TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

APPENDICES

13. WATER FLUCTUATIONS IN THE TALTSON RIVER WATERSHED

13.1 INTRODUCTION

The following Key Line of Inquiry (KLOI) presents the effects assessment of the Expansion Project on Taltson River watershed. The Taltson River watershed was specifically identified in the Terms of Reference (TOR) for the Taltson Hydroelectric Expansion Project Developer's Assessment Report (DAR) (Mackenzie Valley Environmental Impact Review Board; MVEIRB 2008) as an area of concern by the MVEIRB and by various community members during the development of the TOR. Trudel Creek is part of the Taltson River watershed. Trudel Creek currently serves as one of two channels for Taltson River flow from the Forebay. Under current conditions, it is the main channel, while flow through the Twin Gorges power plant conveys only a small portion of the total Taltson River flow. The proposed Expansion Project would cause a reversal of these roles, in that Trudel Creek would only convey a minimum flow of 4 m^3/s, flow in excess of that required for full power production, and flows during scheduled and unscheduled outages. A separate effects assessment was completed for Trudel Creek (KLOI Ecological Changes in Trudel Creek, Chapter 14). However, in order to complete an effects assessment of the Expansion Project for the Taltson River watershed as a whole, the findings of the Trudel Creek effects assessment were incorporated into this chapter; see Section 13.2 (Methods) for details.

The assessment addresses effects of the Project on water quantity (Section 13.3), water quality (Section 13.4), mercury (Section 13.5), ice structure (Section 13.6), wetlands (Section 13.7), aquatic resources (Section 13.8), fisheries (Section 13.9) and wildlife (Section 13.10). Fisheries and wildlife were identified as the key end-users within the Taltson River watershed, whereby changes in water quantity and quality, ice regime, aquatic resources and wetlands directly affect fish and wildlife. As such, significance determination of residual effects on fish and wildlife were presented in their respective sections and in the Section 13.11 (Summary and Conclusions).

The effects assessment followed the methodology outlined in Chapter 10. However, where necessary, minor changes were made to the methodology based on the specifics of assessing effects on the Taltson River watershed. These minor changes in methodology are discussed in Section 13.2 and presented in the appropriate sections of Chapter 13.

Each effects assessment Section (13.3 to 13.10) includes a summary of the existing environment and predictions of changes based on both the 36 MW and 56 MW expansion options being considered. Where possible, the quantitative and qualitative predictions of effects were presented together to minimize duplication.

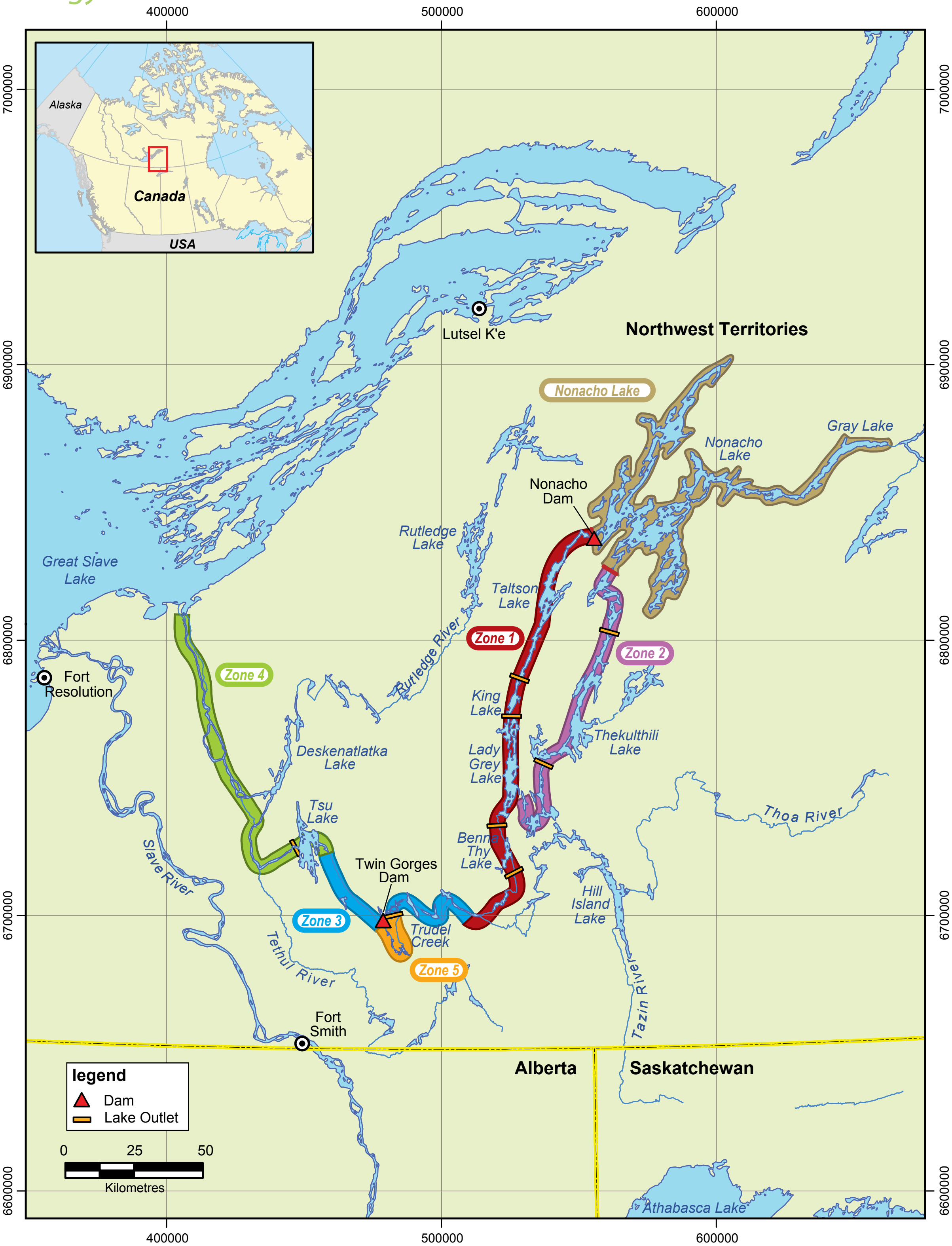
13.1.1 Taltson Expansion Project and Taltson River Watershed

