REPORT

Environmental Studies and Screening-Level Environment Assessment

Snare Hydroelectric Facility

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1.0 INTRODUCTION

1.1 Background

The Northwest Territories Power Corporation (NTPC) operates the Snare Hydroelectric Facility (the Facility) located on the Snare River, approximately 145 km northwest of Yellowknife, Northwest Territories (NT). The Facility is a cascade development with four hydro generation stations that span approximately 25 fluvial km, utilizing the difference in elevation between Bigspruce Reservoir (above Snare Rapids) and Strutt Lake (63.3 m difference). These generating stations, in order of upstream to downstream, are Snare Rapids (8.5 megawatts [MW]), Snare Falls (7.4 MW), Snare Cascades (4.3 MW), and Snare Forks (9.2 MW) (Figure 1). The project drainage area supplying the Snare Rapids Generating Stations (Bigspruce Reservoir) is 15,200 km^2, with a mean annual flow of 48.3 m^3/s. The Bigspruce Reservoir represents the main storage for the system. The incremental drainage areas intercepted by each of the three downstream plants are relatively small, such that the increases in intercepted flow are negligible relative to flows received at Snare Rapids. The combined generating stations provides power to the North Slave Electrical System which provides power to the communities of Yellowknife, Behchokǫ̀, Dettah, and N’Dilo along with the power generated by the Bluefish Hydroelectric Facility, the Jackfish Generating Plant, and the Frank’s Channel Generating Plant. NTPC is applying for a new water licence to continue operation of the Facility.

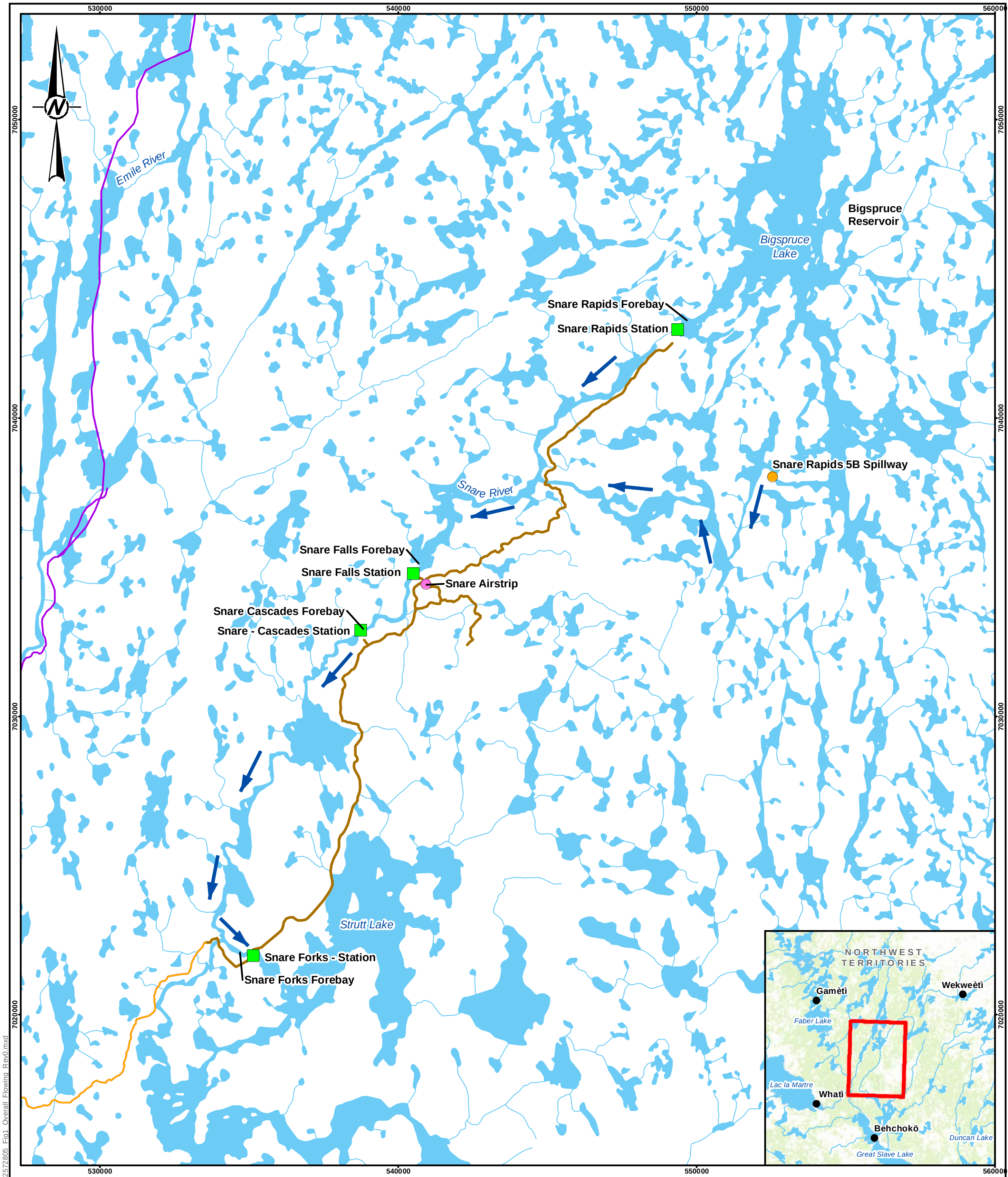
The Facility currently operates under two Type A Water Licences issued by the Wek'èezhìi Land and Water Board (WLWB) to regulate the storage and use of water for hydroelectric generation. One Water Licence regulates Snare Rapids, Snare Falls, and Snare Forks. A second Water Licence regulates Snare Cascades (owned by Dogrib Power Corporation and operated by NTPC).

1.2 Setting

The Facility is located on the traditional lands of the Tłı̨chǫ and the North Slave Métis Alliance and is composed of existing titled lands, leases, and easements for permanent facilities and Tłı̨chǫ Quarry Permits and/or Access Agreements for temporary undertakings such as winter roads and quarries. There is a strong partnership with the Tłı̨chǫ Government for operation of the Facility due to Dogrib Power Corporation ownership of the Snare Cascades Facility and the Tłı̨chǫ Lands Access and Economic Agreements for supporting infrastructure. The Snare River was a traditional trail for the Tłı̨chǫ, using the Snare River system for fishing, trapping, hunting, and travel to or from headwater areas to the north and east (Tłı̨chǫ Government 2013). The remoteness of the Snare River limits its use for recreation, and the major use of the Snare River system since 1948 has been hydroelectric power generation (Rescan 1994a).

1.3 Purpose

This document is intended to summarize existing information from past studies to outline existing environmental data and provide context on potential impacts from the Facility throughout the next water licence. It provides information where available and outlines areas where more information is needed. It will support Preliminary Screening and be a key reference document that can be referred to when discussing potential impacts to the aquatic environment during the Licence review phase. It provides a summary of previously completed environmental studies at the Facility to-date, supplemented by other mercury studies completed at Bluefish and Taltson hydroelectric facilities. A screening-level environmental assessment is provided, focusing on the effects of current operations of the Facility on various components of the ecosystem.



LEGEND

🟩	GENERATION STATION	━	ALL-SEASON ROAD	─	WATERCOURSE
●	SNARE AIRSTRIP	━	SNARE WINTER ROAD	▇	WATERBODY
●	SNARE RAPIDS 5B SPILLWAY	━	GNWT WINTER ROAD		
➡	FLOW DIRECTION				

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1:175,000 KILOMETRES

REFERENCE(S)
BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 11 DATUM: NAD 83

CLIENT
NORTHWEST TERRITORIES POWER CORPORATION

TITLE
SNARE HYDROELECTRIC FACILITY OVERVIEW

CONSULTANT
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2.0 REGULATORY BACKGROUND

The Facility has operated under several water licences and land use permits since 1976, summarized in Table 1.

Table 1: Snare Hydroelectric Facility Land Use Permits and Water Licences

Issue Date	Expiry Date	Purpose/Location	Issuing Authority	Authorization Number	Licensee
Land Use Permits					
14 December 2000	12 December 2007	Quarrying, winter road	Mackenzie Valley Land and Water Board (MVLWB)	MV2000F0058	NTPC
19 October 2007	18 October 2014	Winter road	WLWB	W2007F0001	NTPC
17 January 2013	23 November 2015	Quarrying, winter road, and petroleum storage	WLWB	W2012Q0004	NTPC
27 October 2014	26 October 2021	Winter road	WLWB	W2014F0002	NTPC
19 July 2018	4 January 2022	Quarrying	WLWB	W2018Q0003	NTPC
4 January 2022	3 January 2027	Quarrying, winter roads, satellite camps	WLWB	W2021Q0011	NTPC
Water Licences					
15 June 1976	30 May 1999	Storage and diversion of water for hydro power, Snare Forks	NWTWB	N1L5-0161	NCPC/NTPC
1 October 1976	30 May 1999	Storage and diversion of water for hydro power, Snare Falls	NWTWB	N1L5-0151	Northern Canada Power Commission (NCPC)/NTPC
1 October 1976	30 May 1999	Storage and diversion of water for hydro power, Snare Rapids	NWTWB	N1L5-0150	NCPC/NTPC
1 October 1976	30 September 1986	Storage and diversion of water for hydro power, Snare Cascades	NWTWB	N1L5-0352	Northern Canada Power Commission
10 August 1994	31 October 2004	Storage and diversion of water for hydro power, Snare Cascades	MVLWB	N1L4-1624	Dogrib Power Corporation
13 January 1999	-	Merging of water licences: N1L4-0150, N1L4-0151 and N1L4-0161 merged into N1L4-0150	NWTWB	N1L4-0151	NTPC
30 May 1999	29 May 2024	Storage and diversion of water for hydro power, Snare Rapids, Snare Falls, Snare Forks	Northwest Territories Water Board (NWTWB)/WLWB	N1L4-0150	NTPC
28 September 2004	27 September 2014	Storage and diversion of water for hydro power, Snare Cascades	MVLWB	MV2003L4-0014	Dogrib Power Corporation
5 September 2014	29 May 2024	Storage and diversion of water for hydro power, Snare Cascades	WLWB	W2014L4-0001	Dogrib Power Corporation

WLWB = Wek'èezhìi Land and Water Board; NTPC = Northwest Territories Power Corporation; MVLWB = Mackenzie Valley Land and Water Board; NWTWB = Northwest Territories Water Board; NCPC = Northern Canada Power Commission.

