NORTHWEST TERRITORIES POWER CORPORATION
Empowering Communities
Health, Safety, & Environment, 4 Capital Drive, Hay River, NT X0E 1G2

April 2022

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Taltson Hydro Overhaul- Environmental Impacts Assessment Summary

Hello Shannon,

The Northwest Territories Power Corporation (NTPC) owns and operates the Taltson Hydroelectric Facility (Taltson Hydro), located 56 km northeast of Fort Smith, Northwest Territories within the Taltson River watershed. Taltson Hydro was built in 1965 and is the main source of power to the South Slave communities of Enterprise, Fort Resolution, Fort Smith, Hay River and K'atlodeeche First Nation. Taltson Hydro operates under the Mackenzie Valley Land and Water Board (MVLWB) Type A Water Licence (WL) MV2011L4-0002

In 2023 NTPC plans to complete the refurbishment of the turbine and generator within the generating plant at Taltson Hydro which is regulated by Type A WL MV2011L4-0002. As required by MV2011L4-0002 *Part G: Conditions Applying to Modifications.* The details of the refurbishment of the turbine are presented in the *Taltson Overhaul Scope Summary for Regulatory Submission.* This letter has been prepared to summarise the environmental impacts assessments for the project. The Taltson Facility and tailrace is presented in Figures 1 and 2.

Overview

Taltson Hydro completes a 2-3 week shutdown every summer for annual maintenance. The overhaul shutdown will occur from Mid-April until Mid-October. The 2021 flow data is presented in the Taltson Hydro Annual Water Licence Report- MV2011L4-0002. In 2021 the flow through the plant was only an average of 6% of the total flow around the facility. When the plant shuts down the water is directed through the South Valley Spillway. Due to a legacy design a section of the tailrace below the plant dewaters when the plant is shutdown. The tailrace is the only location that will be impacted by the overhaul shutdown. NTPC completes detailed environmental monitoring as required by the Taltson Aquatic Effects Monitoring Plan (AEMP). The scope of the monitoring plan is not impacted by the overhaul shutdown and the plan will continue to be implemented as approved.

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Figure 1

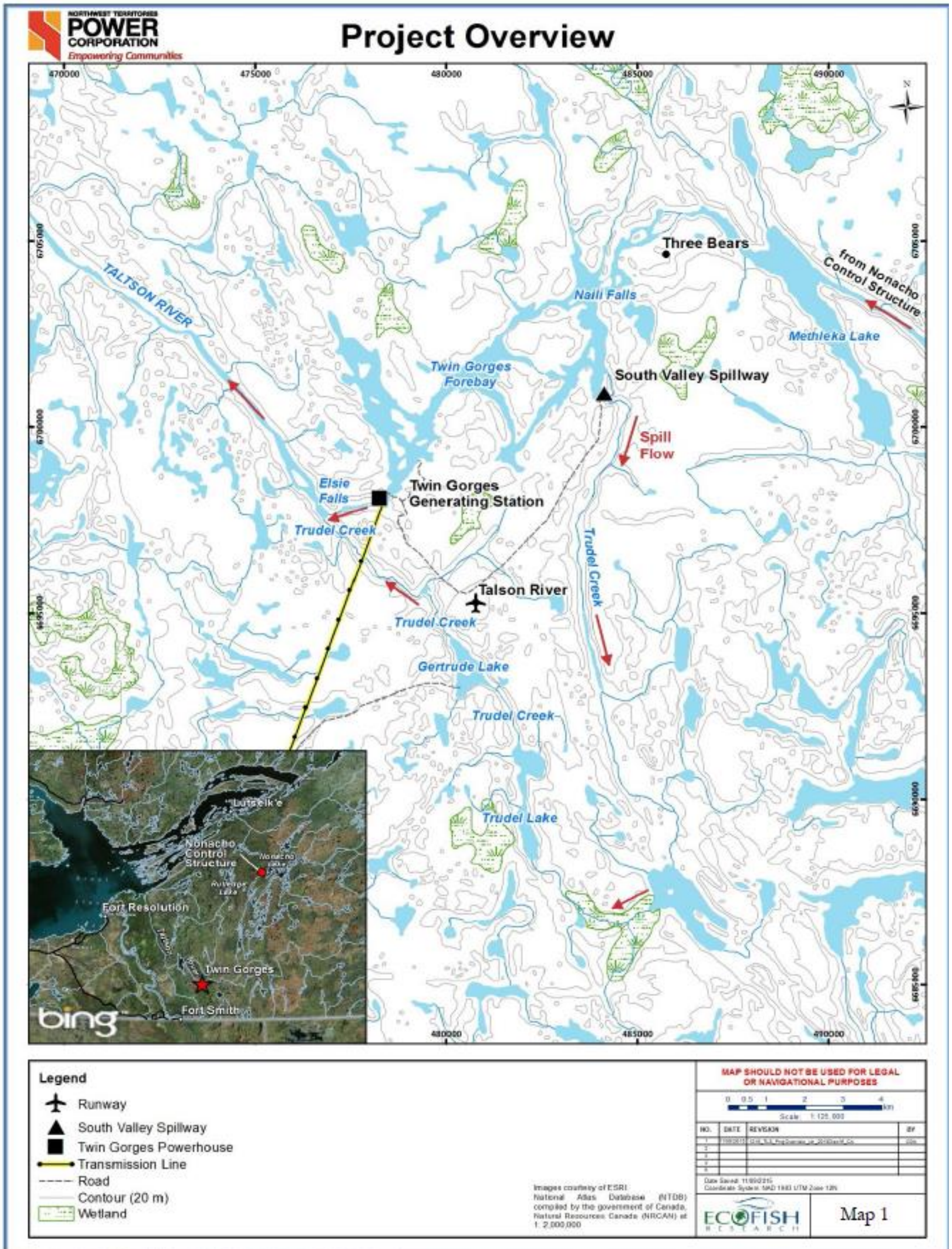

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Figure 2

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Furbearing Mammals

Under the previous water licence for Taltson Hydro NTPC developed and completed a Water Effects Monitoring Program (WEMP) that included monitoring and assessment of fur-bearing mammal use and habitat in the Taltson basin and any impacts from operations.

Past fur-bearing assessments are presented on the registry for water licence N1L4-0154. No fur-bearing mammal use was ever noted in the tailrace area below the facility between the facility and the confluence with the South Valley Spillway/Taltson River as it is not suitable habitat with steep canyon walls and rock faces. As such the overhaul shutdown have no impact on furbearing mammals in this area as there are no fur-bearing mammals use in the areas that are dewatered.

Fur-bearing mammal use was noted in the forebay during past monitoring completed under the WEMP. As such NTPC completed an assessment of the environmental implications of the water level changes in the Forebay Reservoir from the extended overhaul shutdown for furbearing semi-aquatic mammals that may be residing in lodges or burrows on the shoreline of the Forebay Reservoir. This Technical Memo is included in Appendix A. this investigation found that the impacts to fur-bearing mammals in the forebay are negligible to minimal given the very small increase in water level in the forebay that the shutdown results in (average of 35-56cm).

Fisheries Aquatic Habitat

Detailed flow data is reported annually under Taltson Hydro Annual Water Licence Report-MV2011L4-0002. The flow through the South Valley Spillway varies widely based on flow through the system. In 2021 flow ranged from 146 cms to 842cms through the South Valley Spillway. Given this wide variation in flow and the minimal amount of flow that goes through the plant (6% average) the additional flow added to the South Valley Spillway during a shutdown is negligible in comparison to the natural variations in flow this area experiences and as such any impacts to aquatic habitat in the South Valley Spillway from the overhaul shutdown are negligible. This determination is supported by past monitoring reports completed under the WEMP for N1L4-0154 and the AEMP for MV2011L4-0002.

Due to a legacy design the annual maintenance shutdown at Taltson result in the dewatering of 700 m of riverbed in the spillway which results in fish stranding mortalities. NTPC has been in close communication with Fisheries and Oceans Canada (DFO) on this issue since 2012. Through stakeholder engagement, NTPC identified several measures to improve fish habitat to offset fish mortalities. NTPC applied to DFO in 2018 for a Fisheries Act Authorization (FAA) to continue operations while enhancing fish habitat to offset fish mortalities. DFO issued FAA 18-HCAA-01487 for the annual Taltson shutdown in August 2020 and NTPC is implementing the required offsetting measures which include a habitat installation project at Bluefish Hydro in 2021 and a Walleye Spawning Study in 2022 for the Little Buffalo River and Slave River.

NTPC has been engaged with DFO since early 2021 on what is required under FAA 18-HCAA-01487 for the overhaul shutdown. NTPC completed an assessment of the potential impact to fisheries in the tailrace area and Elsie Lake. This document is included in Appendix B for reference for the MVLWB but DFO is the lead regulator for this file. NTPC is gathering further data during the 2022 shutdown on Elise Lake to determine if the overhaul shutdown will result in an increase or decrease in fish mortality and will submit an FAA amendment to DFO in the fall of 2022 for the overhaul shutdown. The FAA amendment will involve stakeholder engagement for which the MVLWB will be included in the process.

If you have any questions regarding or if there is any further information we can provide please contact me at mmiller@ntpc.com.

Sincerely,

Matthew Miller, M.Sc., P.Eng.
Senior Environmental Licensing Specialist
Northwest Territories Power Corporation

April 2022

Appendix A- Taltson Overhaul Furbearing Assessment Memo

TECHNICAL MEMORANDUM

DATE August 17, 2021 **Project No.** CX21466504-TM-001-Rev0

TO Matthew Miller, M.Sc., P.Eng.
Northwest Territories Power Corporation

FROM Ross Phillips, Damian Panayi, and Cameron Stevens **EMAIL** ross_phillips@golder.com

DESKTOP ASSESSMENT OF TALTSON SHUTDOWN ON FURBEARING SEMI-AQUATIC MAMMALS

Summary

This memo provided an investigation into the magnitude of water level increase from the planned shutdown and the potential effect on food caches and lodge occupancy for muskrat and beaver in the Forebay Reservoir at Taltson Hydroelectric Facility. Although the shutdown events may occur during ice covered conditions when risks of mortality from lodge displacement may be highest, the calculated water fluctuations of 0.14 to 0.21 m are anticipated to have minor effects on beaver and muskrat during late winter and early spring. While these changes may occur more rapidly than natural water level changes, they remain less than the average water level changes through the season, and would be offset by low water levels in late winter / early spring when the lodge is most resilient to flooding. It was also assumed that the study species have evolved behavioural responses that account for natural water fluctuations for the long-term persistence of populations. In conclusion, the implications of water level changes in the Forebay Reservoir from extended shutdowns are not significant for furbearing semi-aquatic mammals that may be residing in lodges or burrows in the area.

Introduction

The Taltson Hydroelectric Facility is an 18 megawatt (MW) facility located within the Taltson River watershed 56 km northeast of Fort Smith in the Northwest Territories. It includes the Twin Gorges Generating Station (the Generating Station), the Twin Gorges Forebay Reservoir (the Forebay Reservoir) and the South Valley Spillway. Outflow from the Forebay Reservoir follows through the Generating Station and the South Valley Spillway, an uncontrolled spillway also on the Forebay Reservoir located 6 km upstream of the Generating Station. The South Valley Spillway has been continuously spilling since the closure of the Pine Point Mine in 1986. When the Twin Gorges Generating Station is not operational (i.e., during shutdown periods), the Forebay Reservoir Elevation rises to the elevation required to pass all flows from the Taltson River through the South Valley Spillway alone.

The objective of this memorandum is to assess the environmental implications of the water level changes in the Forebay Reservoir from extended shutdowns at the Taltson Hydroelectric Facility for furbearing semi-aquatic mammals that may be residing in lodges or burrows on the shoreline of the Forebay Reservoir (e.g., muskrat [*Ondatra zibethicus*], beaver [*Castor canadensis*]). This involved an investigation into the magnitude of water level increase and the potential effect on food caches and lodge occupancy for muskrat and beaver in the Forebay Reservoir. Assuming the earliest the shutdown would occur under late winter to early spring conditions, the proposed shutdown event has the potential to overlap with ice covered conditions when there is risk of mortality from lodge displacement. In other words, a water level increase outside the normal (or typical) range of water levels during the late winter to early spring period would potentially result in a measurable effect on local populations of muskrat and beaver. Potential effects are also discussed with consideration of species life history and adaptive capacities to environmental change.

Shutdown Effects on Forebay Water Levels

The effect of shutdowns on Forebay Reservoir water levels was established based on review of a memorandum discussing changes in Forebay Reservoir water level change during shutdowns (Grabke 2020), analysis of rating curves, and analysis of historic hydrometric data from the Taltson Hydroelectric Facility (NTPC 2021).

Grabke (2020) estimated the increase in Forebay Reservoir water elevations during a plant shutdown depending on the pre-shutdown Forebay Reservoir elevation and the power generation rate (i.e., plant load) prior to shutdown. The approach adopted by Grabke (2020) uses the outflow rating curve of the South Valley Spillway to estimate the increased water levels associated with increased conveyance through the South Valley Spillway during a shutdown when the Generating Station is not operational. This method did not consider shutdown duration and assumed a steady state condition where flows remain relatively unchanged during the shutdown.

The increase in water surface elevation required to convey flow of the Taltson River through the South Valley Spillway during a shutdown can be determined by the vertical distance between the rating curve for combined flows, including both the South Valley Spillway and the Generating Station, and the rating curve for the South Valley Spillway alone. Rating curves for the South Valley Spillway (Figure 1) were based on the weir equation for the South Valley Spillway presented by Grabke (2020) and the rating curve for combined flow based on hydrometric monitoring data for the year 2020 (NTPC 2021). The year 2020 was selected because of the relatively high range of water surface elevation and flows observed in 2020. The absolute change in water surface elevation during a shutdown is expected to be lowest under low flow conditions, which are typically observed in late winter / early spring, and increase with increasing flow as the snow melts during the freshet period.