The Expansion Project proposes to add between 36 MW and 56 MW of power generating capacity at Twin Gorges plant. The existing plant included the construction of the Nonacho dam and the powerhouse in the Twin Gorges Forebay, which resulted in a shift in the hydrology within the Taltson River watershed. The expansion would add to the existing 18 MW capacity that was established in 1965 to provide power to the Pine Point Mine. Closure of the mine in 1986 allowed the distribution of power supply to the communities of Hay River, Fort Smith Fort Fitzgerald and Fort Resolution, NWT. During operations at Pine Point Mine, the Twin Gorges plant was operating at or near capacity for just over 20 years. Flows on the Taltson River at Twin Gorges greatly exceed the flow required to generate the 18 MW capacity of the Twin Gorges plant. Thus, water in excess of that required for maximum power generation was spilled over the South Valley Spillway (SVS) and into the headwaters of Trudel Creek. Upon closure of Pine Point Mine, power generation dropped to between 9 MW and 11 MW. As a result, additional water was spilled into Trudel Creek. This hydrologic regime has been maintained since 1986.

The Project proposes to maximize the use of the currently spilled water for power production and introduce greater hydrological control to increase generating capacity. The construction and operation of a new control structure on Nonacho Lake and the construction of new generating facilities at Taltson Twin Gorges may result in additional changes to the hydrological characteristics of the Taltson River watershed.

The hydrological changes to Taltson River watershed from the Expansion Project have the potential to change the biophysical and biological components of the aquatic environment of Trudel Creek. As such, and in accordance with the Terms of Reference for the DAR (MVEIRB 2008), an assessment of the potential effects associated with water fluctuations in the Taltson River was conducted.

To understand the potential water fluctuations in the Taltson River, a HEC-ResSim model was developed to analyze the shift in hydrological conditions from Nonacho Lake downstream to Great Slave Lake. This model was developed using measured river sections and flows and predicts the Expansion Project flow regime under different operating scenarios. In order to develop the HEC-ResSim model, the Taltson River watershed was divided into distinct zones, as summarized in Figure 13.1.1. Of the identified zones, aerial photographs were collected in Zone 3 from the existing Twin Gorges facility down to Tsu Lake (Appendix 13.1A).



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Geographic Setting of the Taltson Basin Flow Model** (503-004 / a22589w)	**Figure 13.1.1**

13.1.1.1 TALTSON RIVER BIOPHYSICAL HISTORY

Hydrological conditions within the Taltson River watershed since construction of the Twin Gorges facility and Nonacho Dam in 1964 have varied as a result of the operational activities. In order to describe the biophysical conditions associated with the Taltson Basin, the hydrology has been divided into two time periods. These time periods include Current (1964 to present) and Pristine (pre-1964). Throughout the historical time periods, the conditions of the watershed, hydrology, channel morphology, and fish habitat availability have varied substantially. For the purposes of this discussion, the Current and Pristine time periods are summarized simultaneously.

The current biophysical conditions in the Taltson River began in 1964 with the construction of the Nonacho Dam and the Twin Gorges facility. Other activities occurring within the Taltson River during the Current time period include: a commercial fishery operated on Nonacho Lake, the operation of three fishing lodges throughout the basin, mineral exploration, and the diversion of the Tazin River to support a hydroelectric development project in Saskatchewan. There are no reasonably foreseeable projects in the watershed that would result in further residual effects.

