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DRAFT - Iqaluit Nukkiksautiit Project Environmental & Regulatory Evaluation

Prepared for:

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Commonly Appearing Abbreviations

CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
CPL	Canadian Projects Limited
ECCC	Environment and Climate Change Canada
FEED	Front End Engineering and Design
DFO	Fisheries and Oceans Canada
GN	Government of Nunavut
HEP	hydroelectric power
IOL	Inuit Owned Land
IQ	Inuit Qaujimajatuqangit
KPC	Knight Piesold Consulting
LVP	Landsvirkjun Power
MAD	mean annual discharge
mASL	metres above sea level
NIRB	Nunavut Impact Review Board
NLCA	Nunavut Land Claim Agreement
NNC	Nunavut Nukkiksautiit Corporation
NGL	Nunavut Nukkiksautiit Corporation, Growler Energy, Landsvirkjun Power
NuPPA	Nunavut Planning and Project Assessment Act
NPC	Nunavut Planning Commission
NWB	Nunavut Water Board
QIA	Qikiqtani Inuit Association
QEC	Qulliq Energy Corporation
SEM	Sikumiut Environmental Management Limited
SIJJA	SIJJA Consulting
TC	Transport Canada
TLA	Territorial Lands Act
WSC	Water Survey of Canada

Executive Summary

1.0 Introduction

Growler Energy Inc. (Growler) and Nunavut Nukkiqsautiit Corporation (NNC), in collaboration with the Qikiqtani Inuit Association (QIA), are investigating opportunities related to renewable energy development on Inuit Owned Land (IOL) in the Iqaluit area, hereafter referred to as the Iqaluit Nukkiqsautiit Project. This Inuit-led study focuses on water and wind power potential in the region, to reduce reliance on diesel fuel for electricity generation. Sikumiut Environmental Management Limited (SEM) has been retained to provide professional consulting services for environmental assessment and regulatory support. Stakeholder and Indigenous consultation services are being provided by the Firelight Group (Firelight), and SIJJA Consulting (SIJJA). Specialist engineering services are supplied by Canadian Projects Limited (CPL), Landsvirkjun Power (LVP), and Frobisher Energy Services (Frobisher). The Iqaluit Nukkiqsautiit Project is currently in Phase 2 – Generation and Selection of the Preferred Alternatives.

1.1 Scope of Work

SEM has been tasked with supporting the Project selection and definition process by addressing the following:

1. Summarize the existing environmental baseline information for each of the candidate Project Alternatives;
2. Provide input to the ranking and selection of Project Alternatives by addressing environmental and regulatory risks associated with each;
3. Identify the baseline information needs (work scope, schedule, and budget) to proceed with the environmental assessment and permitting processes for the selected Project; and
4. Provide an overview description of the applicable regulatory considerations, extending to actual construction/commissioning of the selected Project.

1.2 Project Background

Electricity in Iqaluit is currently supplied by six diesel generators, with a total nominal capacity 17.6 MW. Total electricity generation in 2021 was 59.2 GWh, equating to ~15 million litres of diesel fuel (Canadian Projects Limited, 2023). While there are challenges in locating electricity generation alternatives in the region, there is considerable impetus for the reduction of carbon loading and the utilization of renewable sources. Load profiles indicate increased daily demands mid-day and evening, with higher overall demand

during winter season. Future consideration will be given to transitioning of thermal heating from heating oil to electrically based heating. This measure would substantially increase system demand in the winter season. Some combination of hydroelectricity, wind, and pumped storage hydro energy system will be required to displace or replace diesel and heating oil-based energy demand.

During the period 2005-2012 the Qulliq Energy Corporation (QEC), as the sole electrical utility in Nunavut, undertook a series of studies to determine the feasibility of developing hydroelectric generation to supply electricity to the City of Iqaluit, offsetting or replacing the existing diesel generation plant (Qulliq Energy Corporation, 2013). The objectives were to meet Iqaluit's energy requirements with a cost-effective renewable energy source, to stabilize and potentially reduce overall energy costs for QEC and ratepayers, and to reduce reliance on fossil fuel (diesel generated power). The resulting development would reduce the community's carbon footprint and reduce QEC's exposure to fuel price risks / market volatility.

Starting in 2005, Phase I Prefeasibility studies were undertaken by Knight Piésold Consulting (KPC) to identify and rank potential hydroelectric project sites within a 100 km radius of Iqaluit. Between 2006 and 2008, further comprehensive studies on engineering, environmental baselines, Inuit knowledge and financial analysis were conducted to narrow down preferential hydro sites.

In 2006, site visits were made to review geotechnical conditions and identify specific locations for project components. As a result, fourteen (14) potential hydroelectric projects sites were identified and ranked. Six of these were identified as appropriate for further investigation: Armshow River – Long, Armshow River – Right Lake, Jaynes Inlet, McKeand River, Anna Maria Port, and Cantley Bay.

The Phase II Prefeasibility Studies initiated in 2007, focused on four project sites: the Armshow River – Mainstem, Armshow River – Right Lake, Cantley Bay, and Jaynes Inlet. Public consultations took place to gather more information from land users, hunters, cabin owners, and other key stakeholders on the relevant social and economic drivers influencing project selection decisions . In 2008, the selected Iqaluit Hydroelectric Project was described as a staged development of hydroelectric power from sites in Jaynes Inlet (12.5 MW) followed by Armshow South (7.3 MW) (Qulliq Energy Corporation, 2013). In 2014 however, the Iqaluit Hydroelectric project was put on hold by QEC due to the large capital investment required.

More recently, in the 2021 Canadian federal budget, the Minister of Northern Affairs announced funding for infrastructure projects across Inuit Nunangat as part of the government's Indigenous Community Infrastructure Fund. In response, the QIA re-opened the door to renewable energy in Iqaluit with an application to the fund, in partnership with Growler and LVP. The organization is funded over four years, and, in addition to Iqaluit, is examining renewable energy projects in Sanikiluaq, Pond Inlet, and Igloolik. The scope of work for Iqaluit involves a re-assessment of hydro-electric generation options as well as consideration of wind-generation and pumped-storage hydroelectricity (PSH). The re-evaluation of

hydroelectric opportunities is to include alternative layouts conducive to terrain and climate, such as lateral diversions and tunnels. Load forecasting is also being revised in terms of the total energy demand in Iqaluit over the next fifty years and is to encompass the demand for thermal energy.

1.3 History of Environmental Studies

The available baseline environmental information is almost exclusively the result of the previous hydroelectric project feasibility studies. The work undertaken had been incrementally focused geographically in response to and as a consequence of efforts to select the most suitable hydroelectric generation sites. The 2005-2008 examination of watersheds near Iqaluit followed a sequenced approach. An initial reconnaissance identified candidate sites on five watersheds. A limited program of baseline environmental field surveys was conducted of the candidate watersheds, with an increased level of effort focused on the two most attractive sites and culminating with a project proposal (Iqaluit Hydroelectric Project) submitted for review by the Nunavut Impact Review Board (NIRB File No. 13UN006) (Qulliq Energy Corporation, 2013). Following a July 15, 2013 determination by the Minister that an EIS would be required, draft Environmental Assessment Guidelines were issued by NIRB in August 2013, however further work was suspended when the project was put on hold.

The initial Phase 1 Prefeasibility examination (2005-2006) was reconnaissance in nature and produced limited environmental baseline material. The Phase II Prefeasibility Studies initiated in 2007, focused on four projects sites: the Armshow River – Mainstem, Armshow River – Right Lake, Cantley Bay, and Jaynes Inlet. The work carried out for environmental assessment included preliminary fisheries and aquatic surveys to document fish presence using various sampling methods, overview descriptions of fish habitat, and a consideration of fish movement patterns (i.e. determine anadromy) using strontium analysis of otoliths. Aerial surveys were also undertaken to identify raptor use and delineate raptor habitat. Desktop reviews were conducted of soil and vegetation as well as terrestrial wildlife and archaeology. An Inuit knowledge (IQ) study was initiated in 2006.

In 2008, updated hydrological analyses were completed at four of the preferred sites: Armshow River, Armshow South, Cantley Bay, and Jaynes Inlet. During 2008 and 2009, environmental baseline studies were completed for the Jaynes Inlet site by LGL Limited, NordEco, North/South Consultants Inc., and KPC. These studies focused on freshwater ecosystems, marine ecosystems, birds, carnivores, small mammals, and caribou. This work included a descriptive Ecological Land Classification report produced in 2009 by KPC, a Spring 2009 Environmental Baseline Study Report by RSW Inc., and an Environmental Baseline Studies Final Report by RSW Inc. issued in 2011.

In 2012 KPC prepared a Draft Gap Analysis and Risk Assessment of Supplemental Environmental Baseline Studies. The report indicated that most of the key environmental components at Jaynes Inlet were addressed to meet minimum requirements, but supplemental baseline programs were recommended either to fill gaps or strengthen the existing dataset. Considerably less baseline information was available for the Armshow River system. Aquatics surveys were at a reconnaissance level and no terrestrial work had been completed. The gap analysis was completed at a time when project elements were not fully developed, e.g. transmission corridor routing, sources of aggregate. The level of information available was, however, deemed adequate to support the environmental registration process.

The 2012 Gap Analysis report noted that collection of supplemental baseline studies targeted for 2013, was to include soil and vegetation surveys, terrestrial wildlife surveys, hydrology surveys, water and sediment quality studies, and fish/fish habitat surveys. Further engineering studies were also planned, including geotechnical drilling, test pitting and surface geological and terrain mapping.

On November 23, 2012 the Nunavut Impact Review Board (NIRB) received QEC's "Iqaluit Hydro-Electric Baseline Study" project proposal. Several permits were granted to QEC for studies slated to occur from March 2013 to February 2015, including: a Scientific Research License from the Nunavut Research Institute (NRI), a Land Use Permit from Aboriginal Affairs and Northern Development Canada (AANDC), and a Type B Water License from the Nunavut Water Board (NWB). The field studies proposal and associated licenses were registered under ID# 12YA048 in the public NIRB registry. However, it appears that these studies were not initiated.

In February 2013, QEC submitted the proposal for the Iqaluit Hydroelectric Project to NIRB thereby initiating the environmental screening process for the sites at Jaynes Inlet and Armshow River South (Qulliq Energy Corporation, 2013). A series of study applications were also submitted in 2013, including to the QIA for Access of Inuit Owned Land, Nunavut Parks for a Nunavut Territorial Parks Use Permit, AANDC for a Land Use Permit for Crown Land, and the NWB for a General Water License. NIRB started its review in July of 2013 and issued the Draft Guidelines for the Preparation of an Environmental Impact Statement (EIS) to QEC in August of 2013. The final version of the EIS Guidelines was issued to QEC in November of 2013. However, the project was shelved shortly thereafter.

In 2017 the NIRB acknowledged an update from QEC regarding the project and requested that QEC continue to provide annual updates to advise whether the company intends to re-engage the assessment process. For planning purposes and to ensure the required funding is in place to facilitate the next steps in the review process, the Board advised that a minimum of three (3) months' notice will be required to reactivate the review process.

The Project Proposal as submitted to NIRB (KPC, 2013) provided a review of previous baseline work and includes a listing of References for baseline studies (see Table 1.3.1 below).

Table 1.3.1 List of Selected References cited in KPC 2013.

#	Citation
1	Knight Piésold Ltd. 2006a. Identification and Ranking. Ref. No. VA103-137/1-1, Rev 0 dated January 17, 2006.
2	Knight Piésold Ltd. 2006b. Phase II Pre-Feasibility Report. Ref. No. VA103-137/1-3, Rev A dated August 25, 2006
3	Knight Piésold Ltd. 2006c. Summary of IQ and Land Use Information. Ref. No. VA103-137/1-2, Rev 0 dated October 2, 2006.
4	Knight Piésold Ltd. 2008a. Qikiqgjaarvik Hydrological Analysis. Ref. No. VA103-00137/2-1, Rev 0 dated September 18, 2008.
5	Knight Piésold Ltd. 2008b. Tungatalik Hydrological Analysis. Ref. No. VA103-00137/2-4, Rev 0 dated September 18, 2008.
6	Knight Piésold Ltd. 2008c. Akulikutaaq Hydrological Analysis. Rev. No. VA103-137/2-3, Rev 0 dated September 18, 2008.
7	Knight Piésold Ltd. 2008d. Kangalait Hydrological Analysis. Ref. No. VA103-137/2-2, Rev 0 dated September 18, 2008.
8	Knight Piésold Ltd. 2008e. Iqaluit Hydroelectric Project – 2007 Environmental Baseline Studies - Environmental Baseline Report. Report Ref. No. NB103-137/2-1, Rev. 0, dated April 18, 2008
9	Knight Piésold Ltd. 2011. Qulliq Energy Corporation - Iqaluit Hydroelectric Projects – Comprehensive Development Report. Knight Piésold Ref. No. VA103-137/6-1, Rev. 0 dated April 13, 2011.
10	Knight Piésold Ltd. 2012. Updated Hydrological Analyses - Qikiqgjaarvik and Tungatalik Sites Memo Ref. No. NB12-00472, dated October 16, 2012
11	North/South Consultants Inc. 2008. Aquatic Environment Investigations at the Armshow River, Baffin Island, Winter 2008. May 2008.
12	RSW Inc. 2011. Jaynes Inlet HEP - Environmental Baseline Study - Final Report. Dated April 2011

In our review of material on file, Table 1.3.2 was constructed to list the baseline environmental studies and data collection conducted to support the Iqaluit Hydroelectric Project during the period 2005 – 2012. Note (**in bold**) several cited reports are not in our possession, nor are the original data files in most cases.

Table 1.3.2 Review of Environmental Baseline Studies and Data Collection – Iqaluit Hydroelectric Project.

Year	Undertaking	Source Reference, Notes
2006	Aug 2006 – WSC installed and operated streamflow monitoring stations	Armshow, Armshow South, Cantley and Jaynes
	2006 – LIDAR mapping of the five candidate sites contracted by QEC	Summarized in Identification and Ranking Report (reference VA103-137/1-1). Copy of data needed.
	March 2007 (report on 2006 field studies) Fisheries Assessments for Five Potential Hydroelectric Generating Sites on Southern Baffin Island. By North/South Consultants.	KPC Comprehensive Development Report (CDR) App. E - 474/1666.
	Raptors (KPC) 2006 Raptor Survey of Five Candidate Hydro-electric Sites. Letter report dated March 12, 2007.	Summarized in KPC CDR Section 2.3. KP Ref. No. NB07-00210. Copy of report needed.
	Land use and IQ (KPC). Summary of IQ and Land Use Information. KP Ref. No. VA 103-00137/1-2 Rev A Aug. 26, 2006	Summarized in KPC CDR p.556/1666. Copy of report needed.
	Archaeology (Govt. Nunavut CLEY)	Summarized in KPC CDR Section 2.3. KPC CDR App. F p. 558/1666. Copy of report needed.
2007	2007 Environmental Baseline Studies Summary of the Environmental Baseline Report (Ref. No. NB 103-00137/2-2) Dated April 11, 2008. Reporting on four sites, three short-listed rivers.	KPC CDR App. F 550/1666
2008	Knight Piesold Ltd. 2009 Iqaluit Hydro-Electric Project- Jaynes Inlet. - Final Environmental Baseline Studies Summary Report (Ref. No. NB103-00137/4-4) submitted to Qulliq Energy Corporation Aug. 6, 2009	See KPC CDR App. G. p. 565 of 1666
	Pisiak D. J. and W.J Bernhardt. 2008. Aquatic Environment Investigations at Potential Hydroelectric Generating Sites on Southern Baffin Island. A report prepared for Knight Piésold by North/South Consultants Inc. xi + 241 p	Referenced in KPC CDR App. G p. 554/1666). Copy of report needed.
	Jan. 31 2008 : Socio-Economic Impact Assessment, Iqaluit Hydro Electric Development Project. Report by Enokseot Holdings Ltd.	KPC CDR App. H p 1186/1666
2009	Bernhardt, W.J., K. G. Dawson, and M. Gillespie. 2009. Aquatic Environment Investigations at Jaynes Inlet, southern Baffin Island. A report prepared for Knight Piésold by North/South Consultants Inc. xv + 406 p.	KP CDR App. G p.600/1666
	2009 Spring baseline surveys Jaynes Inlet RSW- Spring 2009 Environmental Baseline Studies Report	KPC CDR App.J p 1435/1666
	March 26, 2009 – Climate Change Impacts Assessment McBean, et al.	KPC CDR App.I - p 1372/1666
	2009 – LIDAR survey of Jaynes Inlet project area.	KPC CDR, p. 10/1666. Copy of data needed.

Table 1.3.2 Review of Environmental Baseline Studies and Data Collection – Iqaluit Hydroelectric Project (cont’d).

Year	Undertaking	Source Reference, Notes
2009	January 31, 2009. Bird and terrestrial Mammal Surveys, QEC Iqaluit Hydro Project – Final Baseline Studies Report. A report prepared for Knight Piésold Ltd. by LGL Ltd.	Appendix B p 1007/1666
	Michael A.D. Ferguson. Caribou Habitat Suitability and Related Inuit Qaujimajatuqangit for the Proposed Hydroelectric Generating Site on the Jaynes Inlet Watershed on Southern Baffin Island. June 2009.	Appendix C p 1037/1666
	Knight Piésold Ltd. Ecological Land Classification 2009 Final Report (Ref. No. NB103-00137/4-2)	Appendix D p 1094/1666
2011	April 13, 2011. KPC Comprehensive Development Report (CDR) (VA103-137/6-1)	
	April 2011 RSW/ Environnement éllimité Inc. Environmental Baseline Study Final Report (P48 0770 E0054 DOC) Integrates previous seasonal studies (2005 to 2010).	
2012	Sept. 14, 2012. Draft Gap Analysis and Risk Assessment (cover letter, tables, Appended review of baseline reports and data gaps).	
	Oct. 2012 Water Survey of Canada report on 2011 and 2012 field operations of hydrometric gauges	

The available baseline biophysical information can be summarized as follows:

- Jaynes Inlet – broad scope of baseline surveys completed; however, selected supplemental studies are required to support an EIS.
- Armshow River – limited aquatic surveys completed; no terrestrial surveys conducted.
- Cantley Bay – desktop study only.
- McKeand River South – desktop study only.
- Sylvia Grinnell River – no information available.
- McKeand River North – no information available.

Note, there may be some field data generated by the proposed Chidliak Diamond Mine located near McKeand River North.