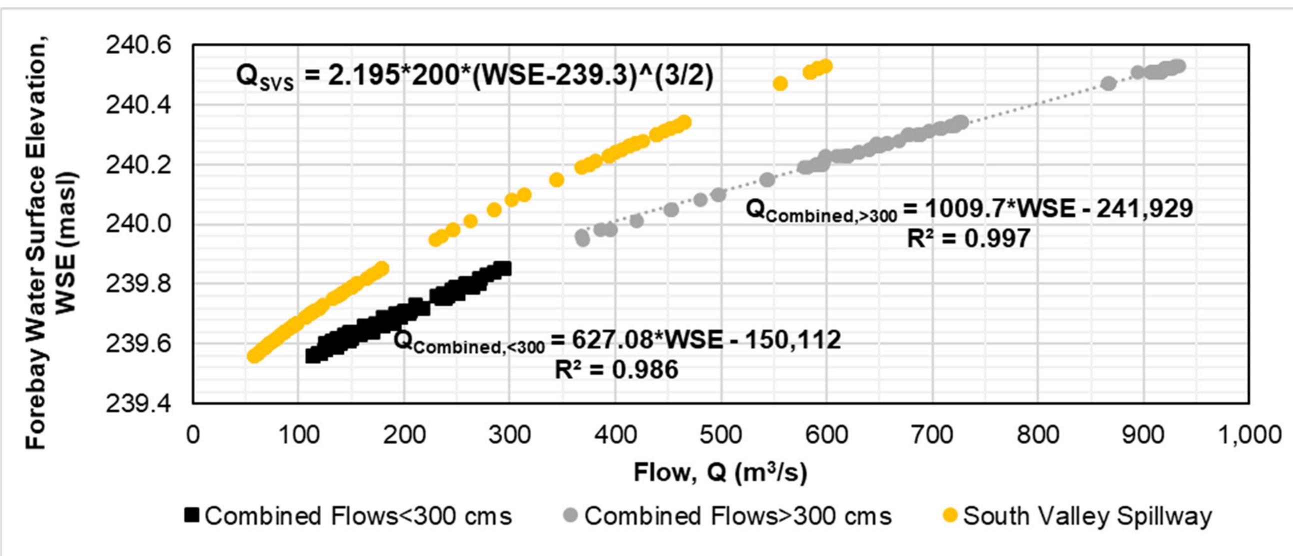

Figure 1: Rating Curves for Combined Flows (Generating Station and South Valley Spillway) as well as the South Valley Spillway (SVS)

Golder reviewed historic hydrometric data (NTPC 2021) to establish Forebay Reservoir water level dynamics over the historical period as well as during historic shutdowns. The reviewed hydrometric dataset consisted of continuous daily data from 1987 to 2020 for Forebay Reservoir water level, Tailrace water level, Taltson Generating Station Plant flow, and South Valley Spillway flow. “Discrete shutdown events” were identified in the historical record as those with zero flow through the Generating Station when all flow from the Taltson River was conveyed by the South Valley Spillway. Fluctuations in water level and flow in the historical record (1987 to 2020) are summarized in Table 1.

Table 1: Summary of Historical Monthly Flow and Forebay Reservoir Water Surface Elevation (1987 to 2020; NTPC [2021])

Month	Total Flow (m^3/s)	Forebay Reservoir WSE (masl)		
	Average	Minimum	Average	Maximum
January	202	239.32	239.72	240.51
February	186	239.32	239.69	240.07
March	153	239.32	239.63	240.22
April	115	239.35	239.56	239.92
May	165	239.35	239.66	240.15
June	264	239.43	239.83	240.32
July	298	239.46	239.89	240.34
August	280	239.51	239.87	240.34
September	263	239.45	239.83	240.52
October	257	239.35	239.81	240.53
November	243	239.39	239.79	240.29
December	223	239.44	239.75	240.14

m^3/s = cubic metres per second; masl = metres above mean sea level

Seasonal fluctuations in Forebay Reservoir water level were assessed for all years in the historical record between 1987 and 2020 with results summarized in Table 2. The analysis focused on the annual range, increase from late winter water levels in response to spring freshet, and the decrease in water levels during winter recession. Under average conditions, water levels increase 0.40 m in response to spring freshet, decrease 0.35 m over winter from October to late April, and have an annual range of 0.56 m. The seasonal fluctuations presented in Table 2 include historical shutdown periods. However, because historical shutdowns have not typically occurred at seasonal extremes, the seasonal fluctuations presented are not sensitive to the inclusion of historical shutdowns.

Table 2: Summary of Historical Seasonal Forebay Water Level Fluctuations (1987 to 2020; NTPC [2021])

Period	Change in Water Level (m)		
	Minimum	Average	Maximum
Annual Range	0.19	0.56	1.09
Spring Freshet Increase	0.16	0.40	0.74
Fall to Late Winter Recession	0.01	0.35	0.97

A total of 42 shutdowns have occurred over the 33 year period of record, seven of which had a duration of only one day. The median shutdown duration was seven days, typically in August. There have only been two historic shutdowns that lasted more than one month. Changes in Forebay Reservoir water level as a function of antecedent Generating Station flow are presented on Figure 2.

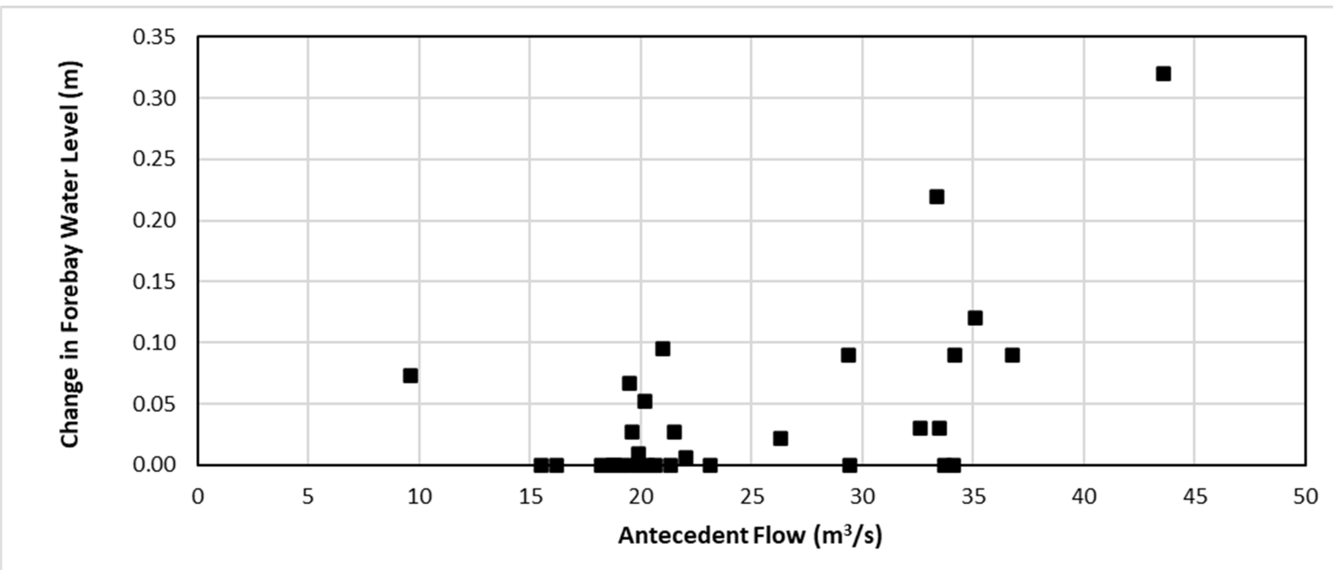

Figure 2: Change in Forebay Reservoir Level as a Function of Antecedent Combined Flow (Generating Station and South Valley Spillway)

Characteristics of historical shutdowns can be summarized as follows:

- Historical increases during shutdowns have been less than 0.32 m with an average of 0.03 m.
- The median shutdown duration was seven days with 17% of shutdown events lasting only one day.
- Almost half (48%) of the historical shutdowns caused no increase in Forebay Reservoir water level.
- The duration of Forebay Reservoir water level increases was temporary with water levels returning to pre-shutdown conditions over a period less than one week following Generating Station start-up.
- The highest increase during a shutdown, which occurred in 1987, is considered an outlier for the purposes of this assessment. During that event, increase in Forebay Reservoir WSE was the result of coincident increases in total Taltson River discharge rather than the shutdown.

The magnitude of change in Forebay Reservoir water level associated with a shutdown is expected to vary according to the magnitude of total flow passing through the system that can fluctuate seasonally. The water level increase would be approximately 0.14 m if the shutdown occurred during late winter (i.e., April) and 0.21 m if the shutdown occurred in mid-summer under average conditions.

For the purposes of evaluating effects on semi-aquatic mammals and aquatic habitat, the Forebay Reservoir water level change during a shutdown can be approximated as 0.14 to 0.21 m under normal hydrological conditions. Therefore, the expected change in water level during a shutdown is less than the typical seasonal variation in water level (0.56 m), and when combined with a typical increase in water level during the spring freshet (0.40 m), remains similar to the typical seasonal variation (Table 2).

Potential Effects of Water Level Increases on Muskrat and Beaver

Semi-aquatic mammals that have been previously recorded in the Forebay Reservoir include both beaver and muskrat. The area immediately above the dam at Twin Gorges was described by a large number of bays, many of which contain marshes, providing moderate to good beaver habitat (Rescan 2000). Both beaver and muskrat were monitored in the Taltson River, including the Forebay Reservoir, during 2001 and 2003 under water licence N1L4-0154 (Rescan 2006). Previous monitoring recorded four active beaver lodges in 2000, resulting in a density of 0.18 lodges per linear km of shoreline surveyed (Rescan 2000). A similar density was recorded in the Forebay Reservoir in 2003 (Rescan 2004). There were also five muskrat pushups (i.e., feeding/resting areas) observed in the Forebay Reservoir in 2001, resulting in a density of 0.225 pushups per km of shoreline surveyed (Rescan 2001).

Although the Forebay Reservoir can provide habitat for both beaver and muskrat, the shoreline supports relatively low densities of animals. For reference, the densities of beaver lodges in Hanging Ice Lake (immediately upstream of the Taltson River system) are over three times higher than densities in the Forebay Reservoir (Rescan 2000), and the densities of muskrat pushups in Hanging Ice Lake are approximately two times higher than those in the Forebay Reservoir (Rescan 2001).

Both species 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 foraging (Bellrose and Brown 1941; Clark 1994). Beavers also prefer twigs and leaves of aspens and poplars (*Populus* spp.) and willows (*Salix* spp.), whereas muskrats primarily consume the roots and stems of hydrophytic plants (e.g., cattail, water lily [*Nymphaea* spp.], horsetail [*Equisetum* spp.]) (Willner et al. 1980).

It is assumed that the study species have evolved behaviours that account for natural water fluctuations in ponds and lakes. For example, a study in Minnesota suggested that beaver are tolerant of annual water level fluctuations of up to 1.5 m (Smith and Peterson 1991), which is almost three-times the average annual change of 0.56 m in the Forebay Reservoir (Table 2). However, water level fluctuations have the potential to negatively impact muskrat and beaver populations by causing 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).

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 generally 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. Furthermore, recognizing that water levels recede during the winter, the predicted water level increases of 0.14 to 0.21 m in the Forebay Reservoir during spring are not anticipated to be large enough to flood burrows or lodges (Table 2). The predicted changes are also well under the maximum annual range of water level changes in the Forebay Reservoir (1.09 m).

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. However, the flooding in the Forebay Reservoir is not expected to wash away or display food caches beyond the range of daily movements of resident beaver and muskrat.

The classification of effects from water level fluctuations in the Forebay Reservoir is provided in Table 3.

Table 3: Classification of Effects from Water Level Fluctuations in the Forebay Reservoir.

Direction	Magnitude	Geographic Extent	Duration/ Reversibility	Frequency	Likelihood of Occurrence
Negative impacts to food caches and the occupancy of lodges and burrows, particularly if ice is present.	Minor: Changes in water levels are more rapid than under natural conditions, but less than natural average annual fluctuations, including spring freshet period	Forebay Reservoir	Short-term/ Reversible: ▪ Forebay Reservoir water level increases last only as long as the duration of the Generator shut down, with some lag time; median shutdown duration is seven days	Infrequent: ▪ A total of 42 shutdowns have occurred over the 33 year period of record ▪ Shutdowns occur annually for routine maintenance	Unlikely ▪ Low likelihood of food caches being washed away, leading to decreased survival ▪ Low likelihood of negative effects on muskrat and beaver occupancy from damage or flooding to dwellings

CLOSURE

Thank you for the opportunity to assist NTPC with this issue. Please contact the undersigned if you have any questions related to this assessment.

Please be aware that Golder has been acquired by and is now a Member of the WSP family of companies. Golder remains as a legal entity and is the proposed contracting entity for this proposal. We are in the process of integrating the resources of our companies. Correspondence for this proposal should continue to be addressed to the undersigned.

Golder Associates Ltd.

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Water Resources Engineer

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Associate, Project Manager

Reviewed by:

Cameron Stevens, M.Sc., Ph.D., P.Biol.
Associate, Project Manager

RP/DP/CS/dh

https://golderassociates.sharepoint.com/sites/146923/project files/6 deliverables/02_taltson memo/rev0/cx21466504-tm-001-rev0_taltson forebay_wl_mammals.docx

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April 2022

Appendix B- Taltson Overhaul Fisheries Assessment Memo

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MEMORANDUM

TO: Matt Miller, P.Eng., Northwest Territories Power Corporation

FROM: Sean Faulkner, M.Sc., R.P.Bio., Steve Nicholl, B.Sc., R.P.Bio., and Jon Abell, Ph.D., E.P., Ecofish Research Ltd.

DATE: August 6, 2021

FILE: 1219-15

RE: Taltson Overhaul – Shutdown Death of Fish and HADD Estimation

1. INTRODUCTION

Northwest Territories Power Corporation (NTPC) is planning to conduct an extended shutdown (April to October) and commissioning of the Taltson Twin Gorges Generating Station (the Station) to facilitate overhaul of the generating equipment. The timing, duration, and frequency (i.e., number of shutdowns) are different than what has been included in the current *Fisheries Act* Authorization (FAA; 18-HCAA01487; DFO 2020), and NTPC has confirmed through engagement with Fisheries and Oceans Canada (DFO) that an amendment to the FAA will be required. This memorandum builds on the large body of data that NTPC has gathered on the study area and annual shutdowns to provide an estimate of fish mortality; an assessment of the potential for harmful alteration, disruption or destruction (HADD) of fish habitat; a summary of potential mitigation measures for consideration; and an estimate of residual effects (i.e., those that remain following application of mitigation) in relation to death of fish and HADD from the proposed shutdown and commissioning activities. Recommendations for additional data collection to reduce uncertainties in the assessment are also provided. The overhaul shutdown was initially planned to occur in 2022 but the project was delayed in 2021 and the timeline for the project is still be determined.