Of the above identified activities, the construction of the Nonacho Dam and the Twin Gorges facility are considered the only activities that have resulted in residual effects on the current conditions within the Taltson River watershed.

The commercial fishery focused on harvesting lake whitefish and lake trout on Nonacho Lake between 1960 and 1981. Closure of the fishery was apparently due to the high cost of flying the product to a viable market, although there is also mention of “mercury in trout and infestation in whitefish” (Azzolini, L. personal communication 2008). As the fishery was closed nearly 30 years ago and stressors to lake whitefish and lake trout stocks have been limited to sport and sustenance fisheries, no residual effects of the commercial fishery are anticipated.

In total, three sport fishing lodges have and continue to operate throughout the Taltson River watershed. These lodges included Nonacho Lake Fishing Lodge on Nonacho Lake, Thekulthili Lodge located on Thekulthili Lake and an independent lodge located near the mouth of Lady Grey Lake. Theses lodges are seasonally-operated, are spread over a large area of the Taltson watershed, and are only capable of supporting low numbers of anglers. In discussions with Nonacho Lake Fishing Lodge, most anglers target larger fish, which are subject to catch-and-release regulations. Based on the vast area of the watershed and the low density of anglers, no residual effects are anticipated with the sport fishery on the Taltson River watershed.

The Taltson River watershed contains very few developments as much of the mining and exploration activity is focused in the regions north of Great Slave Lake.

The Tazin River was dammed as part of the Churchill-Nelson Hydroelectric power development in the 1960s. The diversion of flows from the Tazin River resulted in a reduction of flows into the Taltson River. As baseline information is not available for the Tazin River, the degree of change is unquantifiable and the potential effects to the aquatic and riparian habitats are unknown. As the diversion of flows occurred over 40 years ago, the aquatic and riparian habitats have likely adapted to the new flow regime and there are no or limited residual effects. Therefore, the potential effects associated with the diversion of flows from the Tazin River have not been included in the effects assessment.