2.0 Summary of Alternatives

The current examination encompasses hydroelectric, wind generation and pumped storage schemes for electric power generation and energy storage, including potential combinations of generation that can meet the current and anticipated electric power demand for Iqaluit. As summarized in Table 2.1, the possibilities include five locations for a wind turbine farm along with one possible wind turbine-pumped storage site. Eight hydroelectric power options are also being considered, including all those evaluated in the 2005 pre-feasibility studies by KPC.

Combinations of alternatives are under consideration such as the incorporation of a wind farm and pumped storage to candidate hydroelectric sites. At the direction of the client however, the environmental risk of each generation component is to be considered separately since complete development scenarios have yet to be selected. Note that the risk rating assigned to each scenario will not necessarily be additive (i.e. combining two low-risk generation options does not necessarily result in a low risk rating).

Common to all alternatives will be a transmission corridor to Iqaluit; the farther the generation location from the community, the longer the corridor. Specifics regarding the size and scale of candidate wind turbine sites have yet to be developed, preventing any comparison based on the footprint area of each. The general location of each alternative is given in Figures 2.1-2.2. Overview maps of the proposed transmission corridors for various alternatives, general arrangements as presented by KPC in 2005- 2011, and early concept sketches provided by CPL in 2023 are all given in Appendix A.

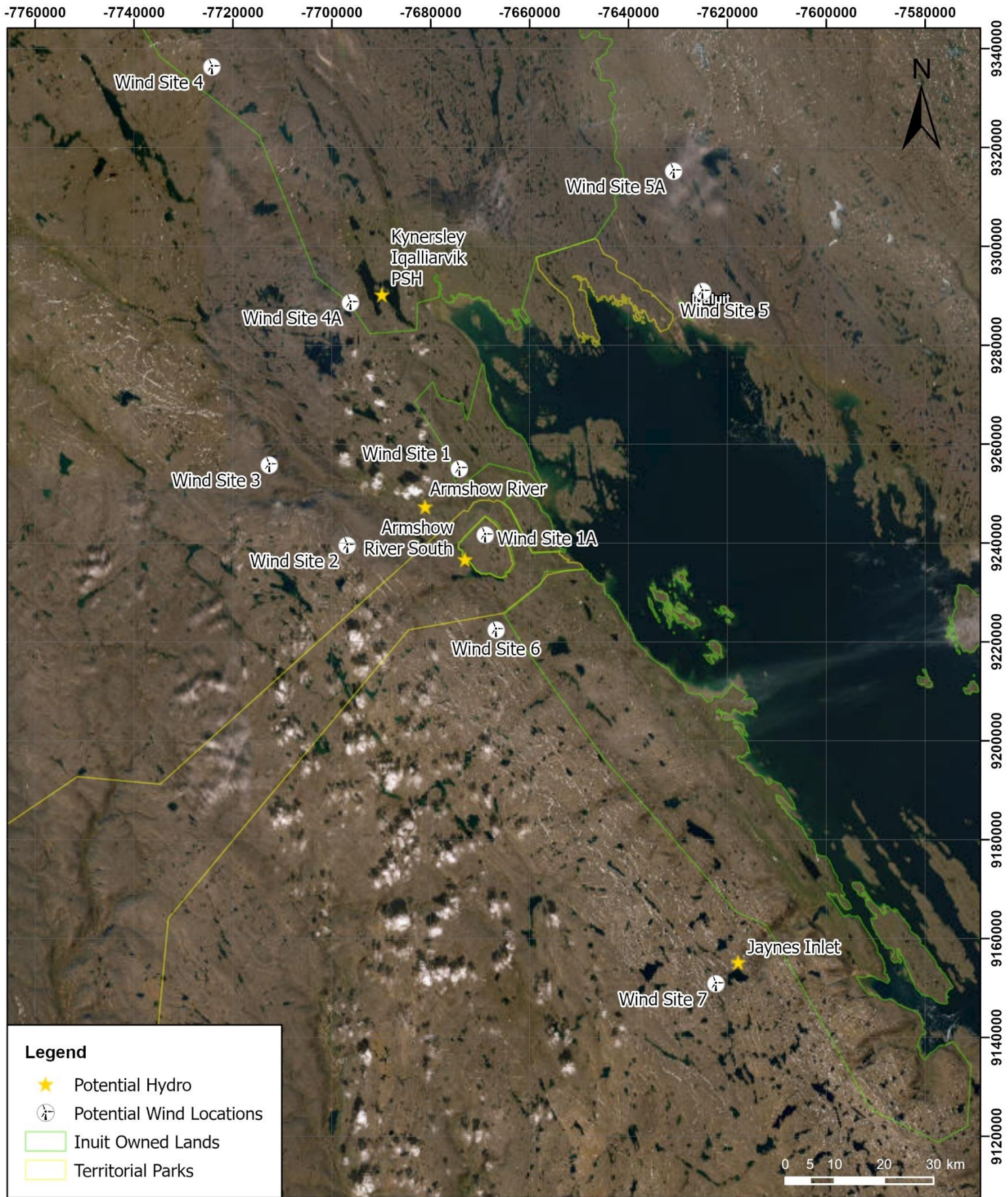
Table 2.1 Index of Project Alternatives.

ID	Location	Type	Sub Alternative	Figure#
1AC	Armshow River	Conventional HEP	Short	2.3
1BC	Armshow River	Conventional HEP	Long	A.4, A.7, A.10, A.11
2CP	Armshow River - Three Lakes	Conventional HEP + PSH	tunnel / shaft preferred, penstock less feasible	A.5, A.26
3AC	Armshow River - South Lake (aka Right Lake)	Conventional HEP	Penstock to the North (powerhouse locations)	A.6, A.8, A.12, A.26
3BC	Armshow River - South Lake (aka Right Lake)	Conventional HEP	Tunnel to the East	A.26
4AC	Jaynes Inlet	Conventional HEP	Penstock	A.13, A.15,
4BC	Jaynes Inlet	Conventional HEP	Tunnel / Penstock	A.14, A.27
5AC	Cantley Bay	Conventional HEP	Base Case	A.17-A.21
5BC	Cantley Bay	Conventional HEP	McKeand River Diversion	
6AC	McKeand River	Conventional HEP	South Dam	A.22
6BC	McKeand River	Conventional HEP	North Dam	A.23, A.24
7C	Sylvia Grinnell River	Conventional HEP	-	A.25

Table 2.1 Index of Project Alternatives (cont'd).

ID	Location	Type	Sub Alternative	Figure#
8P	Kynersley Iqalliarvik Lakes	PSH (closed-loop)		A.28
11W	Iqaluit North (Wind Site 5 or 5A)	Wind		A.29
12W	Qasitujuak Lake Ridge (Wind Site 4 or 4A)	Wind		A.28
13W	Armshow River Lower Ridge (Wind Site 1 or 1A)	Wind	tunnel / shaft	A.26
14W	Armshow River Highlands (Wind Site 2, 3, or 6)	Wind		A.26
15W	Jaynes Inlet Highlands (Wind Site 7)	Wind		A.27

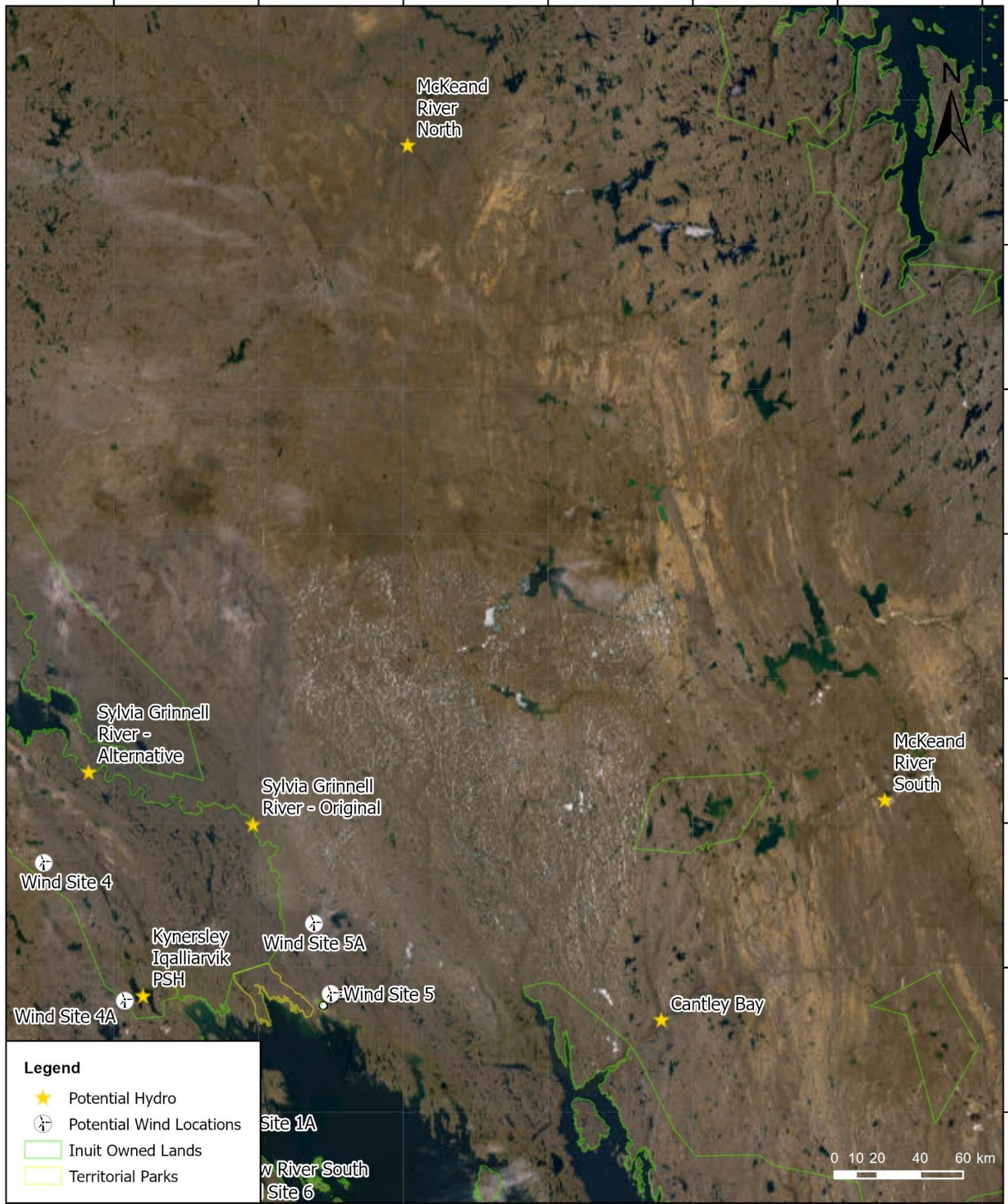
Each alternative was assigned an identification number according to the geographical area in which it would be located, followed by a letter indicating the sub-alternative (A or B), and ending with a letter code indicating the type of electricity generation (C = conventional hydroelectric power, P = pumped storage hydro, W = wind).



Iqaluit Nukkiqsautiit Project	
Figure 2.1 Overview of Project Alternatives (South)	

PREPARED BY: BC	PREPARED BY: SEM
COORDINATE SYSTEM: WGS 1984 Web Mercator	DATE: 03/16/2023

-7700000 -7650000 -7600000 -7550000 -7500000 -7450000 -7400000



Legend

- ★ Potential Hydro
- Potential Wind Locations
- Inuit Owned Lands
- Territorial Parks



Iqaluit Nukkiksautiit Project

Figure 2.2 Overview of Project Alternatives (North)

PREPARED BY: BC	PREPARED BY:
COORDINATE SYSTEM: WGS 1984 Web Mercator	DATE: 03/16/2023

2.1 Physical Features and Activities

For this screening exercise, common components amongst the alternatives were assumed to include:

- site access roads or routes; accompanied by:
 - terrain/vegetation disturbance
 - waterbody diversions/realignments;
 - water crossings;
 - water management infrastructure to divert, control, collect and discharge surface drainage and groundwater seepage to the receiving environment;
- construction workspace and laydown areas;
- storage for fuels, explosives and hazardous wastes;
- energy supply source for construction (assumed to be temporary);
- waste disposal using a portable incinerator and/or transportation to Iqaluit for disposal (assuming proper methods of disposal for all waste streams, and of a quantity that the landfill in Iqaluit is capable of handling);
- temporary worker accommodations;
- creation of new borrow pits and quarries; and
- construction of temporary marine wharf facilities (in some regions) for construction equipment transfer.

Hydroelectric generation projects were assumed to include:

- dam structures (earthen or concrete);
- a storage reservoir;
- a powerhouse containing generating units/turbines;
- spillway structures;
- water intake structures and penstocks; and
- transmission lines, electrical substations, and grid tie-in points.

Wind power generation projects were assumed to include:

- access roads of sufficient width and grade for transport of turbine components;
- laydowns for turbine assembly;
- a concrete turbine base and anchor points augured in concrete;
- wind turbine generators, each of 2.5 MW capacity spaced 300m apart;
- meteorological towers (erected during site feasibility investigation); and
- transmission lines, electrical substations, and grid tie-in points.

Pumped storage hydro (PSH) projects were assumed to include:

- a high elevation and a low elevation water reservoir, accompanied by dams and controlled flow-release structures;
- a pump station containing a generator/motor and a turbine/pump;
- a penstock/tunnel for water flow between the reservoirs;
- a powerhouse containing generating units/turbines;
- transmission lines, electrical substations, and grid tie-in points.

A summary of the available information upon which this screening exercise was completed for each alternative is given below in Table 2.2. Where a PSH scenario is noted, the height of the dam / reservoir size for the higher elevation waterbody is given first. Energy storage capacity of the PSH scenarios nor energy generation capacity for the wind scenarios was defined at the time of this report. The range of transmission lengths given for wind alternatives considers the shortest path of the closest site to Iqaluit, up to if all the indicated multiple sites were developed including the furthest away. Further details regarding the geographic extent of components are given in Section 5.1.

Table 2.2 Summary of Key Alternative Physical Features.

ID	Location	Capacity (MW)	Dam Height (m)	Reservoir Size (ha)	Approximate Transmission (km)
1AC	Armshow River Mainstem - Short	18	80	770	47
1BC	Armshow River Mainstem - Long	19	60	1,630	47
2CP	Armshow River - Three Lakes PSH	UN	10 , UN	580 , 80	56
3AC	Armshow River - South North Penstock	8.8	25	670	47
3BC	Armshow River - South East Tunnel	8.8	25	670	47
4AC	Jaynes Inlet – Penstock	14.6	30	860	96
4BC	Jaynes Inlet – Tunnel & Penstock	14.6	30	860	96
4BCP	Jaynes Inlet PSH	UN	30 , 15	860 , 10	96
5AC	Cantley Bay	15	105	580	50
6AC	McKeand River South	13	60	10500	62
6BC	McKeand River North	20	80	4800	140
7C	Sylvia Grinnell River	8	50	31000	33
8P	Kynerley Iqalliarvik PSH	UN	2, 3	1500 , 1000	17
11W	Iqaluit North (Wind Site 5 or 5A)	10-100	NA	NA	1-12
12W	Qasitjuak Lake Ridge (Wind Site 4 or 4A)	10-100	NA	NA	29-47
13W	Armshow River Lower Ridge (Wind Site 1 or 1A)	10-100	NA	NA	56-60.3
14W	Armshow River Highlands (Wind Site 2, 3, or 6)	10-20	NA	NA	47-95.5
15W	Jaynes Inlet Highlands (Wind Site 7)	10-20	NA	NA	47+10

UN = unknown at time of evaluation

3.0 Summary of Biophysical Environment

SEM was tasked with reviewing the environmental and regulatory materials that were prepared for the previous proponents by KPC (among others), as provided by the NNC. Appendix B presents a series of maps indicating the locations of various environmental baseline studies conducted previously for the Jaynes Inlet Project as proposed in 2013. Studies were mostly focused within the immediate project area, i.e. the Local Study Area (LSA), with fewer studies spread throughout the Infrastructure Regional Study Area (IRSA) (approximately 10 km radius of the generation site), and the Transmission Line Corridor (TLC) (a 10 km-wide swath from the project area to Iqaluit).

A literature and information search of environmentally sensitive ecosystems and species which may be present within the areas under consideration was also conducted to fill knowledge gaps.

For this study, SEM is not responsible for summarizing the human environment, however the link between resource use and ecological importance is assumed to be present. The current evaluation will benefit from revision to include land and resource use information gained from socio-economic studies.

3.1 Air Quality

Effects on air quality will be restricted to the construction period, and receptors of air pollution effects may be restricted to construction personnel in areas which are far away from any permanent settlements. Air quality baseline measurements have not been performed within any of the areas being considered. These may not be required to register a project with the NIRB, however are anticipated to be required as part of an EIS. Air quality data collected by Environment Canada at the station in Iqaluit may be used to initiate the environmental assessment process.

3.2 Climate and Meteorology

Climate information was compiled for the Jaynes Inlet and Armshow River areas in the Climate Change Impacts Assessment, prepared in 2009 by G.A. McBean Consulting. Additional climate change analysis information was included in the KPC 2008 hydrological analysis for the region. In those studies, climate data from the government of Canada's Iqaluit (Station # 2402592) and Kimmirut (Station # 2402673) meteorological stations was assessed for climate trends. Data from both stations showed high year to year variability and only slight trends in annual precipitation, with no statistically significant trends present from about 1970-2006. Temperature trends in Iqaluit showed a slight cooling trend from 1950 to 1970, but a warming trend of 0.5 °C per decade between 1970 and 2006. Temperature trends in Kimmirut exhibited a warming trend of 0.8 °C per decade between 1970 and 2006. The climate record of Iqaluit for the period 1961-1990 indicates a mean annual air temperature of -9.6 °C, with mean July and February temperatures of 7.7 °C and -26.8 °C, respectively. The mean temperature is above freezing for four months, between June and September.

Climate information from previous assessments was updated using current modelling data, which incorporates state-of-the-science methodology and more up-to-date historical climate data. Climate and meteorological data from the Climate Atlas of Canada (Prairie Climate Centre, 2023) were used to assess climate trends for each of the following regions. The Climate Atlas of Canada uses downscaled data derived from 24 CMIP5 global climate models. Predictions were developed for 10 by 10 km grids using the high carbon (RCP8.5) scenario, which assumes that GHG emissions will continue to increase at current rates. It should be noted that the Climate Atlas of Canada uses a baseline period between 1976 to 2005 for comparison to the immediate future (2021-2050) and the near future (2051-2080).

