St. John's, Newfoundland Technical Report Series Number NEW/T; 742, 74p.

Bruce, W.J., C.J. Morry, L.W. Rowe and R.J. Wiseman. 1975. An overview of fisheries problems associated with the proposed Lower Churchill hydroelectric development, Gull Island, Labrador, Resource Development Branch, Internal Report Series Number NEW/1752, 54p.

Bruce, W.J. and R.F. Parsons. 1976. Age, growth and maturity of lake chub (*Couesius plumbeus)* in Mile 66 Brook, Ten Mile Lake, Labrador. Canada Fisheries and Marine Service, Research and Development Directorate, Technical Report Number 683, 13p.

Bryan, J.E. 1973. The influence of pipeline development on freshwater fishery resources of northern Yukon Territory. Aspects of research conducted in 1971 and 1972. Environmental - Social Committee on Northern Pipelines, Task Force on Northern Oil Development. Report Number 736, 63p.

Burgess, W.E. 1978. Chaetodontidae. In W. Fischer (ed.), Food and Agriculture Organization species identification sheets for fishery purposes. Western Central Atlantic (fishing area 31), Volume 2., Rome.

Cahn, A.R. 1936. Observations on the breeding of the lawyer, *Lota maculosa.* Copeia **1936(3)**: 163-165.

Calhoun, A.J. 1944. The food of the blackspotted trout in two Sierra Nevada lakes. California Fish and Game **30**: 80-85.

Campbell, C.E., and R. Knoechel. 1988. Zooplankton communities and trophic structure of lakes on the Avalon Peninsula, Newfoundland, Canada. Verhandlungen Internationale Vereinigung fur Theoretische und Angewandte Limnologie **23**: 297-305.

Campbell, C.E. and R. Knoechel. 1990. Distribution patterns of vertebrate and invertebrate planktivores in Newfoundland lakes as indication of predatorprey and competitive interactions. Canadian Journal of Zoology **68**: 1559-1567.

Canadian Council of Ministers of the Environment. 2007. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated December, 2007. *In* Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Carl, L.M. 1992. The response of burbot (*Lota lota*) to change in lake trout (*Salvelinus namaycush*) abundance in lake Opeongo, Ontario. Hydrobiologia. **243/244**: 229-235.

Carlander, K.D. 1969. Handbook of freshwater fishery biology Vol. 1. Life history data on freshwater fishes of the United States and Canada, exclusive of the *Percifonnes.* Iowa State University Press, Ames, Iowa, 752p.

Carline, R.F. 1980. Features of successful spawning site development for brook trout in Wisconsin ponds. Transactions of the American Fisheries Society **109**: 453-457.

Casselman, J.M. and C.A. Lewis. 1996. Habitat requirements of northern pike, (*Esox lucius).* Canadian Journal of Fisheries and Aquatic Sciences **53 (Supplement 1):** 161-174.

Chadwick, E.M.P. and W.J. Bruce. 1981. Range extension of steelhead trout *(Salmo gairdneri)* in Newfoundland. Naturaliste Canadien **108**: 301-303.

Chapman, C.A. and W.C. Mackay. 1984. Versatility in habitat use by a top aquatic predator, *Esox lucius* L.. Journal of Fish Biology **25**: 109-115.

Chen, L.C. 1969. The biology and taxonomy of the burbot, *Lota lota leptura,* in interior Alaska. University of Alaska, Biological Papers Number. 11, 53p.

Chippett, J.D. 2003. Update COSEWIC status report on the banded killifish *Fundulus diaphanous*, Newfoundland population in Canada, *In* COSEWIC assessment and update status report on the banded killifish *Fundulus diaphanous* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, 21p.

Chisholm, I.M., W.A. Hubert, and T.A. Wesche. 1987. Winter stream conditions and use of habitat by brook trout in highelevation Wyoming streams. Transactions of the American Fisheries Society **116**: 176-184.

Christenson, L.M. and L.L. Smith. 1965. Characteristics of fish populations in upper Mississippi backwater areas United States Fish and Wildlife Service Circular Number 212.

Clark, C.F. 1950. Observations on the spawning habits of the northern pike, *Esox lucius,* in northwestern Ohio. Copeia **1950**: 285-288.

Coad, B.W. 2007. Fishes of Canada's National Capital Region. http://www.briancoad.com/NCR/Catostomidae.htm. Accessed February 2009.

Coad, B.W. and G. Power. 1973. Observations on the ecology and phenotypic variation of the threespine stickleback, *Gasterosteus aculeatus* L., 1758, and the blackspotted stickleback, *G. Wheatlandi* Putnam, 1967, (Osteichthyes: Gasterosteidae) in Amory Cove, Quebec. Canadian Field Naturalist **87**: 113-122

Coad, B.W., H. Waszczuk, and I. Labignan. 1995. Encyclopedia of Canadian fishes. Canadian Museum of Nature and Canadian Sportfishing Productions Incorporated, 928p.

Committee on the Status of Endangered Wildlife in Canada. 2006. Committee on the Status of Endangered Wildlife in Canada assessment and status report on the American eel *Anguilla rostrata* in Canada. Committee on the Status of Endangered Wildlife in Canada Ottawa, x + 71 p.

Congalton, R. 1991. A review of assessing the accuracy of classifications of remotely sensed data. Remote Sensing of Environment **37**: 35-46.

Congalton, R.G. and K. Green. 1999. Assessing the accuracy of remotely sensed data: principles and practices. Lewis publishers, Florida, 137 p.

Congalton, R.G. and R.A. Mead. 1983. A quantitative method to test for consistency and correctness in photo interpretation. Photogrammetric Engineering and Remote Sensing **49(1)**: 69-74.

Cooper, G.P. 1936. Importance of forage fishes, p. 305330. *In* Silcox, F.A. (ed)., Proceedings of the first North American wildlife conference, Washington, D.C., February 37, 1936.

Cowan, G.I. McT. and E.M. Baggs. 1988. Incidences of lacustrine spawning of the ouananiche, *Salmo salar*, and the brook charr, *Salvelinus fontinalis,* on the Avalon Peninsula, Newfoundland. Journal of Fish Biology **32**: 311-312.

Crossman, E.J. 1978. Taxonomy and distribution of North American esocids. American Fisheries Society Special Publication **11**: 13-26.

Cunjak, R.A. and J.M. Green. 1983. Habitat utilization by brook trout (*Salvelinus fontinalis)* and rainbow trout (*Salmo gairdneri)* in Newfoundland streams. Canadian Journal of Zoology **61**: 1214-1219.

Cunjak, R.A. and G. Power. 1986. Winter habitat utilization by stream resident brook trout (*Salvelinus fontinalis)* and brown trout (*Salmo trutta).* Canadian Journal of Fisheries and Aquatic Sciences **43**: 1970-1981.

Curry, R.A., and D.L.G. Noakes. 1995. Groundwater and the selection of spawning sites by brook trout (*Salvelinus fontinalis).* Canadian Journal of Fisheries and Aquatic Sciences **52**: 1733-1740.

Day, J.R. and M.H. Taylor. 1981. Observations of *Fundulus heteroclitus* in a nontidal environment. Proceedings of the New Jersey Mosquito Control Association, 129-136.

Dawe, P. 2003. Water Quality Trends in Selected Water Bodies of Newfoundland and Labrador. Water Resources Management Division, Department of Environment, St. John's NL. pp56

Dempson, J.B. and J.M. Green. 1985. Life history of the anadromous Arctic charr *(Salvelinus alpinus)* in the Fraser River, northern Labrador. Canadian Journal of Zoology **63**: 315-324.