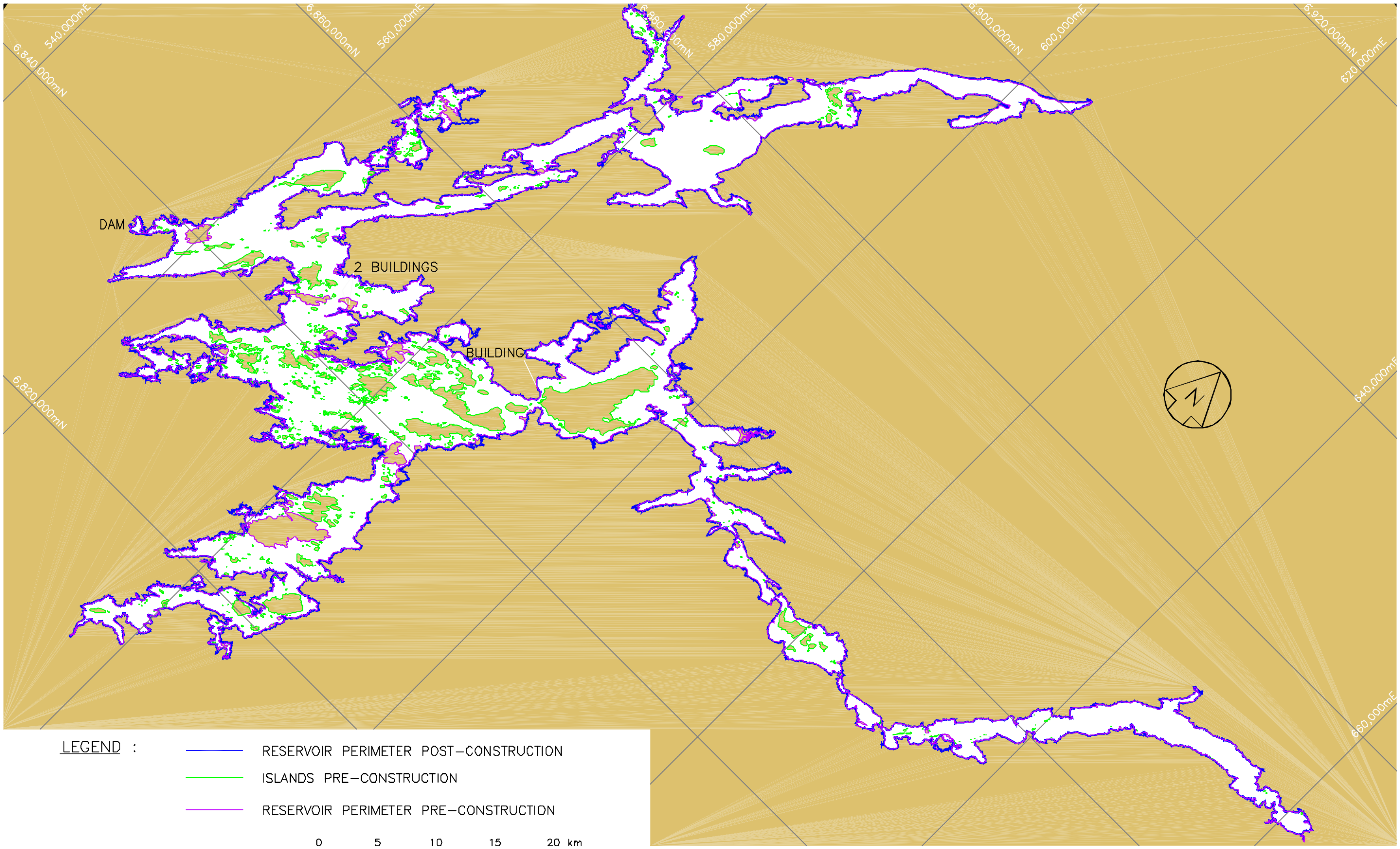
13.1.1.2 NONACHO DAM

The construction of the existing Nonacho control structure and dam facilities resulted in three main residual effects to the Taltson River watershed, including flooding of Nonacho Lake, creation of a regularly connected outlet from Nonacho Lake into the Taltson River via the Tronka Chua Gap, and the creation of habitat at the Nonacho control structure.

13.1.1.2.1 Nonacho Lake Flooding

Nonacho Lake water levels during the Pristine time period were 320.5 m on average. Water Survey Canada data indicate that the water level elevation in Nonacho Lake increased almost three metres from 320.5 m in March-May 1968 to 323.4 m in August 1968 (WSC 2008) in response to the original installation of the Nonacho Lake control structure. A 1998 analysis (NWT Power Corporation 1998) indicates that the area of flooding was estimated as 80 km^2 (+/- 8 km^2) and the length of shoreline increased by nearly 200 km (to 2,198 km from 2,010 km). Currently it is impossible to compare (in terms of quantity or quality) the existing riparian habitats to those of the pristine lakeshore; however, Traditional Knowledge indicates that post flooding, fish health declined and less wildlife was available for hunting and trapping. Figure 13.1.2 illustrates the Nonacho Lake perimeter pre- and post-construction.

Dezé energy



LEGEND :

RESERVOIR PERIMETER POST–CONSTRUCTION

ISLANDS PRE–CONSTRUCTION

RESERVOIR PERIMETER PRE–CONSTRUCTION

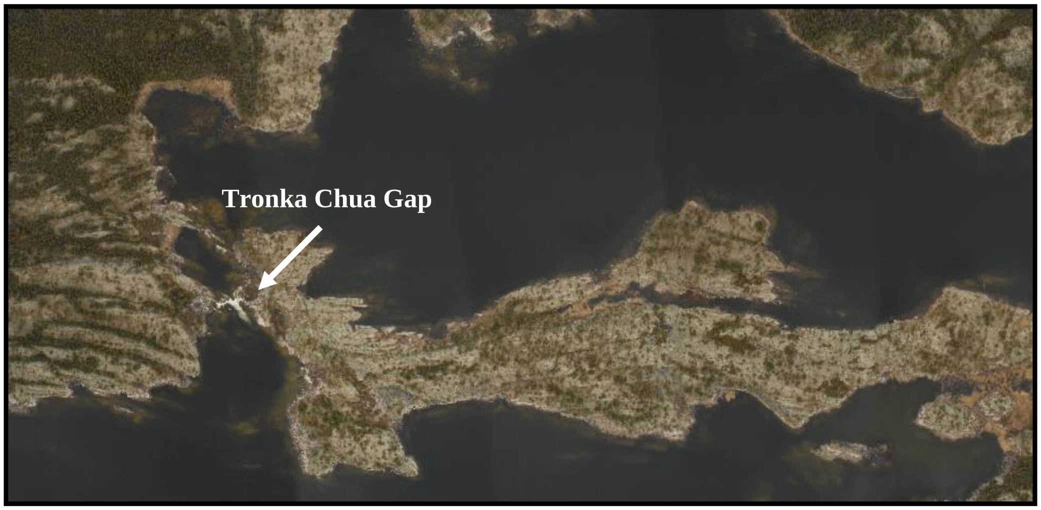
0 5 10 15 20 km

TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report** **2009**	**Nonacho Lake Perimeter Pre and Post Construction**	**Figure** **13.1.2**

13.1.1.2.2 Connectivity at Tronka Chua Gap

Engineering studies indicate that the water in Nonacho Lake during the Pristine time period could have passed through Tronka Chua Gap during “a really big flood year, but it was far from a regular occurrence” (T. Vernon, personal communication 2008). Post-flooding and during the Current time period, the creation of regular flows through Tronka Chua Gap resulted in a major change to the drainage patterns of the watershed and continuous flows throughout Zone 2 (Figure 13.1.3).