Sea ice concentrations and length of ice season are expected to decline significantly in the future. In addition, warmer temperatures may increase permafrost degradation. This will cause increased rates of rock weathering and loading of nutrients, sediment, dissolved organic and inorganic carbon, and possible contaminants to the waterbodies in the region. Permafrost degradation could also increase infiltration of

water into the ground, affecting the relationship between precipitation and discharge. The magnitude of peak-runoff in spring and early summer may be reduced by thawing permafrost. It is also possible that the loss of permafrost coupled with enhanced evaporation in a higher temperature climate may cause shallow Arctic River and lake systems to dry out. Careful monitoring of water levels, permafrost layer depth, evaporation and precipitation will be required to deduce the net effect of these factors on the volume of water available for hydroelectric generation.

3.2.1 Armshow River Region

The Armshow River Grid was selected to gather climate and meteorological data for the Armshow River, Jaynes Inlet, Kynersley-Iqalliarvik lakes, the Qasitujuak Lake Ridge, and the Iqaluit North regions. Total annual mean precipitation is projected to increase from 461mm (1976-2005) to 580 mm by 2051-2080, with increases occurring every season. The seasonal increases were estimated to be 37 mm for winter, 19 mm for spring, 27 mm for summer and 34 mm for fall. The annual mean temperature is projected to increase from -9.8 °C (1976-2005) to -4.1 °C by 2051-2080. It was predicted that seasonal increases will occur for annual mean temperature, with the greatest increases in winter (+10 °C) followed by summer and fall (+5 °C), and spring (+4 °C). Due to these climate shifts, the frost-free season was expected to increase from 57 days (1976-2005) to 106 days. Furthermore, the average dates of the frost-free period were expected to shift from June 29 to August 29 (1976-2005) to June 7 to September 25 by 2051-2080. The annual net number of freeze-thaw days was expected to decline from 38.5 days (1976-2005) to 32.8 days by 2051-2080.

3.2.2 Ward Inlet Region

The Ward Inlet Grid was selected to gather climate and meteorological data for the Cantley Bay and McKeand River South region. Total annual mean precipitation is projected to increase from 460 mm (1976-2005) to 564 mm by 2051-2080, with increases occurring every season. The seasonal increases were estimated to be 31 mm for winter, 16 mm for spring, 24 mm for summer and 32 mm for fall. The annual mean temperature is projected to increase from -9.6 °C (1976-2005) to -4.1 °C by 2051-2080. It was predicted that seasonal increases will occur for annual mean temperature, with the greatest increases in winter (+9 °C) followed by spring and fall (+5 °C), and summer (+4 °C). Due to these climate shifts, the frost-free season was expected to increase from 50 days (1976-2005) to 100 days. Furthermore, the average dates of the frost-free period were expected to shift from July 3 to August 26 (1976-2005) to June 10 to September 22 by 2051-2080. The annual net number of freeze-thaw days was expected to decline from 40.1 days (1976-2005) to 33.6 days by 2051-2080.

3.2.3 Chidliak Bay Region

The Chidliak Bay Grid was selected to gather climate and meteorological data for the McKeand River North region. Total annual mean precipitation is projected to increase from 460 mm (1976-2005) to 572 mm by 2051-2080, with increases occurring every season. The seasonal increases were estimated to be 32 mm for winter, 17 mm for spring, 27 mm for summer and 35 mm for fall. The annual mean temperature is projected to increase from -10.5 °C (1976-2005) to -5.0 °C by 2051-2080. It was predicted that seasonal increases will occur for annual mean temperature, with the greatest increases in winter (+9 °C) followed by spring and fall (+5 °C), and summer (+4 °C). Due to these climate shifts, the frost-free season was expected to increase from 39 days (1976-2005) to 93 days. Furthermore, the average dates of the frost-free period were expected to shift from July 7 to August 19 (1976-2005) to June 12 to September 17 by 2051-2080. The annual net number of freeze-thaw days was expected to decline from 38.4 days (1976-2005) to 29.9 days by 2051-2080.

3.2.4 Sylvia Grinnell Lake Region

The Sylvia Grinnell Lake Grid was selected to gather climate and meteorological data for the Sylvia Grinnell River region. Total annual mean precipitation is projected to increase from 435 mm (1976-2005) to 551 mm by 2051-2080, with increases occurring every season. The seasonal increases were estimated to be 33 mm for winter, 18 mm for spring, 29 mm for summer and 36 mm for fall. The annual mean temperature is projected to increase from -10.2 °C (1976-2005) to -4.4 °C by 2051-2080. It was predicted that seasonal increases will occur for annual mean temperature, with the greatest increases in winter (+9 °C) followed by spring and fall (+5 °C), and summer (+4 °C). Due to these climate shifts, the frost-free season was expected to increase from 57 days (1976-2005) to 107 days. Furthermore, the average dates of the frost-free period were expected to shift from June 29 to August 28 (1976-2005) to June 5 to September 24 by 2051-2080. The annual net number of freeze-thaw days was expected to decline from 37.3 days (1976-2005) to 31.5 days by 2051-2080.

3.3 Noise and Vibration

It is anticipated that the greatest noise emissions will be generated during the construction period, thus a qualitative analysis of background noise prior to construction will be beneficial to assess the effects of noise on the surrounding environment. Noise and vibration assessments have not been performed within any of the areas being considered. These may not be required to register a project with the NIRB, however are anticipated to be required as part of an EIS.

3.4 Geological Features, Surficial and Bedrock Geology and Geochemistry

A summary of the bedrock geology for each of the regions, adapted from the KPC Comprehensive Development Report, is given below in Table 3.4.1. Site reconnaissance of the six short listed project sites was done in August 2006 to assess the surficial geology and terrain hazards and to modify project layouts based on observed site conditions. An examination of the geomorphology or geochemistry has not been conducted at any of the areas being considered. This information is not anticipated to be required to register a project with NIRB, however changes in river morphology as related to fish habitat and water quality would require assessment in the EIS. As well, the acid rock drainage (ARD) and metal leaching (ML) potential would need to be assessed at locations where rock would be blasted and crushed, as ARD/ML has the potential to affect long-term water quality.

Table 3.4.1 Summary of Bedrock Geology (Knight Piésold Consulting Ltd, 2011).

Location	Description
Armshow River / Jaynes Inlet	The Armshow River and Jaynes Inlet region is positioned on substantial monzogranitic plutons (Cumberland batholith) which intrude the platform, basement and foreland basin. The Cumberland batholith consists of coarse to medium grained gigantic metaplutonic rocks. The most prominent rock type is orthopyroxene-biotite-monzogranite that is massive to weakly foliated. Garnet-biotite-orthopyroxene-cordierite and epidote bearing phases occur to a lesser extent. Bedrock geology is comprised of competent weathered granite that is locally migmatized.
Cantley Bay	Cantley Bay is positioned on highly metamorphosed rock. Bedrock geology is comprised of weathered granite, predominantly migmatite with foliation dipping Northwest.
McKeand River North / South	McKeand River is situated on metamorphic rock, most likely formed from deeply eroded Precambrian basement rock complexes. Bedrock geology is primarily hypersthene granite.
Sylvia Grinnell River	Bedrock geology is primarily of igneous origin – monzogranite (Cumberland Batholith). Principal rock type is orthopyroxene-biotite-monzogranite that is massive to weakly foliated. Minor garnet-biotite-orthopyroxene-cordierite and epidote bearing phases are present. Surficial Geology of Sylvia Grinnell River consists of till, outwash, deltaic gravel and sandy alluvium. Till is a clast supported silty sand; clasts are granule to large boulder size. Outwash is sand and minor silt and gravel.

3.5 Hydrological Features and Hydrogeology

KPC prepared a hydrological assessment in 2009 for the proposed hydroelectric developments at Jaynes Inlet, Armshow River, and Cantley Bay. The Jaynes River watershed, and the majority of the Armshow River watershed, are located on the Baffin Upland ecoregion, a high plateau located in the interior of the Meta Incognita Peninsula on southern Baffin Island. The lower catchment of the Armshow River is in the lower region of the coastal Meta Incognita Peninsula ecoregion. The majority of the Cantley River watershed is located on the Hall Peninsula Upland ecoregion, a high plateau located in the interior of the Hall Peninsula on southern Baffin Island.

The mean annual precipitation in all three regions ranges from 300 to over 500 mm. The hydrological regime in the region typically consists of early summer snow melt and late summer permafrost melt and rainfall. Throughout the period between November and May, the rivers are mainly frozen and have little to no streamflow. As part of feasibility studies and environmental baseline work, hydraulic modelling for the region can be updated using the WSC's station data at Sylvia Grinnell River near Iqaluit, for which historical data exists from 1971-2001 and 2006-2018 and real-time hydrometric data exists from 2021 to present. The need for additional stream and lake gauging programs can be devised once an alternative is selected.

Historical hydrometric data (water level and flow) is available for McKeand River near the South confluence, however, is limited to the years of 2007-2008. Investigations of the hydrological environment were not completed by the previous proponents within the Kynerley or Iqalliarvik lakes.

3.5.1 Jaynes River

The Jaynes River watershed is north-east facing and its elevation ranges from 750 mASL in its upper headwaters to 0 mASL where it drains into Jaynes Inlet on Frobisher Bay. The location of the proposed intake for the 2013 Jaynes Inlet Project was at the outlet of the largest lake within the Jayne Inlet catchment, with an elevation of 451 mASL and a drainage area of 203 km².

A total of four successful discharge measurements were collected at the streamflow gauging station installed by Water Survey of Canada (WSC) on the Jaynes River in August 2006. The measurements ranged from a low of 0.7 m³/s to a high of 28.5 m³/s. Based on the mean annual discharge (MAD) of 2.9 m³/s at the gauge site, this equates to a range of 24% of MAD to 983% of MAD. This information was used to develop a stage-discharge rating curve for the gauge, with an overall uncertainty of +/- 7.3%. The rating curve was developed using a conservative approach with respect to energy generation modelling given the limitations of the available data. The MAD calculated from the regression analysis was 3.9 m³/s, which equates to a mean annual unit runoff of 19 L/s/km². This differs significantly from the estimate of between

11 and 15 L/s/km² that was determined based on regional information available on comparable rivers (Apex River, Sylvia Grinnell River, and Soper River).

As of the 2008 report, very little data had been collected on the Jaynes River (1 year of concurrent streamflow data and four discharge measurements), therefore there was significant uncertainty associated with the rating curve developed for Jaynes River. Given this uncertainty, it was considered prudent to scale down the calculated flows by 25%, resulting in an MAD of 2.9 m³/s and mean annual unit runoff of 14 L/s/km² which was consistent with regional patterns at the time. Historical hydrometric data (water level and flow) collected by the WSC is available for Jaynes River at the outlet of Jaynes Lake (2006-2013), and Jaynes River 10 km below the outlet of Jaynes Lake (2012-2014), which can be used to update the provided estimates.

3.5.2 Armshow River

The Armshow River watershed is north-east facing and the Armshow River mainstem ranges in elevation from 650 mASL in its upper headwaters to 0 mASL where it discharges into the Bay of Two Rivers on Frobisher Bay. Armshow River South ranges in elevation from 750 mASL in its upper headwaters to 50 mASL at its confluence with the mainstem. The location of the proposed intake for the 2013 Armshow River HEP on the mainstem has an elevation of 49 mASL and a drainage area of 2026 km². The location of the proposed intake for the 2013 Armshow River South HEP has an elevation of 49 mASL and a drainage area of 278 km².

A total of five successful discharge measurements were collected at the streamflow gauging station installed by WSC in August 2006 on the Armshow River mainstem. The measurements ranged from a low of 2.6 m³/s to a high of 212 m³/s. Based on the MAD of 24.9 m³/s, this equates to a range of 10% to 852% MAD. This information was used to develop a stage-discharge rating curve for the gauge, with an overall uncertainty of +/- 5.4%. There was uncertainty associated with the rating curve as it was defined by only five data points with unknown accuracy. The MAD calculated from the regression analysis was 33.2 m³/s which equates to a mean annual runoff of 16 L/s/km². This was slightly higher than the estimate of between 10 and 15 L/s/km² that was determined based on information available on comparable rivers (Apex River, Sylvia Grinnell River and Soper River).

A total of three successful discharge measurements were collected at the streamflow gauging station installed by WSC in August 2006 on the Armshow River South. The measurements ranged from a low of 1.9 m³/s to a high of 29.6 m³/s. Based on the MAD of 3.5 m³/s, this equated to a range of 54% to 843% of MAD. This information was used to develop a stage-discharge rating curve for the gauge, with an overall uncertainty of +/- 2.5%. There is uncertainty associated with the rating curve as it was defined by only three data points with unknown accuracy. The MAD calculated from the regression analysis was 4.7 m³/s, which

equated to a mean annual runoff of 17.6 L/s/km². This was significantly higher than the estimate of between 11 and 15 L/s/km² that was determined based on information available on comparable rivers (Apex River, Sylvia Grinnell River and Soper River).

As of the 2008 report, very little data had been collected on the Armshow River South (1 year of concurrent streamflow data and three discharge measurements), therefore there was significant uncertainty associated with the rating curve developed for the Armshow River South. Given this uncertainty, it was considered prudent to scale down the calculated flows by 25%, resulting in a mean annual discharge of 3.5 m³/s and a mean annual unit runoff of 13 L/s/km², which was consistent with regional patterns at the time. A similar situation was encountered for the Armshow River mainstem, thus it was considered prudent to scale down the calculated flows by 25%, resulting in a mean annual discharge of 24.9 m³/s and a mean annual unit runoff of 12 L/s/km². Historical hydrometric data (water level and flow) is available for Armshow South River at the outlet of Armshow South Lake (2006-2014), Armshow River near the mouth (2006-2014), and Armshow North River at outlet Armshow North Lake (2006-2014) which can be used to update the provided estimates.

3.5.3 Cantley River

The Cantley River watershed is south-west facing and ranges in elevation from 740 mASL in its upper headwaters to 0 mASL where it discharges into Frobisher Bay. The location of the proposed intake for the Cantley Bay HEP as proposed in 2008 has an elevation of 122 mASL and a drainage area of 1787 km².

A total of five successful discharge measurements were collected at the streamflow gauging station installed by WSC on the Cantley River in August 2006. The measurements ranged from a low of 0.2 m³/s to a high of 325 m³/s. Based on the MAD of 23.1 m³/s at the gauge site, this equated to a range of 1% MAD to over 1400% MAD. This information was used to develop a stage-discharge rating curve for the gauge, with an overall uncertainty of +/- 50%. Most of the error was associated with the extreme low (1%) MAD and extreme high (1400%) MAD, which are difficult to measure accurately. The MAD calculated from the regression analysis was 23.1 m³/s, which equated to a mean annual unit runoff of 13 L/s/km². This was in line with the estimate of between 10 and 15 L/s/km² that was determined based on regional information available on comparable rivers (Apex River, Sylvia Grinnell River and Soper River). The calculated mean annual discharge rate seemed appropriate given the regional dataset, however, an uncertainty of +/- 25% was considered due to the limited site data and uncertainty in the Cantley River rating curve.

3.6 Groundwater and Surface Water Quality

Aquatic environmental studies in Jaynes Inlet were conducted throughout 2007-2009, and an overview of the reaches studied is given below in Figure 3.6.1. Routine water quality data (as elaborated below in Figure 3.6.2) was collected from freshwater areas of the Jaynes Inlet River system, including nine survey areas along the lower reaches, the Upper Lake, the Lower Lake, as well as the evaluation of water quality and CTD profiling in the Jaynes Inlet estuary and the Cincinnati Press Channel. Maps of water quality sampling sites are included in Appendix B.

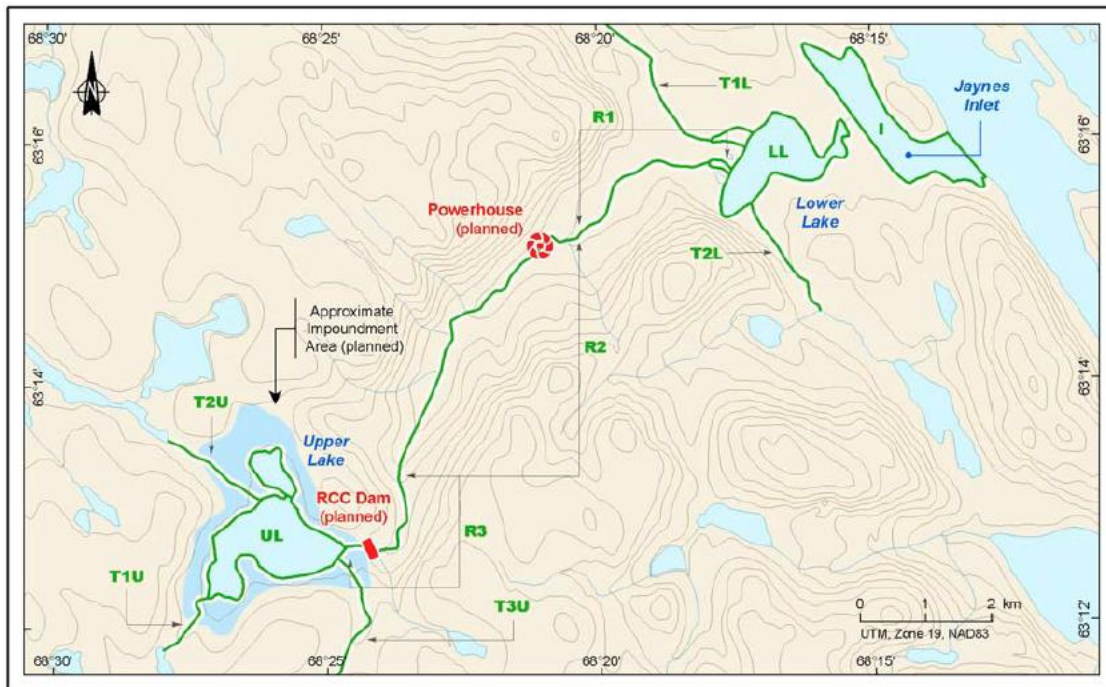


Figure 3.6.1 Aquatic Areas Studied within the Jaynes Inlet LSA (QEC 2011)

Review of materials did not indicate that any investigation of groundwater was completed in the Jaynes Inlet region. No investigation of surface water quality or groundwater quality was completed within any of the other proposed areas, however it was assumed that water quality characteristics in the river systems at the Armshow River, Jaynes Inlet, and Cantley Bay sites were comparable based on 2007 preliminary aquatic environment data.

The need for collection of water quality data can be devised once an alternative is selected, however is anticipated to be required to complete an aquatic environment description for an EIS with regards to

physical parameters measured *in situ* (i.e., water temperature, dissolved oxygen, pH, conductivity, and turbidity) and routine water quality parameters (as elaborated below in Figure 3.6.2).