2. BACKGROUND

2.1. Station Description

The Station is an 18 MW hydroelectric facility located within the Taltson River watershed, ~56 km northeast of Fort Smith in the Northwest Territories (Map 1). The Station runs at ~50% capacity and is the sole source of power, with the exception of back up diesel generators, to the South Slave communities of Hay River, K'atlodeeche First Nation, Fort Smith, Fort Resolution and Enterprise. The Station was built in 1965 to supply electricity to the Pine Point Mine and has operated under multiple Water Licences issued under the Northern *Inland Waters Act,* later superseded by the *Northwest Territories Water Act*. The Station has no all-season road or water access and is accessed only by air using the airstrip, by landing on the Twin Gorges Reservoir, or via a winter road that is built intermittently as required by major projects at the site (CG 2007).

The Station consists of the following main features (Figure 1, Map 1):

- Main dam above the Twin Gorges Generating Station (285 m long, max. 25 m high);
- Twin Gorges Forebay (the Forebay);
- Concrete intake structure (~4 – 13 m deep) located at the southwest corner of the Forebay;
- A buried 4.9-m-diameter steel penstock beginning ~20 m downstream of the intake structure;
- Surge tank located upstream of the penstock connection to the powerhouse;
- Powerhouse (18 MW capacity) with a single, Francis-type turbine;
- Substation and transmission line;
- South Valley Spillway (200 m long) draining into Trudel Creek 6 km northeast of the plant; and
- Nonacho Lake Control Structure and Spillway 160 km northeast of the plant.

The main dam is located ~1.5 km upstream of the confluence of the Taltson River and Trudel Creek (Figure 1). The South Valley Spillway (SVS) is an uncontrolled spillway on the Forebay Reservoir that is located 6 km upstream of the Station. The SVS has been continuously spilling since the closure of the Pine Point Mine in 1986. Elsie Falls, which is located ~300 m upstream of the confluence of the Taltson River and Trudel Creek and ~1,300 m downstream of the main dam, is a barrier to upstream fish passage in the tailrace downstream of the Station (Dezé 2009, Faulkner *et al.* 2017). Further details of the Station are provided in Faulkner *et al.* (2018).

2.1. Description of the Aquatic Environment

2.1.1. Fish Habitat

The study area considered in this assessment extends from the powerhouse downstream to Elsie Falls at the outlet of Elsie Lake and downstream to the confluence with Trudel Creek (referred to as the tailrace section; Figure 1). This area has been studied in detail as part of the mitigation, preparation, and application process for the existing *Fisheries Act* Authorization 18-HCAA01487. The Twin Gorges dam above the powerhouse is a complete obstruction to upstream fish passage for all species and life stages present in the tailrace. Field measurements and desktop analysis suggest that fish entrainment is likely occurring through the unscreened intake at the dam, but the magnitude of entrainment is low (Faulkner *et al.* 2017).

Elsie Falls was assessed to be impassable to upstream fish migration through field assessment, but the falls would not provide a barrier to downstream movement (Faulkner *et al.* 2018, Faulkner *et al.* 2017).

The impassability of Elsie Falls, combined with the presence of large numbers of young-of-year (YOY) of small-bodied fish species, and the lack of large-bodied species such as Walleye (*Sander vitreus*), provide evidence that the fish community in Elsie Lake is isolated and not maintained by upstream migration, though the fish community may be minimally supported by a low level of recruitment of fish entrained through the powerhouse from the Forebay upstream.

Above Elsie Falls the tailrace section is 985 m long and varies between ~25 – 125 m in width, depending on the location. The habitat within the tailrace section is composed of riffles, runs and pools with adequate depths, velocities, cover and substrate (e.g., gravel, cobble, boulder and fines) required for all observed fish species to carry out all life processes (Faulkner *et al.* 2017; Figure 2 and Figure 3). Elsie Lake is 311 m long and has a surface area of ~32,524 m^2. The name "Elsie Lake" is informal and is applied to the widest section of the tailrace that maintains residual water following a shutdown. The depth of Elsie Lake is unknown; however, the depth appears sufficient to provide critical refuge, overwintering and rearing habitat. Below Elsie Falls to the confluence with Trudel Creek is 330 m long with 7,431 m^2 of wetted habitat largely comprised of entrenched bedrock.

2.1.2. Fish Community

The fish community present in the tailrace upstream of Elsie Falls prior to construction of the Station in 1965 is unknown. However, fish stranding and mortality monitoring between 2014 and 2018 during the annual maintenance shutdowns (Faulkner *et al.* 2015a, Faulkner *et al.* 2016a, Faulkner *et al.* 2016b, Buchanan *et al.* 2017, Parsamanesh *et al.* 2018) detected 10 species in the tailrace section:

- Burbot (*Lota lota*);
- Slimy Sculpin (*Cottus cognatus*);
- Longnose Sucker (*Catostomus catostomus*);
- White Sucker (*Catostomus commersoni*);
- Lake Whitefish (*Coregonus clupeaformis*);
- Ninespine Stickleback (*Pungitius pungitius*);
- Northern Pike (*Esox lucius*);
- Trout Perch (*Percopsis omiscomaycus*);
- Yellow Perch (*Perca flavescens*); and
- Pearl Dace (*Margariscus margarita*).

In total, 31,674 fish have been salvaged in the tailrace upstream of Elsie Lake through stranding searches and salvage efforts between 2014 and 2018. The most common fish species captured were

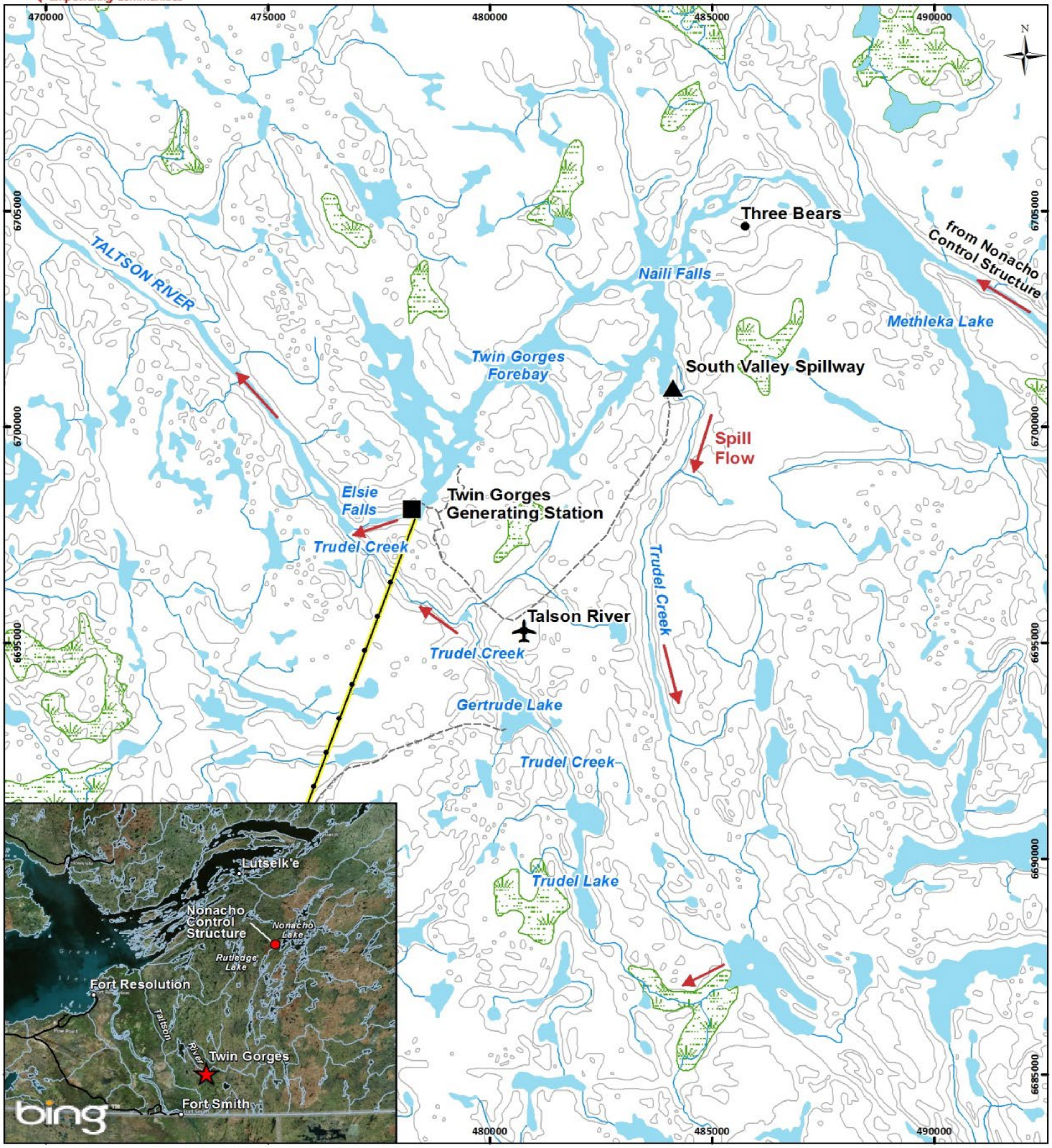
Longnose Sucker (70.4%), Slimy Sculpin (25.3%), Ninespine Stickleback (3.5%), Burbot (0.5%), Trout-perch (0.2%) and Yellow Perch (0.1%) which represented >99.9% of all captures.

Other fish species that could potentially enter the tailrace upstream of Elsie Falls from upstream (via entrainment) include Lake Trout (*Salvelinus namaycush*), Walleye, and Cisco (*Coregonus artedi*) (CG 2009, Rescan 2005); however, these species were not detected in within the tailrace above Elsie Falls between 2014 and 2018, despite the presence of suitable habitat. Walleye have also been detected in the area below Elsie Falls upstream of the confluence with Trudel Creek (Faulkner *et al.* 2017).

The evidence presented in Faulkner *et al.* (2018) supports the hypothesis that fish in the tailrace above Elsie Falls are part of resident self-sustaining populations for several reasons:

- Estimated risk of entrainment is low, based on desktop analysis and physical measurements (Buchanan *et al.* 2016). Although entrainment of larvae and YOY is possible if they are present at the intake, the life history and behaviour of the fish species found in the tailrace do not support recruitment from upstream populations as a key source of recruitment;
- Impassable barrier to upstream fish migration at Elsie Falls;
- Different fish community in the tailrace compared to upstream of the dam and downstream of Elsie Falls (e.g., Walleye and Lake Trout absent);
- Adequate habitat to support all life-history stages of the species present in the tailrace (e.g., rearing, spawning, overwintering);
- Persistence of a fish community of high density despite the occurrence of mortality in the tailrace during annual shutdowns for maintenance and unplanned outages since the Station was built in 1965 (Faulkner *et al.* 2017); and
- Based on the migration behaviours of the most common species (i.e., Longnose Sucker, Slimy Sculpin, and Ninespine Stickleback) and the persistence of large numbers of fish within the tailrace, the downstream movement/loss of fish over Elsie Falls is expected to be low (Faulkner *et al.* 2017, Faulkner *et al.* 2018).

Project Overview



Legend

- Runway
- South Valley Spillway
- Twin Gorges Powerhouse
- Transmission Line
- Road
- Contour (20 m)
- Wetland

Images courtesy of ESRI.
National Atlas Database (NTDB) compiled by the government of Canada, Natural Resources Canada (NRCAN) at 1: 2,000,000

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 0.5 1 2 3 4 km
Scale: 1:125,000

NO.	DATE	REVISION	BY
1	11/09/2015	1219_TLS_ProjOverview_Ltr_2013Dec16_CA	CGA
2			
3			
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Date Saved: 11/09/2015
Coordinate System: NAD 1983 UTM Zone 12N

ECOFISH RESEARCH

Map 1

Path: M:\Projects-Active\1219_Taltson\MXD\Overview\1219_TLS_ProjOverview_Ltr_2013Dec16_CA.mxd

Figure 1. Taltson Twin Gorges Generating Station Facility Layout.

Figure 2. Tailrace section looking downstream towards Elsie Lake. Photograph taken on August 14, 2016.

Figure 3. Tailrace section above Elsie Lake looking upstream towards the powerhouse. Photograph taken on August 14, 2016.

2.1.3. Hydrology

The Station is the only source of power for the South Slave region and is operated in direct response to the real-time power demand within the region. The operating regime of the station has changed since construction, from near-capacity, to seasonally variable, to consistently below capacity. When the Pine Point Mine was operational, the Station was running near capacity (18 MW) with operating flows of 86 m^3/s or more (data from 1987, Figure 4) (Buchanan *et al.* 2016). Between the mine closure and the institution of the Water Effects Monitoring Program (WEMP) (1989 – 1998; FSC 1999), average operating flows ranged from 40 – 45 m^3/s in the winter and 30 – 35 m^3/s in the summer (Figure 4). The seasonal pattern apparent in Figure 4 reflects higher energy demands in the serviced communities during the winter months. However, data from individual years indicate that there are spikes in discharge (up to 50 – 75 m^3/s) with brief maintenance shutdowns occurring in the summer (i.e., June, July, or August). After 1999, power flows became more consistent and were slightly lower than in previous years (Figure 4). During this time, average discharge in winter ranged from 23 – 35 m^3/s and dropped to ~20 – 25 m^3/s in summer, while maximum discharge in individual years was 27.9 m^3/s in summer and 46.4 m^3/s in winter. Brief maintenance shutdowns still occurred in the summer, as occurred between 2012 and 2016 (Figure 5).

Figure 4. Discharge from the Twin Gorges Generating Station between 1987 and 2012. Data from grouped years are average values with shutdowns removed. Data from 1987 are raw (from Buchanan *et al.* 2016).