Note: A water licence for Snare Cascades between 1986 and 1994 could not be located. Some documents referred to Licence N1L5-0150 as N1L4-0150.

3.0 SNARE HYDROELECTRIC FACILITY ENVIRONMENTAL STUDIES AND SETTING

3.1 Overview of Construction History and Operating Conditions

The Facility was constructed in phases between 1948 and 1996, as outlined in Table 2.

Table 2: Sequence of Snare Hydroelectric Dam Construction

Year	Generating Station	Inundated Waterbody or Watercourse	Surface Area		Water Level	
			Pre-development	Post-development	Pre-development	Post-development (Full Supply Level)
1948	Snare Rapids	Bigspruce Lake, Kwijenne Lake, Upper Snare River	70 km^2	131 km^2	207.3 m (Bigspruce) 210.1 m (Kwijenne)	222.3 m
1961	Snare Falls	Snare River	3.60 km^2	5.64 km^2	186.8 m	202.4 m
1975	Snare Forks	Judd Lake, Snare River	6.04 km^2	10.9 km^2	179.0 m	182.9 m
1996	Snare Cascades	Snare River	0.20 km^2	0.27 km^2	167.6 m	173.7 m

Note: Surface areas and water levels taken from the Facility reservoir mapping documents prepared by an NTPC Hydro officer (Grabke 2000, 2002).

Snare Rapids is the oldest plant in the Snare Hydro System, completed in 1948. The plant reservoir (Bigspruce Reservoir) was created by the construction of the Snare Rapids main dam and perimeter dam (Figure 2). These dams raised the level of Bigspruce Lake from approximately 207.3 m to 222.3 m; Kwijenne Lake was also flooded by raising its water level from 210.1 m to 222.3 m, such that Bigspruce Lake and Kwijenne Lake have functioned as a single water body since 1948. Snare Falls is located 15.5 km downstream of Snare Rapids and has been in service since 1961 (Figure 3). It is a compact development with all core infrastructure within a radius of 200 m. Development of Snare Falls involved the construction of a main dam and two perimeter dams to create a forebay reservoir. Forebay reservoir water levels flood back to the tailrace of Snare Rapids. Snare Cascades is located approximately 3 km downstream from Snare Falls, utilizing the 9.1 m of head available between the tailrace of Snare Falls and the forebay of Snare Forks (Figure 3). This plant has been in service since 1996. Snare Forks is approximately 10 km downstream of Snare Cascades and the plant has been in service since 1975 (Figure 4). The design of this plant considered the natural features of the site, namely the forks in Snare River where the river splits around an island. The Snare Forks Forebay is contained by the Strutt Lake Dam, Snare Forks Dam, three freeboard dykes, and the spillway weir, flooding back to the tailrace of Snare Cascades (Figure 5).

The North Slave Electrical System and the Facility have a unique operating approach in that the North Slave Electrical System is an isolated system that is not connected to the North American power grid. As such the facilities within the Facility only generate as much power as is needed by the system. The storage at Bigspruce retains only approximately one year of water accumulation and there is very little hydro peaking. NTPC’s water management plan is based on maximizing the use of hydro generation given reservoir levels and forecasted inflows. The units run on a managed daily and annual cycle that aligns with power requirements of the system and the water management plan. Bigspruce Reservoir represents the main storage for the system. In general, Bigspruce Reservoir builds it water level throughout the spring and summer when inflows are higher and then water is slowly released, and the reservoir drops throughout the fall and winter when inflows are relatively low and demand is higher. This can result in daily or seasonal fluctuations in flows and water levels downstream of the facility, as well as seasonal or annual water level fluctuations in the water supply reservoirs. The maximum and minimum water levels are governed by NTPC's Water Licence. In general, the water level in Bigspruce Reservoir begins to drop around November. At this time the inflow to the system is less than that released for power generation (outflow). The water level of Bigspruce Reservoir continues to decline until inflow once again equals outflow. Inflow typically increases to match outflow in June of the following year. It is at this time that Bigspruce Reservoir reaches its lowest level of the year. Inflow begins to exceed outflow as snow melt, summer rain, and reduced power requirements begin. During this time water reserves are built up in Bigspruce Reservoir until the maximum water level is obtained or until outflow again exceeds inflow. The replenishing of reserves during the summer and fall are essential if winter and spring power demands are to be met. Fluctuations in the water levels for the forebays for the current water licences include the following:

- Bigspruce normal flow water elevation maximum = 222.3 m, and minimum = 217.9 m
- Snare Falls normal flow water elevation maximum = 202.4 m, and minimum = 201.8 m
- Snare Cascades normal flow water elevation maximum = 184.5 m, and minimum = 181.88 m
- Snare Folks normal flow water elevation maximum = 175.26 m, and minimum = 173.13 m

NTPC has requested and received approval for temporary exemptions to minimum water levels on at least three occasions (WLWB 2005, 2015 and 2023). The minimum water levels proposed in the new water licence will lower these levels by 0.3 m to reflect the operational realities of low water levels and the need to lower reservoirs on occasion to undertake maintenance.

The generating stations may also need to execute occasional stop-flow procedures, shutting down all flow downstream of the facility for maintenance activities that require a full flow outage. All plants have the ability to release water from the facility spillway to provide a source of downstream flow during the maintenance activities to avoid or minimize effects on fish populations related to dewatering. The Snare Rapids 5B spillway is located at the end of an arm off the southern end of Bigspruce Reservoir (i.e., Spillway 5B); the spillway is a stoplog type structure comprising six openings of 6 m (wide) x 2.5 m (deep) and two openings 6 m x 5.8 m. During high water or a plant shutdown, water is released from the spillway returning to the Snare River via a 13-km long waterway that includes two small lakes, before rejoining the main channel of the Snare River 7.5 km downstream of the Snare Rapids Generating Station. The design of the Snare Falls Spillway includes two gates, each 5.8 m by 7.0 m; whereas Snare Cascades Spillway is a 70 m wide labyrinth spillway at 182.88 m and the Snare Folks Spillway is a long low concrete weir 100 m in length which automatically controls flood discharge. Snare Cascades and Snare Forks spillways are uncontrolled spillways (without gates) such that the flow of water into the spillway is uncontrolled once the water elevation exceeds the dam elevation at the respective spillway.

Figure 2: Snare Rapids Generating Station; Bigspruce Reservoir in background; Spillway 5b not shown.

Figure 3: Snare Falls Generating Station, showing all core infrastructure within 200 m radius and dam above an existing waterfall; 15.5. km downstream of Snare Rapids.

Figure 4: Snare Cascades Generating Station, natural channel adjacent to dam serves as spillway; dam built above a steep chute or series of rapids, 3 km downstream from Snare Falls.

Figure 5: Snare Folks Generating Station, 10 km downstream of Snare Cascades where flows ultimately discharge into Strutt Lake; Snare Folks Spillway in background.

3.2 Indigenous Knowledge

NTPC is in discussions with the Tłı̨chô regarding the incorporation of Indigenous Knowledge (IK) into the operation of the Facility. To date, little IK has been documented on the Snare River. Aquatic monitoring reports for waterbodies downstream of the Facility include acknowledgement of the importance of IK to the monitoring programs, but do not typically include a detailed summary. Information from the Tlicho Aquatic Effects Monitoring Program available at the time of writing has been summarized in this application to help inform the discussion. It is NTPC's intent to build upon this summary through an IK study for the Snare River basin, developed in collaboration with the Tłı̨chô Government in the coming months.

The aquatic environment around Snare River has experienced many changes during the lifetime of Tłı̨chô Elders. Water temperatures have risen, and lakes along the river no longer freeze to the bottom creating winter drainage and lower water levels. Snowmobile travel on waterbodies with thinner ice is more challenging. Higher water temperatures are also impacting permafrost, and in turn contributing to land slumping (IAEMP 2012[1]).

"Water is considered healthy if it is clear and smells fresh and clean" (IAEMP 2012). Rivers running through the barrens or the Horn Plateau have good water quality for drinking. The re-introduction of beaver to the waters in the region in the 1950s has impacted water quality in some water bodies, changing its smell and drinkability. Beaver dams influence water levels and flows, which in turn has changed fish habitat and spawning areas in some waterbodies. In James Lake, fish are no longer good to eat due to changed water quality, and the large pike die-off in Russell Lake may have been caused by beaver damming the lake tributaries.

Fish from the waters in the region have and continue to play an important role in Tłı̨chô life. On the subject of fish quality, Elders have noted that:

> *"Fish are considered healthy if the are fat, the texture is firm, and the flavour is good… Fish found in cool, deep water have a nice firm texture and fish found in warm, shallow water have softer flesh… If fish flesh is soft and rips easily it is not good to eat. The gills should be red or pink and vibrant (versus white) indicating they are fresh and have not drowned in the net. There should be no visible worms or parasites on the skin or in the flesh and the fish should not be deformed. Where there is concern of contamination, elders say to open guts to make sure the fish is healthy and then you cook it. Fat, healthy fish were kept for human consumption whereas skinnier fish were fed to the dogs. The shape and colour of the scales can indicate disease if they are irregular. An alternate method of the typical dryfish preparation was demonstrated for when people were in a hurry or if men wanted to preserve fish for a short time period. This type of dryfish would not last as long and remained slightly soft"* (IAEMP 2012)

Fish have also changed over the years. Some Elders say that fish is not as tasty today, perhaps because they are not as fat. Today, fish are larger than in the past, but leaner. Whitefish in particular contain less fat today and have a greater presence of worms in the tissue. The flesh of some fish today is "gummy". Industrial development in the region has been identified as one potential source of changes in fish tissue taste and texture, potentially through contamination of water sources including dumping or leaks of oil and fuels onto ice roads and into the water (IAEMP 2012).