Dence, W.A. 1948. Life history, ecology and habits of the dwarf sucker, *Catostomus commersonii utawana* (Mather), at the Huntington Wildlife Station. Roosevelt Wildlife Bulletin **8**: 81-150.

Department of Fisheries and Aquaculture. 2002. American eel harvesting pilot project Labrador straits. Fisheries Diversification Program. Project Summary: FDP 293.

Department of Fisheries and Oceans (DFO). 2007. Newfoundland and Labrador Angler's Guide.

DeRoche, S.E. 1969. Observations on the spawning habits and early life of lake trout. Progressive FishCulturist **31**: 109-113.

Dickinson, A.B. 1974. Metazoan parasites of *Fundulus heteroclitus* (Linnaeus, 1766) from insular Newfoundland. M.Sc. thesis, Memorial University of Newfoundland, St. John's, Newfoundland, 98p.

Dion, R.D., M. Richardson, L. Roy, and F.G. Whoriskey. 1994. Spawning patterns and interspecific mating of sympatric white (*Catostomus commersoni)* and longnose (*C. catostomus)* suckers from the Gouin reservoir system, Quebec. Canadian Journal of Zoology **72**: 195-200.

Downhomer, J.F. and L. Brown. 1979. Seasonal changes in the social structure of a mottle sculpin (*Cottus bairdi)* population. Animal Behaviour **27**: 451-458.

Edsall, T.A. 1970. The effect of temperature on the rate of development and survival of alewife eggs and larvae. Transactions of the American Fisheries Society **9:** 376-380.

Edsall, T.A., G.W. Kennedy, and W.H. Horns. 1993. Distribution, abundance, and resting microhabitat of burbot on Julien's Reef, southwestern Lake Michigan. Transactions of the American Fisheries Society **122**: 560-574

Edwards, E.A. 1983. Habitat suitability index models: Longnose sucker. United States Department of the Interior, Fish and Wildlife Service. FWS/OBS82/10.35, 21p.

Edwards, E.A., H. Li, and C.B. Schreck. 1983. Habitat suitability index models: longnose dace. United States Department of the Interior, Fish and Wildlife Service. FWSIOBS82/l0.33, 13p.

Einarsson, S.M., D.H. Mills, and V. Johannsson. 1990. Utilization of fluvial and lacustrine habitat by anadromous Atlantic salmon, *Salmo salar* L., in an Icelandic watershed. Fisheries Research **10**: 53-71.

Eklov, P. 1997. Effects of habitat complexity and prey abundance on the spatial and temporal distributions of perch (*Perca fluviatilis)* and pike (*Esox lucius).* Canadian Journal of Fisheries and Aquatic Sciences **54**: 1520-1531.

Elliott, J.M. 1986. Spatial distribution and behavioural movements of migratory trout *Salmo trutta* in a lake district stream. Journal of Animal Ecology **55**: 907-922.

Emery, A.R. 1973. Preliminary comparisons of day and night habits of freshwater fish in Ontario lakes. Journal of the Fisheries Research Board of Canada **30**: 761-774.

Enk, M.D. 1977. Instream overhead bank cover and trout abundance in two Michigan stream M. Sc. thesis, Michigan State University, Lansing, Michigan, 127p.

Evenson, M.J. 1993. A summary of abundance, catch per unit effort, and mean length estimates of burbot sampled in the rivers of interior Alaska, 198692. Alaska Department of Fish and Game, Fishery Data Series Number 9315, 28p.

Faber, D.J. 1970. Ecological observations on newly hatched lake whitefish in South Bay, Lake Huron, p. 481-500. *In* C.C. Lindsey and C.S. Woods (eds.), Biology of coregonid fish, University of Manitoba Press, Winnipeg.

Fabricius, E. 1954. Aquarium observations on the spawning behaviour of the burbot, *Lota vulgaris* L. Report Institute of Freshwater Research, Drottningholm **35**: 51-57.

Fausch, K.D. and R.J. White. 1981. Competition between brook trout (*Salvelinus fontinalis)* and brown trout (*Salmo trutta)* for positions in a Michigan stream. Canadian Journal of Fisheries and Aquatic Sciences **38**: 1220-1227.

Fenderson, O.C. 1964. Evidence of subpopulations of lake whitefish, *Coregonus clupeaformis,* involving a dwarfed form. Transactions of the American Fisheries Society **93**: 77-94.

Fitzpatrick, D.G. 1988. A comparative study of aspects of the biology of sympatric sticklebacks (*Gasterosteus aculeatus)* and (*Apeltes quadracus)* at Point Verde, Placentia Bay, Newfoundland. B.Sc. Hon. Thesis, Memorial University of Newfoundland, St. John’s, Newfoundland, 49p.

Forbes, S.A. and R.E. Richardson. 1920. The fishes of Illinois 2nd edition, Natural History Survey Division, State of Illinois, 357p.

Ford, B.S., P.S. Higgins, A.F. Lewis, K.L. Cooper, T.A. Watson, C.M. Gee, G.L. Ennis, R.L. Sweeting. 1995. Literature reviews of the life history, habitat requirements mitigation/compensation strategies for thirteen sport fish species in the Peace, Liard and Columbia river drainages of British Columbia. Canadian Manuscript Report of Fisheries and Aquatic Sciences Number 2321, xxii+342p.

Franklin, D.R. and L.L. Smith Jr. 1963. Early life history of the northern pike, *Esox lucias* with special reference to the factors influencing the numerical strength of year classes. Transactions of the American Fisheries Society **92**: 91-110.

Fraser, J.M. 1982. An atypical brook charr (*Salvelinus fontinalis)* spawning area. Environmental Biology of Fishes **7**: 385-388.

Fraser, J.M. 1985. Shoal spawning of brook trout, *Salvelinus fontinalis*, in a Precambrian shield lake. Le Naturaliste Canadien **112**: 163-174.

Fritz, E.S. and E.T. Garside. 1974. Salinity preferences of *Fundulus heteroclitus* and *F. diaphanus* (Pisces: Cyprinodontidae): Their role in geographic distribution. Canadian Journal of Zoology **52**: 997-1003.

Frontier Hydro Development Limited and Algonquin Power Corporation Incorporated. 1997. Southwest River (Port Blandford) Hydroelectric Development Environmental Preview Report.

Frost, N. 1938. Trout and their conservation. Newfoundland Department of Natural Resources, Fisheries Service Bulletin Number 6, 16p.

Frost, N. 1940. A preliminary study of Newfoundland trout. Newfoundland Department of Natural Resources, Fisheries Service Bulletin Number 9, 30p.

Garside, E.T. 1970. New samples of the piscifauna of insular Newfoundland. Canadian Field Naturalist **84**: 385-386.

Garside, E.T. and G.C. Morrison. 1977. Thermal preferences of mummichog, *Fundulus heteroclitus* L., and banded killifish, *F. diaphanus* (LeSeueur), (Cyprinodontidae) in relation to thermal acclimation and salinity. Canadian Journal of Zoology **55**: 1190-1194.

Gee, J.H. and K. Machniak. 1972. Ecological notes on a lakedwelling population of longnose dace *(Rhinichthys cataractae).* Journal of the Fisheries Research Board of Canada **29**: 330-332.