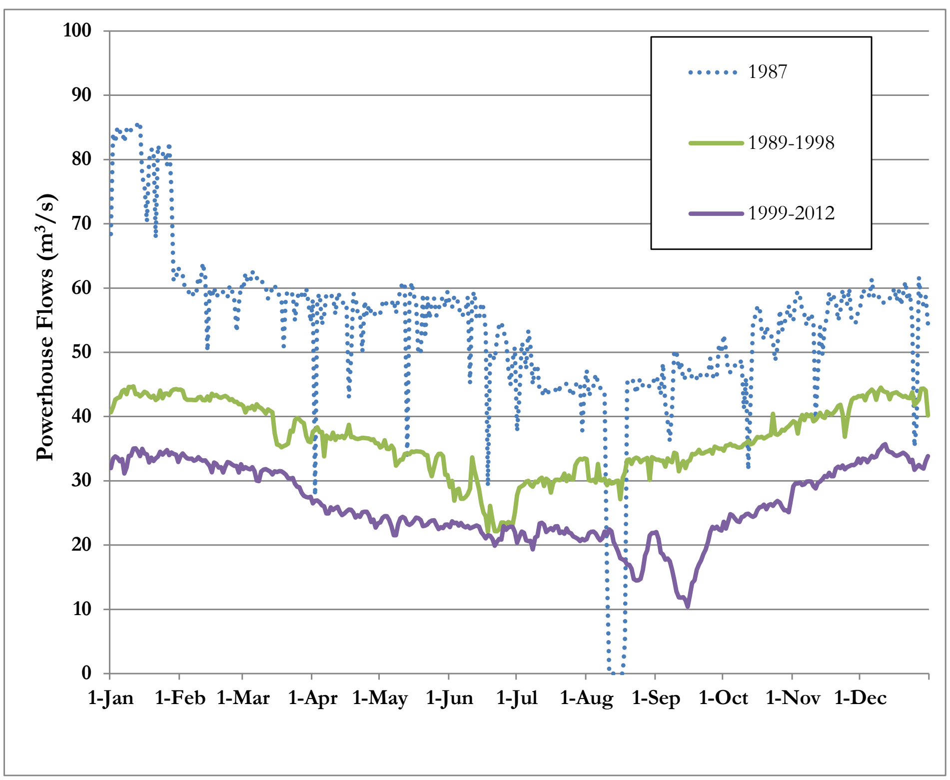
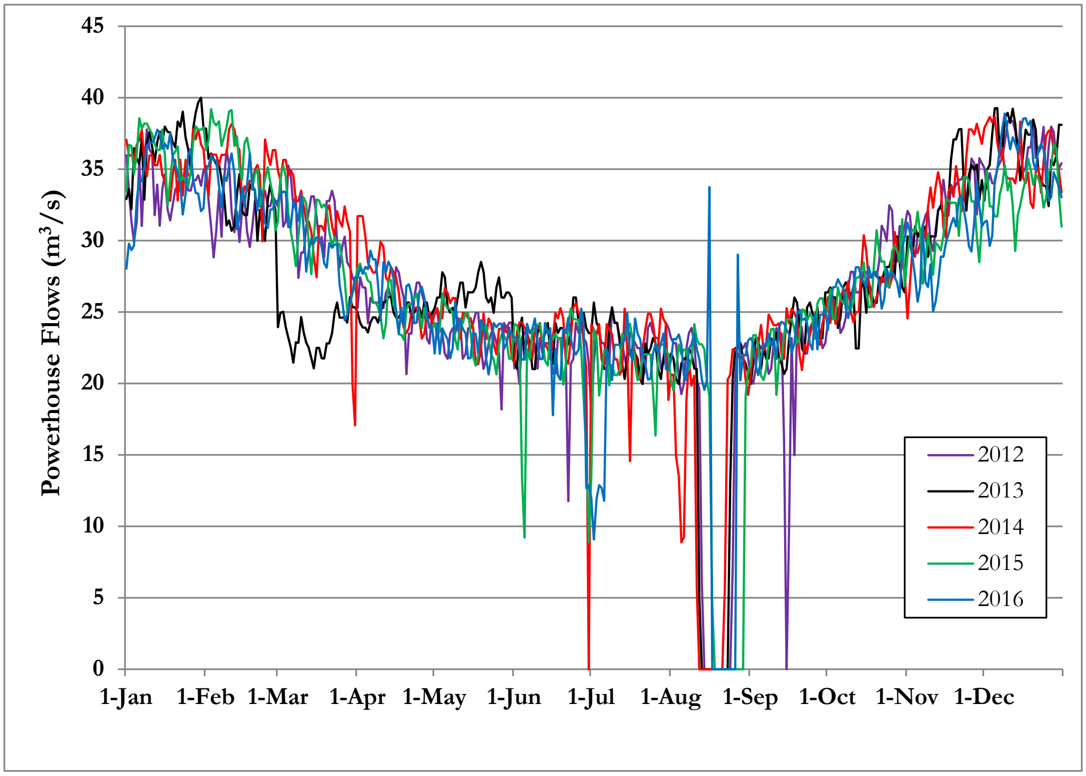


Figure 5. Raw discharge data from the Twin Gorges Generating Station for years between 2012 and 2016.



2.2. Shutdown Description

An FAA (18-HCAA01487) was previously issued for annual maintenance shutdowns. Information to support the application including a list of all previous submissions is provided in Faulkner *et al.* (2018). Annual maintenance and inspection of the turbine and draft tube area is essential to ensure reliable power for the communities of the South Slave region and requires a temporary shutdown of the powerhouse for roughly 2 weeks every summer. Due to a legacy of the design during the original construction of the facility, the annual maintenance shutdown results in the dewatering of the Taltson River below the plant upstream of Elsie Lake.

The work(s), undertaking(s), or activity(ies) associated with the FAA (18-HCAA01487) included:

> "*Annual powerhouse shutdown during the summer for a period of approximately 2 to 3 weeks, resulting in the stranding of fish in the tailrace below the generating station and Elsie Falls.*"

The FAA authorized:

> "*Death of fish as a result of stranding resulting in a loss of approximately 420 kilograms/year (kg/yr) of Age 1 equivalents, that does not include any aquatic species at risk listed under Species at Risk Act and species listed in the Aquatic Invasive Species Regulations.*"

The proposed overhaul will require a shutdown from approximately April 13 to September 20, and multiple commissioning tests will be required from September 20 to October 11. These wet commissioning activities are expected to require intermittent flow releases over three weeks when there are expected to be at least 13 events where flows are ceased in the tailrace for wet commissioning activities for Litostroj Engineering and may include up to four additional tests by NTPC as part of operator training (Miller, pers. comm. 2021). These intermittent flow releases are estimated to vary in length from 0.5 hours to 18 hours for wet commissioning activities, and between 2 hours and one week for operator training. Flow releases prior to stoppage will range up to approximately 66 m^3/s (Litostroj Engineering 2020).

Overall, the overhaul shutdown timing and duration differs from that included in the FAA (18-HCAA01487). The change in timing will affect the life stages present in the dewatered section, while the increase in duration may lead to additional dewatering and water quality degradation not previously assessed. The commissioning activities will lead to multiple wetting and subsequent dewatering events in the tailrace habitat, which could pose additional risk to fish above that considered in the existing FAA.

3. POTENTIAL EFFECTS TO FISH AND FISH HABITAT

3.1. Assessment Methods and Scope

The *Fisheries Act* prohibits the death of fish by means other than fishing (hereafter referred to as the death of fish), and the harmful alteration, disruption or destruction of fish habitat (HADD). The potential changes in death of fish and HADD relative to those authorized under the current FAA (18-HCAA01487) are assessed below.

The potential for harm to fish within the tailrace during the extended shutdown necessary for the overhaul was assessed by evaluating relevant DFO Pathways of Effects (PoE; DFO 2018) in the context of the existing assessment of the annual shutdown (Faulkner *et al.* 2018), details of proposed activities, and available information about the fish community and habitats in the tailrace.

It was determined that the shutdown and commissioning have the potential to cause:

- *Mortality of fish due to Stranding/Isolation* - Based on the monitoring conducted in 2014 through 2018, maintenance shutdowns result in stranding mortality of fish present in the tailrace.

- *Reduction in the Quality and Quantity of Fish Habitat* – Shutdowns temporarily reduce habitat availability and quality in the tailrace.

Key differences between the overhaul activities (shutdown and commissioning) and the scope of the existing FAA that authorizes death of fish are:

- The change in the timing of the shutdown will change estimates of mortality, relative to those included in the current FAA. Notably, YOY of most species will not be present at the start of shutdown in April, reducing risk of stranding of YOY.
- The increase in duration of the shutdown may lead to residual pools that contain fish to dewater or be subject to water quality deterioration leading to mortality. Mortality due to these mechanisms is not expected to have occurred during previous annual shutdowns of two to three weeks duration.
- The increase in duration of the shutdown may lead to deterioration of water quality in Elsie Lake, which could cause additional mortality.
- Commissioning activities will lead to short term wetting and dewatering of the tailrace, where fish could colonize and be subjected to stranding.

The duration of the shutdown may also lead to additional HADD that could reduce fisheries productivity:

- Reduction of rearing habitat in the tailrace above Elsie Falls; and
- Reduction of spawning habitat in the tailrace above Elsie Falls for spring/summer spawning fish species.
- Deterioration of water quality in Elsie Lake; and
- Reduction in food production for fish in Elsie Lake.

Flow and habitat changes in Trudel Creek have not been considered in this assessment. Increased flow in Trudel Creek during the shutdown period may lead to increases in habitat but may also lead to increases in sediment transport, which is being assessed under the Sediment and Erosion Management Plan (NTPC 2012).

3.2. Death of Fish

3.2.1. Shutdown and Dewatering of Tailrace

Death of fish was estimated for the annual shutdowns based on Age-1 equivalents, which was included in the current FAA (18-HCAA01487; see Faulkner *et al.* 2018 for further detail). This estimate of fish mortality was based on DFO input and considered the six most abundant species, which accounted for 99.9% of the salvaged fish recorded. The death of fish included in the current FAA includes 420 kg

Age-1 equivalents, included 402 kg Age-1 equivalents estimated in Faulkner *et al.* (2018) and increased by ~4% to account for salvage not being conducted in future years. To account for an April shutdown, the YOY for spring/summer spawning fish were removed from the estimate (Table 1). The estimated death of fish following the proposed April shutdown salvage is ~404 kg of Age-1 equivalents (a reduction of ~14 kg estimated in Faulkner *et al.* (2018) and ~16 kg from the value of 420 kg/yr authorized in the current FAA). This approach assumes similar use of the tailrace habitat above Elsie Lake in April as was detected in August; however, this may overestimate the effect if Elsie Lake is preferred overwintering/early spring habitat (e.g., because it is deeper).

The extended duration of the shutdown may lead to additional mortality in the three residual pools (3,685 m^2) that otherwise sustain fish during the approximately 2–3 week shutdown in the summer that is typically conducted annually (Map 2 and Map 3). Without mitigation, and assuming these pools are not adequately sustained by groundwater/hyporheic flows, additional mortality could occur due to water quality alteration or predation, regardless of whether the pools fully dewater. Assuming that these pools provide "critical risk[1]" habitat and the same methods in Faulkner *et al.* (2018) and removal of spring spawning YOY discussed above, an additional 92.6 kg of Age-1 Equivalent mortality may occur. However, monitoring and salvage of these residual pool habitats are proposed to mitigate this additional mortality (see Section 4.1). There is also uncertainty in habitat connection and maintenance of sufficient water quality to support fish in the tailrace area below Elsie Falls. This area should be assessed further to assess connectivity and habitat availability to confirm whether this area is expected to support fish during the overhaul shutdown.

[1] Critical Risk habitat was defined as habitat areas with low gradient with a large percentage of gravel and cobble substrate that typically included isolated pools that were the last areas that held water after the shutdown event (Faulkner *et al.* 2016a).

Table 1. **Estimated fish mortality in Age-1 Equivalents from current FAA shutdown and an April shutdown at the Taltson Facility due to an extended shutdown.**

Scenario	Species	Age-1 Equivalents							
		YOY		Juvenile		Adult		Total	
		#	kg	#	kg	#	kg	#	kg
Current FAA	Burbot	8	0.1	267	3.2	0	0.0	274	3.3
	Slimy Sculpin	1,849	2.4	23,543	30.2	133,674	171.5	159,066	204.0
	Longnose Sucker	428	11.5	6,066	162.8	324	8.7	6,818	182.9
	Ninespine Stickleback	88	0.0	1,820	1.0	4,937	2.7	6,845	3.7
	Trout-perch	0	0.0	335	0.2	4,833	3.6	5,168	3.8
	Pearl Dace	0	0.0	20	0.1	987	4.1	1,007	4.2
	Subtotal	2,373	14.0	32,050	197.5	144,755	190.6	179,178	402.1
	Total With Salvage Removal Adjustment (4%)							**186,345**	**418.2**
Overhaul Shutdown	Burbot	8	0.1	267	3.2	0	0.0	274	3.3
	Slimy Sculpin	0	0.0	23,543	30.2	133,674	171.5	157,217	201.7
	Longnose Sucker	0	0.0	6,066	162.8	324	8.7	6,389	171.5
	Ninespine Stickleback	0	0.0	1,820	1.0	4,937	2.7	6,757	3.7
	Trout-perch	0	0.0	335	0.2	4,833	3.6	5,168	3.8
	Pearl Dace	0	0.0	20	0.1	987	4.1	1,007	4.2
	Subtotal	8	0.1	32,050	197.5	144,755	190.6	176,813	388.2
	Total With Salvage Removal Adjustment (4%)							**183,886**	**403.7**
Difference Between Scenarios								**-2,460**	**-14.4**

3.2.2. Commissioning Activities

Wet commissioning activities will result in at least 17 wetting and subsequent dewatering events from September 21 to October 5 or 11, plus three contingency tests may also be reasonably expected (Lapointe, pers. comm. 2021; Table 2). The dates of the specific tests may vary and will depend on the success of each test. NTPC has tentatively proposed two options for operator training, anticipated to be October 4 and 5 (Option 1), or October 4 and 11 (Option 2); Miller, pers. comm. 2021). These intermittent flow releases will vary in duration from <1 hour to up to approximately 18 hours for Option 1, or up to approximately one week (168 hours) for Option 2. Flow releases prior to the shutdown will range from approximately <1 m^3/s to 66 m^3/s (Table 2). These commissioning activities may pose a stranding risk to fish in the tailrace upstream of Elsie Lake; however, this risk is reduced compared to that of a typical annual shutdown, given the limited time that fish will have to access the habitat that will be dewatered. The colonization of the tailrace upstream of Elsie Lake prior to dewatering will depend on swimming ability, abundance of the fish in Elsie Lake, and motivation for them to move upstream.