In terms of fish species, there were once more Coney in the area of the Snare River around Russell Lake and Slemon Lake. Coney were shared and highly valued amongst the Tłı̨chô people, and used to come in two types that were different from the Coney harvested today (IAEMP 2012). łıwezǫǫ̀ is not commonly found in Russell Lake or Slemon Lake (IAEMP 2015)[2].

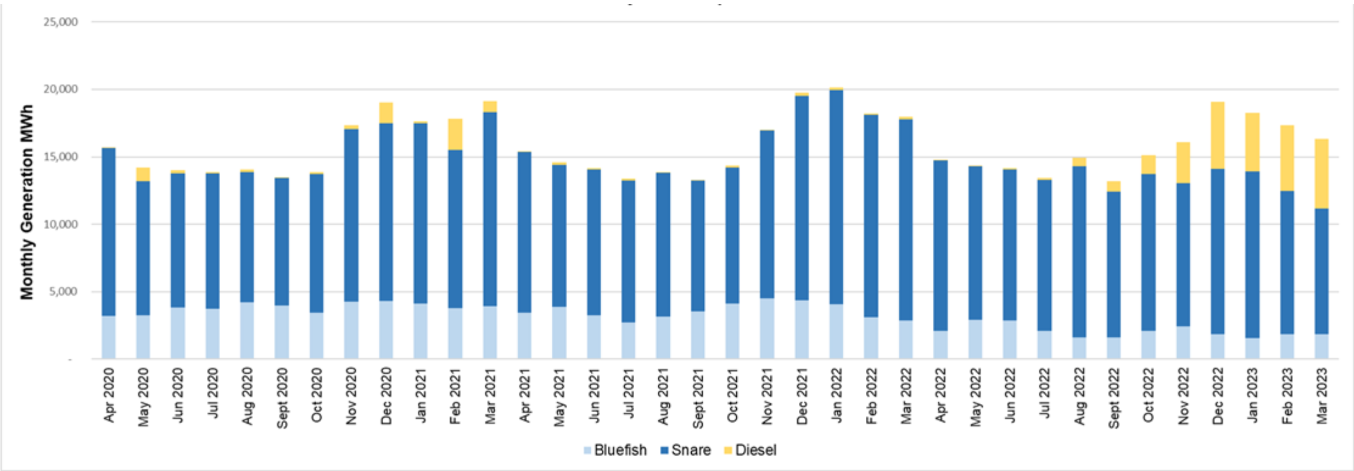
A summary of the types of the fish found in the waters around the mouth of the Snare River and associated lakes is provided in *Common Fish in the Tlicho Region*[3]:

- Nǫhkwèe - Burbot (Loche): Primarily used for subsistence. The liver is highly valued by the Tlicho.
- Łiwezǫ̀ǫ̀ - Lake Trout: Primarily used for subsistence. Often dried and smoked for long-term use. Seasonal harvest avoids spawning periods as the fish has little fat and the meat is mushy or rubbery.
- Įhdaa - Northern Pike (Jackfish): Not targeted for subsistence use. Eaten when caught.
- Ehts’ę̀ę / Ehch’ę̀ę - Walleye (Pickerel): Primarily used for commercial trade.
- Wıìle - Inconnu (Coney): Primarily used for subsistence.
- Ts'étı̨ą - Arctic Grayling: Not targeted for subsistence use. Eaten when caught.
- Łih - Lake Whitefish: Primarily used for subsistence. Most important food species to the Tlicho.
- Łih - Round Whitefish: Primarily used for subsistence. Not as common as Lake Whitefish.
- Łìhtsoa - Cisco: Primarily used for bait on traplines.
- Dehdoo - Longnose Sucker: Not targeted for subsistence use. Eaten when caught.
- Kwìezhìı - White Sucker: Primarily used for subsistence.
- Dahts’a - Ninespine Stickleback: Not consumed or used.
- Dahts’a - Spottail Shiner: Not consumed or used.

3.3 Greenhouse Gas Emissions

The North Slave Electrical System provides power to the communities of Yellowknife, Behchokǫ̀, Dettah, and N’Dilo and has only two sources of generation: hydroelectricity and diesel generators. It is important to note that the North Slave Electrical System is not connected to the continental electrical grid. Diesel generation is used when hydro generation is insufficient to meet the demand or if there are faults along the transmission lines from the hydroelectric facilities. Therefore, diesel generation fills the shortfall in hydroelectric generation when needed, but at a higher cost and with the associated greenhouse gas emissions. The benefit of the Snare Hydroelectric Facility is the generation of the electricity that would otherwise be generated by diesel generators.

Sources of power generation for the North Slave Electrical System from April 2020 to March 2023 are illustrated in Figure 6.



Source: NTPC

Figure 6: Bluefish, Snare, and Diesel Electricity Generation in the North Slave Electrical System

Currently, the only way to replace the hydroelectric generation in the North Slave Electrical System is through diesel generation. Diesel generation creates high levels of greenhouse gas emissions. Minimizing greenhouse emissions is a goal of all levels of government in Canada and is one of the key goals of the Government of the Northwest Territories 2030 NWT Climate Change Strategic Framework, 2019-2023 Climate Change Action Plan, 2030 Energy Strategy and the 2022-2025 Energy Action Plan (GNWT 2018a, 2018b, 2018c, 2020). Reducing greenhouse gas emissions is also a key focus of federal initiatives and legislation such as Canada's Pan-Canadian Framework on Clean Growth and Climate Change, A Healthy Environment and a Healthy Economy and the 2030 Emissions Reduction Plan (ECCC 2016, 2020, 2022).

NTPC has provided the following estimates of the carbon dioxide equivalent (CO2e) emissions that have been offset each year through hydroelectric generation at the Facility since 2018/2019:

- 107,938 tonnes in 2018-19
- 103,017 tonnes in 2019-20
- 99,508 tonnes in 2020-21
- 101,568 tonnes in 2021-22
- 97,958 tonnes in 2022-23

3.4 Environmental Studies

A summary of environmental studies in the Snare River basin is presented in Table 3. A description the studies that included field programs is outlined in Sections 3.4.1 to 3.4.6.

Table 3: Environmental Studies and Reports on the Snare Watershed

Year	Title	Study Description	Citation
1973	The Impact of the Strutt Lake Hydro Project on the Snare River, N.W.T.	A baseline survey conducted in 1973 on the limnology and fisheries of the Snare River system from the Snare Falls Reservoir to the outlet of Strutt Lake to determine the predicted impact of a hydroelectric facility at the north end of Strutt Lake	Weagle and Cameron 1974
1974	Strutt Lake Hydroelectric Development Snare River, NWT: Environmental Impact Assessment	This document could not be found.	Pearse Bowden Economic Consultants Limited and Envirocon Ltd 1974
1974	Snare Forks Walleye Survey	This document could not be found.	Envirocon 1974
1976	Fish Resource Data from Indin Lake, NT	Fish population surveys and bathymetry surveys conducted in Indin Lake, Upper Snare River, in 1976 to assess predicted impacts of development a generating station at the outflow of Indin Lake	Jessop et al. 1993
1977	Fish Resource Data from the Snare River, NT	Fish population surveys conducted in 1977 in the Snare River watershed in areas influenced by hydroelectric development, from Bigspruce Lake downstream to Slemon Lake	Jessop et al. 1994
1994	Biophysical Environmental Study: Snare Cascades Hydroelectric Project	An environmental study of the Snare River between the forebay of the Snare Falls generating station and the downstream end of the Snare Forks reservoir, with surveys completed including fisheries, water quality, sediment quality, and benthic invertebrates	Rescan 1994a
1994	Preliminary Environmental Appraisal, Snare Cascades Hydroelectric Project	A preliminary environmental appraisal based on previously collected data describing the environmental setting at the Snare Cascades downstream of Snare Falls, and a description of potential environmental impacts caused by development of the Snare Cascades generating station	Rescan 1994b
1996	Upper Snare River Hydroelectric Development Sites S7 and S4, Preliminary Environmental Screening Report	A preliminary environmental screening based on previously collected data describing the environmental setting in the Upper Snare River downstream from Indin Lake and a description of potential environmental impacts of development a generating station at the outflow of Indin Lake	Nishi-Khon/SNC Lavalin 1996
2000	Snare River Minimum Flow Assessment Report	An investigation to assess the effect of removing the minimum required flow from Snare Falls and Snare Forks hydroelectric dams	Rescan 2000
2000	Biological Characterization of the Snare River System	Biological characterization of the Snare River system from Bigspruce Reservoir to Strutt Lake, with surveys for fisheries, water quality, sediment quality and benthic invertebrates	Rescan 2001
2002	Phase I and II Environmental Site Assessment Northwest Territories Power Corporation Snare Rapids Power Plant, Northwest Territories	Environmental Site Assessment completed at Snare Rapids to identify potential environmental concerns identified by visual examination of surface features and operating practices. Phase II involved soil sampling and surface water sampling for petroleum hydrocarbons.	Golder 2002a
2002	Phase I and II Environmental Site Assessment Northwest Territories Power Corporation Power Plant Snare Falls, Northwest Territories	Ditto at Snare Falls	Golder 2002b