Geen, G.H., T.G. Northcote, G.F. Hartman, and C.C. Lindsey. 1966. Life histories of two species of catostomid fishes in Sixteen Mile Lake, B.C., with particular reference to inlet stream spawning. Journal of the Fisheries Research Board of Canada **23**: 1761-1788.

Geology.com. 2009. Geology dictionary. http://geology.com/dictionary/glossary-w.shtml. Accessed April 2009.

Ghan, D. and W.G. Sprules. 1991. Distribution and abundance of larval and juvenile burbot (*Lota lota)* in Oneida Lake, New York. Verhandlungen Internationale Vereinigung fur Theoretische und Angewandte Limnologie **24**: 2377-2381.

Gibson, R.J., D.E. Stansbury, R.R. Whalen and K.G. Hillier. 1993. Relative habitat use, and interspecific and intraspecific competition of brook trout (*Salvelinus fontinalis*) and juvenile Atlantic salmon (*Salmo salar*) in some Newfoundland rivers, p. 53-69. In R.J. Gibson and R.E. Cutting (eds.), Production of juvenile Atlantic salmon, *Salmo salar*, in natural water. Canadian special publication of fisheries and aquatic sciences, number 118.

Gibson, R.J., J.P. Thonney, and K.G. Hillier. 1984. An easterly extension in the known range for *Fundulus diaphanus* in Newfoundland. Naturaliste Canadien **111**: 213-214.

Giger, R.D. 1973. Streamflow requirements of salmonids (Project Number: AFS621). Oregon Wildlife Commission, Portland, Oregon, 117p.

Grant, C.G.J. and E.M. Lee. 2004. Life history characteristics of freshwater fishes occurring in Newfoundland and Labrador, with major emphasis on riverine habitat requirements. Canadian Manuscript Report of Fisheries and Aquatic Sciences Number 2672, xii + 262p.

Green, B.S., R.C. Chambers. 2007. Maternal effects vary between source populations in the Atlantic tomcod *Microgadus tomcod*. Marine Ecology Progress Series **344**: 185-195.

Greenberg, L.A. 1991. Habitat use and feeding behaviour of thirteen species of benthic stream fishes. Environmental Biology of Fishes **31**: 389-401.

Griffith, R.W. 1974. Environment and salinity tolerance in the genus *Fundulus.* Copeia **1974(3)**: 319-331.

Grimm, M.P. 1989. Northern pike (*Esox lucius* L.) and aquatic vegetation, tools in the management of fisheries and water quality in shallow waters. Hydrobiological Bulletin **23**: 61-67.

Grimm, M.P. and J.J.G.M. Backx. 1990. The restoration of shallow eutrophic lakes, and the role of northern pike, aquatic vegetation and nutrient concentration. Hyrdobiologia **200201**: 557-566.

Griswold, B.L. and L.L. Smith Jr. 1972. Early survival and growth of the ninespine. stickleback, *Pungitius pungitius.* Transactions of the American Fisheries Society **101**: 350-352.

Griswold, B.L. and L.L. Smith Jr. 1973. The life history and trophic relationship of the ninespine stickleback, *Pungitius pungitius,* in the Apostle Islands area of Lake Superior. Fishery Bulletin **71**: 1039-1060.

Grossman, G.D. and M.C. Freeman. 1987. Microhabitat use in a stream fish assemblage. Journal of Zoology **212**: 151-176.

Hagen, D.W. 1967. Isolating mechanisms in threespine stickleback (*Gasterosteus*). Journal of the Fisheries Research Board of Canada **24**: 1637-1692.

Halvorsen, M. and L. Jorgensen. 1996. Lakeuse by juvenile Atlantic salmon (*Salmo salar* L.) and other salmonids in northern Norway. Ecology of Freshwater Fish **5**: 28-36.

Hanek, G**.** and W. Threlfall. 1970. Helminth parasites of the fourspine stickleback *(Apeltes quadracus* (Mitchill)) in Newfoundland. Canadian Journal of Zoology **48**: 404- 406.

Hanson, J.M. and S.U. Qadri. 1980. Morphology and diet of youngofthe year, *Lota lota,* in the Ottawa River. Canadian FieldNaturalist **94**: 311-314.

Hardy, J.D. Jr. 1978. Development of fishes of the midAtlantic bight: An atlas of egg, larval and juvenile stages. Vol. 2: Anguillidae through Syngnathidae. United States Fish and Wildlife Service, Biological Services Program Project Number FWS/OBS78/12, 458p.

Harris, R.H.D. 1962. Growth and reproduction of the longnose sucker *Catostomus catostomus* (Foster), in Great Slave Lake. Journal of the Fisheries Research Board of Canada **19**: 113-126.

Hartman, G.F., T.G. Northcote and C.C. Lindsey. 1962. Comparison of inlet and outlet spawning runs of rainbow trout in Loon Lake, British Columbia. Journal of the Fisheries Research Board of Canada **19:** 173-200.

Harvey, K.A. and K. Warner. 1970. The landlocked salmon (*Salmo salar*): Its life history and management in Maine. Maine Department of Inland Fish and Game, Augusta, Maine, 129p.

Hegge, O., Dervo, B.K., Skurdal, J., and Hessen, D.O. 1989. Habitat utilization by sympatric arctic charr (*Salvelinus alpinus* (L.)) and brown trout (*Salmo trutta* L.) in Lake Atnsjø, southeast Norway. Freshwater Biology **22**: 143-152.

Health Canada. 2008. Guidelines for Canadian Drinking Water Quality Summary Table. May 2008. 14p.

Hindar, K., and Jonsson, B. 1982. Habitat and food segregation of dwarf and normal arctic charr (*Salvelinus alpinus*) from Vangsvatnet Lake, western Norway. Canadian Journal of Fisheries and Aquatic Sciences **39**: 1030-1045.

Holland, L.E. and M.L. Huston. 1984. Relationship of youngoftheyear northern pike to aquatic vegetation types in backwaters of the Upper Mississippi River. North American Journal of Fisheries Management **4**: 514-522.

Hosn, W.A. and J.A. Downing, 1994. Influence of cover on the spatial distribution of littoralzone fishes. Canadian Journal of Fisheries and Aquatic Sciences **51**: 1832–1838.

Houston, J. 1990. Status of the banded killifish, *Fundulus diaphanus,* in Canada. Canadian FieldNaturalist **104**: 45-52.

Hubert, W.A and F.J. Rahel. 1989. Relations of physical habitat to abundance of four nongame fishes in highplains streams: a test of habitat suitability index models. North American Journal of Fisheries Management **9**: 332-340.

Hunt, R.L. 1971. Responses of a brook trout population to habitat development in Lawrence Creek. Department of Natural Resources, Madison, Wisconsin. Technical Bulletin Number 48, 35p.

Inskip, P.D. 1982. Habitat suitability index models: northern pike. Department of Interior, United States Fish and Wildlife Service, Washington, D.C. Vol. 82/10.17.

Jensen, K.W. 1968. Sea trout *(Salmo trutta* L.) of the River Istra, western Norway. ReportInstitute for Freshwater Research, Drottingholm **48**: 187-213.

Johnson, L. 1980. The Arctic charr, *Salvelinus alpinus.* P. 1598. *In* E.K. Balon (ed.), Charrs: salmonid fishes of the genus *Salvelinus.* Dr. W. Junk Publishers, The Hague, Netherlands.