Given the short wetted history (i.e., <18 hours) and limited opportunity for fish to colonize following all events except NTPC operator training under Option 2, the estimated mortality from these activities would be expected to be much lower than an annual shutdown (Table 1). Further, the cumulative nature of the activities may further reduce expected mortality due to conditioning (Irvine *et al.* 2009, Nagrodski *et al.* 2012), similar to the pulse flow mitigation used for the annual shutdown (NTPC 2020). With these considerations, an estimated mortality of 10% of a typical annual shutdown may be appropriate (~42 kg Age-1 equivalents) to account for all commissioning activities with wetted histories less than 18 hours.

Stranding risk under Option 2 with a wetted history of up to 168 hours would be higher as this release would provide more opportunity for fish to colonize the habitat above Elsie Lake and subsequently by stranded. However, the estimated mortality would still be expected to be much lower than an annual shutdown given the wetted history of the annual shutdown is approximately one year. Overall, an estimated mortality of 25% of a typical annual shutdown may be appropriate (~101 kg Age-1 equivalents) to estimate potential effects from the Option 2 shutdown.

There is uncertainty in these estimates, but they may provide a precautionary estimate of death of fish from commissioning activities and operator training. Despite this uncertainty, given the expected low numbers of fish that may colonize and strand under Option 1 and all but one event under Option 2, monitoring and salvage will be used to effectively mitigate this potential effect. Furthermore, an adaptive approach is recommended to adjust monitoring and salvage effort depending on levels of stranding observed in the initial shutdowns (e.g., changing duration or timing of releases if high mortality is found; see Section 4.1.2).

Following the overhaul, the minimum flow expected to be released by the Station is anticipated to be 11.1 m^3/s (Litostroj Engineering 2020), less than the ~20 m^3/s that was estimated to be released at minimum operations (0.113 MW) prior to a typical annual shutdown (Faulkner *et al.* 2018). While ~20 m^3/s was found to keep the majority of stranding sensitive habitat wetted based on visual inspection during annual shutdowns, there may be an increase in stranding risk as flows drop to 11.1 m^3/s, if stranding sensitive habitat is exposed. Based on the two-dimensional hydrodynamic model used to assess flow release mitigation from the South Gorge, a 10 m^3/s flow release from the South Gorge is estimated to maintain wetting of ~93% of the habitat below the residual pool below the South Gorge confluence compared to a baseflow of 37.2 m^3/s. Furthermore, such a 10 m^3/s flow release is estimated to maintain complete wetting of critical and high-risk stranding habitats in this area (calculations based on Bayly *et al.* 2018). Modelling has not been conducted above the South Gorge confluence; however, similar dewatering may be expected in the area above the South Gorge confluence if the release were through the powerhouse. The estimated 7% dewatering from a flow reduction from 37.2 m^3/s to 10 m^3/s, and maintenance of wetting of critical habitats suggests the incremental effect of operating at 11.1 m^3/s compared to ~20 m^3/s will be small. This potential effect will need to be assessed through monitoring and modelling and may require monitoring during long term regular operations and annual shutdowns.

Table 2. Proposed wet commissioning activity table for the Taltson Twin Gorges Generating Station.

Test Phase	Proposed Date	Task ID	Task Name	Power (MW)	Unit Speed Prior to Stoppage	Flow Prior to Stoppage (m^3/s)	Duration of Flow Release Prior to Stoppage (hours)	Pulse Flow Planned	Lockout Planned	Likelihood of Fish Colonization	Fish Salvage Recommended
Litostroj Commissioning	21-Sep	4	First rotation (Bump test)	0	5%	<1	0.5	No	No	Low	No
	21-Sep	7	Unit stop (Initial run)	0	100	11.1	6	Yes	Yes	Low	Yes
	22-Sep	10	Unit stop (Balancing)	0	100	11.1	6	Yes	Yes	Low	Yes
	23-Sep	14	Unit stop (Overspeed verification)	0	125	12.5	12	Yes	No	Low	Yes
	24-Sep	20	Unit stop (Governor Tuning)	0	100	11.1	12	Yes	No	Low	TBD
	25-Sep	23	Unit stop (Excitation Tuning)	0	100	11.1	12	Yes	No	Low	TBD
	26-Sep	25	Unit stop (Sequence Testing)	0	100	11.1	12	Yes	No	Low	TBD
	27-Sep	27	Unit stop (Fake Synchronization)	0	100	11.1	12	Yes	Yes	Low	Yes
	TBD	n/a	Contingency	0	100	11.1	12	Yes	No	Low	TBD
	TBD	n/a	Contingency	0	100	11.1	12	Yes	No	Low	TBD
	TBD	n/a	Contingency	0	100	11.1	12	Yes	No	Low	TBD
	29-Sep	35	25% Load rejection	4.5	100	25.5	12	Yes	No	Low	TBD
	30-Sep	41	50% Load rejection	9	100	40	12	Yes	No	Low	TBD
	01-Oct	45	75% Load rejection	13.5	100	55	12	Yes	No	Low	TBD
	02-Oct	51	100% Load rejection	18	100	66	18	Yes	No	Low	TBD
	03-Oct	54	100% Load rejection (Trip)	18	100	66	12	Yes	Yes	Low	Yes
NTPC/GHD Testing	04-Oct	A	Operator Training 1	18	100	66	14	Yes	Yes	Low	TBD
	04-Oct	B	Operator Training 1	18	100	66	2	Yes	Yes	Low	TBD
Option 1	05-Oct	C	Operator Training 2	18	100	66	16	Yes	Yes	Low	TBD
	05-Oct	D	Operator Training 2	18	100	66	2	Yes	Yes	Low	TBD
Option 2	11-Oct	C	Operator Training 2	18	100	66	168	Yes	Yes	High	TBD
	11-Oct	D	Operator Training 2	18	100	66	2	Yes	Yes	Low	TBD

3.3. HADD

3.3.1. Disruption of Spawning and Rearing Habitat in Tailrace Above Elsie Lake

A disruption in habitat area will occur in the tailrace due to the extended overhaul shutdown. Under typical operations, the wetted area from the powerhouse to the confluence of Trudel Creek totals 69,025 m^2, which comprises 29,070 m^2 of habitat between the powerhouse and Elsie Lake, 32,524 m^2 of habitat in Elsie Lake, and 7,431 m^2 of habitat below Elsie Falls (Map 2). During the overhaul shutdown, it is estimated that this area is reduced to 36,309 m^2, no habitat remaining between the powerhouse and Elsie Lake (this conservatively assumes that 3,685 m^2 of residual pool habitat remaining during the annual shutdowns will not support fish), 30,049 m^2 of habitat in Elsie Lake, and 6,260 m^2 of habitat below Elsie Falls (Map 3). This represents a total reduction of 47% in habitat area (a reduction of ~32,716 m^2), and a 100% reduction in lotic habitat area (a reduction of ~29,670 m^2). This reduction in wetted area will lead to disruption of spawning and rearing habitat for the fish species present in the tailrace that may lead to a reduction in fisheries productivity. This loss estimate is based on observations during a typical annual shutdown, additional loss of habitat area may occur over the extended overhaul shutdown due evaporation or seepage of water from Elsie Lake, which are not included in these estimates.

The fish species present in the tailrace above Elsie Falls are likely to spawn and rear in Elsie Lake, based on knowledge of habitat use by the species assumed present (Table 3). Furthermore, of the ten species identified in the tailrace, all species except for Yellow Perch and Pearl Dace were captured in lake habitats sampled during fish use assessment monitoring in 2019 (Thornton *et al*. 2020), indicating that the fish community is generally adapted to lake habitats in the region. Thus, the disruption of habitat is expected to have limited effect on fisheries productivity. The disruption of rearing habitat in the tailrace above Elsie Lake is also accounted for in the death of fish described in Section 3.2.1. This death of fish of Age-1 equivalents due to dewatering provides an indication of fish that are rearing in this habitat during the growing season, which are already being offset in the current FAA.

Although we expect that fish species residing in Elsie Lake are adapted to and beneficially use the lotic habitats present the quantity and quality of spawning habitat is unknown and may be limited given the small size and overriding influence of the river inflow. If spring spawning fish that typically spawn in the area above Elsie Lake cannot effectively spawn in Elsie Lake during the shutdown there may be a disruption to productivity. However, this potential effect would only occur on a single year of recruitment and if it occurs, may be offset by compensatory growth of older age classes due to less competition. A conservative approach to account for this uncertainty is to assume a spawning habitat loss for spring spawning fish in the dewatered section area above Elsie Lake. The estimated Age-1 equivalents for YOY for spring spawners during the annual shutdown provides an estimate of the abundance of fish that may be affected. Based on this assumption, reduction in spawning habitat may lead to the loss of an additional ~14 kg of Age-1 equivalents (equal to the current FAA YOY Age-1 equivalents; Table 1). This approach would not account for YOY that are not detected in the dewatered section during the annual shutdown but conversely does not account for effective spawning in the lake habitat during the overhaul shutdown.

Table 3. Summary of fish species present in the Taltson tailrace and typical habitat use.

Fish Species	Relative Abundance in Salvage Records (%)	Life Stages Present	Rearing Habitat [1]		Spawning Habitat [1]		Spawning Period
			Type	Description	Type	Description	
Longnose Sucker	70.4	YOY, juvenile, adult	Lotic/lentic	Fry generally prefer shallow low velocity habitat. As the fish mature they typically move to deeper habitat but still prefer low velocity areas.	Lotic/lentic	Spawning generally occurs in streams over gravel in moderate currents, however some populations spawn in shallow water along lakeshores	May/June
Slimy Sculpin	25.3	YOY, juvenile, adult	Lotic/lentic	Most age classes prefer substrate consisting of coarse gravel and cobble. Adults prefer moderate velocity water in rivers and streams; however, younger age classes are typically found in slower moving water than adults. In lakes, this species typically inhabits the littoral zone.	Lotic/lentic	Spawns in lakes and streams, typically lays eggs under a flat rock	May/June
Ninespine Stickleback	3.5	YOY, juvenile, adult	Lotic/lentic	Habitat preference is highly variable, ranging from low velocity habitats in rivers and streams with large amounts of instream vegetation, to open water habitat in lakes and rivers with submergent and emergent vegetation	Lentic	Typically spawn in lakes on a variety of substrates (mud to rocky)	Late May to July
Burbot	0.5	YOY, juvenile, adult	Lotic/lentic	Habitat use by fry and juveniles can vary substantially. Fry can inhabit shoals, but as they mature they typically occupy benthic habitats. Adult Burbot typically occupy deep water habitat and rarely enter water <2 m deep.	Lotic/lentic	Spawn in lakes and streams	Winter to early Spring
Trout-perch	0.2	Juvenile, Adult	Lotic/lentic	Typically prefer habitat consiting of shallow slow moving water with soft substrate, submergent, and emergent vegetation.	Lotic/lentic	Spawn in shallow water over sand and gravel beaches (<1 m depth)	Spring to fall
Yellow Perch	0.1	Juvenile, Adult	Lotic/lentic	Generally prefer lake habitat; however, the species also inhabits rivers and streams. Generally found in the littoral zone in areas with submergent and emergent vegetation.	Lotic/lentic	Spawning typically occurs in littoral areas containing vegetation and woody debris, although spawning can occur over other substrates.	Spring to fall
Lake Whitefish	0.03	YOY, juvenile	Lotic/lentic	Can be found in lake and river habitats. Are known to occupy all areas of lake habitats; however, individuals typically move to deeper water as temperatures increase during the summer	Lotic/lentic	Spawning occurs in shallow shoals to depths of up to 30 m over various substrate types	Fall

Table 3. Continued (2 of 2).

Fish Species	Relative Abundance in Salvage Records (%)	Life Stages Present	Rearing Habitat [1]		Spawning Habitat [1]		Spawning Period
			Type	Description	Type	Description	
Northern Pike	0.02	Juvenile	Lotic/lentic	Pike typically prefer lake or low velocity river habitat focused on shallow areas with submergent and emergent vegetation and available cover; however, juveniles have been found in fast flowing habitat.	Lotic/lentic	Spawn in lakes and streams, typically in shallow water with large amounts of vegetation	May/June
Pearl Dace	0.01	Juvenile, adult	Lotic/lentic	Generally found in slow moving rivers or streams or in the shallow areas of small lakes with a preference of soft bottom habitat with submergent and emergent vegetation	Lotic/lentic	Spawn in shallow water with sand or gravel substrate	May/June
White Sucker	0.01	Adult	Lotic/lentic	Generally found in slow moving rivers or streams, or in the shallow areas of small lakes. The species has a preference for soft bottom habitat with submergent and emergent vegetation.	Lotic/lentic	Spawn in lakes and streams, typically over gravel substrate	May/June
Walleye	Not detected	Not detected	Lotic/lentic	Can be found in lake and river habitats; however, the species generally prefers low velocity habitats in relatively shallow water with submergent and	Lotic/lentic	Spawning in rivers typically occurs over gravel and cobble substrate while lake spawning typically occurs on shallow shoals	May/June
Lake Trout	Not detected	Not detected	Lentic	Are generally found throughout the water column but often move to deeper water as lakes stratify to find cooler temperatures	Lentic	Spawning typically occurs in cobbles and boulders with interstitial spaces at depths ranging from 5 to 50 m; however, spawning has been reported to occur at depths of <1 m	Fall

[1] Rearing and spawning habitat descriptions adapted from McPhail (2007); see McPhail (2007) for primary sources

3.3.2. Degradation of Water Temperature/Quality in Elsie Lake

3.3.2.1. Overview

The approximate five-month shutdown will cause inflow to Elsie Lake to cease, with the exceptions of small ephemeral surface inflows following rainfall events (if rainfall events of sufficient magnitude occur) and hyporheic/groundwater/dam seepage inflows (unknown). This change will cause Elsie Lake to temporarily transition from a rapidly flushed system to a lentic waterbody. Furthermore, Elsie Lake will become shallower: post-shutdown, the depth of Elsie Lake is expected to decline by a minimum of 0.38 m based on the depth of the lake measured at the bedrock hydraulic control at Elsie Falls (Faulkner *et al.* 2017, Faulkner *et al.* 2018), with further reduction in depth expected through the summer due to evaporation. Effects due to changes to water quality/temperature in Elsie Lake are not considered in the current FAA (18-HCAA01487) because the shorter duration of the routine annual shutdown (~2 weeks) is not associated with adverse water quality/temperature effects. However, these physical changes associated with a longer shutdown have potential to change water quality and water temperature, which could adversely alter fish habitat (DFO 2010).