Table 3: Environmental Studies and Reports on the Snare Watershed

Year	Title	Study Description	Citation
2002	Phase I and II Environmental Site Assessment Snare Cascades Power Plant Snare River, Northwest Territories	Ditto for Snare Cascades	Golder 2002c
2002	Phase I and II Environmental Site Assessment Snare Forks Power Plant Snare River, Northwest Territories	Ditto at Snare Forks	Golder 2002d
2010	Behchokǫ Fisheries Monitoring and Education Program	A community-based fisheries monitoring program focusing on Shortjaw Cisco and Inconnu in Marian Lake and the North Arm of Great Slave Lake as part of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program	WRRB and Tłı̨chǫ Government 2011
2011	Įhdak'ètì Aquatic Ecosystem Monitoring Project	A community-based water quality, sediment quality, and fisheries monitoring program on Russell Lake and Slemon Lake near Behchokǫ̀	WRRB and Tłı̨chǫ Government 2012
2012	Tłı̨chǫ Aquatic Ecosystem Monitoring Program, Wekweètì 2012	A community-based water quality, sediment quality, and fisheries monitoring program on Snare Lake near Wekweètì	WRRB and Tłı̨chǫ Government 2013
2014	Environmental Effects of a Drawdown in the Bigspruce Reservoir	A summary assessment of the potential environmental effects in the event of a temporary 1-foot drawdown of the Bigspruce Reservoir at the Snare Rapids Hydro Station, including changes in water chemistry, aquatic life in the reservoir or downstream, and methylation of mercury	Golder 2014
2015	Tłı̨chǫ Aquatic Ecosystem Monitoring Program, Behchokǫ̀ 2015	A community-based water quality, sediment quality, and fisheries monitoring program on Russell Lake and Slemon Lake near Behchokǫ̀	WRRB and Tłı̨chǫ Government 2016
2016	Tłı̨chǫ Aquatic Ecosystem Monitoring Program, Wekweètì 2016	A community-based water quality, sediment quality, and fisheries monitoring program on Snare Lake near Wekweètì	WRRB and Tłı̨chǫ Government 2018

3.4.1 Early Environmental Characterization (1973 to 1977)

Two environmental studies were conducted between 1973 and 1977 to characterize water quality and fish communities in the Snare River system in the region currently influenced by hydroelectric development. The Department of Fisheries and Oceans (DFO) conducted a two-week survey in September 1973 in Strutt Lake, Judd Lake, and Snare Falls Reservoir to assess the potential impact of development of a generating station on the north end of Strutt Lake and suggest mitigation methods (Weagle and Cameron 1974). The study collected data on fish populations and water chemistry. The study found little significant difference between water chemistry and fish growth and condition factor in the reservoir compared to the two lakes, but species composition varied; the most abundant species in the lakes was Lake Whitefish (*Coregonus clupeaformis*) and the most abundant species in the reservoir was Longnose Sucker (*Catostomus catostomus*). DFO conducted another survey in 1977 to collect environmental data on the fish populations in sections of the Snare River altered by the Facility (Jessop et al. 1994). This was an extensive fish sampling and tagging program from Bigspruce Lake downstream to Slemon Rapids. Fish species composition varied among the five areas surveyed; Strutt Lake had the greatest species diversity (10 species) and Bigspruce Reservoir had the lowest species diversity (5 species). Walleye was the most abundant species in the lower Snare River and the second most abundant in Strutt Lake but absent from the other three locations that were further upstream. Lake Whitefish and Northern Pike (*Esox Lucius*) were present in all areas. Tagging results showed that Walleye (*Stizostedion vitreum)* aggregate in the lower Snare River during spawning season and spend the summer in Strutt Lake or further downstream, and that Lake Trout (*Salvelinus namaycush*) and Lake Whitefish have little net movement. Fish population surveys and bathymetry surveys were conducted in Indin Lake, in the Upper Snare River area, in 1976 to assess predicted impacts of the development of a new generating station at the outflow of Indin Lake (Jessop et al. 1993). Ultimately this location was not selected for the new generating station.

3.4.2 Biophysical Environmental Study

A biophysical study was carried out along the Snare River between the forebay of the Snare Falls generating station and the downstream end of the Snare Forks reservoir in July 1994 with the objective of updating chemical and biological information prior to construction of the Snare Cascades generating station (Rescan 1994a) following a preliminary environmental appraisal (Rescan 1994b). The biophysical study included surveys on water quality, sediment quality, fish populations, fish tissue chemistry (i.e., mercury content), benthic invertebrates, acid/base accounting, and reservoir rim stability. Water quality and sediment quality results found the study river to contain low concentrations of all metals analyzed and to be typical of unpolluted Northern watercourses. Mercury concentrations were found to be very low in water and sediment, and high in larger, older predatory fish such as Northern Pike and Walleye (as is typical of Northern waterbodies). The average mercury concentrations measured in Northern Pike (n = 5) and Walleye (n = 5) were 0.226 parts per million (ppm) and 0.400 ppm, respectively, with one Walleye having a concentration of mercury in tissue of 0.556 ppm, which was above the recommended Canadian consumption threshold at the time of 0.5 ppm. Upstream of the Cascades, the fish community was dominated by Arctic Grayling (*Thymallus arcticus*); downstream of the Cascades, the fish community was mixed and dominated by Lake Whitefish, Walleye, Northern Pike, and Longnose Sucker. No significant difference was found in condition factors of Lake Whitefish and Northern Pike between 1994 and 1977. The benthic invertebrate community was dominated by Dipteran larvae and pupae, worms, water mites, microcrustacean and shelled molluscs. Low numbers of juvenile mayflies, stoneflies, and caddisflies were also identified.

3.4.3 Upper Snare River Preliminary Environmental Screening Report

In 1996, a preliminary environmental screening report was prepared based on previously collected data describing the environmental setting in the Upper Snare River downstream from Indin Lake (Nishi-Khon/SNC Lavalin 1996). The report described potential environmental impacts of development a generating station in the Upper Snare River at the outflow of Indin Lake, as NTPC was considering this location for the new generating station. The project did not proceed.

3.4.4 Snare River Minimum Flow Assessment

A minimum flow assessment was conducted to assess the effect of a temporary no-release scenario from Snare Falls and Snare Forks hydroelectric dams on downstream fish and fish habitat (Rescan 2000). The minimum flow discharge from these dams was previously set at 5.66 m^3/s, in place to mitigate impacts to fish and fish habitat. The Snare Rapids and the Snare Cascades dams do not have minimum flow requirements. Of concern was the effect on Arctic Grayling spawning habitat in the Snare Falls and Snare Forks tailraces where an angling survey revealed an abundant Arctic Grayling population in the Snare Falls Tailrace. The assessment was based on a hydraulic model for predicting water levels through the tailraces at various discharge scenarios. The maximum recorded period of no-release at Snare Falls and Snare Forks was 18 and 16 hours, respectively. The model found no detectable differences in water levels in river or lake habitat comparing minimum and no-release flows (i.e., periods of generator shutdown), and differences in velocities were extremely low. Short, infrequent periods of no flow conditions are not expected to significantly impact the spawning success of Arctic grayling.

The impact of no-release conditions at Snare Forks was also investigated downstream of Strutt Lake. The crest at Slemon Rapids was determined to be the major control of Strutt Lake water levels, and the flow at Slemon Rapids was determined to be buffered by the active storage in Strutt Lake. Flows at Slemon Rapids under the two release scenarios, minimum and no-release, were computed to identify resulting hydraulic differences. After 12 hours of minimum and no-release, there were no detectable difference in water levels or flows at the crest of Slemon Rapids. The results successfully quantify the buffering capacity of Strutt Lake, while demonstrating that the minimum release requirement did not significantly alter flows at Slemon Rapids as compared to short periods of zero discharge.

3.4.5 Biological Characterization of the Snare River System

An aquatic survey was conducted during the open-water season in 2000 on the Snare River System from Bigspruce Reservoir to Strutt Lake and compared to previous studies to identify potential effects of the Facility on the aquatic environment (Rescan 2001). The study included surveys on water quality, sediment quality, benthic macroinvertebrates, fish population, and fish tissue chemistry (i.e., mercury content). Fish data were collected from a reference lake (Basler Lake) to compare to potentially impacted lakes. The water quality in the Snare River System was indicative of low-productivity, pristine lakes characteristic of Arctic lakes. Aluminum was the only metal of concern, exceeding federal criteria at several waterbodies and was generally elevated at all waterbodies throughout the open water season. Turbidity increased slightly from upstream to downstream waterbodies. In sediment, chromium and nickel concentrations exceeded federal guidelines at several stations. Nickel concentrations appear to have increased relative to 1994 and other Northern lakes. Mercury concentrations were well below guidelines. The benthic invertebrate community was diverse, and dominated by Dipterans, nematodes, and molluscs. A total of 15 fish species were identified, consisting primarily of Lake Whitefish and Northern Pike, followed by Walleye, Lake Trout, Longnose Sucker, Round Whitefish (*Prosopium cylindraceum*), White Sucker (*Catostomus commeronii*), Lake Cisco (*Coregonus artedi*), Burbot (*Lota lota*), and Arctic Grayling. The same 15 species was described during a previous study of the river in 1973 (Pearse Bowden 1974). Based on a comparison to the historical catch, the 2000 study indicated that Lake Whitefish and Northern Pike remain the most abundant species in the river, and that Longnose Sucker continues to be the dominant species in the Snare Falls Forebay. Arctic Grayling captures were restricted to the Snare Cascades Forebay (e.g., Snare Falls tailrace area) during the 2000 study.

Fish populations were also characterized by length, weight, condition factor, age, sex, maturity, and diet. Condition factors of fish captured were similar to 1977 results, but lower than in the reference lake. Mercury concentration in Northern Pike tissue was high, but typical of Northern waterbodies. Of the areas sampled, average mercury concentrations in Northern Pike were greatest in Bigspruce Reservoir (0.349 µg/g, n =17), followed by Judd Lake (0.344 µg/g, n = 27), and Strutt Lake (0.287 µg/g, n = 36), with the lowest average concentration in the reference lake, Basler Lake (0.196 µg/g, n = 28). While the average concentrations of mercury measured from Northern Pike sampled in 2000 were greater than those observed in 1994 (i.e., 0.226 µg/g, n = 28; Rescan 1994a), the fish sampled were also larger, suggesting the differences likely reflected variation in fish size, rather than increasing mercury concentrations. Overall, the aquatic environment of the Snare River System was similar to previous years and to other oligotrophic Northern lakes. Elevated mercury levels in fish tissue were likely due to naturally elevated levels in large, predatory fish in the NT.