Johnson, R.P. 1971. Limnology and fishery biology of Black Lake, Northern Saskatchewan. Saskatchewan Department of Natural Resources Fisheries Report 9 (1), 47p.

Johnson, T. 1981. Biotope changes and life cycle of *Lota lota* in the Bothnian Sea and a coastal river. Oesterriechische Fischereiverband **34**: 6-9.

Jonsson, B. and F.R. Gravem. 1985. Use of space and food by resident and migrant brown trout, *Salmo trutta.* Environmental Biology of Fishes **14**: 281-293.

Jonsson, N. and B. Jonsson. 2002. Migration of anadromous brown trout in a Norwegian river. Freshwater Biology **47**: 1391–1401

Jorgensen, L., M. Halvorsen and P.A. Amundsen. 2000. Resource partitioning between lakedwelling Atlantic salmon (*Salmo salar* L.) parr, brown trout (*Salmo trutta* L.) and Arctic charr (*Salvelinus alpinus* L.) with emphasis on food. Ecology of Freshwater Fish **9**: 202-209.

Keast, A. and J. Eadie. 1984. Growth in the first summer of life: A comparison of nine cooccurring fish species. Canadian Journal of Zoology **62**: 1242-1250.

Keast, A., J. Harker, and D. Turnbull. 1978. Nearshore fish habitat utilization and species associations in Lake Opinicon (Ontario, Canada). Environmental Biology of Fishes **3**: 173-184.

Keenleyside, M.H.A. 1979. Diversity and adaptation in fish behaviour. Springerverlag, New York, 208p.

Killgore, K.J., R.P.H. Morgan, and J.J. Hoover. 1991. Aquatic plant control research program: Habitat value of aquatic plants for fishes. Technical Report of the United States Army Engineering Corps, Waterways Experimental Station, 38p.

Killgore, K.J., R.P.H. Morgan, and N.B. Rybicki. 1989. Distribution and abundance of fishes associated with submersed aquatic plants in the Potomac River. North American Journal of Fisheries Management **9:** 101-111.

Kircheis, F.W. 1976. Reproductive biology and early life history of the sunapee trout of Floods Pond, Maine. Transactions of the American Fisheries Society **5**: 615-619.

Kirillov, A.F. 1988. Burbot, *Lota Iota,* of Vilyuysk reservoir. Journal of Ichthyology **28:** 49-55.

Kleckner, R.C., McCleave, J.G., Wippelhauser. 1983. Spawning of American eel, Anguilla rostrata, relative to thermal fronts in the Sargasso Sea. Environmental Biology of Fishes **9:** 289-293.

Klemetsen, A., P.A. Amundsen, J.B. Dempson, B. Jonsson, N. Jonsson, M.F. O'Connell, and E. Mortensen. 2003. Atlantic salmon *Salmo salar* L., brown trout *Salmo trutta* L. and Arctic charr *Salvelinus alpinus* (L.): a review of aspects of their life histories. Ecology of Freshwater Fish **12**: 1-59.

Klemetsen, A., P.A. Amundsen, H. Muladal, S. Rubach and J.I. Solbakken. 1989. Habitat shifts in dense, resident Arctic charr Salvelinus alpinus population. Physiology and Ecology Japan, Special Volume **1:** 187-200.

L'AbeeLund, J.H., A. Langeland, B. Jonsson and 0. Ugedal. 1993. Spatial segregation by age and size in Arctic charr: a tradeoff between feeding possibility and risk of predation. Journal of Animal Ecology **62:** 160-168.

L'AbeeLund, J. H. and H. Saegrov. 1992. Piscivory by brown trout (*Salmo trutta*) and Arctic charr (*Salvelinus alpinus*) in Norwegian lakes. Journal of Fish Biology **41:** 91-101.

Lambert, T.R. and D.F. Hanson. 1989. Development of habitat suitability criteria for trout it small streams. Regulated Rivers: Research and Management **3**: 291-303.

Larson, G.E. 1976. Social behavior and feeding ability of two phenotypes of *Gasterosteus aculeatus* in relation to their spatial and trophic segregation in a temperate lake. Canadian Journal of Zoology **54**: 107-121.

Lawler, G.H. 1963. The biology and taxonomy of the burbot, *Lota Iota,* in Heming Lake, Manitoba. Journal of the Fisheries Research Board of Canada **20**: 417-433.

Lea, R.N. 1968. Ecology of the Lahontan cutthroat trout, *Salmo clarki henshawi,* in Independence Lake, California. M.A. thesis, University of California, Berkeley, 95p.

Lee, K.M. 1985. Resource partitioning and behavioural interactions among youngoftheyear salmonids, Chena River, Alaska. M.Sc. thesis, University of Alaska, Fairbanks, Alaska, 75p.

Lee, S.H. 1971. Fecundity of four species of salmonid fishes in Newfoundland waters. M.Sc. thesis, Memorial University of Newfoundland, St. John's, Newfoundland, 114p.

Leggett, W.C. 1965. The effect of the environment on the food, growth, reproduction and survival of ouananiche in eastern Canada. Fish Culture Development Branch. Newfoundland Region, St. John's, Newfoundland, Progress Report Number 27, 87p.

Leggett, W.C. and G. Power. 1969. Differences between two populations of landlocked Atlantic salmon (*Salmo salar)* in Newfoundland. Journal of the Fisheries Research Board of Canada **26**: 1585-1596.

Leim, A.H. and W.B. Scott . 1966. Fishes of the Atlantic coast of Canada. Fisheries Research Board of Canada Bulletin Number 155, 485p.

Lewis, D.B. 1978. The distribution of sticklebacks (Gasterosteidae) on the Avalon Peninsula of Newfoundland, and the meristic and mensural variations of some selected populations. B.Sc. Hon. thesis, Memorial University of Newfoundland, St. John's, Newfoundland, 46p.

Lewis, S.L. 1969. Physical factors influencing fish populations in pools of a trout stream Transactions of the American Fisheries Society **98**: 14-19.

LGL Limited. 1999. Churchill River power project – Atikonak Lake ecosystem study: fish and fish habitat of tributaries. Prepared by LGL Limited, St. John's for Newfoundland and Labrador Hydro, St. John's, Newfoundland, 85p + App.

Liew, P.K.L. 1969. A study on the biology of brown trout, *Salmo trutta* L. from four different habitats on the Avalon Peninsula, Newfoundland. M.Sc. thesis, Memorial University of Newfoundland, St. John's, Newfoundland, 186p.

Lindsey, C.C., T.G. Northcote, and G.F. Hartman. 1959. Homing of rainbow trout in inlet and outlet spawning streams at Loon Lake, British Columbia. Journal of the Fisheries Research Board of Canada **16**: 695-719.

Lyons, J. 1987. Distribution, abundance and mortality of small littoral zone fishes in Sparkling Lake, Wisconsin. Environmental Biology of Fishes **18**: 93-107.

Machniak, K. 1975. The effects of hydroelectric development on the biology of northern fishes, (reproduction and population dynamics) 1. lake whitefish *Coregonus clupeaformis* (Mitchill): A literature review and bibliography. Canada. Fisheries and Marine Service. Research and Development Directorate, Winnipeg, MB. Technical Report Number 527, 67p.

MacKay, H.H. 1963. Fishes of Ontario. Ontario Department of Lands and Forests, Toronto, Ontario, 300p.

MacKinnon, J.V. 1998. Observations on stream spawning brown trout, *Salmo trutta,* from Windsor Lake, Avalon Peninsula, Newfoundland. B.Sc. Hon. thesis, Memorial University of Newfoundland, St. John's, Newfoundland, 62p.