Only limited data are available to assess the potential for water quality/temperature changes; accordingly, the assessment provided here is primarily qualitative and recommendations are provided in Section 6 for further data collection to support a more detailed assessment. A summary of all residual effects is presented in Section 5.3.

3.3.2.2. Water Temperature

After shutdown in April, Elsie Lake will become isolated from the Forebay, which is the main control of water temperature in Elsie Lake during normal operations. Isolation from the Forebay is expected to cause changes to water temperatures, relative to a scenario of no shutdown, or shorter duration shutdown. Two scenario of temperature change are considered possible:

1. The shutdown may result in a reduction in temperature in Elsie Lake, due to greater influence of groundwater inflows, which are expected to be cooler than water withdrawn from the Forebay. The shading provided by the walls of the gorge may also contribute to cooling relative to the Forebay.
2. Alternatively, increased temperatures may occur due to a smaller lake volume (and thus more efficient transfer of heat across the atmosphere–water interface relative to the Forebay) and greater thermal stability (and thus greater warming of isolated surface waters).

Should reduction in temperature occur (scenario 1), the magnitude of cooling is anticipated to be minor and not pose risk of harm to the fish community, given the optimum water temperatures of the fish species present (Table 4), and the timing of the shutdown during the warmest period of the year. Alternatively, increases in water temperature (scenario 2) could result in temperatures increasing beyond the range of baseline conditions and may pose greater risk fish. Accordingly, the assessment below focuses on the potential for warmer maximum temperatures following the shutdown.

The maximum water temperature that may occur in Elsie Lake during a shutdown is uncertain. For context, on August 24, 2019, the surface temperature in the Forebay was approximately 16°C (Thornton *et al.* 2020), which would be reflective of the maximum temperature during operational conditions that year in Elsie Lake, given that the measurement was collected in late summer, and that conditions in Elsie Lake are controlled by discharge of water via the surface water intake in the Forebay (intake depth ~4 – 13 m; Section 2.1). Shortly after a shutdown, a water temperature measurement of 19°C was collected at Elsie Lake on August 13, 2018. During the same shutdown, a surface water temperature measurement of 19°C was taken in the South Gorge Pond on August 12, 2018 (data sourced from Ecofish files). The South Gorge Pond was located adjacent to the Station and was fed by a small flow of seepage through the dam and had an outlet flow that was visually estimated at a few litres per second when assessed on August 12, 2018. Limited warming had therefore occurred in the isolated pond during the short shutdown, despite the pond that was sampled being smaller than Elsie Lake and appearing shallower.

Further spot measurements of up to 20°C were collected near Elsie Lake during August 2014 prior to the operational shutdown (and 22°C in Trudel Creek), suggesting water temperatures in Elsie Lake may be higher than those measured in the South Gorge Pond in August of 2018. Elsewhere, a study of 17 boreal lakes at similar latitudes (60.3-67.1 °N) recorded spot measurements of surface temperatures in July of 17.0–23.0°C (Pienitz *et al.* 1997). The lakes studied had a maximum depth of 3.0-49.0 m, with the warmest temperature (23.0°C) measured in a relatively shallow lake (maximum depth = 5.5 m) at a higher latitude (62.11°N) than Elsie Lake (60.42°N). For further context, a maximum temperature of approximately 23°C seems plausible based on evaluation of regional climate data: based on Environment Canada statistics for Fort Smith (~56 km to the southwest), the highest daily average temperature of 17.0°C occurs in July, when the average daily maximum temperature is 23.3°C (Environment Canada 2021[2]).

Temperature monitoring during an annual maintenance shutdown would help to better understand how water temperature will change in Elsie Lake following a shutdown. Nonetheless, the information summarized above indicates that a peak water temperature of approximately 20°C to 23°C may be experienced in Elsie Lake during the summer of the overhaul; should this occur, fish mortality is not predicted based on the tolerances of the fish community present. This increase in temperature would further exceed the optimal growth temperatures for some species (Ninespine Stickleback, Burbot, and Lake Whitefish), but would be closer to the optimum temperature for others (Yellow Perch, Northern Pike and White Sucker; Table 4) resulting in variable effects on the fish community that may

[2] Climate normals are calculated for the period 1981–2010, which is the most recent period that has been analyzed by Environment Canada for this station.

be positive or negative depending on species. This assessment has taken a precautionary approach by focussing on potential negative effects due to increased maximum summer water temperatures; however, increases in temperature earlier in the growing season may also lead to increased productivity and fish growth not considered here. Alternatively, as described above, a minor reduction in Elsie Lake water temperature is also possible depending on the status of groundwater seepage and local topographic shading. Such cooling could reduce water temperature further below the optimum temperatures for warm water fish species such as White Sucker (Table 4), although the effects of such minor cooling on fish production are expected to be limited.

Changes are also expected to the thermal stability of Elsie Lake due to shutdown. Temperature data are lacking; however, it is expected that vertical thermal stratification is absent in Elsie Lake during typical operations due to the high flushing rate[3]. Following shutdown, vertical thermal stratification may form in Elsie Lake, although the formation of stratification and its persistence through the summer period will depend on the lake being sufficiently deep[4]. If stratification occurs in Elsie Lake during the shutdown, the presence of a cooler bottom layer (hypolimnion) would provide a potential temperature refuge for fish from warm surface temperatures that may occur by late summer. For reference, monitoring in the Forebay showed the presence of a thermocline at a depth of between approximately 11 m and 15 m on August 24, 2019 (Thornton *et al.* 2020).

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[3] For example, assumptions of outflow discharge of 20 m^3/s (Section 0), lake surface area of 29,000 m^2 (Section 2.1.1), and mean depth of 5 m (hypothetical; bathymetry data unavailable) yield a water residence time of only ~2 hours.

[4] For context, although depth is an imperfect criterion to define stratification characteristics, temperate lakes with mean depth of >10 m typically persistently stratify throughout the summer, whereas shallower lakes are more susceptible to intermittent mixing (polymictic) following wind events (Kirillin and Shatwell 2016).

Table 4. Temperature and oxygen requirements of the fish community in Elsie Lake and nearby area. Species that have not been detected in the tailrace above Elsie Falls are highlighted grey.

Fish Species	Upper Incipient Lethal Temperature (UILT) (°C) [1]	Mean Optimum Growth Temperature (°C) [2]	Acute Dissolved Oxygen Sensitivity Classification (mg/L) [3]	Dissolved Oxygen Guild [4]
Longnose Sucker	26.8	Unknown	>2.0	M
Slimy Sculpin	22.8	Unknown	Unknown	S
Ninespine Stickleback	27.2 [5]	17.1 [5]	Unknown	M
Burbot	23.3	16.6	>2.0	M
Trout-perch	Unknown	Unknown	Unknown	M
Yellow Perch	25.6	25.4	<1.0	M
Lake Whitefish	23.9	14.7	>2.0	M
Northern Pike	31.0	23.0	<1.0	M
Pearl Dace	29.2 [6]	Unknown	<2.0	T
White Sucker	27.8	25.5	1.0 - 2.0	T
Walleye	29.7	22.1	1.0 - 2.0	M
Lake Trout	24.3	10	>2.0	M

[1] The upper incipient lethal temperature is that at which 50% of the fish in an experimental trial survive for an extended period; values taken from Hasnain *et al.* (2010)

[2] Values taken from Hasnain *et al*. (2010)

[3] Classifications based on acute tolerances of adults. Requirements of embryos, fry and juveniles appear to follow approximately the same ranking, but the requirements of early life stages are invariably greater than those of adults. Dissolved oxygen requirements to sustain long-term health of the population, and to avoid depression of growth, development or reproduction, are substantially higher than acute lethal limits, and are also much more similar among species (Barton and Taylor 1994).

[4] S=sensitive, M=mesotolerant, T=tolerant; ratings from Tang *et al.* (2020)

[5] Threespine Stickleback was used as a surrogate

[6] Redbelly Dace was used as a surrogate

3.3.2.3. Water Quality

Isolation of Elsie Lake may cause changes to water quality variables, principally dissolved oxygen. If thermal stratification forms (see above), then dissolved oxygen is expected to decline in isolated bottom waters (hypolimnion). The rate of dissolved oxygen will depend on the physicochemical characteristics (and hence oxygen demand) of the sediments, which are unknown. However, it is likely that the benthic substrate is largely inorganic and therefore has low biochemical oxygen demand, given the generally inorganic status of shoreline substrate (assumed to be indicative of benthic substrate; Figure 2), the high flushing rate, and the presence of the dam upstream that may be expected to trap organic material. Consistent with observations at other lakes in the area (Thornton *et al.* 2020), surface waters in Elsie Lake are expected to remain well-oxygenated, e.g., above the federal guidelines for warm water aquatic life of 5.5 mg/L (non-early life stages) to 6.0 mg/L (early life stages) (CCME 1999). This expectation that surface waters will remain well-oxygenated may be invalid if water level decline results in concentration of the fish community into particularly shallow (e.g., maximum depth < 2 m) habitats, where oxygen is consumed by respiring fish and, potentially, decaying fish that died due to stranding (Section 3.2.1). The steep shoreline around Elsie Lake (Figure 2) indicates that deeper habitats will be present throughout the shutdown however, collection of bathymetry data in Elsie Lake would inform this aspect of the assessment.

Review of literature relating to the anticipated fish community in Elsie Lake demonstrates that most fish species that may be affected are tolerant of depleted dissolved oxygen concentrations (Table 4). Yellow Perch and Northern Pike are particularly tolerant of low dissolved oxygen with an acute sensitivity classification (level that can cause short-term mortality) of less than 1.0 mg/L for adults, while White Sucker, Pearly Dace, and Walleye adults have a sensitivity classification of 1.0 to 2.0 mg/L (juvenile fish may be more sensitive; Barton and Taylor 1994). Recently, Tang *et al.* (2020) completed a thorough review of the dissolved oxygen tolerances of Great Lake fish species for DFO, which considered applicable literature pertaining to populations throughout the species' ranges. The authors classified fish into three sensitivity guilds, with sublethal effects broadly expected at the following dissolved oxygen ranges: <2 mg/L (tolerant guild), 4 mg/L (mesotolerant guild), and >4 mg/L (sensitive guild). Of the fish species listed in Table 4, two were deemed tolerant, eight mesotolerant, and one sensitive (Slimy Sculpin). Slimy Sculpin comprised 25% of all fish salvaged, although there is uncertainty about the classification of "sensitive" for this species as Tang *et al.* (2020) note that information about this species was not directly reviewed. A DFO study of habitat use by sculpins in the Northwest Territories notes that Slimy Sculpin "can withstand re-occurring extreme conditions" and have been observed in a small, isolated lake (maximum depth = 7 m) with late winter dissolved oxygen concentration < 3 mg/L (Cott *et al.* 2008 cited in Arciszewski *et al.* 2015). Longnose Sucker, which is by far the most abundant species salvaged (70% of all fish salvaged), was classified as "mesotolerant" of low dissolved oxygen by Tang *et al.* (2020).

Water level decline in Elsie Lake following shutdown also has potential to increase turbidity and suspended sediment concentrations in Elsie Lake. These effects could arise if water level decline results in mobilization of fine sediments, e.g., by exposing fine sediments to wave action. The magnitude of this potential effect is expected to be low given the expectation that benthic substrate is largely inorganic (see above). Accordingly, this potential increase in turbidity is not expected to adversely affect fish, although further information about benthic substrate would inform this aspect of the assessment.

Physical changes to Elsie Lake may also disrupt the productivity of the waterbody, as described further in Section 3.3.3 below.

3.3.2.4. Summary

The proposed shutdown could indirectly lead to changes in water temperature and water quality in Elsie Lake. Based on knowledge of the expected fish community and assumptions about fish habitat, these changes are not expected to adversely affect fish; however, this prediction has high uncertainty as information about fish habitat is generally lacking. A key uncertainty is the bathymetry of Elsie Lake and the expected reduction in depth/volume of the lake during the shutdown. Water temperature (surface and bottom), water quality, riparian/littoral habitat type, and substrate composition (type, organic matter content) in Elsie Lake are also unknown, and further information about these factors would reduce uncertainty in this assessment. In particular, data collection during an annual shutdown prior to the overhaul shutdown would be insightful, e.g., to quantify temperature change in Elsie Lake relative to the Forebay.

Additional data collection during an annual shutdown will allow better understanding of these potential effects (see Section 6). However, even with additional data, there will be uncertainty regarding potential effects. Mitigation or an adaptive management plan may therefore need to be considered to ensure that water quality changes do not cause HADD to fish habitat (see Section 4.1.2 and 4.2.2).

3.3.3. Disruption to Habitat Productivity in Elsie Lake

In addition to the direct loss of rearing habitat caused by dewatering (Section 3.3.1), the proposed extended shutdown for the overhaul could result in further disruptions to the productivity of rearing and foraging habitats in the Elsie Lake. Changes to habitat productivity could principally arise from three mechanisms:

1. Reduced invertebrate drift from upstream due to isolation of Elsie Lake;
2. Reduced littoral production in Elsie Lake due to temporary dewatering of littoral habitat during the growing season; and
3. Increased plankton and periphyton production in Elsie Lake due to physical habitat changes.

Reduced invertebrate drift (mechanism one listed above), may occur due to cessation of inputs of zooplankton from the Forebay, as well as reduced input of macroinvertebrate drift from the lotic habitat that will be dewatered immediately downstream of the main dam. Baseline zooplankton data are lacking but zooplankton subsidies from the Forebay are presumed low due to the expected oligotrophic status of the Forebay. Furthermore, reduced inputs of zooplankton may be offset to some extent by increased plankton productivity in Elsie Lake (mechanism three listed above). Baseline data are also lacking regarding macroinvertebrate drift from lotic habitats in the tailrace upstream of Elsie Lake, which likely provide good habitat for aquatic invertebrates (e.g., Trichoptera larvae) due to coarse substrate, and shallow turbulent habitat. Despite this, baseline macroinvertebrate drift productivity in this section may be limited by the legacy of annual shutdowns, although this is uncertain as invertebrate communities adapted to disturbed systems can be resilient to periodic drying (e.g., Leigh *et al.* 2016, Vander Vorste *et al.* 2016). Assuming an invertebrate drift biomass of 0.3 mg/m^3 and mean flow into Elsie Lake of 23 m^3/s (Figure 4) during typical operations in the summer yields a first-order approximation of the magnitude of invertebrate drift input into Elsie Lake from the upper tailrace of 0.60 kg/day, which equates to 95 kg of invertebrate biomass for the duration of the proposed 160 day shutdown[5]. For context, given the moderate length of the lotic section of the upper tailrace (~750 m), and the generally short drift distance by individual invertebrates (typically <100 m; Brittain and Eikeland 1988), the loss of production due to cessation of invertebrate drift to Elsie Lake is expected to be substantially smaller than the loss of production associated with the reduced foraging opportunities within the upper tailrace due to dewatering (Section 3.3.1).