3.4.6 Environmental Effects of a Drawdown in the Bigspruce Reservoir

The objectives of the desktop study conducted by Golder (2014) were to predict environmental effects that might result from temporarily lowering the water level below 217.9 m, including changes in water chemistry, impacts to aquatic life in the reservoir or downstream, and methylation of mercury. Environmental effects of a potential increase in the drawdown level of 0.3 m below the licenced minimum were considered to be negligible with small positive effects on water quality because of increased dilution rates and small negative impacts on productivity related to decreased relative water residence time in the reservoir and reduced surface area of the reservoir. Water residence time, variability in surface area and water level variation were expected to be within normal inter-annual variation. Furthermore, microbial activity that accelerates methylation of mercury should be the same or decrease from what is presently occurring naturally because the reservoir drawdown results in decreased risk of flooding new vegetation and decreased temperatures and decreased relative water residence time. Any potential impacts from the proposed drawdown level were determined to not be measurable when compared to normal variation of these parameters within the reservoir. However, downstream flows could be significantly impacted if the level of drawdown results in operations not being able to maintain normal minimum flows. It was recommended this risk is addressed in operational plans to avoid dewatering extensive reaches of the downstream riverine habitats for fish and other aquatic life. The request for the temporary drawdown was approved (WLWB 2015), as were at least two other similar requests (WLWB 2005, 2023).

3.4.7 Tłı̨chǫ Aquatic Ecosystem Monitoring Program Studies

The Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) is a community-based monitoring program as a collaboration between the Wek’èezhìi Renewable Resources Board (WRRB) and the Tłı̨chǫ Government with the objectives of building and maintaining a community-based monitoring program that meets the needs of the Tłı̨chǫ people in determining whether fish, water, and sediment quality are changing over time, and whether fish and water remain safe to consume. Other partners involved in the TAEMP include the WLWB, community members (e.g., elders, fishers and youth), DFO, the Government of the Northwest Territories Department of Environment and Natural Resources Water Resources Division (GNWT ENR) and Department Health and Social Services (GNWT HSS), and Environment and Climate Change Canada (ECCC). The program rotates through the four Tłı̨chǫ communities of Behchokǫ̀, Gamètì, Wekweètì, and Whatì and monitors water quality, sediment quality, and fisheries community and health in nearby waterbodies and watercourses. Relevant programs include the 2010 fisheries monitoring on Marian Lake (WRRB and Tłı̨chǫ Government 2011), the 2011 and 2015 aquatic monitoring on Slemon and Russell lakes (downstream of the Facility; WRRB and Tłı̨chǫ Government 2012, 2016), and the 2012 and 2016 programs on Snare Lake (upstream of the Facility), which are within the Snare River watershed (WRRB and Tłı̨chǫ Government 2013, 2018). Although these programs did not study directly within the Facility area, they are representative of other waterbodies in the Snare watershed.

During these monitoring programs, mercury concentrations were measured in a variety of fish species, including Lake Trout, Lake Whitefish, Northern Pike, and Walleye. Mercury concentrations were consistently greatest in large piscivorous fish, such as Lake Trout, Northern Pike, and Walleye. For the 2010 fisheries monitoring on Marian Lake (WRRB and Tłı̨chǫ Government 2011), mercury concentrations were measured in nine Inconnu, which ranged from approximately 0.1 to 0.3 mg/kg. For the 2011 and 2015 aquatic monitoring on Slemon and Russell lakes (WRRB and Tłı̨chǫ Government 2012, 2016), mercury concentrations were measured in Northern Pike, Walleye, and Lake Whitefish. Average mercury concentrations measured in Northern Pike were 0.460 mg/kg in 2011 (n = 13) and 0.441 mg/kg in 2015 (n = 17). Average mercury concentrations in Walleye were 0.271 mg/kg in 2011 (n = 11), and 0.196 mg/kg in 2015 (n = 11). Average mercury concentrations in Lake Whitefish were 0.068 mg/kg in 2011 (n = 10), and 0.047 mg/kg in 2015 (n = 20). For the 2012 and 2016 programs on Snare Lake (WRRB and Tłı̨chǫ Government 2013, 2018), mercury concentrations were measured in Lake Trout and Lake Whitefish. Average mercury concentrations measured in Lake Trout were 0.410 mg/kg (excluding one outlier) in 2012 (n = 20), with six fish exceeding the Health Canada guideline of 0.5 mg/kg and were 0.399 mg/kg in 2016 (n = 20), with three fish exceeding the Health Canada guideline. Average mercury concentrations measured in Lake Whitefish were 0.134 mg/kg in 2012 (n = 20) and 0.163 mg/kg in 2015 (n = 20). None of the Lake Whitefish sampled exceeded the Health Canada guideline of 0.5 mg/kg.

3.5 Mercury in Fish

3.5.1 Mercury Accumulation in Fish Tissue

Mercury is an element found within the aquatic environment derived from both natural and anthropogenic sources. Mercury occurs in both organic and inorganic forms, with the organic form of mercury, methylmercury, produced through biological and chemical methylation of inorganic mercury. Methylmercury is toxic to biological organisms, binding to proteins in tissues and bioaccumulating over time, which can present a significant risk to higher trophic levels in aquatic ecosystems, as well as human consumers (De Pew et al. 2013). In fish, mercury is almost entirely composed of methylmercury, absorbed through the diet. Bioaccumulation is influenced by environmental factors, such as water chemistry and rates of mercury methylation, as well as biological factors, such as trophic level, size, and age, with bioaccumulation increasing with size, age, and trophic status. Due to these properties, mercury concentrations are typically greater in larger, older, piscivorous fish, such as Lake Trout, Northern Pike, and Walleye, when compared to non-piscivorous fish such as Lake Whitefish (Table 4).

Table 4: Fish Tissue Mercury Concentrations in Select Fish Species from the Northwest Territories and Canada

Species	Northwest Territories[a]		Canada[b]	
	Sample Size	Average (mg/kg)	Sample Size	Median (mg/kg)
Lake Trout	1,855	0.38	21,324	0.28
Lake Whitefish	1,917	0.11	16,779	0.09
Northern Pike	1,169	0.38	52,881	0.38
Walleye	868	0.47	64,898	0.41

a) Data sourced from Lockhart et al. (2005).

b) Data sourced from De Pew et al. (2013).

3.5.2 Effects of Impoundment on Mercury Accumulation

The impoundment of hydroelectric reservoirs typically leads to increasing concentrations of mercury in fish tissue (Bilodeau et al. 2017). These increases result from the flooding of large quantities of organic matter in the inundated area containing inorganic mercury. The inorganic mercury is then converted into methylmercury during bacterial decomposition of the organic matter, resulting in an increase in methylmercury in the aquatic environment. Methylmercury is then absorbed by fish, primarily through their diet, resulting in an increase in mercury concentrations in fish tissue. The magnitude and duration of changes in mercury concentrations in fish tissue are dependent on impoundment characteristics (e.g., flooded area, annual volume of water flowing through the reservoir, filling period, water temperature, and percentage of flooded area located in the drawdown zone [Bodaly et al. 1993; Bilodeau et al. 2017; French et al. 1998]), making it difficult to reliably predict potential impacts in the aquatic environment.

The effects of impoundment on mercury concentrations and population dynamics in fish were monitored for more than a 30-year period in northern Quebec at the La Grande hydroelectric complex, following construction of a series of seven hydroelectric dams on the La Grande River (Bilodeau et al. 2016, 2017). The results of this program provide one of the most comprehensive datasets available examining long term impacts of impoundment on population dynamics and mercury concentrations in fish. Increases in mercury concentrations observed in fish tissue from the La Grande hydroelectric complex ranged from 2- to 8- fold, with maximum concentrations ranging from 0.33 to 4.66 mg/kg ww (Table 5). Peak mercury concentrations were observed 4 to 14 years following impoundment, and then gradually declined over time before returning to baseline concentrations 10 to 31 years following impoundment. Piscivorous fish (i.e., Lake Trout, Northern Pike, and Walleye), exhibited greater increases in mercury concentrations as well as greater peak concentrations when compared to non-piscivorous fish (i.e., Lake Whitefish and Longnose Sucker). Piscivorous fish also took longer to reach peak mercury concentrations and return to baseline concentrations following impoundment, with all species returning to baseline within 31 years.

Table 5: Changes in Fish Tissue Mercury Following Impoundment at the La Grande Hydroelectric Complex (Bilodeau et al. 2017)

Species	Mercury Increase (fold)	Peak Mercury Concentration (mg/kg)	Time to Reach Peak Concentration (y)	Time to Return to Baseline (y)
Lake Trout	3	2.53 to 2.63(a)	9 to 11	21
Lake Whitefish	2 to 5	0.33 to 0.53(b)	5 to 8	10 to 15
Longnose Sucker	3 to 6	0.34 to 0.72(b)	4 to 11	11 to 20
Northern Pike	3 to 8	1.65 to 4.66(a)	9 to 14	24 to 31
Walleye	4 to 5	207 to 2.82(b)	9 to 10	20 to 25

a) Standardized to a length of 700 mm.

b) Standardized to a length of 400 mm.

3.5.3 Mercury Accumulation in Hydroelectric Reservoirs in the Northwest Territories

In addition to the Snare Hydroelectric Facility, there are two other major hydroelectric facilities operating in the NT. These include the Bluefish Hydroelectric Facility located 39 km north of Yellowknife, and Taltson Twin Gorges Generating Station located 64 km north of Fort Smith.

3.5.3.1 Bluefish Hydroelectric Facility

The Bluefish Hydroelectric Facility was originally constructed in early 1940s, and later replaced in 2012. Since 2014, fish tissue concentrations of mercury have been monitored in Slimy Sculpin from both the inundated area and a control area of Bluefish Lake. Similar to observations made in the La Grande hydroelectric complex, mercury concentrations in Slimy Sculpin from the Bluefish Lake were initially greater in the inundated area. Length adjusted mean concentrations were initially 120% greater in the inundated area (0.044 mg/kg) than the control area (0.020 mg/kg) in 2014, which declined over time to a difference of 13% in 2022 (i.e., 0.026 and 0.023 mg/kg, respectively), approaching background levels in the control area (WSP 2023).