Marcus, M.D., W.A. Hubert, and S.H. Anderson. 1984. Habitat suitability index models: lake trout (exclusive of the Great Lakes). United States Fish and Wildlife Biological Service Program FWS/OBS82/10.84, 12p.

Martin, N.V. and C.H. Olver. 1980. The lake charr, *Salvelinus namaycush,* p. 205-277. *In* E.K. Balon (ed.), Charrs – salmonid fishes of the genus *Salvelinus.* Dr. W. Junk Publishers, The Hague, Netherlands.

Matthess, G. 1982. The properties of groundwater. J. Wiley and Sons, Inc., Toronto, Ontario.

McAllister, D.E. and B.W. Coad. 1974. Fishes of Canada's national capital region. Canada, Fisheries and Marine Service Miscellaneous special publication Number 24, 200p.

McCarraher, D.B. and R.E. Thomas. 1972. Ecological significance of vegetation to northern pike, *Esox lucius,* spawning. Transactions of the American Fisheries Society **101**: 560-563.

McCarthy, J.H. 1996. Brook charr *(Salvelinus fontinalis* Mitchell) movement and habitat use in the Copper Lake watershed, Corner Brook, Newfoundland, and a preliminary assessment of the impact of forest harvesting activity. M.Sc. thesis, Memorial University of Newfoundland, St. John's, Newfoundland, 171p.

McCarthy, J.H., C.G.J. Grant and D.A. Scruton. 2007. Draft standard methods guide for the classification and quantification of fish habitat in rivers of Newfoundland and Labrador.

McCrimmon, H.R. 1956. Fishing in Lake Simcoe. Ontario Department of Lands and Forests, Toronto, Ontario, 137p.

McCrimmon, H.R. and O.E. Devitt. 1954. Winter studies on the burbot, *Lota Iota lacustris,* of Lake Simcoe, Ontario. Canadian Fish Culturist **16**: 34-41.

McPhail, J.D. 1997. A review of burbot *(Lota Iota)* life history and habitat use in relation to compensation and improvement opportunities. Canadian Manuscript Report of Fisheries and Aquatic Sciences Number 2397, viii + 37p.

McPhail, J D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Fisheries Research Board of Canada Bulletin Number 173, 381p.

Mecum, R.D. 1984. Habitat utilization by fishes in the Tanana River near Fairbanks, Alaska. M.Sc. thesis, University of Alaska, Fairbanks, Alaska.

Mercer, K.M. 1962. Report on a reconnaissance survey of nine important streams on the Great Northern Peninsula. Progress report Number 16, Department of Fisheries, Canada, Fish Culture Development Branch Newfoundland Region.

Methven, D.A., R.L. Haedrich, and G.A. Rose. 2001. The fish assemblage of a Newfoundland estuary: Diel, monthly and annual variation. Estuarine, Coastal and Shelf Science **52**: 669-687.

Meyer, W.H. 1962. Life History of Three Species of Redhorse (*Moxostoma*) in the Des Moines River, Iowa. Transactions of the American Fisheries Society **91**: 412–419.

Minckley, W.L. 1962. Studies of the ecology of a spring stream, Doe Run, Meade Co., Kentucky. University of Louisville, 374p.

Mohr, L.C. 1984. The general ecology of the slimy sculpin (*Cottus cognatus)* in Lake 302 of the experimental lakes area, northwestern Ontario. Canadian Technical Report of Fisheries and Aquatic Sciences Number 1227, 16p.

Mohr, L.C. 1985. Depth distribution of the slimy sculpin (*Cottus cognatus)* in a small lake in northwestern Ontario. . Canadian Technical Report of Fisheries and Aquatic Sciences Number 1374, 13p.

Moore, J.W. 1975. Distribution, movements and mortality of anadromous Arctic charr, *Salvelinus alpinus* L., in the Cumberland Sound area of Baffin Island. Journal of Fish Biology **7**: 339-348.

Moores, R.B., and E.G.,M. Ash. 1984. Fishway and counting fence operations in Newfoundland and Labrador, 194979. Canadian Data Report of Fisheries and Aquatic Sciences Number 477, v + 123 p.

Morrow, J.E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Co., Anchorage, Alaska, 248p.

Naesje, T. 1995. Effects of introduced *Mysis relicta* on habitat utilization and feeding of Arctic charr. Nordic Journal of Freshwater Research **71**: 359–371.

Nead, M. and J.K. Buttner. 1987. Response of the brackish water mummichog to different salinities. Progressive Fish Culturist **49**: 136-137.

Nelson, J.S. 1968. Hybridization and isolating mechanism between *Catostomus commersoni* and *C. macrocheilus* (Pisces: Catostomidae). Journal of the Fisheries Research Board of Canada **25**: 101-150.

Newfoundland and Labrador Department of Environment and Conservation (NL DEC). 2010. Newfoundland and Labrador Water Resources Portal. http://maps.gov.nl.ca/water/index.aspx#PublicWater. Accessed September 2010.

Nikolskii, G.V. 1954. Special ichthyology. 2nd edition. Moscow, U.S.S.R.. Translated from Russian, Israel Program for Scientific Translations, Jerusalem, 538p.

Normandeau, D.A. 1969. Life history and ecology of the round whitefish, *Proso cylindraceum* (Pallas), of Newfound Lake, Bristol, New Hampshire. Transactions of the American Fisheries Society **98**: 7-13.

O'Connell, M.F. 1982. The biology of anadromous *Salvelinus fontinalis* (Mitchill, 1815) and *Salmo trutta* (Linnaeus, 1758) in river systems flowing into Placentia Bay and St. Mary's Bay, Newfoundland. PhD. dissertation, Memorial University of Newfoundland, St. John's, Newfoundland, 335p.

O'Connell, M. F. and J.B. Dempson. 1996. Spatial and temporal distributions of salmonids in two ponds in Newfoundland, Canada. Journal of Fish Biology **48**: 738-757.

Page, L., and Burr, B. 1991. Field guide to freshwater fishes of North America. Boston, MA: Houghton Mifflin.

Parsons, R.F. 1975. The limnology and fish biology of Ten Mile Lake, Labrador. Fisheries and Marine Service, Resource Development Branch, St. John's, Newfoundland. Technical Report Series. Number NEW/T753, 75p.

Paterson, R.J. 1968. The lake trout *(Salvelinus namaycush)* of Swan Lake, Alberta. Alberta Fish and Wildlife Division, Edmonton, Alberta, Research Report Number 2, 149p.

Pearcy, W.G. and S.W. Richards. 1962. Distribution and ecology of fishes of the Mystic River Estuary, Connecticut. Ecology **43**: 248-259.

Peck, J.W. 1982. Extended residence of youngoftheyear lake trout in shallow water. Transactions of the American Fisheries Society **111**: 775-778.

Pepper, V.A. 1976. Lacustrine nursery areas for Atlantic salmon in insular Newfoundland. Fisheries and Marine Service, Resource Development Branch, St. John's, Newfoundland. Technical Report Number 671, 60p.

Pepper, V.A., N.P. Oliver, and R. Blundon. 1985. Juvenile anadromous Atlantic salmon of three lakes of Newfoundland. Internationale Revue der Gesamten Hydrobiologie **70**: 733-753.

Petrosky, C.E. and T.F., Waters. 1975. Annual production by the slimy sculpin population in a small Minnesota trout stream. Transactions of the American Fisheries Society **104**: 237-244.