Routine Water Quality Parameters	Metals and Ions	
Alkalinity	Aluminum	Sodium
Bicarbonate (HCO_3^-)	Antimony	Strontium
CaCO_3	Arsenic	Tellurium
Carbonate (CO_3^{2-})	Barium	Thallium
Hydroxide (OH)	Beryllium	Tin
Nitrogen	Bismuth	Titanium
Ammonia	Boron	Tungsten
Nitrate	Cadmium	Uranium
Nitrite	Calcium	Vanadium
Total Kjeldahl nitrogen	Cesium	Zinc
Carbon	Chloride Dissolved	Zirconium
Total organic carbon	Chromium	
Dissolved organic carbon	Cobalt	
Phosphorus	Copper	
Total phosphorus	Hardness (CaCO_3)	
Orthophosphate	Iron	
Water clarity	Lead	
Total dissolved solids	Magnesium	
Total suspended solids	Manganese	
Turbidity (NTU)	Mercury	
Real colour (TCU)	Molybdenum	
pH	Nickel	
Conductivity ($\mu\text{S}/\text{cm}$)	Potassium	
Algal pigments	Rubidium	
Chlorophyll a (Chl a) ($\mu\text{g}/\text{L}$)	Selenium	
Pheophytin ($\mu\text{g}/\text{L}$)	Silicon Dissolved	
Reactive silica (SiO_2)	Silver	

Figure 3.6.2 Routine Water Quality Parameters, Metals, and Ions Measured in Water Samples within the Jaynes Inlet Study Region from 2007-2009.

3.6.1 Jaynes River, Upper Lake, and Lower Lake

In situ surface water measurements and routine water quality samples were taken from nine locations along the Jaynes Inlet river, from the mouth of the river at Frobisher Bay along the mainstem tributary to 0.5 km upstream of the upper lake. Based on analysis of field measurements and routine water quality parameters, freshwater in the Jaynes River system was described as well oxygenated, clear (low turbidity and total suspended solids (TSS)), near neutral (pH 6.5-7.0), soft (hardness less than 60mg/L as CaCO_3),

dilute (low conductivity and total dissolved solids(TDS)), nutrient poor (low phosphorus and nitrogen), and having low primary productivity (low chlorophyll-a and pheophytin-a concentrations). The lower reaches of the Jaynes River watershed can be categorized as either oligotrophic or ultra-oligotrophic based on total phosphorus and chlorophyll-a concentrations. Dissolved oxygen, pH, nitrate, nitrite, and ammonia levels in each routine water quality sample were all within the Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines (CEQGs) for the Protection of Aquatic Life. Most metal and major ion samples were within the CEQGs with two exceptions: one sample had a copper concentration that just barely surpassed the CEQG, and one sample had a lead concentration that was roughly 2.5 times the suggested CEQG. These are presumed to have been collected from stations WC-1 and WC-14S respectively, as these sites had the higher concentrations noted in previous tables given in the report, however it is difficult to be certain due to cryptic sample names on the analytical certificates included.

In the Upper and Lower lakes, the water column was sampled at the top (0.5 from the surface) and at the bottom (1m from the floor). Vertical temperature, oxygen, and conductivity profiles collected from the Upper Lake and the Lower Lake indicated there was no thermal stratification in either lake during the summer or fall, however there were slight decreases in water temperature with depth. Dissolved oxygen concentrations in both lakes were at saturation (10.95 to 13.32 mg/L or 102% to 106% saturation), and specific conductance was low. The pH was near neutral (6.8-7.4). Total suspended solids (TSS) concentrations were low, with values ranging from 0.2 to 1.0 mg/L (surface and bottom samples), and turbidity values from 0.2 to 0.37 NTU. As a result, the water in the Upper Lake and Lower Lake can be described as very clear. Chlorophyll-a (Chl a) concentrations were low, with values varying from 0.06 to 0.42 g/L (surface and bottom samples). Water in the Jaynes Inlet system is classified as ultra-oligotrophic based on total phosphorus (TP) and Chl a results attained from both lakes. TP concentrations measured for the Lower Lake and Upper Lake were less than 0.003 mg/L and Chl a concentrations measured for the Lower Lake and Upper Laker were 0.06 g/L and less than 0.42 g/L, respectively. None of the parameters in the CCME CEQGs for the protection of aquatic life were exceeded in either of the lakes.

3.7 Sediment Quality

Sediment was sampled at three stations in the Lower Lake and three stations in the Upper Lake of the Jaynes Inlet Project area in 2009. Marine sediment was sampled at three stations in the Jaynes Inlet estuary. Sampling locations are included in Appendix B. No investigation of sediment was completed within any of the other areas under consideration.

The need for collection of sediment quality data can be devised once a project is selected, however is anticipated to be required to complete an EIS with regards to: sediment composition and grain size, total

organic carbon (TOC), nitrogen, total phosphorus, metals and major ions, and polycyclic aromatic hydrocarbons (PAHs).

At Jaynes Inlet, most sediment from the Upper Lake and Lower Lake consisted of sand (51-90%) and silt (4.4-47%), with some gravel (<0.1-12%) present. The TOC values ranged from 1.6-6.5 g/kg. All the sampled parameters were below the concentrations listed in the CCME Canadian Sediment Quality Guidelines (CSQGs) for the Protection of Aquatic Life, with the exception of copper at station 1 in the Upper Lake. Most of the sediment collected for analysis in the estuary consisted of sand (39-87%) and silt (0.2-48.8%), with some gravel (0.2-29%) present. The TOC values ranged from 1.6-7.1 g/kg. The concentrations of the sampled parameters in the estuary were all below the limits set in the CSQGs.

3.8 Freshwater Environment – Lower Trophic Community

Freshwater lower trophic community levels were sampled from nine survey areas along the lower portions of the Jaynes River system in 2007-2009, including the Upper and Lower lakes, the river between them, and several of the tributaries. Samples were analyzed to gain an understanding of the composition, distribution, and abundance of periphyton, zooplankton, drifting aquatic invertebrates, and benthic invertebrates. Locations of study are given in Appendix B. No investigation of the freshwater lower trophic community was completed within any of the other proposed areas.

3.8.1 Jaynes River

Throughout the areas sampled at Jaynes River, the periphyton community was found to be comprised of algae, fungi, and bacteria which develop on submerged rocks and other substrates in the waterways. The lower reaches of the Jaynes River watershed are covered in low concentration of periphyton. The abundance of periphyton was more prevalent in the summer than in the fall of 2008. The Upper Lake and Lower Lake zooplankton composition and density consisted of small numbers of cladocerans (water mites), and larger numbers of cyclopoid copepods (small crustaceans).

Drifting aquatic invertebrates are an essential food source for fish in general, particularly for Arctic char. The diversity of drifting invertebrates varied between sites but looked to be greatest in the downstream portion of the Lower Lake. The majority of invertebrates drifting down the tributaries were chironomid larvae. The abundance of the invertebrate populations seemed to be higher in the summer than in the fall at most sites, but there did not appear to be a distinct difference between areas. In contrast, fall had a higher diversity of drifting invertebrate taxa than summer did. Nematoda (worms), Ostracoda (small crustaceans), Hydracarina (water mites), and Chironomidae (midges) make up the benthic invertebrate

populations in the Upper and Lower Lakes. Chironomidae was the most abundant group found among all the benthic invertebrate samples collected in the Upper Lake and Lower Lake.

3.9 Fish and Fish Habitat

In 2006, North/South Consultants Inc. conducted preliminary fish surveys to identify the presence of migratory or landlocked Arctic char (*Salvelinus alpinus*) and to visually detect naturally-occurring barriers to migratory fish passage in Jaynes River, Armshow River, Cantley River, and McKeand River. This information was supplemented by literature review for Sylvia Grinnell River. A summary of the findings is provided below in Table 3.9.1.

Fish sampling in 2006 was conducted using an array of methods (hoop nets, electrofishing, angling, and gill nets) throughout each of the watersheds. Further details regarding the 2006 surveys are given in the following sections. Further studies of fish and fish habitat were conducted within the Jaynes Inlet Project area from 2007-2009, locations of which are given in Appendix B. No further studies have been conducted in the other areas under consideration.

Table 3.9.1 Migratory versus Landlocked Arctic Char and Barriers to Fish Passage.

Location	Arctic Char Population	Natural Barrier(s)
Jaynes River	Three distinct freshwater resident populations, including dwarf variants in the headwater lake (based on physical appearance, strontium analysis of otoliths later confirmed).	An abrupt set of waterfalls at the mouth of the river blocks anadromous fish access to the system. Numerous sets of falls and rapids along the river preclude the upstream movements of fish, hence the three distinct populations.
Armshow River	Majority along mainstem believed to be freshwater residents, however strontium analysis of otoliths verified that one (1) had fed in a marine environment, indicating that fish passage between upstream areas and Frobisher Bay is possible. Significant concentration of anadromous char at the mouth of the river.	Visual assessment did not indicate barriers to upstream fish movements along the mainstem. Series of rapids/falls upstream of the river mouth may act as a barrier at varying times of year depending on flow conditions.
Cantley River	Based on physical appearance most of the larger fish caught in the river looked to be freshwater residents. Strontium analysis of the otoliths of a small population of captured fish from the lake of Reach 3 suggested that none of those fish had fed in a marine environment and were most likely freshwater inhabitants.	Possible barrier to upstream fish movement was a substantial series of rapids at the upstream end of Reach 1.
McKeand River	Strontium analysis of otoliths on a limited number of fish captured indicated that those fish had spent their entire lives in freshwater. Likely that most char caught in 2006 were freshwater residents.	Possible barrier comprised of a large set of waterfalls located near the mouth of the river, however because water flow was high at the time of the site visit the falls appeared more like a large rapid. Although water velocity was high, it seemed that char may be able to ascend the falls under those circumstances. There did not appear to be any other impediments, such as river morphology or flow conditions, to prevent fish from migrating upstream.
Sylvia Grinnell	Confirmed anadromous population, migrate downstream to feed in a marine environment in June and begin their upstream migration in August. Recreational migratory fishery around the territorial park. Freshwater resident population may also be present.	Nonapparent. Falls at the mouth of the river system does not prevent the upstream movement of fish. Arctic char gather at the base of the falls until a high tide allows them to ascend the falls.

3.9.1 Jaynes River

Fish habitat within the lower portion of the Jaynes River was described in four reaches based upon topography and aquatic habitat: an overview of the reaches studied in 2006 is given below in Figure 3.9.1. Reach 1 contains a broad, flat area at the confluence of several valleys and includes a large lake that is connected to the ocean by a short section of riffle habitat. Entrance to the river is through a series of abrupt rapids that was hypothesized to obstruct fish passage. The river runs across a large delta with fine substrate mainly composed of sand and silt. Reach 2 is upstream of the delta where the valley becomes narrower and the river is more contained, with pools dispersed throughout long sections of riffle and rapid habitat. Reach 3 consists of a long succession of rapids and falls which is undoubtedly an obstacle to fish migration. Throughout this reach, there are numerous vertical drops greater than 5 meters. Reach 4 comprises a high elevation headwater lake and inflowing tributaries that would form the proposed reservoir as envisioned in 2006.

In 2007-2008 North/South Consultants Inc. carried out further aquatic studies during the summer and fall to identify fish habitat utilization and fish movements, and completed contaminant analysis of fish muscle tissue. Fisheries sampling was conducted using a variety of capture techniques including gill-netting, hoop-netting, electrofishing, and angling. 195 Arctic char and 3 threespine stickleback were captured during summer 2008, and 122 Arctic char and 104 threespine stickleback were captured during fall 2008. Neither of these species are listed on Schedule 1 of the SARA as of March 2023, however Arctic char are an important food source for people in the region and are fished recreationally. Arctic char were distributed throughout the lower reaches of the Jaynes Inlet watershed and were present in all survey areas in 2008. Compared to char, sticklebacks are much scarcer in Jaynes Inlet; all of the fish that were caught were in lower lake tributaries within 1 km of the lower lake.

Arctic char in the Jaynes Inlet system are exclusively freshwater residents. There are at least three distinct populations of freshwater resident Arctic char, divided by substantial falls that impede fish movements. The Lower Lake and its tributaries are home to one community, the Upper Lake and lower-most portions of its tributaries are home to another, and at least one population lives in the headwaters upstream of the Upper Lake. The Upper Lake population of char is believed to stay in the lake year-round, while young char from the Lower Lake may enter the tributaries in the summer.

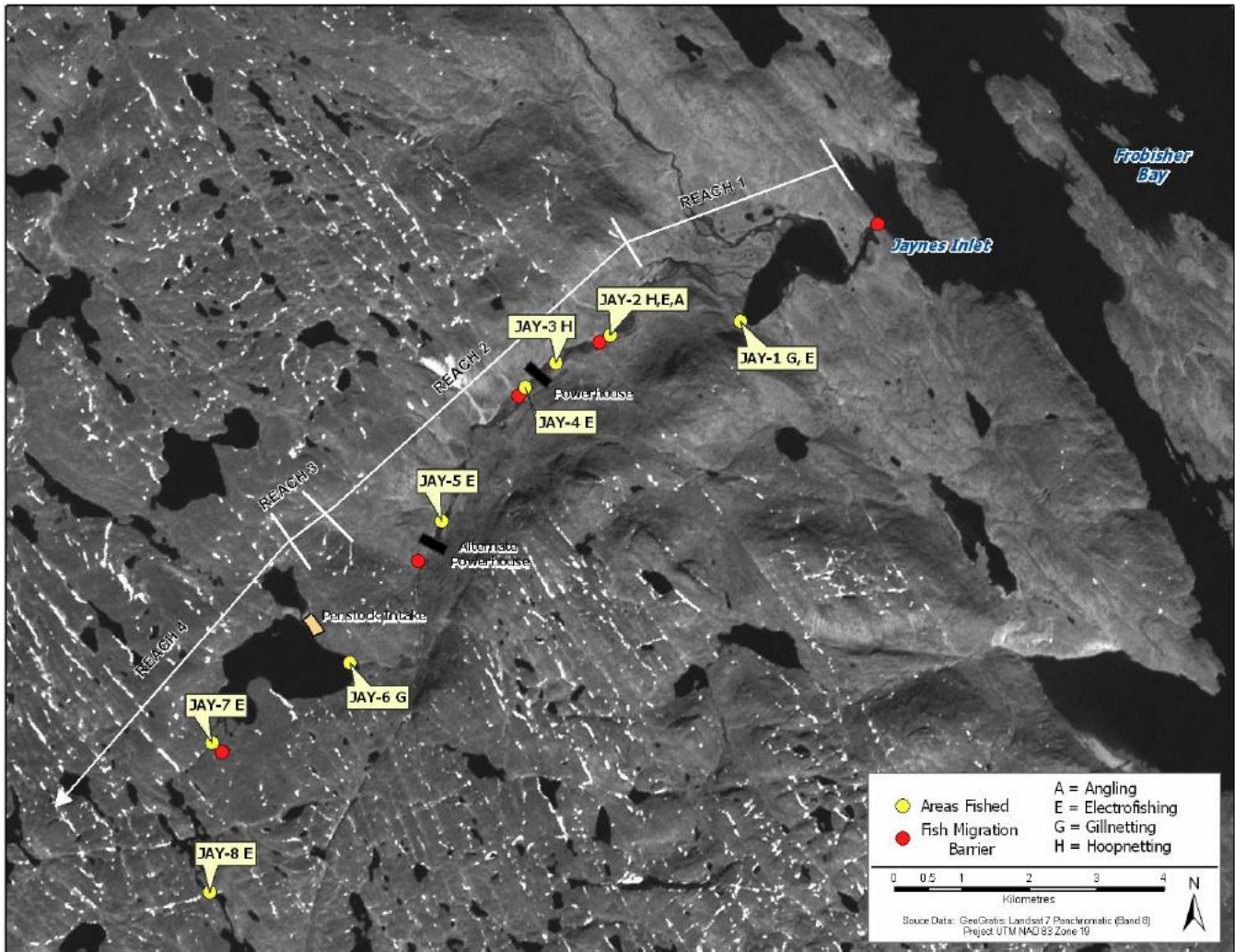


Figure 3.9.1 Preliminary Fishing Studies within the Jaynes River Watershed (North/South Consultants 2006).

Strontium content Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) analysis of otoliths indicated that none of the sampled char from the Lower Lake had ever been in a marine environment. The sizable set of falls at the outlet of the river system prevents anadromous char from moving upstream.

Fish muscle tissue for Arctic char captured at Jaynes Inlet in 2007 and 2008 were analyzed for trace metal contaminants. Most trace elements were either absent or present in concentrations below the laboratory detection limit. Mercury concentrations ranged from 0.03-0.44 ppm for analyzed fish. For comparison, the Canadian Food Inspection Agency prescribed a maximum limit of 0.5 ppm total mercury in retail fish. The suggested tolerable daily intake established by Health Canada for methylmercury is 0.2 µg per kg of body weight per day, and there are currently no territorial fish advisories in Nunavut.

3.9.2 Armshow River

Fish habitat within the Armshow River was described in five reaches: an overview of the reaches studied in 2006 is given below in Figure 3.9.2. Reach 1 extends upstream from the river's mouth to approximately 4.8 km upstream from the Bay of Two Rivers. The river flows through a broad valley and mostly consists of riffle habitat with a few pools or rapids. The bottom substrate in the river is mainly made up of boulders and cobble, and water velocity is fast. Reach 2 extends upstream along the mainstem and is composed primarily of fast flowing water that moves through a constrained valley. There is a large set of rapids or falls in the center of this reach that was hypothesized to prevent fish migration. Habitat mainly encompasses pool and rapid sequences, and the substrate is mostly bedrock and boulder/cobble, with small areas of gravel and sand. Reach 3 includes a broad, flat valley approximately 8km upstream of the river mouth where the river widens and slows down as it proceeds up the main section of the river. Habitat is comprised of runs, large pools, and occasional rapids. Substrate is primarily made up of boulders and cobble, although gravel and sand bars can be found. Reach 4 continues upstream past the proposed reservoir and contains straight sections of river constrained by a small valley and a sharp elevation change. Habitat is predominantly rapids/riffles and runs, with large pools dispersed. Reach 5 contains the headwater lake and its outflowing tributary which constitutes the Right Lake of Armshow. Where the tributary joins the Armshow mainstem is distinguished by a sharp elevation change, fast water, and riffle habitats.