Figure 13.1.3 — Tronka Chua Gap during the Current Time Period



13.1.1.2.3 Habitat Creation at Nonacho Control Structure

During the Pristine time period, the nature of the original outflow channel from Nonacho Lake into the Taltson River is unknown; however, it is likely that the channel contained either a waterfall or steep cascade morphology. The construction of the Nonacho control structure and the Nonacho dam required the blasting of a spillway channel and the installation of a flow control structure. These construction activities resulted in an alteration of habitat conditions during the Current time period.

Under current conditions, the blasted spillway channel is defined by cascade pool morphology and is characterized by fast-flowing waters (Figure 13.1.4). The spillway channel is approximately 350 m in length and ranges in width from 60 m at the inlet to 115 m at the outlet. A riffle pool side-channel is located approximately 105 m downstream from the spillway rock sill. The side channel is 6 m wide on average and 150 m in length.

Figure 13.1.4 — Nonacho Control Structure during the Current Time Period

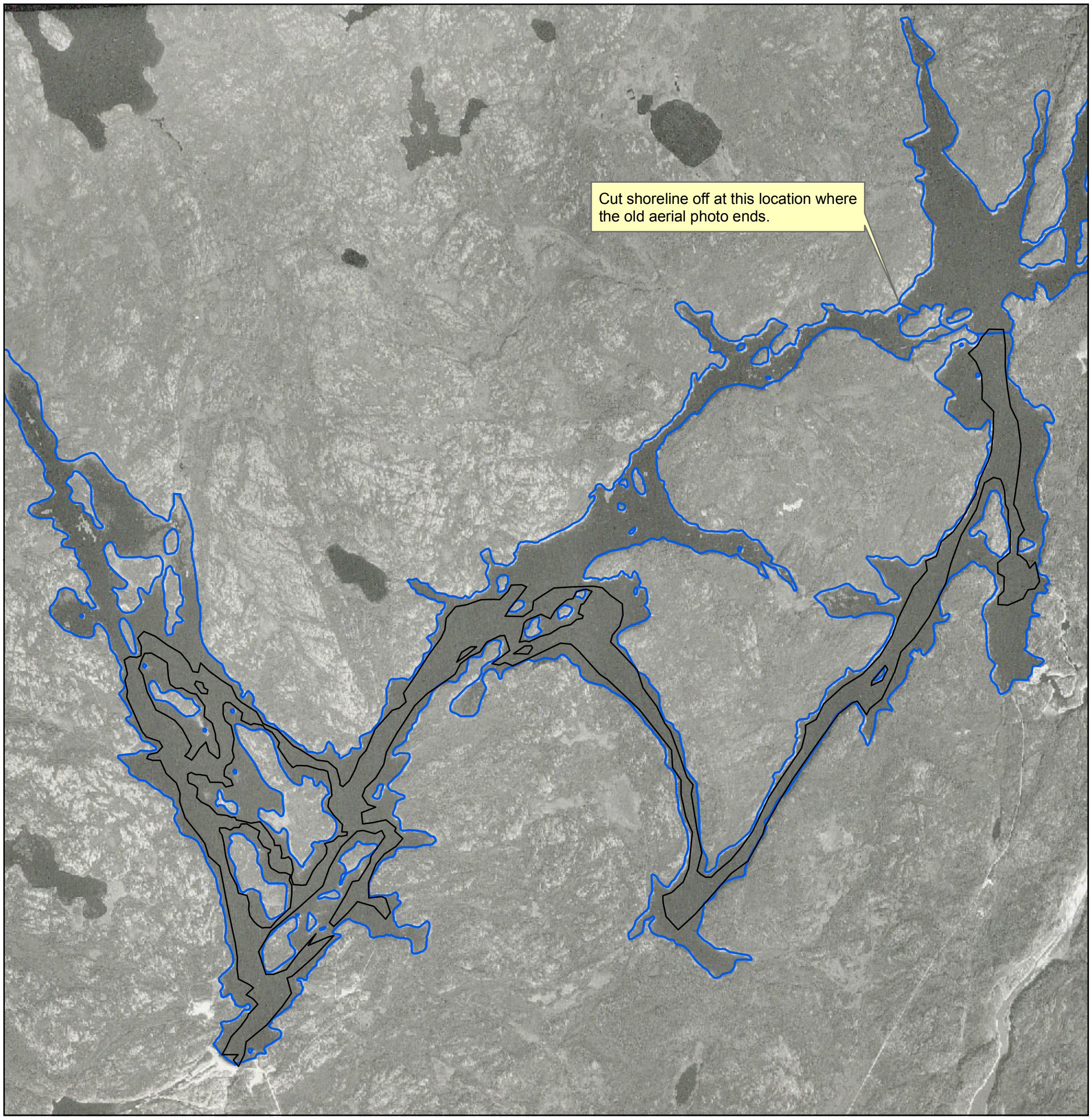
13.1.1.3 TWIN GORGES FOREBAY

The construction of the Twin Gorges facilities entailed a number of significant effects to the lower Taltson River system, namely, the flooding of the Forebay area upstream of the powerhouse and the alteration of the channel at Twin Gorges itself.