Porter, T.R. 2000. Observations of rainbow trout *(Oncorhynchus mykiss)* in Newfoundland 1976 to 1999. Canadian Stock Assessment Secretariat Research Document Number 2000/043, 9p.

Porter, T.R., L.G. Riche and G.R. Traverse. 1974. Catalogue of rivers in insular Newfoundland. Fisheries and Marine Service. Newfoundland Region. Resource Development Branch. Data record series NEW/D; 749, 4p.

Portt, C.B., C.K. Minns, and S.W. King. 1988. Morphological and ecological characteristics of fishes common in Ontario lakes. Canadian Manuscript Report of Fisheries and Aquatic Sciences Number 1991, vi + 37p.

Power, C. 1980. The brook charr, p. 141203. *In* E.K. Balon (ed.), Charrs, Salmonid Fishes of the Genus *Salvelinus*. Dr. W. Junk Publishers, The Hague, Netherlands.

Power, G. and D. Cressman. 1975. Atlantic salmon (*Salmo salar*) taken in the sea in north Labrador. Journal of the Fisheries Research Board of Canada **32**: 307-309.

Propst, D.L. 1982. Warmwater fishes of the Platte River basin, Colorado: Distribution, ecology, and community dynamics. Ph.D. dissertation, Colorado State University, Fort Collins, 284p.

Raleigh, R.F. 1982. Habitat suitability index models: brook trout. Western Energy and Land Use Team. Instream Flow and Aquatic Systems Group; Biological Services Program, United States Fish and Wildlife Service FWS/OBS82/10.24, vi+42p.

Raleigh, R.F. and D.A. Duff. 1980. Trout stream habitat improvement: ecology and management, p. 6777. *In* W.King (ed.), Proceedings of Wild Trout Symposium II. Yellowstone Park, Wyoming.

Randall, R.G., C.K. Minns, V.W. Cairns, and J.RE. Moore. 1996. The relationship between an index of fish production and submerged macrophytes and other habitat features at three littoral area in the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences **53**: 35-44.

Rawson, D.S. 1942. A comparison of some large alpine lakes in western Canada. Ecology **23**: 143-161.

Reckahn, J.A. 1970. Ecology of young lake whitefish (*Coregonus clupeaformis)* in South Bay, Manitoulin Island, Lake Huron, p. 437460. *In* C.C. Lindsey and C.S. Woods (eds.), Biology of coregonid fishes. University of Manitoba Press, Winnipeg.

Reddin D.G., R.J. Poole, W. King, S. Oliver, R. Nuna and T. Parr. 2008. Harvests in various fisheries for salmonids, Atlantic salmon returns to rivers and environmental conditions in Labrador, 2005. Canadian Science Advisory Secretariat Research Document Number 2008/024, iv+24p.

Reiser, D.W. and T.A. Wesche. 1977. Determination of physical and hydraulic preferences of brown and brook trout in the selection of spawning location. Water Resources Research Institute, Water Resources Service.

Richardson, L.R. 1939. The spawning behaviour of *Fundulus diaphanus* (LeSueur). Copeia **1939(3)**: 165-167.

Riche, L.G. 1965. A preliminary biological survey of the Naskaupi, Kenamu and Lower Churchill Rivers. Fisheries and Marine Service, Fish Culture Development Branch. Newfoundland Region Report Number 30.

Robbins, C.R. and E.E. Deubler. 1955. The lifehistory and systematic status of the burbot, *Lota lota* lacustris (Walbaum), in the Susquehanna River system. New York State Museum Circular Number 39, 49p.

Rook, E.J.S. 1999. Flora, fauna, earth, and sky...the natural history of the northwoods. http://www.rook.org/earl/bwca/nature/fish/moxostomamac.htm. Accessed February 2009.

Rozas, L.P. and W.E. Odum. 1987. Fish and macrocrustacean use of submerged plant beds in tidal freshwater marsh creeks. Marine Ecology Progress Series **38**: 101-108.

Rubin, J.F. 1987. Studies of three spawning grounds of the Arctic charr (*Salvelinus alpinus* (L.)) in Lake Geneva, using the submarine F.A. Forel, p. 120-127. *In* J. Hammar and L. Nyman (eds.), Proceedings of the Fourth International Society of Arctic Charr Fanatics workshop on Arctic charr, 1986.

Rubin, J.F. 1993. The spawning grounds of the Arctic charr, *Salvelinus alpinus* L., at La Raisse in Lake Neuchatel, studied using the submarine F.A. Forel. Bulletin de la Societe Vaudoise des Sciences Naturelles **82**: 345-356.

Rubin, J.F. and B. Buttiker. 1992. The spawning grounds of the Arctic charr, *Salvelinus alpinus* L., in Lake Geneva. Bulletin Francais de la Peche et de la Pisciculture **325**: 69-82.

Rulifson, R.A. and M.T. Huish. 1982. Anadromous fish in the southeastern United States and recommendations for development of a management plan. United States Fish and Wildlife Service, 525p.

Rupp, R.S 1965. Shorespawning and survival of eggs of the American smelt. Transactions of the American Fisheries Society **94**: 160-168

Ryan, P.M. 1980. Fishes of the Lower Churchill River, Labrador. Fisheries and Marine Service Technical Report Number 922, vii+189p.

Ryan, P.M. 1984. Age, growth, and food of threespine stickleback (*Gasterosteus aculeatus)* in three lakes of central Newfoundland, Canada. Canadian Technical Report of Fisheries and Aquatic Sciences Number 1325, 16p.

Ryan, P.M. 1988. Trout in Canada's Atlantic provinces. Underwater World Fastsheet. Fisheries and Oceans Canada, Ottawa, Ontario. Catalogue Number Fs 4133/581988E, 6p.

Ryan, P.M., and R. Knoechel. 1994. Lake use by brook trout, *Salvelinus fontinalis*, in insular Newfoundland, Canada. Verhandlungen der Internationalen Vereinigung fur Theoretische und Angewandte Limnologie **25**: 2068-2073.

Sandlund, O.T., B. Jonsson, H.J. Malmquist, R. Gydemo, T. Lindem, S. Skulason, S.S. Snorrason, and P.M. Jonasson. 1987. Habitat use of Arctic charr, *Salvenlinus alpinus,* in Thingvallavatn, Iceland. Environmental Biology of Fishes **20**: 263-274.

Savage, T. 1963. Reproductive behavior of the mottled sculpin, *Cottus bairdi* Girard. Copeia. **1963(2)**: 317-325.

Savino, I.F. and R.A. Stein. 1989. Behavoiural interactions between fish predators and their prey: Effects of plant density. Animal Behavior **37**: 311-321.

Schneberger, E. 1972. The white sucker, its life history, ecology and management. Department of Natural Resources, Madison, Wisconsin, 18p.

Scott W.B. and E.J. Crossman. 1964. Fishes occurring in the fresh waters of insular Newfoundland. Queen's Printer, Ottawa, Ontario. iv + 124 p.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Bryant Press Limited, Ottawa, Ontario, xix + 966p.

Scott, W.B and E.J. Crossman. 1998. Freshwater fishes of Canada. Galt House Publications Limited, Oakville, Ontario, xx + 966p.

Scott, W.B., and M.G. Scott. 1988. Atlantic fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences Number 219, 731p.