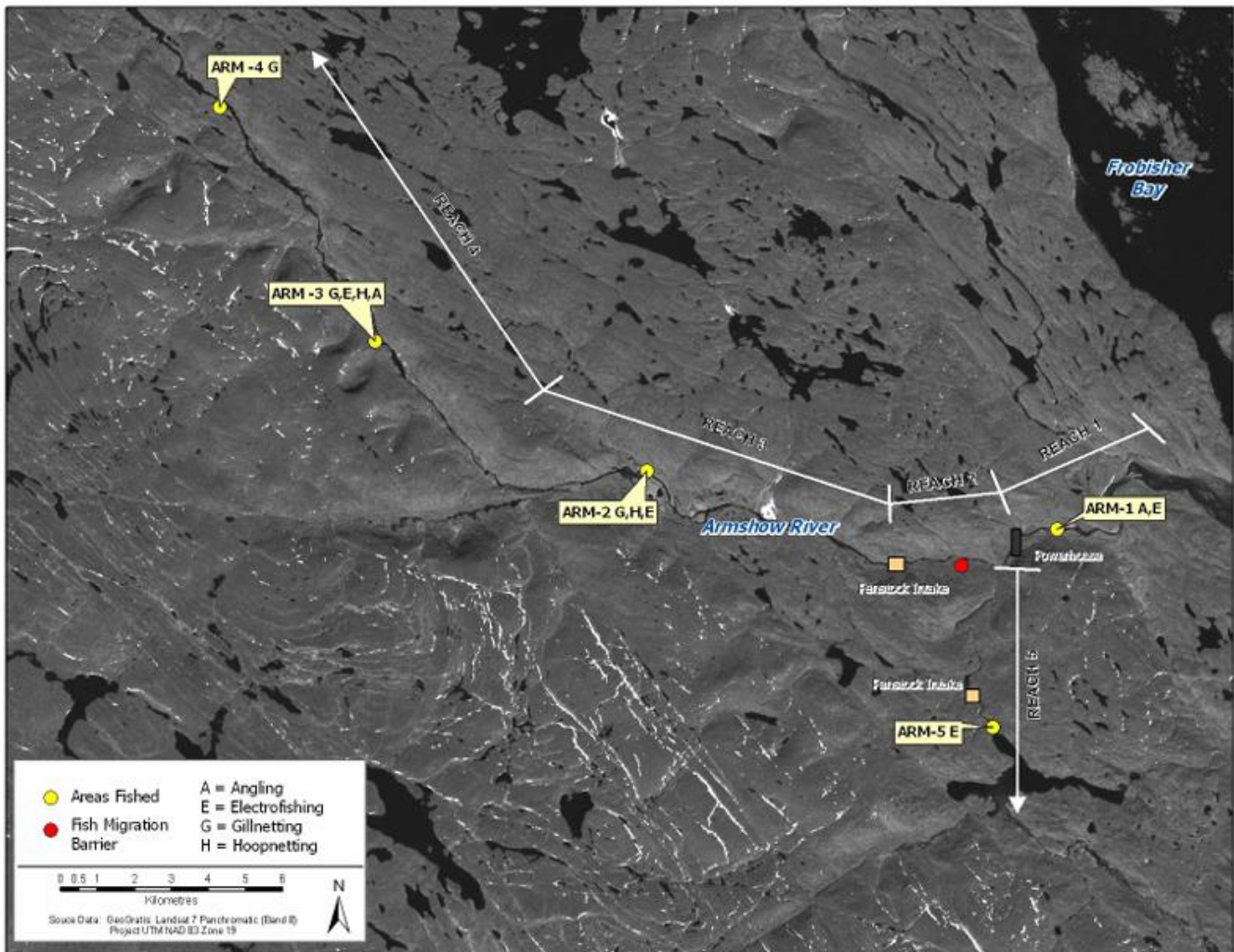


Figure 3.9.2 Preliminary Fishing Studies within the Armshow River Watershed (North/South Consultants 2006).

Visual assessment of the Armshow River revealed that there did not seem to be any barriers to upstream fish movements along the Armshow River mainstem, even though a series of rapids/falls upstream of the river mouth may act as a barrier at varying times of year depending on flow conditions. Arctic char were captured all along the Armshow River mainstem and a significant concentration of anadromous char were found at the mouth of the river. Fish passage to upstream areas within the river mainstem does not appear to be restricted for anadromous fish, despite the fact that the majority of the char discovered throughout the proposed development site are believed to be freshwater residents. Strontium analysis of otoliths verified that one captured Arctic char had fed in a marine environment, indicating that fish passage between upstream areas and Frobisher Bay is possible.

3.9.3 Cantley River

Fish habitat within Cantley River was described in four reaches in 2006, as depicted below in Figure 3.9.3. Reach 1 is primarily made up of fast flowing water over boulder and large cobble substrate and stretched from the mouth of the river to approximately 3km upstream to just above the proposed powerhouse site. A large portion of this reach is made up of run and pool habitat, while rapids make up the remaining portion. Reach 2 is typified by swiftly moving water through a confined valley, creating rapids and riffles. Reach 3 consists of a wide valley that would contain most of the proposed reservoir, about 5.0 km upstream from the upper extent of tidal influence. Through this area, the topography is comparatively flat, and the river expands significantly as it meanders through the valley. There are many wide pool and side channels, and a sizeable lake is located near the upper end of this reach. Reach 4 returns to fast flowing water, resulting in rapids and pool sequences in a small valley with a rapid elevation increase.

Visual assessment of Cantley Bay hypothesized that the only possible barrier to upstream fish movement was a substantial series of rapids at the upstream end of Reach 1. Based on physical appearance of Arctic char during the study, most of the larger fish that were caught in this river looked to be freshwater residents. Strontium analysis of the otoliths of a small population of captured fish from the lake of Reach 3 suggested that none of those fish had fed in a marine environment and were most likely freshwater inhabitants.

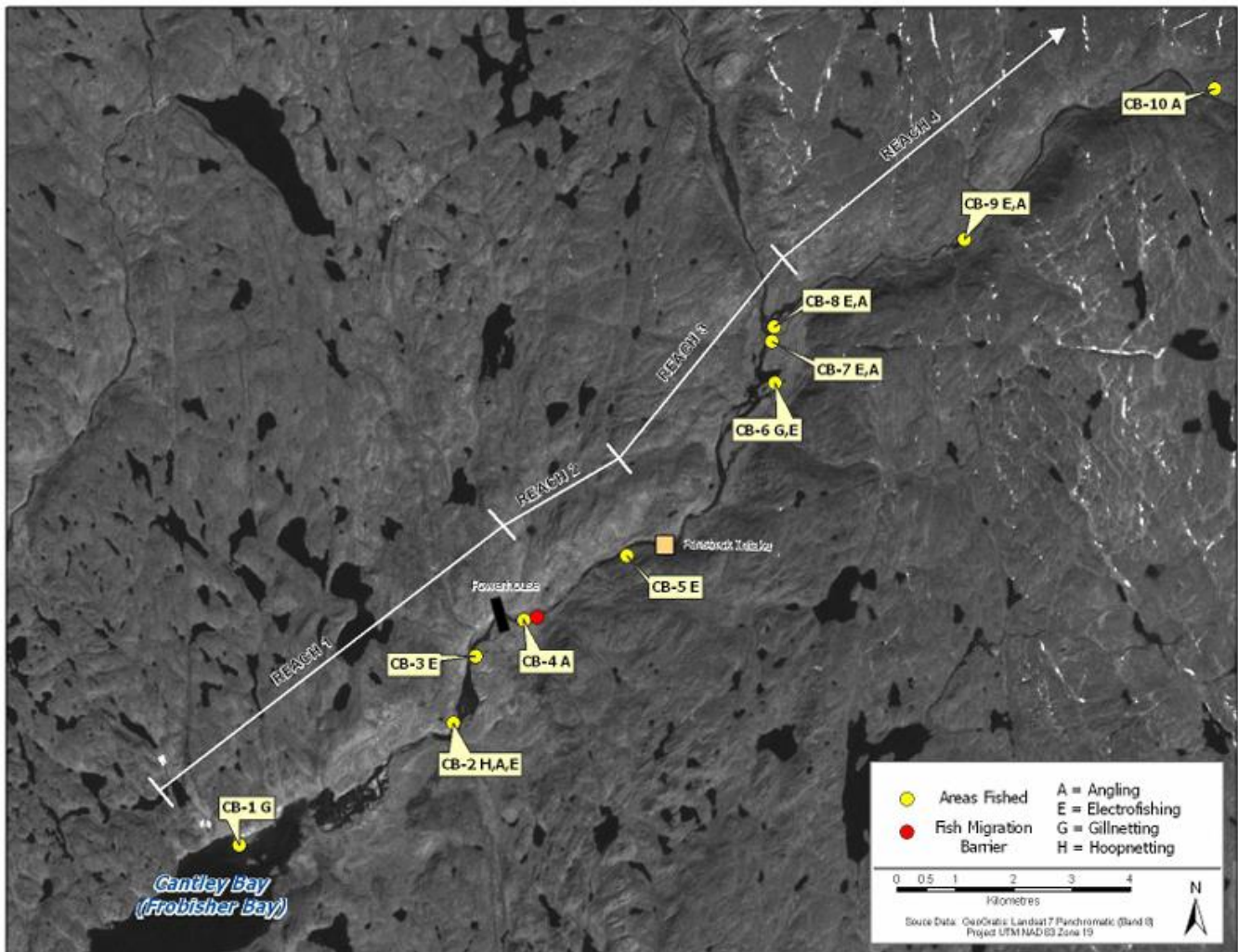


Figure 3.9.3 Preliminary Fishing Studies within the Cantley Bay Watershed (North/South Consultants 2006)

3.9.4 McKeand River

Fish habitat within the McKeand River was described in three reaches in 2006, locations of which are given below in Figure 3.9.4. In the areas studied it was found that the aquatic habitat is primarily comprised of run (70%) and rapid sequences (30%). Water depth was greater than 2.0 m in most areas, and water velocity was estimated to be 1.5 m/s in run habitat. Along the McKeand River, there is almost no floodplain; the river is constrained and barely meanders except in the upper portions of Reach 3.

water velocity was high, it seemed that char may be able to ascend the falls under those circumstances. There did not appear to be any other impediments, such as river morphology or flow conditions, to prevent fish from migrating upstream. Large rapids exist far upstream of the proposed development site which might act as a possible barrier to fish movements. The preliminary fish surveys executed along the McKeand River in 2006 covered approximately 200 km, including locations upstream and downstream of the planned development area. Strontium analysis of otoliths on a limited number of fish captured upstream of the development site indicated that those fish had spent their entire lives in freshwater, and it is likely that most of the arctic char caught in this study were freshwater residents.

3.10 Marine Environment

Field campaigns to describe the marine environment were conducted in the nearshore marine area of Jaynes Inlet in summer and fall 2008, and spring 2009. Sampling locations are included in Appendix B. No investigation of the marine environment was completed near any of the other proposed areas.

Sampling in the Jaynes Inlet estuary and Cincinnati Press Channel was accompanied by conductivity-temperature-depth (CTD) profiles, and a description of the nearshore marine habitat. Water quality data collected included: alkalinity, nitrogen (ammonia, nitrate, nitrite), total phosphorus, organic carbon, water clarity (TDS, TSS, turbidity, colour), pH, conductivity, and algal pigments (chlorophyll-*a*, and pheophytin). Efforts were made to characterize the marine environment within the Jaynes Inlet estuary at both low tide and high tide.

Vertical CTD profiles taken during high tide showed that most mixing of fresh and marine waters occurred within the intertidal bay. The Jaynes Inlet River empties into Frobisher Bay in a small, confined, narrow channel and therefore tidal influence has a significant impact on water depth within the bay, which varies from about 6 m at high tide to less than 1 m at low tide. The shorelines of the intertidal bay and surrounding areas are made up of bedrock outcrops and slender beaches consisting of boulders, cobble, and finer grain sediments. Substrate within the bay is comprised of clay and sand, and smaller amounts of boulder and cobble interspersed.

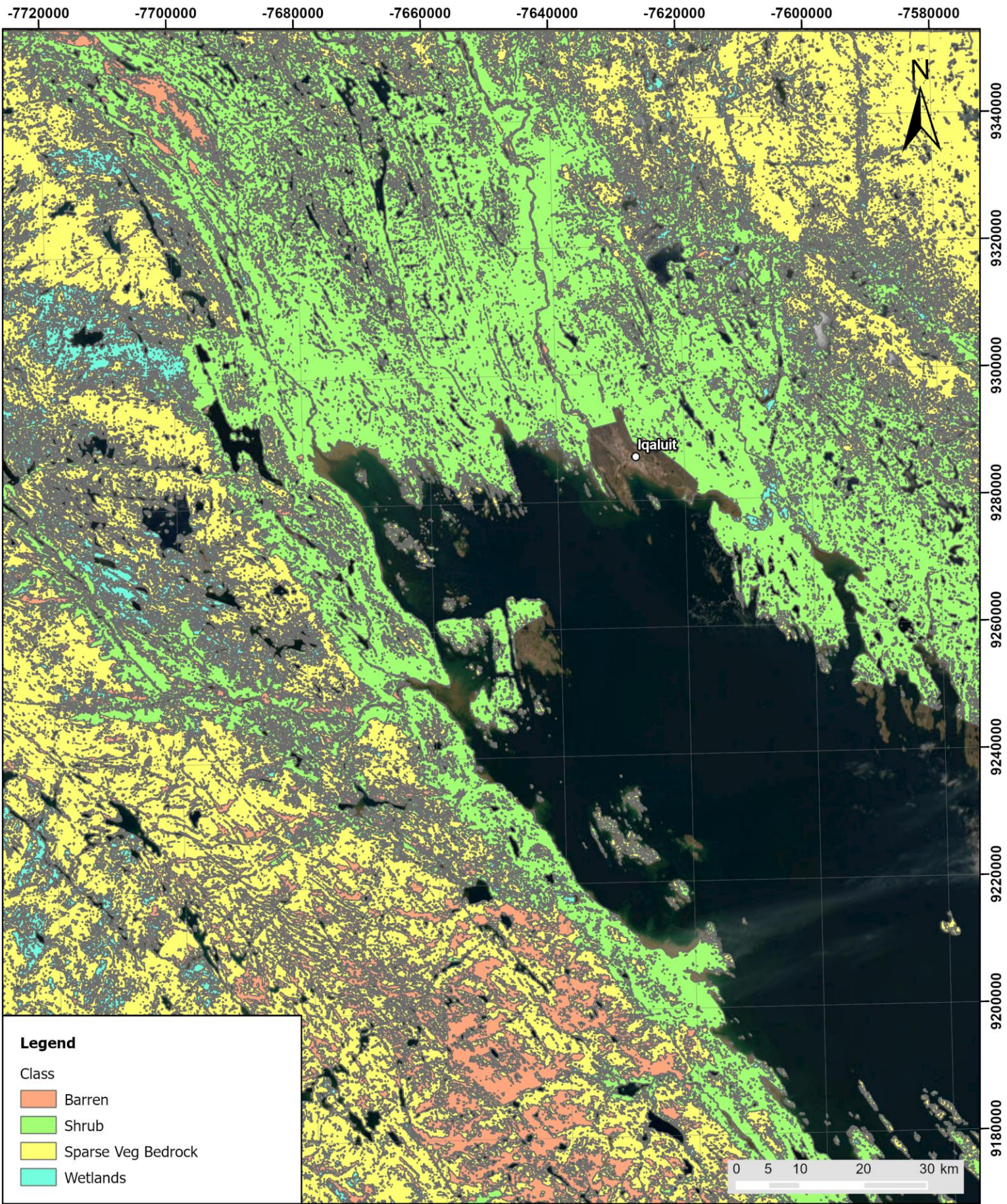
TSS concentrations ranged from 10.6 to 20.0 mg/L at high tide and from 0.8 to 21.0 mg/L at low tide. These latter values correspond to turbidity values of 0.93 to 1.40 NTU, which indicates that the TSS are primarily made up of fine sand. Chl *a* concentrations acquired were extremely low, varying from 1.3 to 2.2 µg/L at high tide and from 0.2 to 1.85 µg/L at low tide. Marine water quality in the Inlet and Channel can be typified as clear, nutrient-poor (low phosphorus and nitrogen), near neutral pH, and exhibiting low primary productivity (low Chl *a*). All sampled parameters were below the concentrations established in the CCME CEQGs for the protection of aquatic life.

3.11 Terrestrial Landforms & Vegetation

From 2006-2008 KPC conducted desktop analysis of satellite vegetation data, surficial geology, and topography to develop a vegetation map and ecological land classification (ELC) encompassing the Iqaluit region, including the Jaynes Inlet and Armshow River areas and a portion of the Cantley Bay area. An updated ELC for the region was completed by SEM in 2023. The SEM ELC study classified local ecosystems, including vegetation classes and associated habitats through use of Sentinel-2 satellite imagery obtained on September 23, 2022. Multiple data strips were merged into a single raster and a composite image was created using the red, green, and infrared bands of the data. A series of supervised classifications were run on this dataset, and the classes were modelled after the similar ELC study conducted by KPC in 2008. Once the classifications were completed and matched the ground surface, the raster was converted to a shapefile and each class was assigned unique symbology as appears below in Figure 3.11.1.

Landscape conditions vary widely in the region. There are moist lowlands, wet slopes, well-drained slopes, dry terraces, and bedrock hilltops. The abundance of plant communities ranges from barren (least abundant) to continuous (most abundant). In general, the low-lying areas, especially along the coastline, are the most productive. The lower portions of inland valleys are also very productive, likely due to the high moisture conditions and protection from abrasive high winds. Vegetation productivity is lower typically at higher elevations, however, for most downstream portions of the proposed infrastructure in Armshow River, Jaynes Inlet, and Cantley Bay, the local ecosystems are mapped as highly productive.

Three previous field studies focused on vascular plant species in Frobisher Bay were referenced by KPC to better understand the landscape ecology of the region. Calder (1951) conducted a study of the flora of a section of the north shore of Frobisher Bay, McLaren (1964) published a study of the flora in the vicinity of Ogac Lake on the south coast of Frobisher Bay, and Avens Associates Ltd. (1991) conducted an inventory of plant species for the then proposed Silvia Grinnell Park. A total of 207 vascular plant species were identified within the Frobisher Bay region, with 164 from Sylvia Grinnell Park, 141 from the north shore study and 124 from the south shore study.



	Iqaluit Nukkiksautiit Project	PREPARED BY: JMC	PREPARED BY: 
	Figure 3.1 Iqaluit Region Ecological Land Classification(2023)	COORDINATE SYSTEM: WGS 1984 Web Mercator	DATE: 03/04/2023

3.11.1 Jaynes Inlet

Conclusions drawn from the more detailed ELC completed in 2008 focused on the Jaynes Inlet Regional Study Area (RSA), indicated in Appendix B. A total of 16 plant community types were found to exist that can be categorized into six dominant community components. These include lichens, moss, sedge, wood rush, heath, and dwarf birch. Lichens occur most frequently as the dominant community throughout the Jaynes Inlet Regional Study Area (RSA), with five plant community types. Heath is the second most dominant with four community types, followed by sedges with three community types. Communities dominated by dwarf birch (two community types), wood rush (one community type) and moss (one community type) occur less frequently.