Appendix 13.1A (Elsie Falls to Tsu Lake Photomosaic) indicates the current conditions downstream of Twin Gorges Dam from Elsie Falls to Tsu Lake.

13.1.1.3.1 Twin Gorges Forebay Flooding

An analysis of pre- and post-flood conditions of the Forebay indicates that the surface area of the Forebay increased from 254.9 ha to 756.9 ha and the shoreline increased from 46.0 km to 80.3 km (Figure 13.1.5). Therefore, the flooding of the Twin Gorges Forebay resulted in changes to the surface water area, shoreline distances, water depths, and seasonal lake elevations. These changes result in a net increase in habitat quantity; however, the lack of information available during pristine conditions does not allow for comments on the changes to habitat quality.



October 1, 2008

Legend

Original Lake Area - 255 ha

Current Lake Area - 757 ha

1:30,000

Note:
The existing 1:50,000 map data matched the 1980 aerial photo (A25574-76), therefore, it was used to calulate the 'current' lake area.

The 'original' lake area was digitized from the 1955 photo (A14857-151).

TALTSON HYDROELECTRIC EXPANSION PROJECT	Developer's Assessment Report 2009	Twin Gorges Forebay Pre and Post Flooding	Figure 13.1.5

13.1.1.3.2 Habitat Changes at Twin Gorges

During the pristine time period, flows discharged the Forebay through an open bedrock channel that spilled over Elsie Falls. The creation of the dam and powerhouse resulted in the diversion of flows at this location through a penstock pipeline to the powerhouse and back into the bedrock channel. Conditions below the powerhouse location to Elsie Falls have likely shifted as well due to the significant amount of water that passes through Trudel Creek.

13.1.2 Mitigation and Monitoring

A number of mitigation measures, including design features and operational guidelines, have been identified to reduce the overall potential for negative effects throughout the Taltson River Basin, as summarized below. Discipline-specific (i.e., Fisheries Resources) mitigation measures are outlined in each discipline Section.

13.1.2.1 Nonacho Lake Control Facility

- Maintaining minimum release flows and minimum lake level as per current water licence, and maintaining maximum lake levels within historic range.
- Continued unregulated releases into Tronka Chua system.
- Restoration of site disturbances to the extent possible.

13.1.2.2 Twin Gorges Generation Facilities

- Low canal and gate entrance velocities to minimize entrainment of fish into turbine flows.
- Possible provision of a bypass spillway to maintain flow levels below Elsie Falls.
- Ramping of normal start/stop operations of generation plants.
- Multiple similar turbine units to sustain operational equilibrium conditions, and avoid transient conditions to the extent possible.

13.1.2.3 South Valley Spillway

- Provision of a minimum release facility to support flows in Trudel Creek.

13.1.2.4 Construction Access

- Use of ice roads to the maximum extent possible, limiting permanent land disturbance.
- Decommissioning of portage and other land sections of access roads with slash.

13.2 METHODOLOGY

The methodology utilized for the assessment of the environmental changes to Taltson River watershed adhered to the methods outlined in Chapter 10 (Assessment Methods and Presentation). Minor modifications were made to the methodology presented in Chapter 10 so that a focused effort appropriate to the Taltson River watershed could be made.

13.2.1 Taltson River Assessment Methodology

The Project proposes to increase the control of flows discharging from Nonacho Lake. This would result in a change to the Taltson hydrograph from Nonacho Lake downstream to the Twin Gorges Forebay. The change in hydrograph would result in a series of biological and physical changes that would act as stressors on fish and wildlife via changes in water quantity, water quality (specifically mercury), ice regime, aquatic resources and wetlands. As such, the effects assessment is structured so that the effects assessment on fish and wildlife stressors are presented first, followed by an effects assessment and determination of significance for fish and wildlife.

To enable this assessment, the Project components and associated activities were first identified. Next, activities that had the potential to interact with an assessment endpoint, either directly or indirectly via measurement endpoints, were identified based on a general understanding of the Project. This step was meant to identify all possible pathways from a typical hydroelectric project and did not necessarily consider the specifics of the Expansion Project. The intent was to be conservative and include all possible pathways. An assessment endpoint is the key component of a VC that should be assessed in order to determine if the VC is significantly affected by the proposed development. Assessment endpoints can be quantified but it is often difficult to do so. A measurement endpoint is a quantifiable feature that the assessment endpoint depends on. For example, a measurement endpoint for aquatic resources would be loss of habitat, while the assessment endpoint would be preservation of productivity, biodiversity and community structure. Measurement endpoints were sometimes used to qualify effects to assessment endpoints when the assessment endpoints were either difficult to qualify or there was overlap between measurement and assessment endpoints.