Scruton, D.A. 1984. A survey of selected lakes in Labrador, with an assessment of lake status and sensitivity in relation to acid precipitation. Canadian Technical Report of Fisheries and Aquatic Sciences Number 1296, v+115p.

Scruton, D.A., T.C. Anderson, C.E. Bourgeois, and J.P. O'Brien. 1992. Small stream surveys for public sponsored habitat improvement and enhancement projects. Canadian Manuscript Report of Fisheries and Aquatic Sciences Number 2163, v + 49pp.

Scruton, D.A. and R.J. Gibson. 1995. Quantitative electrofishing in Newfoundland: Results of workshops to review current methods and recommend standardization of techniques. Canadian Manuscript Report of Fisheries and Aquatic Sciences Number 2308, 11+148p.

Scruton, D.A., D.R. Sooley, L. Moores, M.A. Barnes, R.A. Buchanan, and R.N. McCubbin 1997. Forestry guidelines for the protection of fish habitat in Newfoundland and Labrador. Department of Fisheries and Oceans, St. John's, Newfoundland, 63p.

Smith, K.E.H. 1988. The Atlantic salmon. Underwater World Factsheet. Fisheries and Oceans Canada, Ottawa, Ontario. Catalogue Number Fs 4133/191988E, 8p.

Smith, M.W. 1952. Limnology and trout angling in Charlotte County Lakes, New Brunswick. Journal of the Fisheries Research Board of Canada **8**: 383-452.

Smith, P.W. 1979. The fishes of Illinois. Illinois State Natural History Survey, University of Illinois Press, Chicago, Illinois, xxix+314 p.

Sooley, D.R.E., E.A. Luiker and M.A. Barnes. 1998. Standard methods guide for freshwater fish and fish habitat surveys in Newfoundland and Labrador: rivers and streams. Fisheries and Oceans, St. John's, Newfoundland, iii + 50p.

Sorokin, V.N. 1971. The spawning and spawning grounds of the burbot *(Lota iota* (L.)). Journal of Ichthyology **11**: 907-915.

Stewart, L.L. and P.J. Auster. 1987. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic) – Atlantic tomcod. United States Fish and Wildlife Service Biological Report Number 82 (11.76)/United States Army Corps of Engineers Report Number TR EL824, 8p.

Suehanek, P.M., R.L. Sundet, and M.N. Wenger. 1984. Resident fish habitat studies. *In* D.G Schmidt, S.S. Hale, D.L. Crawford and P.M. Suchanek (eds.), Alaska Department of Fish and Game, Susitna Hydro aquatic studies Report 2: resident and juvenile anadromous fish investigations (May October 1983), Anchorage, Alaska, 40p.

Symons, P.E.K. 1976. Behavior and growth of juvenile Atlantic salmon (*Salmo salar)* and at three competitors at two stream velocities. Journal of the Fisheries Research Board of Canada **33**: 2766-2773.

Szedlmayer, S.T. and K.W. Able. 1996. Patterns of seasonal availability and habitat use by fishes and decapod crustaceans in a southern New Jersey estuary. Estuaries **19**: 697-709.

Tallman, R.F. and J.H. Gee. 1982. Intraspecific resource partitioning in a headwaters stream fish, the pearl dace *Semotilus margarita* (Cyprinidae). Environmental Biology of Fishes **7**: 243-249.

Tallman, R.F., K.H. Mills, and R.G. Rotter. 1984. The comparative ecology of pearl dace *(Semotilus margarita)* and fathead minnow *(Pimephales promelas)* in lake 114, the experimental lakes area, northwestern Ontario, with an appended key to the cyprinids of the experimental lakes area. Canadian Manuscript Report of Fisheries and Aquatic Sciences Number 175, 27p.

Taylor, M.H. 1986. Environmental and endocrine influences on reproduction of *Fundulus heteroclitus.* American Zoologist **26**: 159-171.

Taylor, M.H. and L. DiMichele. 1980. Ovarian changes during the lunar spawning cycle of *Fundulus heteroclitus*. Copeia **1980(1):** 118-125.

Taylor, M.H., L. DiMichele, and G.J. Leach. 1977. Egg stranding in the life cycle of the mummichog, *Fundulus heteroclitus.* Copeia **1977(2)**: 397-399.

Taylor, M.H., G.J. Leach, L. DiMichele, W.M. Levitan, and W.F. Jacob. 1979. Lunar spawning cycle in the mummichog, *Fundulus heteroclitus* (Pisces: Cyprinodontidae). Copeia **1979(2)**: 291-297.

Thibodeau, M.L. and J.R.M. Kelso. 1990. An evaluation of putative lake trout *(Salvelinus namaycush)* spawning sites in the Great Lakes. Canadian Technical Report of Fisheries and Aquatic Sciences Number 1739, vii + 30p.

Thompson, D.H. and F.D. Hunt. 1930. The fishes of Champaign County. A study of the distribution and abundance of fishes in small streams. Illinois Division of Natural History Survey Bulletin, Volume 19, 71p.

Thornburgh, K.R. 1986. Burbot life history and habitat requirements: southcentral, western and interior regions, p. 377-388. *In* B. Dun (ed.), Alaska habitat management guide: life histories and habitat requirements of fish and wildlife. Alaska Department of Fish and Game, Division of Habitat, Juneau, Alaska.

Toner, E.D. and G.H. Lawler. 1969. Synopsis of biological data on the pike, *Esox lucius* (Linnaeus, 1758). Food and Agriculture Organization Fisheries Synopsys Number 30 (Revision 1).

Trautman, M.B. 1981. The fishes of Ohio with illustrated keys. Ohio State University Press, Columbus, xxv +782p.

Twomey, K.A., K.L. Williamson, and P.C. Nelson. 1984. Habitat suitability index models and instream flow suitability curves: white sucker. United States Fish and Wildlife Service Number FWS82, 56p.

Van SnikGray, E. and J.R. Stauffer Jr. 1999. Comparative microhabitat use of ecologically similar benthic species. Environmental Biology of Fishes **56**: 443-453.

Van Vliet, W.H. 1970. Shore and freshwater fish collections from Newfoundland. National Museum of Natural Sciences. Publications in Zoology Number 3, 30p.

Van Zyll de Jong, M.C., N.P. Lester, R.M. Korver, W. Norris, and B.L. Wicks. 1999. Brook trout *Salvelinus fontinalis* (Mitchill), population dynamics and recreational fishery in Indian Bay Brook, Newfoundland (1995-1998). Canadian Stock Assessment Secretariat 99/97, 41p.

Venne, H. and P. Magnan. 1995. The impact of intraand interspecific interactions on young of the year brook charr in temperate lakes. Journal of Fish Biology **46**: 669-686.

Virgl, J.A and J.D. McPhail. 1994. Spatiotemporal distribution of anadromous (*trachurua)* and freshwater (*leiurus)* threespine sticklebacks, *Gasterosteus aculeatus.* Canadian FieldNaturalist **108**: 355-360.

Walters, V. 1955. Fishes of the western Arctic America and eastern Arctic Siberia: taxonomy and zoogeography. Bulletin of the American Museum of Natural History **106**: 255-368.

Walton, B.D. 1980. The reproductive biology, early life history, and growth of white suckers, *Catostomus commersoni,* and longnose suckers, *C. catostomus,* in the Willow Creek — Chain Lakes System, Alberta. Fish and Wildlife Division, Fisheries Research Report Number 23, Edmonton, Alberta, 180p.