Field vegetation studies were conducted in spring 2009 by RSW Inc. within the Jaynes Inlet Project area, locations of which are given in Appendix B. Due to the lack of aerial photos and large size of the local study area (50 km²), it was decided to gather data on a topographic basis. Sampling efforts were stratified to cover the main vegetation habitats and focus on the rarest habitats. A total of 127 vegetation units were sampled, and 161 information sites were chosen to collect various data on the topographic situation, geomorphological features, slope, soil texture, rockiness, etc. A total of 137 plant species were identified, with hilltop habitats being characterized by a lower species diversity. Lichen-dominated vegetation predominantly occurs in these dry substrate conditions, partially due to the low amounts of organic material and abundance of frost shattering in the soils. Lichens outnumber vascular plants in this community type and those vascular plants that are present tend to form dense mats. Important species in this dry habitat are Arctic white heather (*Cassiope tetragona*) and Entireleaf Mountain Avens (*Dryas integrifolia*). The number of species along the valley was variable, depending on the habitat conditions. The lichens, moss, sedge, wood rush, heath and dwarf birch plant communities dominated the valley area. None of the species observed during the field work are listed in Schedule 1 of the SARA as of March 2023. In areas with rivers and small tributaries, observed wetlands were quite small and dominated by sedge species forming the Grassland Tundra. The floodplain and its deposits around the lower lake, where plant communities in dry sandy and gravelly places are dominated by species like Bog billberry (*Vaccinium uliginosum*) and crowberry (*Empetrum nigrum*). The coastal escarpment lacked suitable habitat and was quite poor in species abundance.

3.11.2 McKeand River North

Desktop review of the terrestrial environment and vegetation was not completed by the previous proponents within the McKeand River North watershed. Peregrine Diamonds conducted environmental baseline studies from 2009-2017 and De Beers continued data collection from 2019-2021 for the adjacent Chidliak Diamond Mine Project (De Beers Group, 2022). According to the publicly available data from those studies, the mid-arctic climate causes the region's vegetation to be discontinuous, with low shrub tundra vegetation like purple saxifrage, *Dryas* spp., and various rushes and sedges predominating. The broad erosion surface orientated along plains of geological weakness characterizes the ecoregion's overall physiographic aspect. In higher elevations, there are valleys that are dissected with steep-sides and filled with glaciers and hummocky surfaces that are sparsely covered by sandy till. Bedrock outcrops are common, and Turbic Cryosols are the dominant soils.

3.12 Terrestrial Wildlife and Wildlife Habitat

A desktop terrestrial wildlife review was conducted as part of the pre-feasibility and preliminary environmental baseline studies in the Jaynes Inlet, Armshow River, and Cantley Bay regions. Incidental observations of terrestrial wildlife were also documented during 2006 aerial surveys.

Reported observations gathered through the Inuit knowledge IQ study conducted in 2006, as well as harvest data collected from the Nunavut Wildlife Harvest Study, were collated and summarized by KPC to account for land use activities and wildlife observations. The Armshow River mainstem had the highest amount of recreational activity, mostly revolving around the harvest of fish and caribou, as well as whales and walrus in the coastal vicinity. Although no caribou were observed at that time in Armshow River, caribou tracks were identified, especially along the riverbanks. Cantley Bay accounted for the most mammal and bird observations overall; notably five active raptor nests were recorded. One sub-adult caribou was observed and a few lightly traveled caribou trails were noted.

Within the watershed of the McKeand River North, the previous proponents did not conduct any assessments of terrestrial wildlife and wildlife habitat. Peregrine Diamonds performed environmental baseline studies from 2009 to 2017, and De Beers continued data collection for the adjacent Chidliak Diamond Mine Project from 2019 to 2021 (De Beers Group, 2022). In those studies, it was found that low productivity results in low populations of terrestrial mammals in the ecoregion, including the arctic hare, arctic fox, arctic wolf, and caribou. Few caribou have been seen since 2009, and surveys conducted over several years indicate that caribou are present in the nearby study area at very low population densities.

The Government of Nunavut completed comprehensive aerial surveys of caribou in 2012 in the South Baffin Region (Jenkins, Goorts, & Lecomte, 2012), as well as aerial surveys and ground surveys in 2014

throughout all of Baffin Island (Campbell, Goorts, Lee, Boulanger, & Pretzlaw, 2015). Both studies were paired with collection of Inuit knowledge collected in 10 communities (Jenkins, Goorts, & Lecomte, 2012; Campbell, Goorts, Lee, Boulanger, & Pretzlaw, 2015). Those studies indicated low numbers of caribou throughout the South Baffin Region, with an estimated abundance of caribou between 1065 – 2067 animals aged one year or older in 2012 (Jenkins, Goorts, & Lecomte, 2012) and between 3,169 – 5,935 adults, yearlings, and calves in 2014. Previous projections of population size range between 60,000 and 180,000 for early 1990's (Jenkins, Goorts, & Lecomte, 2012). Examination of telemetry data revealed that the average annual distance travelled during spring by the South Baffin caribou was 137 km, while distances travelled during fall were considerably greater at 282 km/year (Campbell, Goorts, Lee, Boulanger, & Pretzlaw, 2015). Different times of year are important for the lifecycle of caribou on South Baffin Island, which can be broken into 6 seasons: 1-Spring Migration (April 1st to May 29th), 2- Calving (May 30th to June 25th), 3- Post-calving and summer (June 26th to August 12th), 4- Late Summer and Fall Migration Pre-breeding (Aug 13th to October 22nd), 5- Breeding/Fall Migration post-breeding (Oct 23rd to December 15th), and 6- Winter (December 16th to April 4th) (Campbell, Goorts, Lee, Boulanger, & Pretzlaw, 2015). According to this data, developments at McKeand River and Cantley Bay may pose the greatest concern for interactions with caribou, as these overlap with historic and current sensitive calving areas, as well as the spring migratory and post-calving period (Campbell, Goorts, Lee, Boulanger, & Pretzlaw, 2015). Alternatives in Armshow River and Sylvia Grinnell River are situated within the spring migration range of South Baffin caribou. There is also some potential for overlap during the rut and early winter periods for the options at Sylvia Grinnell and Iqaluit North.

Wildlife surveys for birds and terrestrial mammals was completed by LGL Ltd. and RSW Inc. between 2008-2009 for the Jaynes Inlet Project, locations of which are given in Appendix B. The main components of the terrestrial mammal surveys included a general representation of mammal species present within an approximately 10 km radius of the generation site called the Infrastructure Regional Study Area (IRSA) and within a 10 km-wide swath for the Transmission Line Corridor (TLC) from the project area to Iqaluit, a detailed description of mammal species richness and relative abundance in the immediate Local Study Area (LSA), identification of species at risk, and a delineation of habitat use by mammal species present in the LSA. Some geographic overlap exists between the locations of these studies and the alternatives in the Armshow River, Kynerley Iqalliarvik lakes, and Iqaluit areas, and findings can generally be extended to those areas. Further details regarding the Jaynes Inlet studies are given in the following section.

3.12.1 Jaynes Inlet

Terrestrial studies conducted in summer 2008 used several methods to survey small mammals and carnivores in the Jaynes Inlet area: small mammal trapping, transects for mammal sign, and incidental observations. An environmental baseline study conducted in spring 2009 used aerial helicopter surveys and ground-based transects for mammals and mammal signs. Sightings of large and medium sized

mammals were recorded during helicopter surveys within the IRSA and TLC, and one helicopter transect was conducted to locate potential denning sites. Ground-based transects used for bird surveys (as detailed in Section 3.13) were concurrently surveyed for signs of mammals (sightings, tracks, scats, browse, dens, etc.). A total of 13 transects covering approximately 9,900 m in various habitat types were surveyed, a summary of the findings is presented below in Table 3.12.1.

Table 3.12.1 Summary of Terrestrial Mammal Species Observations in Jaynes Inlet Region.

Common Name	Scientific Name	Mammal Sightings and Signs ¹ (Location)	
		2008	2009
Arctic hare	<i>Lepus arcticus</i>	Scats (UL, LV)	2 (UL), scats (UL, LV, LL)
Brown lemming	<i>Lemmus trimucronatus</i>	7 (LV), runs/burrows	Runways/tunnels/scats (UL, LV, LL) ²
Greenland Collared lemming	<i>Dicrostonyx groenlandicus</i>	1 (LV)	Runways/tunnels/scats (UL, LV, LL) ²
Grey wolf	<i>Canis lupus</i>	Tracks (UL)	Tracks (LV), scats (LL)
Arctic fox	<i>Alopex lagopus</i>	Tracks (UL)	Tracks/scats (UL, LV, LL)
Red fox	<i>Vulpes vulpes</i>	Tracks (UL)	Tracks/scats (UL, LV, LL)
Ermine/Short-tailed weasel	<i>Mustela erminea</i>	1 (LV), tracks (UL)	1 (LL), tracks/scats (LV)
Barren-ground caribou	<i>Rangifer tarandus groenlandicus</i>	2 (LV, TLC)	2 (LV), tracks/scats (LV, LL)

¹Signs include tracks, scats, overgrazing, trails, dens, runways, and tunnels.

² Since no trapping was performed in 2009, Brown Lemming signs could not be differentiated from Collared Lemming signs as both were known to be found in the study area.

Infrastructure Regional Study Area = IRSA, Lower Lake = LL, Lower Valley = LV, Transmission Line Corridor = TLC, Upper Lake = UL, Upper Valley = UV

Visual observations or signs were recorded for eight small mammals and carnivores during the 2008 field surveys; and seven terrestrial mammal species were recorded during the 2009 field surveys, however, eight species were likely present in the study area. As of March 2023, the Barren Ground Caribou is listed as Endangered by COSEWIC and is under consideration for status change from Special Concern on Schedule 1 of the SARA. No other terrestrial SARA were observed in those studies.

Arctic Hares were not seen in the 2008 wildlife surveys, and the lack of sightings suggested that the species was not abundant in the Jaynes Inlet area. Arctic Hares were observed twice in the 2009 wildlife surveys, and scats were found at all elevations and ecosystem types. Brown Lemmings were much more common than Greenland Collared Lemmings. Incidental observations of lemming runs, scats, and burrows were noted in all parts of the study area in 2008. Small mammal traps captured only one Greenland Collared Lemming compared to 13 Brown Lemmings. No direct observations of lemmings were made in 2009; however, numerous indicators such as runways, tunnels, and scats were found in different habitat types. Nearly six times as many recent lemming signs were found in areas at lower elevations than habitat around the Upper Lake. Brown lemmings appeared to prefer moist habitats with a high proportion of vegetation

cover, based on trapping methods. These results imply that the region surrounding the Lower Lake contains more appropriate or even vital habitats for Brown Lemmings. The Brown Lemming prefers a wetland environment, where it feeds on plants such as sedges and grasses. The Collared Lemming, on the other hand, favours a drier environment, where it primarily feeds on forbs and shrubs.

Foxes and wolves are known to be present in the study area, but none were seen during the field programs, and no evidence of den sites was found. Grey wolf tracks were discovered on the beach near the northeast edge of the Upper Lake in 2008, and tracks were discovered in the lower valley along the north bank of the river near the proposed location of the powerhouse in 2009. Scats were detected close to the Lower Lake. No foxes were observed, even though Arctic Fox and Red Fox traces and scats were found in a variety of habitats. Two sightings of caribou and a few recent tracks and scats were recorded during the 2008 and 2009 terrestrial mammal field programs. There were numerous indications of previous Caribou use from the Upper Lake to the Lower Lake, including bones, trails, and overgrazed areas.

NordEco conducted caribou-specific studies in September 2008-April 2009 to determine whether the core development area was suitable for caribou habitat, to assess the vegetation map of Jaynes Inlet produced by the Canada Centre for Remote Sensing, and to have discussions with the Amarok Hunters and Trappers Organization (HTO) about any potential local concerns relative to caribou. Using a pixel-nested-plot sampling design, randomly selected plot locations were surveyed in the upper valley and lower valley. It was inferred that not many caribou were using the area in 2008, since there were very few sightings of caribou during the field program and faeces collected were more than a year old. Most plots showed some signs of previous caribou grazing; extensive sign of past heavy grazing was seen in Plot 03 and less so in Plot 12 on prostrate dwarf shrub tundra. Such evidence included thick clumps of dislodged moss, loose and broken pieces of small shrubs, exposed soil among vegetated clumps, grazed surfaces of moss, and fragmented pieces of lichen. Vegetation plot analyses revealed that all vegetation types exhibited signs of caribou grazing to some degree but plots on graminoid moss tundra showed less sign. Past heavy grazing could explain the low abundance of lichens noted in 2008 for some plots. The few caribou in the region had avoided areas that were still recovering from former heavy grazing and had been foraging where there were a variety of lichens. Based on the number of animal faeces, the greatest amount of caribou use was associated with the prostrate dwarf shrub vegetation type, and the least amount of caribou use was related to the graminoid-moss tundra vegetation type.

Further fieldwork was conducted in April 2009 to determine whether caribou might have access to forage in the late winter by measuring snow cover hardness and depth within the Jaynes Inlet watershed. Snow depth and hardness did not show any recurring trends relative to vegetation or soil type, or any of the physical characteristics of elevation, slope, and aspect. According to the information gathered from the Amarok HTO in 2008-2009, there were very few caribou in the area, despite the fact that they foraged and over-wintered in the area throughout the late 1990s and/or early 2000s.

3.13 Birds and Bird Habitat

A desktop avifauna review was conducted as part of the pre-feasibility and preliminary environmental baseline studies in the Jaynes Inlet, Armshow River, and Cantley Bay regions. In addition to desktop review, aerial surveys were conducted in 2006 to look for potential sites for raptor nests, especially those of Peregrine Falcons (*Falco peregrinus*) given that these are an ecologically important predator species. The subspecies of Peregrine Falcon present in Nunavut (*anatum/tundrius*) was previously listed as Special Concern on Schedule 1 of the SARA, however, was de-listed in February of 2023 largely due to the recovery of this species because of the ban of organochlorine pesticides in Canada. None of the other avian species observed throughout the pre-feasibility or environmental studies are currently listed under the SARA.

KPC completed cursory wildlife surveys in 2006, during which aerial raptor surveys were completed to identify habitat use within the potential flooded boundary of each candidate site. No raptors or nest sites were recorded for Jaynes Inlet. One adult Peregrine Falcon was spotted in Armshow River but no active nests were discovered within the proposed flooded boundary of the project site. On cliffs at the Armshow River's lower end, a gull colony with about 25 pairs of Glaucous Gulls (*Larus hyperboreus*) and flightless young were identified. One active Gyrfalcon (*Falco rusticolus*) nest was found within the proposed flooded boundary of the Cantley Bay project site, however little suitable raptor nesting habitat was identified in the 2006 aerial surveys. One active and two empty Peregrine Falcon nests were found at McKeand River, however the available nesting habitat for raptors was sub-optimal with mostly gently sloping hills.

It is important to note that the Cantley Bay site stood out from the other preferred candidate hydroelectric developments owing to its five confirmed active raptor nests and had the most mammal and bird observations recorded overall based on data compiled for the 2007 environmental baseline studies from Land Use Information Series Maps, the Government of Nunavut Raptor Data Base, and Knight Piésold Ltd.

The prior proponents did not carry out any further evaluations of birds in the McKeand River North watershed, however some studies have been conducted for the adjacent Chidliak Diamond Mine. It was found that the available habitat for the majority of breeding bird species is considered unproductive in the region. Throughout the study area, waterfowl and waterbirds were widely dispersed and occupied lakes, small ponds, the McKeand River and its larger tributaries (and the adjacent uplands) in low densities. No waterfowl or waterbird sensitive areas were identified. Five species of raptors were spotted in the area, and evidence of possible nesting sites for the Peregrine Falcon, Gyrfalcon, Snowy Owl, and Common Raven was documented (De Beers Group, 2022).

As described above in Section 3.12, wildlife surveys for birds and terrestrial mammals were completed by LGL Ltd. and RSW Inc. between 2008-2009 for the Jaynes Inlet Project within the IRSA, the TLC, and the LSA. Some geographic overlap exists between the locations of these studies and the proposed alternatives in Armshow River, Kynersley-Iqalliarvik, the lower portion of the Sylvia Grinnell, and Iqaluit areas, and findings can generally be extended to those areas. Further details regarding the Jaynes Inlet studies are given in the following section.

3.13.1 Jaynes Inlet

Bird surveys were completed by LGL Ltd. during the post-breeding season between August 5 and 12, 2008 and by RSW Inc. during the breeding season between July 16 and 22, 2009, locations of which are given in Appendix B. Ground-based surveys and aerial surveys were conducted to determine the presence, abundance, distribution, and habitat use of various bird species. 19 bird species were observed in 2008 and 22 bird species were observed in 2009. The following Table 3.13.1 summarizes the species observed according to the area in which they were recorded. The Lower Valley (LV) corresponds to the region that starts at the first set of falls nearest the estuary and includes the Lower Lake and up the valley to the mouth of the river. The Upper Valley (UV) corresponds to the region starting from the mouth of the river at the Upper Lake and surrounding watershed. The Transmission Line Corridor (TLC) corresponds to the 2013 proposed transmission corridor which departs from Iqaluit and continues along the head of Frobisher Bay and along the coast.

Table 3.13.1 Summary of Bird Species Observations in Jaynes Inlet Region.