Once all possible pathways were identified, Project mitigation was reviewed to determine if the pathways were Valid, Invalid or if the potential effects were reduced to Minor through mitigation and/or design features.

All Valid pathways that lead to effects on assessment endpoints were carried forward to the effects classification. Effects on measurement endpoints were identified and quantified where possible. A qualitative assessment of residual effects on the assessment endpoints was then completed using the following criteria: direction, magnitude, geographic extent, duration, frequency, reversibility and likelihood. An overall rating of the residual effect was also completed based on the individual criteria ratings and professional judgement. Each effect was qualified separately.

Where not specified, the definitions used to classify residual effects used the definitions outlined in Table 13.2.1, which are specific to the Taltson River but based mainly on those definitions presented in Chapter 10.

Table 13.2.1 — Definitions of Terms Used in the Residual Effect Classification

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood
Neutral: no residual effect **Adverse:** a less favourable change relative to baseline values or conditions **Beneficial:** an improvement over baseline values or conditions	**Negligible:** no predicted detectable change from baseline values **Low:** effect is predicted to be within the range of baseline values **Moderate:** effect is predicted to be at or slightly exceeds the limits of baseline values **High:** effect is predicted to be beyond the upper or lower limit of baseline values so that there is likely a change of state from baseline conditions	**Small-scale:** Single zone, or portion thereof, within the Taltson Basin **Medium-scale:** Multiple zones with the Taltson Basin **Regional (large-scale):** Taltson Basin **Beyond Regional:** Slave River watershed	**Short-term:** effect is reversible at end of two to three years **Medium-term:** effect is reversible after 10 years **Long-term:** effect is reversible after the assumed 40-year operation period **Indefinite:** the duration of the effect is indefinite beyond the assumed 40-year operation period	**Reversible:** effect would not result in a permanent change of state of the population compared to "similar"[1] environments not influenced by the Project **Irreversible:** effect is not reversible (i.e. duration is indefinite or permanent)	**Isolated:** confined to a specific discrete period **Periodic:** occurs intermittently but repeatedly over the 40-year assessment period **Continuous:** occur continually over the 40-year assessment period	**Unlikely:** effect is likely to occur less than once in 100 years **Possible:** effect is possible within a year; or at least one chance of occurring in the next 100 years **Likely:** effect is probable within a year; or at least one chance of occurring in the next 10 years **Highly Likely:** effect is very probable (100% chance) within a year

[1] "similar" implies an environment of the same type, region, and time period

Not all components of the Taltson River watershed environment took the assessment to a qualitative stage. Water quantity (Section 13.3) was only discussed quantitatively, where baseline data was presented together with predictive data from the 36 MW and 56 MW expansion options. Water quality (Section 13.4) data was presented quantitatively and compared to various existing guidelines. A general qualitative assessment was completed as well based on magnitude of change to specific water quality parameters. Given the nature of ice processes and the baseline data available, the assessment of effects on the ice regime of the Taltson River watershed was more general and qualitative, but did not include a qualitative assessment of residual effects.

The effects assessment for aquatic resources and wetlands was both quantitative and qualitative in that both sections include residual effects classifications. The residual effects classifications and the quantitative changes in the various measurement endpoints of aquatic resources and wetlands played a key role in the assessment of fisheries resources and wildlife.

Determination of significance was only completed for fisheries resources and wildlife. The significance determination tables present all effects on a given assessment endpoint. The determination of significance was made after considering all the individual effects in summation on a given assessment endpoint. This includes the residual effects identified in the Trudel Creek effects assessment. That is, the pathways that led to effects on fish and wildlife VCs within Trudel Creek were included in the process to determine the overall significance of effect from the Expansion Project.

The assessment of effects of fisheries resources deviated slightly from the above and from what is outlined in Chapter 10. The deviations from the standard methods were based on the Department of Fisheries and Oceans Canada's (DFO) Risk Assessment Framework (RAF). The RAF identifies Pathways of Effects (POE) on fisheries resources for common in-stream and land-based activities. These POEs describe "cause and effect relationships" that are known to exist, and the mechanisms by which stressors ultimately lead to effects in the aquatic environment. Each cause-and-effect relationship is represented as a line, known as a pathway, connecting the activity to a potential stressor, and a stressor to some ultimate effect on fish and fish habitat, known as an assessment endpoint.

As such, analysis of the potential effects to the fisheries resource incorporated those pathways and assessment endpoints identified by DFO. The DFO-identified pathways and assessment endpoints vary from the methodologies outlined in Chapter 10 in that the assessment endpoints are not specific to a Valued Component but rather to a specific parameter (i.e., water quality) that could affect the Valued Component. In this way, they direct and support the method used for assessment of the ecology of the Taltson River basin, with various parameters acting as stressors to fish and wildlife.