3.5.3.2 Taltson Twin Gorges Generating Station

In 1965, the Taltson Twin Gorges Generating Station was constructed to provide hydroelectric power to the Pine Point Mine, with Nonacho Lake raised to provide a hydroelectric reservoir for the generating station. Total mercury concentrations in fish tissue at Nonacho Lake have been monitored intermittently in Lake Trout and Lake

Whitefish since 1975 (i.e., 1975, 1986, 2003, 2004, 2010, and 2019), with the addition of Northern Pike in 1986 (i.e., 1986, 2004, 2013, and 2019). Since monitoring began for these species, total mercury concentrations have declined in Nonacho Lake (Ganshorn et al. 2020). For Lake Trout, average mercury concentration declined 71% from 1.058 mg/kg in 1975 to 0.308 mg/kg in 2003 and have largely stabilized since. For Lake Whitefish, average mercury concentration declined 45% from 0.185 mg/kg in 1975 to 0.102 mg/kg in 2019. For Northern Pike, average mercury concentration declined 22% from 0.390 mg/kg in 1986 to 0.303 mg/kg in 2013 and appear to have stabilized. For each of these species, mercury concentrations in Nonacho Lake have returned to concentrations similar to other populations in the Northwest Territories and Canada (Table 4).

As baseline data for Nonacho Lake were not available for comparison, beginning in 2003 mercury concentrations were also monitored in Rutledge Lake for Lake Trout, Lake Whitefish (i.e., 2003, 2004, 2013, and 2019) and Northern Pike (2013 and 2019), to provide a reference area for comparison. Throughout the monitoring period, mercury concentrations were greater in Nonacho Lake for all three species. In 2019, while mercury concentrations were similar to other fish populations in the Northwest Territories and Canada (Table 4), average mercury concentrations in Nonacho Lake were 193% greater for Lake Trout, 70% greater for Lake Whitefish, and 79% greater for Northern Pike, when compared to Routledge Lake.

3.6 Fisheries

In addition to mercury generation, hydropower infrastructure has the potential to alter habitat and potentially impact fisheries through various pathways, some of which have been previously examined at the Snare Facility (e.g., Rescan 2000, 2001; Golder 2014), while other pathways require further study. The operation of a hydroelectric dam, in general, can result in flow alteration of the river due to requirements for hydrogeneration operations and the occasional flow outages for maintenance. These flow changes have the potential to affect habitat conditions as they relate to water levels and wetted area, and flow outages can cause dewatering in some areas. Operations can also result in water level fluctuations in the upstream reservoir that can also affect habitat conditions and result in dewatering of some areas. Flow changes and the characteristics of the water discharged from the submerged intake in the forebay of the plan can also affect water quality and water temperatures in the river downstream of the respective plant. Changes to the physical characteristics of the receiving waters can then result in changes in fish habitat productivity if they affect habitat suitability (water temperature), nutrient concentrations or food supply associated with benthic invertebrate communities.

Dams associated with hydroelectric developments that lack fish passage mitigations such as fishways, fish ladders or similar bypass structures can constitute barriers to fish passage, preventing both local fish movements and larger-scale seasonal migrations. The potential effects on fish populations may include loss of habitat connectivity or accessibility, changes in fish distribution or species composition, or reduce overall fish abundance or population productivity. The potential effects on fish also depend on whether the dam is positioned over a passable section of the river, versus a natural barrier (e.g., Snare Falls). If positioned over a passable section of the river, effects on upstream movements of fish are predicted, and the magnitude of effects may vary depending on the movement patterns and habitat utilization by the resident fish species. Although the historical effect of dam construction on fish populations present at the time of construction is not known, any populations present today would confirm that critical habitats for all life stages are available to sustain fish populations in the river or sections of the river. Indeed, a fisheries survey in 2000 revealed an abundant Arctic Grayling population in the Snare Falls Tailrace (i.e., Snare Cascades Forebay) 39 years after the Snare Falls operations began (Rescan 2000). Furthermore, the species composition within the Snare River system has remained similar between 1973 and 2000, suggesting that critically habitats for all life stages are present in most sections of the Snare River under the long-term flow regime of the Facility (Rescan 2001).

Downstream migration of fish at a dam can also pose a challenge for a species. It is expected that the resident large-bodied species that persist today in the Snare River (Arctic Grayling, Lake Whitefish, Walleye, Northern Pike, and Longnose Sucker) have the capacity to move considerable distances throughout a riverine system for reproduction, rearing, and foraging, or simply move throughout reservoirs where they may traverse forebay areas and approach an intake. Risks at the intake itself include injury and mortality resulting from entrainment, when fish pass through hydropower infrastructure (e.g., turbine), or from impingement, when fish become trapped against infrastructure (e.g., intake screen), associated with hydroelectric facilities. Furthermore, the potential for entrainment and impingement may be higher near intakes positioned within a confined channel or relatively shallow location compared to intakes positioned at a deeper location (e.g., less productive location) in an open reservoir setting. The presence of an intake velocity or spilling-induced velocity in a confined channel has the potential to direct fish to that location. Similarly, the presence of optimal fish habitat near an intake or spillway has the potential to attract fish to that location.

Entrainment and/or impingement can have serious consequences for fish populations. There is an extensive body of literature that has documented fish entrainment at other hydropower facilities (Barnthouse 2013; Algera et al. 2020). Stress, injury, and mortality of entrained fish can result from contact with the turbines, and extreme and rapid changes in pressure. However, there are no field studies or modelling research of fish entrainment or impingement at the Facility and no information to indicate if this occurs, or to what extent fish mortalities may occur.

3.7 Semi-Aquatic Furbearers

Although there have been no focused studies on semi-aquatic mammals on the Snare River, the following provides a synthesis of life history requirements of beaver (*Castor canadensis*) and muskrat (*Ondatra zibethicus*), and the potential for interaction with Facility operations recognizing that beaver and muskrat are locally known to be present along the Snare River between Bigspruce Reservoir and Strutt Lake. Beaver lodges can be found on a variety of waterbodies, including lakes and small creek drainages (Jenkins and Busher 1979; Larter and Allaire 2009). Willow (*Salix* spp.) and trembling aspen (*Populus tremuloides*) are important habitat components for beaver in the NWT (Jenkins and Busher 1979; Larter and Allaire 2009). Muskrats can occupy most aquatic habitats in North America, including creeks, rivers, and lakes (Willner et al. 1980; Cott et al. 2016).

Both muskrats and beavers prefer watercourses and waterbodies with stable water levels, avoiding areas with high water fluctuations during burrow and lodge construction (Allen 1983; Allen and Hoffman 1984). Habitat preferences for muskrats can be similar to beaver, however, muskrats generally prefer shallower areas for foraging (Bellrose and Brown 1941; Clark 1994). Beavers also prefer twigs and leaves of aspens and willows (Jenkins and Busher 1979), whereas muskrats primarily consume the roots and stems of hydrophytic plants (e.g., cattail [*Typha* spp.], water lily [*Nymphaea* spp.], horsetail [*Equisetum* spp.]) (Willner et al. 1980).

Water level fluctuations can negatively impact muskrat and beaver populations by causing displacement, mortality (e.g., through displacement from flooding of lodges that are required for survival), changing access to winter food caches, and changing the distribution of vegetation required for forage and lodge construction. Muskrat and beaver are most susceptible to water fluctuations during the winter (Allen 1983; Allen and Hoffman 1984) when food is limited and stored in caches. Increased flows or water levels can flood muskrat and beaver out of their dwellings, while decreased water levels can change access to food caches and dwelling entrances (Erb and Perry 2003; Deze Energy 2009). One potential indirect effect to survival may occur if rapid water changes remove food caches when there is limited forage available in upland areas during late winter or early spring. There is potential for increased predation risk if individuals are required to replace their winter food caches through additional travel and foraging on the land.

Young juvenile beaver and muskrat can be vulnerable to drowning if there are dramatic water level increases that flood burrows and lodges when individuals are not yet fully mobile (Erb and Perry 2003). Muskrats can give birth to three litters per year, with one litter born in each the fall, spring, and summer (Willner et al. 1980). Beavers typically have one litter per year in the spring or early summer (Jenkins and Busher 1979). Therefore, rapid water increases during the early spring may not pose a major risk of mortality compared to other times of the year because muskrat young that are born in the fall are highly mobile and ready to leave the den, and beaver young are not yet born by late winter and early spring.

4.0 SPECIES AT RISK

The intent of the federal *Species at Risk Act* (Government of Canada 2002) and the territorial *Species at Risk (NWT) Act* (GNWT 2009) is to protect species at risk from becoming extirpated or extinct because of human activity. While the former was enacted by the Government of Canada, the latter was enacted by the Government of the Northwest Territories (GNWT) and applies only to wild animals and plants managed by the GNWT. For the purposes of this document, species may be of concern because of either their federal or territorial status. Species of concern are identified that are known to be or are expected to be in the Bigspruce Lake, Snare River, or Strutt Lake area and could potentially interact with the Facility (Table 6). At-risk wildlife and insects were identified in the Facility area, but no at-risk plant, amphibian, or fish species are anticipated to be present. No critical wildlife habitat is present in the Facility area.

Table 6: Wildlife Species at Risk that may Interact with Snare Hydroelectric Facility

Species	Status[(a)]		Potential Effects	Recovery Strategy or Management Plan Available?	Justification
	Species at Risk (NWT) Act	***Species at Risk Act* (Federal)**			
Little Brown Myotis (*Myotis lucifugus*)	Special Concern	Endangered	None	Yes – Federal and Territorial	No expected human disturbance of roosting sites No hibernacula are known to be present The lease area is at the outer extent of documented range
Barren-ground Caribou (*Rangifer tarandus groenlandicus*)	Threatened	Under Consideration	Possible	Yes – Federal and Territorial	Infrequent and discrete periods of minor development or activity
Wolverine (*Gulo gulo*)	No Status	Special Concern	None	No	Infrequent and discrete periods of minor development or activity
Bank Swallow (*Hirundo rustica*)	Not Applicable	Threatened	Possible	Yes – Federal	No planned removal of potential nesting structures The lease area is at the outer extent of documented range
Barn Swallow (*Hirundo rustica*)	Not Applicable	Threatened	Possible	No	No planned removal of human-built potential nesting structures (i.e., old buildings, culverts)
Common Nighthawk (*Chordeiles minor*)	Not Applicable	Threatened	Possible	Yes – Federal	Unlikely potential for collision with motor vehicles and aircraft. No impact by human activity to food sources or habitat loss and degradation. No planned removal of forested area within the lease area
Olive-sided Flycatcher (*Contopus cooperi*)	Not Applicable	Threatened	Possible	Yes – Federal	No planned removal of forested area within the lease area. Site housekeeping practices discourage predator attractants. No planned activity that will disturb habitat
Red-necked Phalarope (*Phalaropus lobatus*)	Not Applicable	Special Concern	Possible	Yes – Federal	No planned activity within grass-sedge nesting habitat May be affected by water level changes
Rusty Blackbird (*Euphagus carolinus*)	No Status	Special Concern	Possible	Yes – Federal	No planned removal of forested area within the lease area May be affected by water level changes
Short-eared Owl (*Asio flammeus*)	No Status	Special Concern	Possible	Yes – Federal	No planned activity that will disturb habitat
Yellow Rail (*Coturnicops noveboracensis*)	Not Applicable	Special Concern	Possible	Yes – Federal	No planned activity that will disturb habitat May be affected by water level changes
Transverse Lady Beetle (*Coccinella transversoguttata*)	No Status	Special Concern	None	No	No use of pesticides and herbicides within the lease area
Yellow-banded Bumble Bee (*Bombus terricola*)	No Status	Special Concern	None	Yes – Federal	No use of pesticides and herbicides within the lease area

a) GNWT 2022.