Water level decline could cause reduced littoral production (mechanism two listed above) due to dewatering and desiccation of littoral habitat, e.g., rooted aquatic plant communities that provide habitat for invertebrates. Information about littoral and riparian communities is lacking; however, the magnitude of this effect is expected to be low due to the riverine nature of Elsie Lake, and the apparent dominance of inorganic substrate (e.g., bedrock) along the shoreline (Figure 2). Further information about riparian and littoral communities would inform this aspect of the assessment.

The increased water residence time in Elsie Lake, and the potential for increased surface water temperatures, could increase phytoplankton and periphyton productivity in Elsie Lake (mechanism three listed above). This change is expected to have a neutral or positive effect on water column productivity. Proliferation of algal blooms is not expected due to the assumed oligotrophic status of the Elsie Lake. Increased primary production and increased residence time are expected to promote increased production of zooplankton (a food source for juvenile fish) in Elsie Lake. This increased zooplankton production is expected to offset the reduced production described above in relation to

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[5] This estimate is highly uncertain but may be biased high, consistent with a precautionary approach. Invertebrate drift biomass for the riverine section of the tailrace is unknown and representative values for similar waterbodies in NT could not be identified based on a literature review. For context, mean daily invertebrate drift biomass values of ~0.05-0.35 mg/m^3 were measured over several months in a dam tailwater in Utah (Miller and Judson 2014); drift biomass of ~0.01-0.18 mg/m^3 was measured in samples collected from three second-order forested streams in BC (Naman *et al.* 2016); drift biomass of ~0.1–0.7 mg/m^3 (six of nine values < 0.3 mg/m^3) was measured in small (channel width = 5-10 m) streams in Oregon (Weber *et al.* 2014); and drift biomass of 0.19 – 0.59 mg/m^3 (>90% of values < 0.3 mg/m^3) was measured during the growing season over seven years in a small (mean annual discharge = 8.5 m^3/s) regulated river in BC (Suzanne *et al.* 2021).

mechanism one to some extent, although zooplankton is expected to only be a food source for some species and life stages (notably juveniles).

Given the limited information, it is appropriate to take a precautionary approach and conclude that the net effect of the three mechanisms described above will be reduced food availability for fish in Elsie Lake. However, there is uncertainty regarding this prediction as the potential for increased productivity as Elsie Lake transitions from a pool-dominated lotic system to a shallow lake (mechanism three) is uncertain. Furthermore, there is expected to be increased nutrient input to Elsie Lake associated with the decay of fish stranded in the tailrace above Elsie Lake.

The potential impacts of reduced invertebrate food input from the tailrace upstream of Elsie Lake and the Forebay will also depend on the feeding preferences of fish species and life stages in Elsie Lake. In general, negative effects may be expected for fish that feed on invertebrates due to the reduction in invertebrate drift, or if there is a reduction in secondary productivity in Elsie Lake. However, with expected increases in fish density, positive effects are predicted for piscivores (e.g., Northern Pike and Burbot). During the five-month duration of the shutdown, an alteration of the fish community to greater dominance of large-bodied piscivores is predicted, but there is uncertainty regarding the net change in total fish production. As described in Faulkner *et al.* (2018), the density of fish in the tailrace is expected to be high relative to regional benchmarks. Therefore, this implies that the fish community in the tailrace may be close to carrying capacity, indicating that a decline in invertebrate availability would have a direct adverse effect on fish production.

In summary, a net reduction in fish production is assessed to occur due to the shutdown, although the magnitude is challenging to quantify and will vary by fish species and life stage. The net magnitude of the indirect effects to habitat productivity that are described in this section is expected to be lower than loss of productivity due to the direct temporary loss of habitat due to dewatering (~32,716 m^2) and estimated death of fish described in Section 3.3.1 and 3.2.1, respectively. Mitigation options in relation to this impact are limited but mitigation could potentially be provided if necessary to provide additional primary and secondary production in Elsie Lake (Section 4.2.3).

4. AVOIDANCE AND MITIGATION MEASURES

A number of avoidance and mitigation measures were examined for the annual shutdown (Faulkner *et al.* 2018), which would also be considered for the overhaul shutdown. These measures included:

- Altering shutdown timing to reduce YOY mortality (being achieved during the overhaul);
- Controlled flow ramping (not operationally feasible for last 20 m^3/s step);
- Night-time ramp-down (committed to and included in FAA, also to be employed during the overhaul);

- Providing continuous flow (NTPC concluded this option is not feasible for this site due to high cost-benefit ratio, significant maintenance and operational burden, and risk of failure);
- Fish salvages in all dewatered areas (NTPC considered fish salvages of all dewatered habitat in the tailrace are not a feasible mitigation measure for long-term use during annual shutdowns due to high cost-benefit ratio with limited success (~4%) and safety concerns regarding interactions with Black Bears which feed on the salvaged fish);
- Pulse flows (NTPC (2020); committed to and included in FAA, also to be employed during the overhaul); and
- Channel restructuring/contouring (NTPC considered this to not be feasible due to expense and risk that modifications will not function as intended for the long term due to maintenance constraints).

A detailed description and rationale for selection or exclusion of these mitigations is provided in Faulkner *et al.* (2018).

4.1. Death of Fish

4.1.1. Shutdown and Dewatering of Tailrace

Following the requirements of the current FAA, mitigation during the shutdown will include night-time ramp-down and implementation of a pulse flow as described in the FAA and standard operating procedure for the Station (NTPC 2020). In addition, salvage of the residual pool habitat (3,385 m^2) is also proposed to reduce mortality in these key areas. These areas were observed to sustain fish during the shorter duration of the normal annual shutdowns. Salvage of these areas is proposed to occur after the shutdown and before water quality or temperatures deteriorate. To avoid ice conditions, this salvage could occur in late April or May.

This only includes salvage of individual pools in dewatered areas in the tailrace above Elsie Lake; there is uncertainty regarding the potential for death of fish during the overhaul shutdown in the section between Elsie Falls and Trudel Creek confluence, which may require additional assessment and data collection during an annual maintenance shutdown prior to the overhaul shutdown. If connectivity and water quality are of concern in this area, salvage may also be required to mitigate effects.

4.1.2. Commissioning Activities

The commissioning activities will lead to intermittent wetting and dewatering of the tailrace area. There is a potential for fish to colonize the wetted areas and subsequently be dewatered. The shutdowns will be mitigated by conducting pulse flows consistent with the current FAA requirement: "Implement pulse flows, where the time between the cessation of flow and the start of the pulse flow is approximately 72 minutes, to allow fish to emigrate out of the shallow waters into deeper waters immediately prior to shutdown." However, following the overhaul works additional operational controls may be available to optimize the pulse release to further reduce impacts to fish (e.g., start the pulse sooner). These potential changes to increase mitigation of fish stranding will be assessed throughout the commissioning period.

Mitigation for these shutdowns could include exclusion nets to keep fish out of the wetted areas and/or monitoring and salvage. For exclusion nets to be effective, they would need to cover the approximately 125-m-wide section of the tailrace immediately above Elsie Lake; however, these nets would also need to withstand relatively high flows of the commissioning activities. The maximum flows expected during commissioning (up to ~66 m^3/s) will make maintaining exclusion nets impractical for complete mitigation but could be employed as part of ongoing monitoring described below on a site-specific basis to keep fish out of identified critical margin habitat.

Given the short duration of wetting following NTPC operator training Option 1 (i.e., <18 hours), the commissioning tests are expected to result in relatively low levels of fish colonization prior to dewatering. Accordingly, a monitoring and salvage program may provide effective mitigation for to account for the fish that do attempt to colonize the briefly wetted habitats during the commissioning activities. Monitoring and salvage is proposed in an adaptive approach where initial search results would be used to assess risk and requirements for subsequent search and salvage requirements and may also be used to adjust potential mitigations for subsequent commissioning activities. At a minimum, monitoring and salvage is proposed for the initial tests of 6 hours duration of wetting and 12 hours duration of wetting, and during the final shutdown (Table 2). This approach would allow confirmation of stranding effects and further mitigations to be employed, if required. For example, additional crews could be recommended to increase salvage efficiency, or a recommendation provided for altering the approach to subsequent tests to minimize stranding mortality through operational adjustments (e.g., adjustments of pulse flows, duration of flow release or continuous flow release between tests). This monitoring and salvage program would need to be developed in collaboration with NTPC to ensure all safety requirements can be met (e.g., lock out and night access).

However, monitoring and salvage may not be effective for commissioning activities with extended durations of wetted history, such as following NTPC operator training Option 2 (i.e., up to 168 hours wetted history). If substantial numbers of fish enter the tailrace above Elsie falls during longer duration flow releases, it is expected fish salvages for subsequent dewatering may be comparable to previous salvage attempts at ~4% effective with similar effort applied (Faulkner *et al.* 2018). NTPC testing will also attempt to limit the duration of dewater between back-to-back tests on the same day to less than 1 hour to limit dewatering mortality; however, this duration of dewatering depends on test results and cannot be relied on as mitigation.

If search and salvage is determined to not be feasible by NTPC due to safe access restrictions, a conservative approach to estimating potential mortality from these commissioning activities may need to be applied to allow for offset.

4.2. HADD

4.2.1. Disruption of Spawning and Rearing Habitat

No specific mitigation is proposed for the temporary loss of spawning and rearing habitat in the tailrace upstream of Elsie Lake due to the shutdown. The fish species present in the tailrace upstream of Elsie Falls are capable of rearing and spawning in lake habitats, and therefore ensuring water quality, temperature and food production remain appropriate will limit potential decreases in productivity (see Section 4.2.2 and 4.2.3).

4.2.2. Degradation of Water Quality/Temperature Elsie Lake

Mitigation of potential effects of increased water temperatures or declining water quality within Elsie Lake would be difficult and costly to implement. Mitigation could include continual or intermittent flow release (through the powerhouse or through the South Gorge) or use of bubblers to maintain appropriate dissolved oxygen concentrations. Continual flow release was previously determined to not be feasible by NTPC for this site due to high cost-benefit ratio, significant maintenance and operational burden, and risk of failure. However, given the remote location of Elsie Lake, the implementation of solar or generator powered bubblers/aeration may be a feasible option if required.

Salvage of the area could also be considered; however, given the moderate size of Elsie Lake, the benthic behaviour and small size of many of the fish present, it would be unlikely to be effective at removing a large portion of the fish community. In addition, given the isolated nature of these fish populations, removal of fish from this area would reduce fish productivity in this area, which itself would require offsetting.

Given uncertainties in potential effect and relatively high costs of mitigation, a monitoring approach with triggers to initiate mitigation (e.g., use of bubblers) may be appropriate to ensure no residual effects (death of fish or HADD (Section 4.2.2)). The details of an adaptive management plan and specific triggers would need to be developed with additional onsite data and in collaboration with NTPC.

4.2.3. Disruption to Habitat Productivity

There is limited potential to implement mitigation measures in relation to potential reductions in habitat productivity (Section 3.3.3). Lake fertilization has been conducted in the arctic to support Lake Trout in a benthically dominated food web (Lienesch *et al.* 2005); however, it is not an established method to benefit benthivorous species such as Longnose Sucker (a species that accounts for 70% of all fish salvaged). Hypoxia is also a risk following lake fertilization (Lienesch *et al.* 2005). Instead, direct addition of food to the lake (e.g., dried food sourced from an aquaculture supplier) could mitigate for the temporary loss of production, although this is not an established method to mitigate effects to wild fish populations, and it is uncertain whether the fish community in Elsie Lake would feed on commercially produced food.

To an extent, the fish mortalities in the tailrace above Elsie Lake from the shutdown will provide nutrients to promote additional primary and secondary productivity in Elsie Lake during the shutdown. This would occur passively as the fish decay and nutrients are transported through the limited seepage and potential surface flow following rain; however, as further mitigation a portion of these fish carcasses could be collected during the planned salvage activities and placed in Elsie Lake. The placement of these carcasses in Elsie Lake would ensure that nutrients from the fish carcasses promote increased productivity to at least partially mitigate the potential loss in productivity from lack of delivery from upstream food sources. For context, the estimated biomass of fish that will be stranded substantially exceeds the first order estimate of the loss of invertebrate drift from the upper tailrace during the shutdown (~100 kg; Section 3.3.3) although, unlike invertebrates, the fish community is not expected to feed directly on dead fish tissue, and this comparison does not account for other changes to productivity such as a potential reduction in benthic littoral production in Elsie Lake.

Overall, there is uncertainty regarding the overall effect of the potential reduction in productivity on the fish community. A monitoring approach combined with adaptive management can be used to address uncertainty and ensure additional losses to productivity are mitigated. Further details regarding the scope of such a strategy could be refined following fish community and fish habitat monitoring during an annual maintenance shutdown prior to the overhaul shutdown, which are expected to lead to better understanding of the potential effects to productivity.

5. RESIDUAL EFFECTS

5.1. Death of Fish

The estimated death of fish from the overhaul shutdown is estimated to be ~404 kg of Age-1 equivalents (Table 1). This estimation assumes salvage will be conducted to mitigate death of fish from residual pools that are unable to support fish over the extended duration of the shutdown and similar fish abundance and use of the tailrace in April as has been observed in August. If use is lower in April (i.e., more fish use Elsie Lake in April under more typical overwintering conditions) this approach will overestimate the residual death of fish. For commissioning activities with short-wetted histories (<18 hrs) monitoring and salvage in an adaptive approach may mitigate stranding mortality[6]. However, under Option 2, fish colonization during the 168-hour wetted history may allow substantial numbers of fish to enter the dewatered habitat and preclude the effectiveness of salvage. Under this scenario we would estimate that an additional death of 101 kg Age-1 equivalents may occur. Accordingly, a total estimated death of fish from the initial shutdown in April and commissioning activities is estimated to be 404 kg Age-1 equivalents for Option 1, and 505 kg Age-1 equivalents for Option 2.