Guild	Common Name	Scientific Name	Bird Sightings and Signs ¹ (Location)	
			2008	2009
Loons	Red-throated Loon	<i>Gavia stellata</i>	3 (LV)	1 (LV), 2 (Inlet)
	Common Loon	<i>Gavia immer</i>	1 (LV)	1 (UL), 2 (LV), 2 (TLC)
Ducks	Common Eider	<i>Somateria mollissima</i>	55 (Inlet)	9 (Inlet), 1 (TLC), Nest (LV)
	Red-breasted Merganser	<i>Mergus serrator</i>	9 (Inlet)	1 (LV), 2 (TLC)
	Long-tailed Duck	<i>Clangula hyemalis</i>	37 (Inlet)	23 (LV), 3 (Inlet), 2 (TLC)
	Northern Pintail	<i>Anas acuta</i>	12 (Inlet)	8 (LV)
Geese	Canada Goose	<i>Branta canadensis</i>	229 (LV)	20 (LV), 19 (Inlet), 1 (IRSA), 37 (TLC), Scats/tracks (UL)
Hawks	Rough-legged Hawk	<i>Buteo lagopus</i>	7 (LV)	2 (IRSA)
Falcons	Peregrine Falcon	<i>Falco peregrinus</i>	1 (LV)	2 (LV), 1 (IRSA)
	Gyrfalcon	<i>Falco rusticolus</i>	0	1 (IRSA), 1 (TLC)
Owls	Snowy Owl	<i>Bubo scandiacus</i>	32 (TLC), Pellets (LV)	Pellets (LV)
Gulls	Glaucous Gull	<i>Larus hyperboreus</i>	573 (TLC), 54 (Inlet), 2 (UL)	29 (Inlet), 10 (LV)
	Herring Gull	<i>Larus argentatus</i>	2 (LV), 1 (TLC)	1 (Inlet), 1 (TLC)
	Iceland Gull	<i>Larus glaucoides</i>	75 (TLC), 3 (LV)	0
	Great Black-backed Gull	<i>Larus marinus</i>	1 (LV)	0
Plovers	Semipalmated Plover	<i>Charadrius semipalmatus</i>	0	3 (LV)
Passerines	Common Raven	<i>Corvus corax</i>	2 (LV), 4 (TLC)	2 (LV), 7 (TLC)
	Horned Lark	<i>Eremophila alpestris</i>	1 (LV)	4 (LV)
	American Pipit	<i>Anthus rubescens</i>	37 (LV), 20 (UL)	38 (LV), 21 (UL), 6 (Inlet)
	Lapland Longspur	<i>Calcarius lapponicus</i>	4 (LV)	3 (LV)
	Snow Blunting	<i>Plectrophenax nivalis</i>	2 (UL), 3 (TLC)	2 (UL), 3 (LV), 2 (TLC)
	Northern Wheatear	<i>Oenanthe oenanthe</i>	0	1 (LV)
	Hoary Redpoll	<i>Carduelis hornemanni</i>	0	1 (UL)
Ptarmigan	Rock Ptarmigan	<i>Lagopus muta</i>	0	Scats (UL), Scats (LV)

¹Signs include tracks, scats, pellets or previously occupied nests.

Infrastructure Regional Study Area = IRSA, Lower Lake = LL, Lower Valley = LV, Transmission Line Corridor = TLC, Upper Lake = UL, Upper Valley = UV

The findings of the post-breeding surveys in 2008 found that birds do not frequently use much of the Jaynes Inlet area during that season. Canada Geese were the most abundant waterfowl species in the study area. Flocks of geese were seen grazing in the lower valley to prepare for migration, and it appeared that the grassy plains surrounding the lower lake is an important area for grazing and moulting. The inlet itself is a crucial region, used by several waterfowl species for brood-rearing and moulting. The cliffs along the bank of the river valley are nesting areas for Common Raven, Rough-legged Hawk, and Peregrine Falcon. The upper valley area is sparsely vegetated and barren, very few birds were found in this habitat. An unusually high number of Snowy Owls were found along the possible transmission line route. Snowy Owls are nomadic, and their migratory patterns are unpredictable; prey availability may be the reason why large numbers of Snowy Owls were seen.

The results of the breeding surveys in 2009 demonstrated that within the LSA bird species richness and abundance was higher at lower elevations, such as in the Lower Valley area. Vegetation productivity is greater at lower elevations and habitats provide better cover, food, and weather conditions. Waterfowl and loon observations predominated in the local study area for this reason. Long-tailed Duck and Canada Goose were the most abundant species, followed by Northern Pintail. Helicopter scans of the IRSA revealed that none of the higher elevation lakes or ponds were being utilized by loons or ducks, however 70% of the surveyed lakes had ice cover in mid-July. The main aquatic birds that appeared to frequent the Upper Lake region was the Canada Goose: numerous scats and tracks were observed along ground-based surveys. No Snowy Owls were seen in the IRSA or along the TLC in 2009, however, pellets were found in the lower valley region. A helicopter survey conducted to detect cliff-nesting raptors found a Rough-legged Hawk and an active nest on the north slope of the IRSA. In the southern IRSA, near the mouth of Jaynes Inlet, a Rough-legged Hawk was spotted soaring and old nesting sites were observed. One Peregrine Falcon was observed during the aerial raptor survey, accompanied by an active nest located in the lower valley area on a cliff beside the main river.

4.0 Regulatory Context

The regulatory process by which a project will be approved can have significant implications on the overall project schedule, as well as cost. The following provides a brief overview of regulatory factors which may distinguish the alternatives under consideration. Appendix C contains a detailed description of permitting requirements for construction and operation of renewable energy infrastructure, as well as for the right to commence environmental baseline studies of the selected project.

All project combinations will be assessed pursuant to the Nunavut Land Claim Agreement (NLCA) and the *Nunavut Planning and Project Assessment Act* (NuPPAA). The Nunavut Planning Commission (NPC) is the point of entry into the integrated regulatory system in Nunavut. The project will first be assessed for conformance to any applicable Land Use Plan (LUP), followed by screening conducted by the Nunavut Impact Review Board (NIRB), and approval by the Nunavut Water Board (NWB) where applicable. Coordination of the environmental assessment process amongst the NPC, NIRB, NWB, federal agencies, and the municipal government is possible and can be beneficial to the overall project schedule. Critical to every project schedule is the requirement that the environmental assessment (i.e. the NIRB project certificate) be completed before other regulatory authorizations will be issued.

Given that the previously proposed Iqaluit Hydroelectric Project in 2013 was subject to a full environmental impact review by NIRB, any of the hydroelectric and PSH alternatives under consideration will likely require the same level of examination. Depending on the footprint and number of turbine generators, the various wind farm candidates (in the absence of associated pumped storage or hydroelectric generation) may not go to full review. The scope of study to prepare an Environmental Impact Statement (EIS) to the satisfaction of the NIRB will be both broad and comprehensive. Initiating studies in the near term would serve to save time on the overall project approval schedule while contributing information to support selection of a preferred development scenario.

Baseline environmental information requirements are explicitly prescribed by the DFO to quantify fish habitat subject to harmful alteration, disruption or destruction (HADD), associated with any of the hydroelectric generation and pumped storage options. The requirements to negotiate an acceptable offset plan and obtain a *Fisheries Act* Authorization (FAA), will add a regulatory and design complexity to those types of projects.

With respect to siting considerations, land tenure issues provide a distinction whereby the necessity for negotiating leases upon multiple types of land adds to the overall regulatory complexity and cost of the project. Projects sited upon Commissioner's Land (untitled lands not within municipal boundaries nor federal lands) will be less expensive to develop upon than Inuit Owned Lands, where a commercial lease

and an IIBA would need to be negotiated. Right-of-Way agreements, such as for transmission line corridors, penstocks, and access roads, are less of a deterrent than for siting of generation but still need to be taken into account. Projects sited within the boundaries of Territorial Parks, such as the Katannilik or Sylvia Grinnell parks, are likely to arouse significant public concern.

The Nunavut Water Board places an additional regulatory burden on the various hydroelectricity options by requiring annual water use fees based on the generation capacity of the project. The various options being considered for hydroelectric development are estimated to be able to produce between 10-50 MW of power annually and would fall under the Type A group, meaning that they would be classified by the NWB as follows: Class 2 – 5-10 MW with \$4,000 annual fee, Class 3 – 10-20 MW with \$10,000 annual fee, or Class 4 20-50 MW with \$30,000 annual fee. There is no precedent of pumped-storage hydro (PSH) in Nunavut, thus the inclusion of the technology introduces some regulatory uncertainty for water licensing however it is assumed that PSH would be included in the hydroelectricity category.

A summary of the regulatory distinctions amongst the alternatives under consideration are given in Table 4.1. The extent of intrusion into Inuit Owned Lands (IOL) and Territorial Parks was rated on a scale of 1-5, where 1 was no intrusion, 2 was some intrusion (a small portion of the envisioned linear infrastructure), 3 was a moderate amount of intrusion (a large portion of the envisioned linear infrastructure), 4 was a large amount of intrusion (the generation site is very close to the land or is surrounded by a parcel of it), and 5 was an incredibly large amount of intrusion (the generation site is sited upon the land).

Table 4.1 Summary of Distinguishing Project Development-Related Authorizations.

ID	Location	NIRB EIS	DFO FAA	IOL	Park	NWB WUL Class
1AC	Armshow River Mainstem - Short	Y	Y	3	3	3
1BC	Armshow River Mainstem - Long	Y	Y	3	3	3
2CP	Armshow River - Three Lakes PSH	Y	Y	3	2	
3AC	Armshow River - South North Penstock	Y	Y	4	2	2
3BC	Armshow River - South East Tunnel	Y	Y	4	2	2
4AC	Jaynes Inlet – Penstock	Y	Y	4	2	3
4BC	Jaynes Inlet – Tunnel & Penstock	Y	Y	4	2	3
4BCP	Jaynes Inlet PSH	Y	Y	5	2	
5AC	Cantley Bay	Y	Y	2	1	3
6AC	McKeand River South	Y	Y	1	1	3
6BC	McKeand River North	Y	Y	1	1	4
7C	Sylvia Grinnell River	Y	Y	4	4	2
8P	Kynersley Iqalliarvik PSH	Y	Y	5	1	
11W	Iqaluit North (Wind Site 5 or 5A)	N	N	1	1	NA
12W	Qasitujuak Lake Ridge (Wind Site 4 or 4A)	Y	N	5	1	NA
13W	Armshow River Lower Ridge (Wind Site 1 or 1A)	Y	N	5	5	NA
14W	Armshow River Highlands (Wind Site 2, 3, or 6)	Y	N	4	2	NA
15W	Jaynes Inlet Highlands (Wind Site 7)	Y	N	4	2	NA

5.0 Evaluation of Environmental and Regulatory Sensitivity

An environmental sensitivity evaluation was completed to support the process of screening the many candidate options currently under consideration. Given the level of detail available on the candidate projects, as well as the uneven availability of environmental (biophysical) information, a major challenge has been to select comparable risk factors. Nevertheless, a small set of relevant factors have been identified and applied to the required assessment. Information regarding each alternative under consideration was obtained from CPL where available, however some assumptions were made in the absence of project definition. At the current stage of planning, it has not been possible to develop complete, distinct project scenarios, e.g. bringing together the ingredients of wind generation and storage with hydro generation. Consequently, this evaluation is focused on the identified individual components. Once combined into discrete development scenarios, the risk evaluation will need to be revised as the results are not cumulative.

SEM was tasked with contributing to CPL’s Project Selection Risk Screening Matrix (the matrix) on the parameters of Biophysical Environment, Protected Areas, and Regulatory. An initial draft of the matrix included parameters for NIRB (percentage of similarity of the project to the scope of the Jaynes Inlet and Armshow River hydroelectric projects proposed to NIRB in 2013) and Inuit Owned Land (percentage of the project footprint on IOL including transmission line), however these were removed due to the redundancy with the parameters under SEM’s purview. The following Table 5.1 describes each parameter and the 1-5 numeric scale on which they were ranked (1 being the most favorable and 5 being the least).

SEM conducted several ranking sessions involving in-house environment professionals - environmental assessment specialists, aquatic and terrestrial biologists, professional engineers, and permitting specialists. Rationale for the rankings is provided in the subsequent sections, and the results assigned to each alternative are provided in Table 5.2.

Table 5.1 Project Selection Risk Screening Parameters and Interpretation.

Parameter	Description	Scale Interpretation
Biophysical Environment	The geographic extent of project components and distinguishing components of the biophysical environment were considered together to indicate potential project-biophysical environment interactions including vegetation/habitat as well as aquatic, terrestrial, and avian species. It includes potential adverse effects on Species at Risk, contaminant uptake (ecological risk), population dynamics and habitat disturbance/disruption/destruction. It considers the potential for residual adverse effects to be Significant. It does not include the consideration of induced effects (harvesting/resource use, economy, tourism).	<ol style="list-style-type: none"> 1. No negative residual effects; no mitigation measures required. 2. Small number of negative residual effects; all addressed with standard (proven) mitigation measures. 3. At least one predicted negative residual effect, addressed with standard (proven) mitigation/monitoring measures. 4. At least one predicted negative residual effect, requiring custom-designed mitigation and monitoring measures. 5. Several predicted negative residual effects, some requiring custom-designed (unproven) mitigation and monitoring measures and/or compensation requirements.
Regulatory	Anticipated or dictated level of effort to fulfill regulatory requirements in terms of time and cost, and the potential extent of regulatory stakeholder concerns. Involvement of multiple authorities or agencies across multiple levels of jurisdiction.	<ol style="list-style-type: none"> 1. Project very likely to occur with minimum time, financial and regulatory requirements (NIRB review not required). 2. Project likely to occur with minimal time, financial and regulatory implications (NIRB likely to conduct review and release with terms and conditions). 3. Project may be possible with time, financial and regulatory implications. 2-3 years of regulatory framework before breaking ground. (NIRB full review and EIS required, involvement with DFO/NWB for water crossings only, some land tenure issues). 4. Project may be possible but with extensive time, financial and regulatory implications. 3+ years of regulatory framework components before breaking ground. (NIRB full review and EIS required, some involvement with DFO, many land tenure issues). 5. Project may be possible but will require extensive time, financial and regulatory implications such as extensive protection measures to avoid or reduce detrimental effects to fish habitat or species at risk habitat. Negotiation of IIBA for water rights or subsurface rights on IOL.

Table 5.1 Project Selection Risk Screening Parameters and Interpretation (cont'd).

Parameter	Description	Scale Interpretation
Protected Areas	Extent of intrusion by project infrastructure into areas designated in legislation, e.g. national or territorial parks, or reserves (wildlife/ecological/conservation).	1. Negligible to no intrusion. 2. Limited intrusion by a small portion of the linear infrastructure. 3. Moderate amount of intrusion of a large portion of the linear infrastructure. 4. Large amount of intrusion by core project features (e.g. the generation site). 5. Key project features are entirely contained within a protected area.

5.1 Geographic Extent and Biophysical Environment

The foremost parameter to reflect differences in biophysical effects is the physical extent (footprint) of each candidate project. Keeping the common components amongst the proposed alternatives in mind (as described in Section 2.0), the geographic area which is going to be disturbed comprises several project elements:

- surface area of affected watersheds
- surface area of land disturbance due to flooding of reservoirs
- length of transmission corridors
- length of access roads
- length of penstock / tunnel
- number / size of marine wharf facilities

The sum of these surface areas provides an approximation of the quantity of terrestrial and aquatic habitat that will be directly affected by the candidate infrastructure. The footprint of each alternative may also serve as an indirect indicator of sensory disturbance such as noise during construction, atmospheric pollution from vehicle emissions and dust, and water quality degradation via runoff or pollutant spills. For this exercise, the greater the geographic extent, the greater the environmental risk.

Input data were obtained from CPL and the comprehensive development report by KPC, and results are presented in Table 5.1.1, ranked by size of affected area.

In compiling the geographic area ranking, the following estimates and assumptions were made:

- The estimated total freshwater aquatic area affected is confined to the reservoir surface areas. The size of the affected watershed was considered separately. The approximate amount of terrestrial habitat to be lost by creation of reservoirs was devised by subtracting the size of the existing waterbody (estimated using Google Earth imagery) from the indicated surface area of the reservoir.
- Streams which may experience altered flow regimes due to diversions into dams/penstocks/tunnels, or waters crossed by transmission spans/access roads are not accounted for in this exercise.
- The footprint of aquatic environment corresponding to each marine barge was conservatively estimated at 0.05 hectares (ha). This includes a rough estimate of the size of the barge itself, and the anticipated effects to the surrounding local marine environment for the construction of the barge and associated vessel berthing.
- It was assumed that transmission corridors would be constructed 60 m wide to account for electrical infrastructure and accompanying access trails. It was assumed that access roads required to transport wind turbine components are already accounted for in this estimate.
- The terrestrial footprint for penstocks was estimated to be 10 m wide along the entire length of the penstock.
- The terrestrial footprint for tunnels was estimated to be 10 m wide along the entire length of the tunnel, however this does not account for the more substantial surface disturbance associated with tunnel excavation and the need for disposal of excavated material.
- The length of access roads is in addition to those already accounted for along the transmission corridors, e.g. the access roads pertain to those leading from the marine barge to the powerhouse construction site. Access roads were assumed to be 10 m wide along the entire length of the road.
- Where multiple sites for wind farms are given, the estimates for all the wind alternatives assumes the worst-case scenario in which every wind site will be developed, up to the maximum capacity range. It was assumed that access roads for wind turbine construction will be in line with transmission corridors. None of the wind alternatives incorporates the aquatic or terrestrial disturbance created by the pairing with either a conventional hydroelectric power or a pump-storage hydro scheme.
- The terrestrial footprint of disturbance for each wind area was calculated by dividing the maximum capacity range by 2.5 MW to obtain the maximum number of turbines. Assuming each turbine requires a 300 m radius, the surface area of terrestrial disturbance per turbine was

calculated at 28.3 ha. For example, wind developments having 100 MW capacity were assumed to affect a minimum of 1,132 ha of terrestrial habitat.

- The length of the transmission corridor for the standalone Kynersley Iqalliarvik and Qasitujuak Lake Ridge wind alternative was estimated based on a kml file provided by CPL. It was assumed that both tied in together at the confluence of the lines approximately 12km northwest of Iqaluit.
- The access road for Armshow River – Three Lakes PSH was assumed to be 23.6km long (an additional 10km from those at Armshow River South to account for the upstream placement of the powerhouse). The transmission corridor for Armshow River – Three Lakes PSH was assumed to be 56 km (the same as the Armshow River – Three Lakes hydroelectric option as presented in 2005). The size of the lower PSH reservoir was estimated based on the size of the existing lake given in Google Earth. The penstock for Armshow River – Three Lakes PSH was estimated to be approximately 3 km long from the CPL concept sketch pdf file provided.
- The Armshow River Highlands Wind was assumed to include site 2, 3, and 6 based on the higher elevations of those areas.
- The location of the Jaynes Inlet Highlands wind farm was not given in the kml provided by CPL, and the location was estimated from the Screening Alternatives Workshop presentation. The transmission corridor/road was assumed to be 10km longer than the HEP scenarios.
- For the Jaynes Inlet PSH scenario, it was estimated that water from the lower reservoir would be pumped through a penstock 7.5 km all the way up to the upper reservoir.
- The location of Wind Site 5A for Iqaluit North was estimated from the concept sketches. The transmission corridor/road lengths were estimated: for Wind Site 5A it is 12 km long, while for Wind Site 5 is 1 km, totalling 13km together.
- The Cantley Bay McKeand Diversion alternative was not described in any of the provided materials; thus it was omitted from evaluation.