5.0 SCREENING-LEVEL ENVIRONMENTAL ASSESSMENT

5.1 Methods

The objective of this assessment is to provide a summary of potential effects of the continued operation of the Facility on the surrounding environment. Where there was uncertainty, potential effects were overestimated. This assessment was completed using the following steps:

- Identification of potential impacts by which the Facility may affect the components of the ecosystem, directed by objectives, summaries or conclusions in previously completed environmental studies and assessments at the Facility.
- Description of relevant environmental design features, operational activities or mitigation, where mitigation refers to the actions used to eliminate or reduce environmental effects from a pathway and may include processes and procedures. Monitoring can also be used to identify where additional mitigation may be required under an adaptive management framework.
- A qualitative, screening level characterization of the resulting residual effects (i.e., the residual effects that may remain after mitigation has been applied), both as a narrative and classified according to standard environmental assessment criteria and professional opinion (Table 7). In cases where no residual effects were identified, assessment criteria were not assigned.

Table 7: Assessment Criteria

Criteria	Description
Direction	Direction is related to the type of an effect and indicates whether the effect on the environment is negative or adverse (i.e., less favourable), positive (i.e., an improvement), or neutral (i.e., no change). While positive changes are identified, more focus is given to changes likely to cause adverse effects on the environment or to cause public concern.
Magnitude	Magnitude is a measure of the intensity of an effect, or the degree of change caused by the Facility relative to baseline condition. A ‘negligible’ effect is sufficiently small to likely not result in a noticeable change to the ecosystem component, while a ‘low’ magnitude residual effect may result in a noticeable change, but that change may be one that is within the range of natural variation and/or affects a specified small percentage of the population. A ‘moderate’ or ‘high’ magnitude residual effect may be one that is outside the range of natural variation and/or affects most or entire population, or a moderate or large percentage of the population.
Geographic Extent	Geographic extent refers to the area (or distance covered or range) of the effect. Where applicable, the affected waterbody and/or watercourse is listed, and/or site location (see Figure 1).
Frequency	Frequency refers to how often an effect will occur and is expressed as infrequent (isolated or confined to a discrete period) or frequent (occurs intermittently, but repeatedly over the assessment), or continuously over the assessment period.
Likelihood	Likelihood is the probability of an effect occurring. Likelihood considers uncertainty, which may be influenced by a variety of factors such as the likelihood of a negative response to the environment or occurring or the likelihood of mitigation being successful. Three categories are used: ▪ Unlikely: residual effect is possible, but unlikely (less than 10% chance of occurring) ▪ Likely: residual effect is possible, but is not certain (10% to 80% chance of occurring) ▪ Highly likely: residual effect is mostly certain to occur (greater than 80% chance of occurring)

5.2 Screening Results

The pathways whereby the Facility may lead to environmental effects are listed in Table 8. For each pathway, proposed mitigation, and the potential residual effects were identified, and the residual effects were described according to the criteria in Table 7.

Table 8: Screening-Level Environmental Assessment

Ecosystem Component	Facility Interactions	Mitigation, Design, and Operational Considerations	Potential Residual Effects	Preliminary Assessment Classification
Surface Hydrology, and Fish Habitat	Changes to the timing, duration, and frequency of flows, influencing fish survival and habitat	■ The four reservoirs are kept as close to full as possible under normal operating conditions to maximize generation and water use for generation is matched to flow rates in the system, mimicking the hydraulics of a natural system. ■ Water levels in the reservoirs are maintained year-round, minimum water levels do not overlap with critical spawning periods for fall spawning fish, and are regulated through the water licence. ■ Daily minimum, maximum, and mean forebay levels and water flow rates at each powerhouse and over each spillway are measured and recorded as part of a Surveillance Network Program. ■ All operations are based on the Facility Operations, Maintenance and Surveillance Manual (NTPC 2022), includes a Reservoir Operating Report; regulated by the Water Licence. ■ The flow in the river channel downstream of the Snare Falls and Snare Forks generators can be zero m^3/s for a maximum period of 24 hours as required for maintenance. ■ The impacts of lower minimum water levels at Bigspruce Reservoir and Snare Falls have been considered by the WLWB through previous exemptions. ■ Managing flow rates requires balancing the habitat needs of fish in the Snare River with natural water flows, electrical demand, and the need to maintain a reservoir for periods of low water flow. ■ Minimum flow rates below the Snare Falls and Snare Forks hydroelectric dams (5.66 m^3/s; excluding short duration periods of no release during a maintenance shutdown). ■ All plants can maintain relatively high water levels from shutdown of plant generation and the re-direction of water through spillways due to backwater effects of the downstream waterbody.	Drawdowns in the forebay reservoirs may result in negative effects on the productive capacity of habitat related to decreased relative water residence time in the reservoirs and reduced surface area of the reservoirs (Golder 2014). Bigspruce Reservoir experiences the largest range in seasonal water elevations. Facility maintenance (shutdowns) may have localized, temporary effects on fish and fish habitat, for example, variations in downstream water velocity and levels may affect Arctic Grayling spawning habitat; however, an assessment determined that zero flow for a short period of time (less than 18 hrs) did not measurably influence downstream water levels and velocities (Rescan 2000). Backwater effects at all plants provide low risk of death of fish (strandings) from shutdown of plant generation and the direction of water through spillways, however, plant activation and return of water through generating stations may lead to death of fish in the 5B Spillway and Fork Spillway (where there is minimal backwater to offset receding water levels once spillways are closed). A fish habitat survey in 2000 identified Arctic Grayling spawning habitat in the Snare Falls and Snare Forks tailraces and an angling survey revealed an abundant Arctic Grayling population in the Snare Falls Tailrace, approximately 40 years after Snare Falls operations began (Rescan 2000). Furthermore, the relative abundance of species within the Snare River system has remained similar between 1973 and 2000.	**Direction**: Negative **Magnitude**: Negligible for downstream changes related to short duration maintenance shutdowns, and potentially low to moderate under normal operations. **Geographic Extent**: Snare River between Bigspruce Reservoir to Strutt Lake **Frequency and Likelihood**: Infrequent and likely for no-release shutdowns, and continuous and highly likely under normal operations
Fish Populations	Fish entrainment and impingement at intakes and spillway gates	■ Intakes typically positioned at depth in the forebay where fish densities would be relatively low, and may include trash screens (fish screens are not being used). ■ The Snare Rapids 5B spillway is located at the end of an arm off the southern end of Bigspruce Reservoir; the spillway is a stoplog type structure comprising eight openings; water released from the spillway returns to Snare River via a 13 km long waterway, including two small lakes, rejoining the main channel 7.5 km downstream of the Snare Rapids Generating Station. ■ The design at the Snare Falls Spillway includes two gates; whereas Snare Cascades Spillway is a 70 m wide labyrinth spillway, and the Snare Folks Spillway is a long low concrete weir 100 m in length which automatically controls flood discharge.	There are no risks of impingement without fish screens on an intake; however, without fish screens, the risk of entrainment may be higher. Risk of entrainment (and related mortality) at intakes may be very low or negligible where intakes are located at deep areas in the forebay, including Snare Rapids, Snare Falls, and Snare Forks. In contrast to other plants, the Snare Cascades intake is positioned at the downstream end of a confined channel, where velocities may direct fish to the intake. Formal entrainment studies have not been completed. Potential effects of spilling on fish entrainment (and related survival of entrained fish) would be restricted to the period of temporary shutdown; although actual entrainment rates and fates of entrained fish are not known, risk of fish entrainment may be highest on the Snare 5B Spillway where the upstream channel is confined and relatively high velocities during spilling events may direct fish through spillway.	**Direction**: Negative **Magnitude**: Negligible to low for mortality at the intakes during regular operation, but low to moderate through the spillway depending on the timing, duration and frequency of spilling. **Geographic Extent**: Snare River between Bigspruce Reservoir to Strutt Lake **Frequency and Likelihood**: Continuous and unlikely at the intake, and infrequent and likely at the spillway gates