[6] If monitoring and salvage is not effective or cannot be conducted for short, wetted history events, Option 1 would have an estimated death of fish of 42 kg Age-1 equivalents.

5.2. HADD

The reduction in wetted area, including all lotic habitat, during the overhaul shutdown will disrupt fish habitat and may temporarily reduce fisheries productivity in the tailrace if Elsie Lake cannot support the increased fish density (i.e., if spawning or rearing habitat area are limiting; Section 3.3.1) or deterioration in water quality or temperature causes sub-lethal effects (e.g., reduced metabolism) that reduce productivity (Section 3.3.2). Alternatively, fisheries productivity could also temporarily be reduced by indirect effects to habitat productivity described in Section 3.3.3, namely reduced entrainment of invertebrates from upstream (forebay and dewatered tailrace above Elsie Lake) or dewatering of littoral habitats.

There are uncertainties in this assessment due to the lack of data regarding habitats in Elsie Lake, fish abundance, fish habitat use, and water temperature/quality. An adaptive management approach could mitigate for the potential water quality/temperature effects on rearing habitat, i.e., by implementing monitoring and establishing triggers for actions such as implementation of aeration systems. However, there remains uncertainty about the effects of reduced lotic spawning habitat and reduced rearing habitat productivity, for which feasible mitigation measures have not been identified.

A reduction in flow is expected to impact spawning habitat primarily of Slimy Sculpin, Longnose Sucker, and Ninespine Stickleback. If spawning success of these species is reduced in the lake compared to the lotic environment, then residual effects will occur. This residual effect is estimated at ~14 kg of Age-1 equivalents based on data collected on YOY for the current FAA in the dewatered section upstream of Elsie Lake (Section 3.3.1).

Furthermore, additional reductions to fish productivity may occur due to the temporary loss of 32,716 m^2 of rearing habitat in the tailrace, with additional more-minor losses to production possible due to indirect effects to habitat productivity. The estimate of death of fish included in Section 5.1 would largely account for the potential loss of rearing habitat and productivity within the tailrace above Elsie Lake.

The indirect effects on fisheries productivity due to the potential for reduced invertebrate flux into Elsie Lake from the forebay and dewatered tailrace section above Elsie Lake are difficult to estimate. The alterations to habitat caused by the shutdown will have variable (positive and negative) effects to individual fish species and life stages. A decline in productivity is expected for fish that feed on invertebrates (e.g., Lake Whitefish) if secondary productivity is reduced during the shutdown. However, positive effects are predicted for large bodied piscivores such as Northern Pike and Burbot. Overall, a neutral effect or a potential net reduction in fish production may occur due to disruption of habitat productivity in Elsie Lake during the overhaul shutdown. The potential temporary loss of productivity may be mitigated by collecting fish carcasses from the dewatered section of the and adding them to Elsie Lake, and through the natural decay of fish carcasses in the tailrace above Elsie Lake, both of which would be expected to stimulate secondary production by invertebrates in

Elsie Lake. Additional data collection regarding fish abundance and habitat productivity would be required to better estimate this effect. Monitoring during the shutdown could be conducted as part of an adaptive management approach to ensure this potential effect is further mitigated if required, although further work based on the outcome of data collection is required to define the scope of such an adaptive management approach.

5.3. Summary

Residual effects have been assessed separately for the shutdown and commissioning activities (Table 5). Overall, residual death of fish and HADD for the overhaul shutdown is estimated to be ~418 to 519 kg Age-1 equivalents depending on the NTPC commissioning option employed. This estimate comprises an estimated loss of 404 to 505 kg Age-1 equivalents from the shutdown and commissioning activities and 14 kg Age-1 equivalents from the reduction in spawning habitat. The estimated residual effect is up to 519 kg Age-1 equivalents, 24% higher than is authorized in the current FAA. However, the estimated death of fish and HADD will be similar to an annual shutdown, if commissioning activities exhibit short wetted histories (<18 hrs) and if monitoring and salvage are effective mitigation.

This estimate of residual death of fish and HADD is based on the following assumptions:

- Similar fish distribution in the tailrace in April as in August of 2014 to 2016;
- Salvage of residual pool habitat will be undertaken as required to mitigate mortality;
- Lack of flow will lead to reduction of spawning habitat (Slimy Sculpin, Longnose Sucker, and Ninespine Stickleback), but effective spawning habitat will still be present in Elsie Lake;
- Monitoring and salvage, if necessary, will be implemented during wet commissioning to mitigate stranding mortality for short wetted history events in an adaptive approach;
- Fish may access the tailrace above Elsie Lake during longer duration (e.g., 168 hours) flow releases during commissioning and be subject to stranding in substantial numbers where salvage may not be feasible;
- Elsie Lake will support rearing of fish throughout the shutdown period; and
- Adaptive management will be employed, if necessary, to ensure water temperature, water quality and productivity are adequately maintained in Elsie Lake during the shutdown.

There is uncertainty in the assessment due to limitations in the available data, and additional work is recommended to address key uncertainties, allow further refinement of the estimate, and confirm assumptions on potential effects and mitigations. Additional quantitative analysis could be conducted using the field data collected during an annual maintenance shutdown prior to the overhaul shutdown to better inform determination of residual effects.

ECOFISH RESEARCH

Table 5. Summary of residual effects associated with proposed overhaul shutdown and commissioning due to death of fish or harmful alteration, disruption or destruction (HADD) of fish habitat.

Proposed Activity	Potential for Death of Fish or HADD of Fish Habitat	Avoidance or Mitigation Measures	Residual Effect
Station shutdown from approximately April 13 to September 20, resulting in dewatering of sections of the tailrace and isolation of Elsie Lake	- Fish stranding and mortality is expected following the initial shutdown in April - Additional mortality may occur in three residual pools (3,685 m^2) due to gradual dewatering, predation, or water quality alteration	- Night-time ramp-down - Pulse flow prior to shutdown - Salvage of residual pool habitat	The estimated death of fish from the shutdown is ~404 kg of Age-1 equivalents
	Dewatering of ~32,716 m^2 of habitat area during the extended shutdown, disruption to spawning and rearing habitat due to the dewatering upstream of Elsie Lake (~29,670 m^2) during the six month shutdown. Fish species present are adapted to lake habitat; therefore, limited effects on productivity are expected.	Mitigation measures to ensure fish can effectively rear in Elsie Lake described below.	Due to uncertainty in spawning habitat quantity and quality in Elsie Lake, a loss of ~14 kg YOY Age-1 equivalents is proposed (consistent with an annual shutdown). Potential loss of rearing habitat is also accounted for in residual effect of fish stranding, above.
	The isolation of Elsie Lake may change water quality and water temperature. These changes are not expected to cause fish mortality or cause habitat disturbance that adversely affects fish; however, there is uncertainty and mitigation may need to be considered.	- Develop an adaptive management plan that includes triggers to initiate mitigation (e.g., use of bubblers to increase dissolved oxygen concentrations) if monitoring indicates mitigation is warranted.	Temporary reduction in productivity (habitat disturbance) is possible but not expected
	Dewatering may temporarily change productivity in Elsie Lake due to three key mechanisms: 1. Reduced invertebrate drift from upstream due to isolation of Elsie Lake; 2. Reduced littoral production in Elsie Lake due to temporary dewatering of littoral habitat during the growing season; and 3. Increased plankton and periphyton production in Elsie Lake due to physical habitat changes. These changes will cause a disturbance to fish habitat, although effects will vary among species and life stages. Changes to production of some species (e.g., piscivores) are expected to be neutral or positive; however, negative effects are possible for some species. Overall, the activity could cause net reduction in fish production, although this is uncertain due to variability among species, and the likelihood of increased autotrophic and associated secondary production in Elsie Lake (mechanism 3).	- Place the carcasses of fish that died due to stranding in Elsie Lake to promote secondary production - A monitoring approach combined with adaptive management may be employed if deemed necessary to address uncertainty and ensure additional losses to productivity are mitigated	- A temporary decline in productivity (habitat disturbance) is expected for fish that feed on invertebrate drift (e.g., Lake Whitefish), although changes to productivity will be neutral or positive for some species - A temporary net reduction in fish production (habitat disturbance) is assessed to occur due to the shutdown, based on a precautionary assessment with limited information; but may be mitigated through monitoring or adaptive management. Additional data collection is recommended for 2021.
Multiple commissioning tests from September 20 to October 11 that will entail intermittent flow releases	Fish stranding and associated mortality may occur in the tailrace upstream of Elsie Lake during dewatering events	- Pulse flows will be conducted, consistent with the FAA (18-HCAA01487) requirement - Monitoring and salvage to be conducted to mitigate risks following events with short wetted history (<18 hrs) - Nets may be used to exclude fish from temporarily wetted areas	Option 1 (intermittent flow releases of <1 hour to 18 hour duration): No residual effects, assuming monitoring and salvage is conducted Option 2 (intermittent flow releases of ~ 1 week duration): Estimated death of fish is 101 kg Age-1 equivalents

6. RECOMMENDATIONS FOR ADDITIONAL WORK

Additional work during an annual maintenance shutdown prior to the overhaul shutdown is recommended to reduce uncertainties in the assessment. This additional work includes:

- Assessment of Elsie Lake during annual maintenance shutdown:
  - Habitat, depth/bathymetry, water quality (primarily dissolved oxygen), water temperature, benthic substrate composition, fish habitat use;
  - Change in temperature and water quality at multiple depths in Elsie Lake during an annual shutdown relative to withdrawal temperature in the Forebay; and
  - Assess potential locations and feasibility of bubbler installation.
- Assessment of habitat and connectivity below Elsie Falls to Trudel Creek to inform need for monitoring/salvage of this area.

Yours truly,

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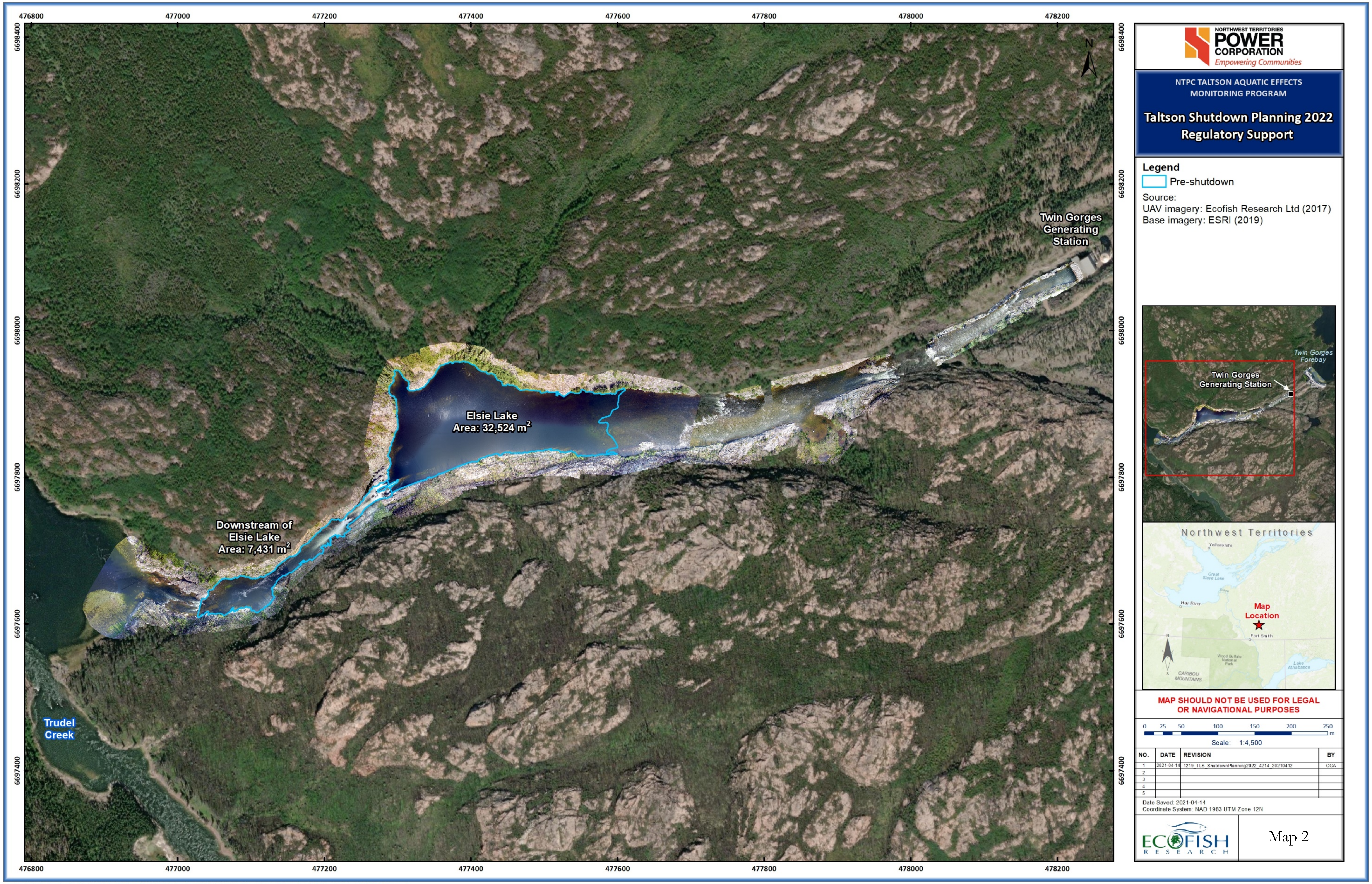
PROJECT MAPS



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NORTHWEST TERRITORIES POWER CORPORATION
Empowering Communities

NTPC TALTSON AQUATIC EFFECTS MONITORING PROGRAM

Taltson Shutdown Planning 2022 Regulatory Support

Legend

Post-shutdown

Source:
UAV imagery: Ecofish Research Ltd (2017)
Base imagery: ESRI (2019)

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

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Scale: 1:4,500

NO.	DATE	REVISION	BY
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Date Saved: 2021-04-16
Coordinate System: NAD 1983 UTM Zone 12N

ECOFISH RESEARCH

Map 3

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