Table 5.1.1 Geographic Extent of Each Alternative.

ID	Description	Watershed (ha)	Size of Existing Waterbod(ies) (ha)	Upper Storage Reservoir (ha)	Lower Storage Reservoir (ha)	Wind Turbines Footprint (ha)	Transmission (km)	Penstock (km)	Tunnel (km)	Access Road (km)	Marine Barge Landings (count)	Estimated Total Aquatic Area Affected (ha)	Estimated Total Terrestrial Area Affected (ha)	Total Area Affected (ha)
7C	Sylvia Grinnell River	298,000	9,800	31,000	0	0	33	0.5	0	33	0	31,000	21,432	52,432
6AC	McKeand River South	419,300	7,800	10,500	0	0	62	0.1	0	0	1	10,500	3,072	13,572
6BC	McKeand River North	775,700	500	4,800	0	0	140	0.5	0	50	1	4,800	5,191	9,991
1BC	Armshow River Mainstem - Long	202,600	407	1,630	0	0	47	6.2	0	13.6	1	1,630	1,525	3,155
8P	Kynersley Iqalliarvik	11,100	2,100	1,500	1,000	0	30	0	4.5	0	0	2,500	585	3,085
4AC	Jaynes Inlet - Penstock	20,300	250	860	0	0	96	6	0	5.2	1	860	1,197	2,057
4BC	Jaynes Inlet - Tunnel & Penstock	20,300	250	860	0	0	96	3.4	2.5	5.2	1	860	1,197	2,057
4BCP	Jaynes Inlet PSH	20,300	390	860	10	0	96	10.9	2.5	5.2	1	870	1,075	1,945
1AC	Armshow River Mainstem - Short	214,800	239	770	0	0	47	3.1	0	13.6	1	770	830	1,600
13W	Armshow River Lower Ridge Wind (Site 1 & 1A)	0	0	0	0	1,132	60.3	0	0	0	1	0	1,494	1,494
12W	Qasitujuak Lake Ridge Wind	0	0	0	0	1,132	51	0	0	0	0	0	1,438	1,438
2CP	Armshow River - Three Lakes PSH	7,700	310	580	80	0	56	3	0	23.6	1	660	713	1,373
3BC	Armshow River - South Lake East Tunnel	27,800	350	670	0	0	47	2	5	13.6	1	670	623	1,293
3AC	Armshow River - South Lake North Penstock	27,800	350	670	0	0	47	6.76	0	13.6	1	670	622	1,292
5AC	Cantley Bay Base	178,400	200	580	0	0	50	5.1	0	7	1	580	692	1,272
11W	Iqaluit North	0	0	0	0	1,132	13	0	0	0	0	0	1,210	1,210
15W	Jaynes Inlet Highlands Wind (Site 7)	0	0	0	0	226	106	0	0	0	1	0	862	862
14W	Armshow River Highlands Wind (Site 2, 3, & 6)	0	0	0	0	226	95	0	0	0	1	0	796	796

The total area affected ranged from approximately 790 ha up to 52,000 ha and was split into the following five categories: very small (less than 1,000ha), small (1,000 – 2,000 ha), medium (2,000 – 3,000 ha), large (3,000 – 10,000 ha), and very large (more than 10,000 ha). In addition to the geographic extent of each alternative, the presence of sensitive, ecologically important, or socio-economically important species and habitats contributed to heightened rankings of the biophysical risk. In summary, these include:

- Migratory arctic char, an ecologically and recreationally important species: scientific literature confirmed they are present in the Sylvia Grinnell River and field studies in 2006 confirmed they are present in the Armshow River mainstem. Not including estuarine areas, landlocked arctic char are present in Jaynes River, Cantley River, and McKeand River. It is unknown if any are present in the Kynersley and Iqalliarvik lakes, however it can be assumed they would be landlocked due to poor connectivity to the marine environment.
- Barren-ground caribou, a species at risk that is also culturally important for Inuit: protected calving grounds overlap heavily with the McKeand River areas. 2014 telemetry data also indicated potential for overlap with Cantley Bay. Sylvia Grinnell River is situated within their spring migration range, as well as Armshow River to a lesser extent.
- Protected migratory birds including common species of raptors, passerines, and waterfowl which are also a food source: congregations of avifauna in coastal areas and in wetlands along low-lying river valleys pose a concern for wind developments.

Further information regarding the biophysical environment is given in Section 3.0.

In the very large categories are the Sylvia Grinnell River, McKeand River South, and McKeand River North hydroelectric alternatives. These three alternatives entail the creation of a very large reservoirs that will correspond with a widespread loss of terrestrial habitat upon flooding following dam construction. As well, the existing waterbodies constitute an enormous area of freshwater aquatic habitat that would require extensive mitigation measures for the HADD of migratory fish/habitat. Sylvia Grinnell River contains and important migratory population of arctic char, and the McKeand River region is known to support the already struggling caribou population in the area during the calving season. As such, all three projects were assigned a “5” on the biophysical ranking scale.

The large category contains the Armshow River Mainstem – Long hydroelectric option and the Kynersley Iqalliarvik lakes PSH. The loss of terrestrial habitat as well as conversion of riverine habitat to lacustrine habitat for the Armshow River Mainstem – Long alternative will comprise over 1,000 ha, and will affect a migratory population of arctic char. Hence the alternative was rated at a “5” on the biophysical ranking

scale. The loss of terrestrial habitat due to reservoir flooding will not be as severe for the closed-loop PSH system at Kynersley Iqalliarvik lakes. However, the offsetting plan for fish habitat altered or lost due to a PSH development will need to be creative, and the drawdown of PSH reservoir may necessitate inter-basin fish transfers between multiple watersheds. The transmission corridor for the Kynersley Iqalliarvik lakes is shorter than for Armshow River, and effects to the marine environment are expected to be less. For those reasons, Kynersley Iqalliarvik PSH was assigned a “4” on the biophysical ranking scale.

Medium sized alternatives included the two hydroelectric options and one PSH variation at Jaynes Inlet. There is far more biophysical information available for the Jaynes Inlet region compared to any other site. The loss of terrestrial habitat due to reservoir flooding will not be as severe as for the Armshow River Mainstem option. However, the proximity to the marine environment is cause for concern and the transmission corridor is amongst the longest of those under consideration. For those reasons, each of the Jaynes Inlet options was assigned a “4” on the biophysical ranking scale.

The small category included the rest of the hydroelectric and PSH alternatives within the Armshow River and Cantley Bay regions, and the wind developments at Armshow River Lower Ridge, Qasitujuak Lake Ridge, and Iqaluit North. Of those, the sizes of the Armshow River Mainstem and Cantley Bay watersheds are very large and the expected effects to the aquatic environment are potential issues of concern. The long transmission corridors for those alternatives would constitute fragmentation of a large amount of terrestrial habitat as well as crossing over numerous waterbodies along the route to Iqaluit. Migratory arctic char exists in the Armshow River system, whereas in Cantley Bay calving caribou are of concern. For those reasons, the alternatives were assigned a “5” on the biophysical scale. The Armshow River Lower Ridge alternative was rated at a “4” on the biophysical scale as these are nearer coastal wetland areas which may be important for migratory birds. The Qasitujuak Lake Ridge wind alternative entails a longer transmission corridor, and the northernmost wind site appears to overlap with a caribou calving area, hence the rating of “4” on the biophysical scale. The Iqaluit North wind alternative has the shortest transmission corridor and is nearest to the already disturbed region of Iqaluit, hence the rating of “2” on the biophysical scale.

The very small category comprises the smaller set of wind alternatives at Jaynes Inlet Highlands and Armshow River Highlands. The only available distinguishing feature amongst these two candidate wind farms is the length of transmission corridors, and potential for interaction with caribou or other terrestrial wildlife. The Jaynes Inlet Highlands was rated at a “4” on the biophysical scale as it entailed the longest transmission corridor amongst any of the alternatives except for McKeand River North. The Armshow River Highlands was rated at a “3” on the biophysical scale, as it entails a shorter transmission corridor and is situated away from any caribou calving areas and far enough away from the coast or any wetlands to be less of a concern for migratory birds.

5.2 Regulatory

The regulatory process by which a project will be approved can have significant implications on the overall project schedule, as well as cost. The chosen project, no matter which alternative or combination, will be assessed by the NPC and NIRB to determine the required level of environmental assessment. Coordination of the environmental assessment process amongst the NPC, NIRB, NWB, federal agencies, and the municipal government is possible and can be beneficial to the overall project schedule. It is however key to the overall project schedule that the environmental assessment (i.e., the NIRB project certificate) must be completed before other regulatory authorities may grant interests in land, issue licenses, permits, or other authorizations.

Projects considered to be the most complex from a regulatory perspective typically involve higher numbers of authorities/agencies across multiple levels of jurisdiction. The “number of permits required” is not a sufficient way to measure how complex a project may become. The extent of regulatory stakeholder concerns, and therefore the time and cost required to obtain final project approval, is a better way to assess this metric.

As described above in Section 4.0, the projects in question that are the most complex would involve preparation and approval of an EIS with NIRB, preparation of an Offset Plan and approval of an FAA with DFO. As such those projects were rated at a “5” on the regulatory scale. Alternatives requiring negotiation of multiple or costly land tenure or access agreements such as within IOL were rated higher on the regulatory scale as well. Legally protected areas in the region relevant to the evaluation are comprised of the Kataniilik Territorial Park and the Sylvia Grinnell Territorial Park. The extent of intrusion by project infrastructure was rated on a scale of 1-5. The Armshow Lower Ridge in particular is situated almost completely on IOL and is surrounded by the Kataniilik Territorial park, which will make permitting for transmission more difficult hence the rating of “4” on the regulatory scale and a “5” on the protected areas scale.

Table 5.2 Results of Project Selection Risk Screening.

Project ID	Location	Biophysical Environment	Regulatory	Protected Areas
1AC	Armshow River Mainstem - Short	5	5	3
1BC	Armshow River Mainstem - Long	5	5	3
2CP	Armshow River - Three Lakes PSH	5	5	2
3AC	Armshow River - South North Penstock	5	5	2
3BC	Armshow River - South East Tunnel	5	5	2
4AC	Jaynes Inlet – Penstock	4	5	2
4BC	Jaynes Inlet – Tunnel & Penstock	4	5	2
4BCP	Jaynes Inlet PSH	4	5	2
5AC	Cantley Bay	5	5	1
6AC	McKeand River South	5	5	1
6BC	McKeand River North	5	5	1
7C	Sylvia Grinnell River	5	5	4
8P	Kynersley Iqalliarvik PSH	4	5	1
11W	Iqaluit North (Wind Site 5 or 5A)	2	3	1
12W	Qasitujuak Lake Ridge (Wind Site 4 or 4A)	4	3	1
13W	Armshow River Lower Ridge (Wind Site 1 or 1A)	4	4	5
14W	Armshow River Highlands (Wind Site 2, 3, or 6)	3	3	2
15W	Jaynes Inlet Highlands (Wind Site 7)	4	4	2

6.0 Conclusions

SEM has completed a draft version of the Environmental and Regulatory Evaluation for the Iqaluit Nukkiksautiit Project. The intention of this evaluation was to summarize previous environmental studies and current regulatory context relating to the hydroelectric, wind generation, and pumped storage schemes for renewable energy development near Iqaluit. SEM provided an overview of the existing environmental baseline data for each of the project alternatives in terms of the freshwater and marine aquatic environment, bird and terrestrial mammal species presence and habitat description, fish abundance, distribution, and habitat description, vegetation and ecological land classification, hydrological features, geological features, and climate change assessment. Furthermore, the project alternatives were ranked comparatively according to biophysical environment, protected areas, and regulatory criteria. The disturbance/disruption of the biophysical environment and the potential adverse effects have been examined at a high level in order to assist with choosing an alternative which is the least concerning from an environmental standpoint. Effort and issues associated with the regulatory process in Nunavut was discussed in detail. Obtaining regulatory approval involves assessment by the Nunavut Planning Commission and Nunavut Impact Review Board and ensuing environmental permitting. Environmental and regulatory concerns connected to each alternative were addressed to assist Growler Energy and Nunavut Nukkiksautiit Corporation with the screening analysis. Moreover, the baseline data requirements were determined to move forward with the environmental assessment and permitting process for the selected project alternative. Lastly, SEM has given a general overview of the relevant regulatory considerations, extending to the construction and commissioning of the selected alternative.

7.0 Recommendations

The information that has been gathered so far provides a broad overview of the biophysical environment in South Baffin Island, such that the general project areas do not differ significantly from one another in terms of species diversity or richness except on a local scale. The requirements to register the project with NIRB are less extensive than for an EIS, and desktop studies will be sufficient to do so once a project is suitably defined. However, if hydroelectric or pumped-storage components are incorporated into the design, an EIS will probably be required. To accelerate the approval process, it will be beneficial to begin collecting the necessary level of baseline data prior to project registration.

Additional fish sampling efforts will need to be carried out for the hydroelectric and pumped storage hydro projects to update the previously collected data and to assess current fish movement patterns and habitat utilization of Arctic char or other fish species. Further freshwater and marine aquatic studies will need to be accomplished to supplement existing data collected for the candidate hydroelectric project river systems; in-stream flow measurements, water and sediment quality sampling, periphyton and benthic

invertebrate sampling, identification of aquatic species at risk (polar bear, beluga whale), and evaluation of marine wildlife present (whales, walruses, seals) in the estuaries will be beneficial.

To address the requirements to obtain the federal FAA for a hydroelectric development, it will be necessary to complete a quantitative description of aquatic habitat within the selected project footprint, and any interconnected waterbodies which would be affected by the development. It will also be necessary to identify and define areas of the river system that may be of critical importance to fish. To evaluate project-related impacts on fish, obtaining a basic knowledge of the seasonal distribution, density, and community composition of periphyton, drifting aquatic invertebrates, and benthic invertebrates is needed as these organisms are important food sources for fish.

Bird and terrestrial mammal species present within the selected regional study area will need to be described as part of the EIS preparation. The presence of birds and bird habitat along the waterways of the proposed hydroelectric facilities should not present significant barriers to development if proper mitigation and monitoring strategies are implemented. To properly assess habitat preferences for bird species that may be present and the potential effects of project development, an acoustic or camera survey for migrating birds, further ground-based surveys, and additional aerial surveys will need to be conducted. As well, it is recommended to conduct winter resident surveys to ensure sufficient coverage for the entire year, especially with the possible introduction of wind turbines to the project design. Wildlife habitat suitability modelling will be required to identify habitat that may be lost or altered as a result of project development and to avoid important caribou foraging/migration/calving areas and carnivore denning sites.

During the next phase of project design, SEM recommends incorporating the following siting and mitigation measures in Table 6.1 below.

Table 6.1 Project Design Environmental Considerations.

Component / Infrastructure	Potential Effects	Design Consideration / Mitigation Measures
Wind Turbine	<ul style="list-style-type: none"> • Displacement of bird species. • Terrestrial habitat loss or fragmentation. • Avoidance behaviour for wildlife – change in migration routes. • Possible siting along migratory bird flyway. Elevated risk of collision with wind turbines. 	<ul style="list-style-type: none"> • Avoid construction near sensitive habitat to minimize disruptions – raptor nesting (rocky coasts or steep cliffs), waterfowl habitat for feeding and brood-rearing (wetlands). • Avoid construction during bird breeding season.
Transmission Corridor	<ul style="list-style-type: none"> • Caribou habitat loss or alteration – decreased foraging ability due to vegetation clearing. • Terrestrial habitat loss or fragmentation. • Displacement for wildlife species – direct mortality, changes to migration routes, changes to predator/prey availability. • Fish habitat loss or alteration 	<ul style="list-style-type: none"> • Use existing roads or other already disturbed routes. • Use shortest path between generation to output site where possible. • Avoid construction near sensitive wildlife habitat – caribou calving areas and migration paths. • Avoid areas of higher vegetation productivity with a focus on areas suitable for caribou foraging - grasses, sedges, shrubs, and forbs. • Avoid wetland areas associated with coastal, riparian, and valley environments, including lowland polygons, fens, and marshes.
Hydroelectric Dam / Reservoir	<ul style="list-style-type: none"> • Restriction of Arctic Char migration. • Fish habitat loss or alteration. • Possible methylmercury contamination in muscle tissue. • Affect subsistence char harvesting, an important food source and cultural activity to the Inuit community. • Terrestrial habitat loss or fragmentation. 	<ul style="list-style-type: none"> • Avoidance of watercourses containing migratory fish. • Consideration of barriers to movement – incorporation of fish passage infrastructure to facilitate both upstream and downstream movement. • Use existing waterbodies rather than creating man-made reservoirs. • Avoid construction near sensitive habitat – raptor nesting (steep cliffs), waterfowl habitat for feeding and brood-rearing (wetlands). • Avoid wetland areas associated with coastal, riparian, and valley environments. • Where flooding of storage reservoir occurs, it may be possible to create fish habitat in the catchment area.

Table 6.1 Project Design Environmental Considerations (cont'd).

Component / Infrastructure	Potential Effects	Design Consideration / Mitigation Measures
Access Road	<ul style="list-style-type: none"> • Caribou habitat loss or alteration – decreased foraging ability due to vegetation clearing. • Displacement for wildlife species – direct mortality, changes to migration routes, changes to predator/prey availability. • Fish habitat loss or alteration 	<ul style="list-style-type: none"> • Use existing roads or other already disturbed routes. • Use shortest path between access points if possible. • Avoid construction near sensitive wildlife habitat – caribou calving areas and migration paths. • Avoid areas of higher vegetation productivity with a focus on areas suitable for caribou foraging - grasses, sedges, shrubs, and forbs. • Minimize the number of water crossings.
Barge dock	<ul style="list-style-type: none"> • Estuarine habitat loss or alteration. • Accidental release of pollutant spills and oil/fuel from vessels. • Increased turbidity from dredging, levelling, and trenching which harms fish and benthic organisms. • Overall decreased water quality. • Displacement of benthic invertebrate communities, marine mammals (Bowhead Whale, Beluga Whale, and Ringed Seal), marine fish (Arctic Char, Dolly Varden Char, Arctic Cod, and Greenland Halibut). • Avoidance behavior for migratory seabirds and waterfowl. 	<ul style="list-style-type: none"> • Routing should be planned to avoid marine mammals. A marine mammal observer can assist with navigation. • Ensure all vessels are equipped with pollution control materials. • Avoid construction during the breeding season for wildlife species.

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