Table 8: Screening-Level Environmental Assessment

Ecosystem Component	Facility Interactions	Mitigation, Design, and Operational Considerations	Potential Residual Effects	Preliminary Assessment Classification
Water Quality and Ecosystem Health	Changes to surface water quality and methylmercury production	▪ NTPC has had a Spill Contingency Plan, reviewed and approved under the water licence. ▪ Water levels in the reservoirs and flows through the generators are regulated by the water licence. ▪ The impacts of lower minimum water levels at Bigspruce Reservoir and Snare Falls have been considered by the WLWB through previous exemptions. ▪ Minimal changes in water levels will reduce the likelihood of increased mercury concentrations caused by inundation events. ▪ Limited amount of non-renewable natural resources are depleted during operation.	Post-impoundment water quality studies of the Snare River system did not suggest large impacts to water quality (Weagle and Cameron 1974; Rescan 2001). An increase of mercury concentration within the tissue of fish was expected due to methylmercury production resulting from flooding events during construction of the four generating stations. Methylmercury levels typically return to normal levels in 20 to 31 years after flooding (Bilodeau et al. 2017). The most recent flooding event occurred in 1996 (27 years ago) during construction of the Snare Cascades GS. All other flooding events occurred over 40 years ago and are methylmercury levels are likely returned to baseline conditions. No ongoing impacts to water quality are expected (no influx of toxins or heavy metals).	**Direction:** Negative **Magnitude**: Negligible to low **Geographic Extent**: Snare River between Bigspruce Reservoir and Snare Folks Forebay **Frequency and Likelihood**: Frequent and unlikely
Wildlife Populations and Wildlife Habitat	Changes to the timing, duration, and frequency of flows, influencing aquatic furbearers	▪ The four reservoirs are kept as close to full as possible under normal operating conditions to maximize generation and water use for generation is matched to flow rates in the system, mimicking the hydraulics of a natural system. ▪ Water levels generally decline over winter as water reserves are used for generation, indicating that muskrat and beaver dwellings are unlikely to be flooded in winter. ▪ Water levels in the reservoirs are maintained year-round, and are regulated through the water licence. ▪ Daily minimum, maximum, and mean forebay levels and water flow rates at each powerhouse and over each spillway are measured and recorded as part of a Surveillance Network Program. ▪ All operations are based on the Facility Operations, Maintenance and Surveillance Manual (NTPC 2022), which includes a Reservoir Operating Report and is regulated by the water licence.	The difference in maximum and minimum water levels in Bigspruce Reservoir is large enough to have possible impacts to muskrat and beaver (4.7 m); whereas the magnitude of impacts would be reduced for other reservoirs where fluctuations in the legislated maximum and minimum daily mean water levels are smaller (e.g., Snare Falls Forebay = 0.6 m change). The timing of the water level changes coincides with natural water levels changes, as reservoir levels at their highest in the fall and declining through the winter, thus mimicking a natural system and avoiding water level increases during the sensitive winter season. The changes are gradual, except when generators must be shut down for mechanical reasons. Residual impacts from initial flooding (>27 years ago) have likely recovered.	**Direction**: Negative **Magnitude**: Low to moderate **Geographic Extent**: Local **Frequency and Likelihood**: continuous and highly likely
	Potential effects to rare, threatened, or endangered species, and their habitat	▪ No further land disturbance is anticipated beyond the requirements of ongoing operation and maintenance of the Facility. ▪ All disturbance will remain within the Facility lease boundaries. ▪ Occasional clearing of vegetation is required within the transmission line corridor. ▪ Hydrogeneration creates little noise (or sensory disturbance), with the exception that some noise is created by flights to and from the Facility, and vehicle traffic on the winter road. ▪ Standard operating procedures are in place to avoid impacts to wildlife during any brushing activities which have been approved under the Snare Land Use Permit.	Species potentially affected include Barren-ground Caribou, Barn Swallow, Common Nighthawk, and Olive-Sided Flycatcher. The majority of works are not expected to impact the habitat, breeding grounds, or livelihood of the wildlife species of conservation concern. Use of winter roads to access site may cause disturbance to caribou; some potential for vehicular collision on the winter roads.	**Direction**: Negative **Magnitude**: Negligible **Geographic Extent**: Vicinity of generating stations and road infrastructure, including winter roads **Frequency and Likelihood**: Infrequent and likely
	Land disturbance and disturbance of vegetation	▪ No further land disturbance is anticipated beyond the requirements of ongoing operation and maintenance of the Facility. ▪ All disturbance will remain within the Facility lease boundaries. ▪ Occasional clearing of vegetation is required within the transmission line corridor. ▪ Small camp with an approved Waste Management Plan. ▪ Standard operating procedures are in place to avoid impacts to wildlife during any brushing activities which have been approved under the Snare Land Use Permit.	No residual effects since the construction of the Facility. Wildlife habitat and ecosystem composition has remained undisturbed.	**Direction**: Neutral **Magnitude**: Not applicable **Geographic Extent**: Not applicable **Frequency and Likelihood**: Not applicable

Table 8: Screening-Level Environmental Assessment

Ecosystem Component	Facility Interactions	Mitigation, Design, and Operational Considerations	Potential Residual Effects	Preliminary Assessment Classification
Noise, Air and Atmosphere	Power generation	▪ Few non-renewable natural resources are depleted during operation. ▪ The Facility provides reliable, low greenhouse gas emission power to the North Slave Electrical System. ▪ Hydrogeneration creates little noise, with the exception that some noise is created by flights to and from the Facility, and vehicle traffic on the winter road. ▪ Operation of the Facility reduces reliance on the diesel generators at the Jackfish Power Facility, reducing noise pollution and greenhouse gas emissions.	The facility has low greenhouse gases, and offsets diesel generation that causes much higher greenhouse gas emissions. Operation of the Facility creates some noise, but offsets noise caused by diesel generators.	**Direction**: Positive **Magnitude**: Moderate to High **Geographic Extent**: Regional **Frequency and Likelihood**: continuous and highly likely
Social, Economics, and Culture	Changes to social and economic variables	▪ On-going service to NWT communities, providing improved quality of life, business opportunities and long-term revenues. ▪ Continued operation of the Facility such that planning/zoning changes are not required. ▪ No increase in urban facilities or services used. ▪ No damage to property incurred during operations.	Long-term cost-effective power generation improves quality of life for NWT residents: ▪ Cost-efficient and continuous source of electricity for Yellowknife. ▪ No human health hazards. ▪ Recreational use of water or aesthetic quality remain unchanged. ▪ Water use for other purposes remain unaffected. ▪ Some impacts to local fishing opportunities.	**Direction**: Positive **Magnitude**: Moderate **Geographic Extent:** Regional **Frequency and Likelihood**: Frequent and likely
	Influence on cultural and heritage components important to NWT communities	▪ Presence and effect to historic property were assessed by archeological surveys conducted in the lease area. ▪ Limited activity or noise created from ongoing operations, all operational and maintenance work will remain within the existing lease area. ▪ No further land disturbance is anticipated beyond the requirements of ongoing operation and maintenance of the Facility. ▪ Minimum flow rates within the Snare River must be maintained.	There may be some impacts to a culturally important and aesthetically pleasing area and historic traditional trail due to construction of the Facility, but there are no additional impacts anticipated due to continued operation.	**Direction**: Neutral **Magnitude**: Not applicable **Geographic Extent**: Not applicable **Frequency and Likelihood**: Not applicable

6.0 SUMMARY OF RESIDUAL EFFECTS

The Facility provides a reliable source of renewable electricity for the communities of Behchokǫ̀, Dettah, N’Dilo, and the City of Yellowknife. The aquatic environment in the Snare River, and the observed and potential impacts of the current and future operations of the Facility are described in this document.

In summary, the incremental construction of the four generating stations at the Facility (1948, 1961, 1975, and 1996) has led to localized effects to the surrounding environment with some minor effects that may extend beyond the outer extents of the lease area. However, wildlife and fish populations that occur at the Facility today are those with self-sustaining characteristics that reflect the current conditions of landscape and watershed. Previously conducted monitoring at the Facility identified a resilient Arctic Grayling population in the Snare Falls Tailrace, approximately 40 years into operation since the construction of the Snare Falls generating station. In addition, the species composition within the Snare River system has not measurably changed between 1973 and 2000, suggesting that the populations that persist today have adapted to the regulated flow regime.

The flow regime under normal operations is guided by maximum and minimum reservoir water levels and downstream minimum flows defined in the current and previous water licences to manage impacts to the aquatic environment. These minimum flows and shutdown times were assessed and developed through previous environmental assessments; as reflected in the desktop study by Golder (2014) and the previous exemptions to minimum water levels by the WLWB (2005, 2015, 2023), the incremental impact of any proposed changes to minimum water levels at Bigspruce Reservoir and Snare Falls are not anticipated to cause significant impacts to the Snare River ecosystem.

The Facility also has the potential for fish entrainment, as recorded at other hydropower facilities, where stress, injury, and mortality of entrained fish can result from contact with the turbines, and extreme and rapid changes in pressure (Barnthouse 2013; Algera et al. 2020). However, the likelihood of fish entrainment at the intakes or spillways and the magnitude of residual effects on fish survival have not been assessed and are not known. It is proposed that the entrainment potential at the plant intakes may be low for fish populations, depending on the location of the intake and the surrounding habitat conditions at the location of intake, but that the entrainment potential may be higher during spilling events, and as such, the frequency and duration of those events would dictate the magnitude of the impact on populations. Specifically, risks of entrainment (and related mortality of entrained fish) may be highest during a spilling event at the Snare 5B Spillway where the upstream channel is confined and relatively high velocities during spilling events may direct fish through spillway. The fate of these fish is unknown.

The impacts of inundation from the construction of a dam on mercury in fish vary over time, first rapidly increasing following impoundment and then gradually decreasing. As the Snare Rapids, Snare Falls and Snare Forks generating stations were all constructed more than 31 years ago, residual effects of inundation on fish tissue mercury concentrations are expected to be negligible in magnitude. As the Snare Cascades generating station was constructed in 1996 (i.e., 27 years ago at the time of writing in 2023), low magnitude residual effects may remain for some piscivorous species in the Snare Cascades reservoir.

The Facility reduces greenhouse gas emissions for the North Slave Electrical System as the Snare Facility replaces generation that would otherwise be provided by diesel generation from the Jackfish facility. Reducing greenhouse emissions is a goal of all levels of government in Canada and is one of the key goals of the Government of the Northwest Territories 2030 NWT Climate Change Strategic Framework, 2019-2023 Climate Change Action Plan, 2030 Energy Strategy and the 2022-2025 Energy Action Plan.

The continued operation of the Facility is not anticipated to result in a significant adverse impact on the environment. Further, the Facility provides many positive benefits to the Northwest Territories through the provision of locally produced renewable energy which reduces the North Slave Electrical Systems reliance on diesel generation and contributions to the local economy through employment and contracts.

Signature Page

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