Weisberg, S.B. 1986. Competition and coexistence among four estuarine species of *Fundulus.* American Zoologist **26**: 249-257.

Webster, D.A. 1962. Artificial spawning facilities for brook trout, *Salvelinus fontinalis.* Transactions of the American Fisheries Society **91**: 168-174.

Wells, L. 1968. Seasonal depth distribution of fish in southeastern Lake Michigan. United States Fish and Wildlife Service, Fisheries Bulletin **67**: 1-15.

Wells, L. 1980. Food of alewives, yellow perch, spottail shiners, troutperch and slimy and fourhorn sculpins in southeastern Lake Michigan. United States Fish and Wildlife Service Technical Paper Number 98, 12p.

Went, A.E.J. 1962. Irish sea trout, a review of investigations to date. Scientific Proceedings of the Royal Dublin Society, p. 265-296.

Wesche, T.A. 1980. The WWRI trout cover rating method: Development and application. Water Resources Research Institute, Laramie. Wyoming, Water Resources Series Number 78, 46p.

Williams, R. and W. Grey. 1975. Stream survey section of anadromous fish project, p. 113. *In* R. Williams, W. Grey and J. Huff (eds.), Study of anadromous fishes in Florida. MS. Compl. Rep. NMFS Grantinaid Prog., AFSC 5. Florida Department of Natural Resources, Mar. Resour. Lab., Mimeo.

Wiseman, R.J. 1971. The limnology, ecology and sport fishery of Thomas Pond: a multiuse reservoir. Fisheries Service, Resource Development Branch, St. John's, Newfoundland Progress Report Number 73, 126p.

Wootton, R.J. 1976. The biology of the sticklebacks. Academic Press, London, 387p.

Wootton, R.J. 1984. A functional biology of sticklebacks. University of California Press. Berkeley and Los Angeles, California.

Worgan, J.P. and G.J. FitzGerald. 1981. Habitat segregation in a salt marsh among adult sticklebacks *(Gasterosteidae).* Environmental Biology of Fishes **6**: 105-109.

Wright, R.M. 1990. The population biology of pike, *Esox lucius* L., in two gravel pit lakes, with special reference to early life history. Journal of Fish Biology **36**: 215-229.

Wurtsbaugh, W.A., R.W. Brocksen, and C.R. Goldman. 1975. Food and distribution of underyearling brook and rainbow trout in Castle Lake, California. Transactions of the American Fisheries Society **104**: 88-95.

6.0 GLOSSARY

This glossary defines terms used throughout this report and are defined according to terminology consistent with Gibson et al. (1993) ; McCarthy et al. (2007); Scruton et al. (1992); Scruton et al. (1997) and Sooley et al. (1998).

Bank height (stream bank) – A measure of the rise of land beside the surface water. This is taken where the surface of the water mets the dry land, measuring perpendicular to the stream, upland to the edge of the riparian zone or physical evidence of highwater (or ice scour). Water is physically confined by the banks, identified as the left or right side bank (designiated by facing upstream).

Cascade – A type of stream habitat classified as fast flowing, turbulent water, with significant white water present resulting from water breaking over exposed rocks (i.e., boulders). This section of a stream consists of a high gradient and stepped series of drops.

Channel width – A horizontal measurment between the highwater marks of the right hand and left hand banks taken perpendicular to the direction of flow.

Downstream – In the direction of the current of a stream; the opposite of upstream.

Fish habitat – The composition of stream substrate, water velocity, gradient, instream and riparian vegetation and other biophysical parametres, creating areas utilized by fish either directly or indirectly, to carry out life processes. These include spwaning, rearing, over-wintering, and migration areas.

Flat – A wide, shallow pool flowing smoothly. It is an area of stream that has low to moderate velocites, smooth water surface, and low water turbulence. Typically, the substrate is comprised of fine sediment, sand, gravels and cobbles.

Flow morphology – A habitat feature described as the rate of which water in the stream is flowing, a result based on the slope and substrate of the stream. The flow of water in the stream interacts with stream channel morphology defining physical habitat (e.g., width, depth, velocity and substrate).

High water mark - a marking alongside the stream or waterbody indicating the highest level which the water rises.

Ice scour – Rubbing and scraping marks, a result of ice movement. Scouring incdicates the level at which the water/snow and ice had reached during periods of high discharge.

Maximum flood bank height – The highest bankfull amount of water within the stream that the channel and bank heights can accomodate.

Rapid – Turbulent irregular swift flows with extensive white water in areas of steep gradient. May have exposed substrate such as rubble or boulders.

Riffle – A shallow section flowing swiftly over partially exposed substrate, cobble or gravel, producing water surface agitation, with little or no white water.

Riparian zone – The interface between land and a stream; it is the immediate vicinity of the stream, which consists of the stream bed, banks and adjacent land. The vegetation within this zone is significant to fish habitat by providing shade and cover; stabilizing banks preventing erosion; nutrient input from detritus and leaf litter falling into streams.

Run – Swift moving water, with little to no surface agitation. Substrate usually consists of gravel, cobble and boulders.

Substrate – The composition of the streambed. This may consist of mud, organics (decaying vegetation, aquatic vegetation), submerged woody debris, various rock sizes ranging from bedrock and boulders to cobble, gravel and sand (see inorganic substrate size classification).

Inorganic substrate size classification:

- Bedrock to solid rock that underlies loose material. It is the basis of the foundation.
- Large Boulder – Very large sized rocks greater than 1 m.
- Small Boulder – Very large sized rocks from 25 cm to 1 m.
- Rubble – Large sized rocks from 14 cm to 25 cm.
- Cobble – Medium sized rocks from 3 cm to 13 cm.
- Gravel – Small sized stones or pebbles from 0.2 to 3 cm.
- Sand – rock derived granular material from 0.006 cm to 0.2 cm.
- Silt – very fine particles of fine grittiness, intermediate in size between sand and clay.
- Clay – moist, sticky, very fine particles that hold a cast when squeezed in hand; contains no grittiness. When rubed against a smooth hard object (e.g., knife blade) it shines. Virtually impermeable when wet and cracks when it dries out.

Transect – A spatial line or strip along which samples/measurments are taken. This line runs across the stream from one bank to the next (e.g., left bank to right bank), perpendicular to the direction of flow.

Upstream – Against the direction of the current of a stream; the opposite of downstream.

Watershed - The geographic area that water drains into streams, rivers and openwaterbodies within a perimeter of higher elevation areas. It can be outlined on a topographic map by connecting points of highest elevations (usually ridge crests) between adjacent stream valleys (Geology.com 2009).

Wetted width - A distance measurment of the water surface width at the waters edge from each bank (left and right bank). Measurment is taken at surface measured right angles to the direction of flow.

Velocity – A gauge of speed commonly measured in metres per second (m/s). In this study the velocity of water was measured.

Zone – A unit of the Universal Transverse Mercator (UTM) geographical referencing system whereby the earths surface between 80^{o}S and 84^{o}N is divided into 60 longituduinal zones. Each of the 60 longitudinal zones is 6^{o} in width (total = 360^{o}). Each longitudinal zone is then divided into 20 latitudinal bands spanning 80^{o}S and

84^oN . Each band is 8^o in height except for the last band between 72^o and 84^o is 12^o high. The division of the earths surface into longitudinal zones and latitudinal bands provides a geographical referencing system whereby any position on the earths surface, within the coverage area, can be located (http://en.wikipedia.org/wiki/UTM_coordinates).