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF PLATES

13. WATER FLUCTUATIONS IN THE TALTSON RIVER WATERSHED

13.3 ALTERATIONS OF WATER QUANTITY

13.3.1 Introduction

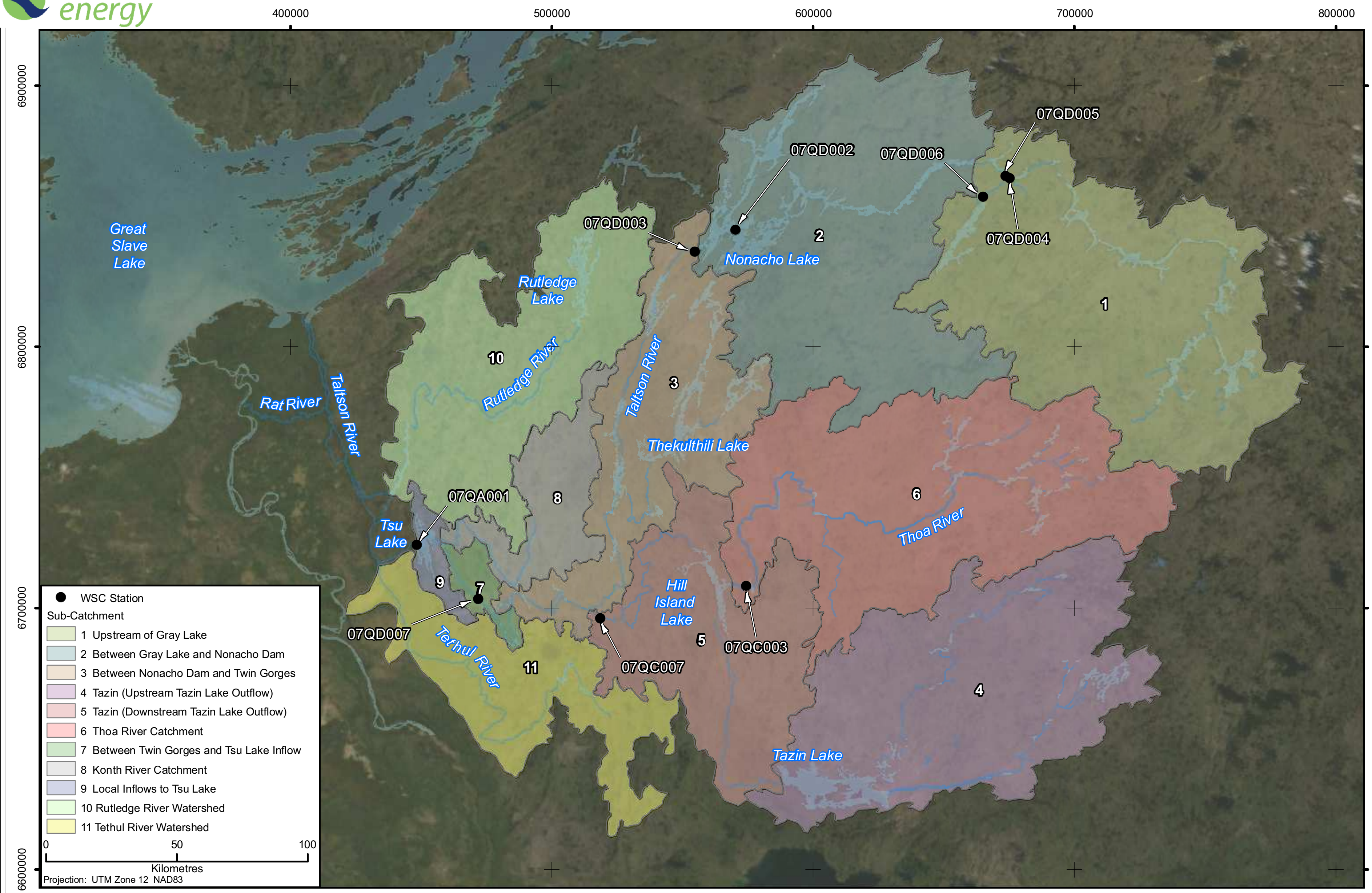
13.3.1.1 TALTSON BASIN DESCRIPTION

The Taltson River basin is a relatively large drainage area of approximately 60,000 km^2 located between Lake Athabaska and Great Slave Lake (Figure 13.3.1). The region is characterized as a subhumid, high boreal ecoclimate with typically cool summers and very cold winters. The basin comprises a relatively complex system of interconnected lakes, draining generally southwest from the higher elevation Canadian Shield area and then northwards along, and eventually into, the Slave River Lowlands. The river enters Great Slave Lake on its southern shore at the western end of the Simpson Island chain. Two main tributaries form the lower Taltson River on which the existing generation facility was developed – the mainstem Taltson River and the Tazin River. The hydrological setting of the Taltson Basin is presented in detail in Sections 6.1.3 (Taltson River Basin & Existing Twin Gorges Power Development) and 9.3 (Taltson Basin Hydrology) which includes discussion of historical observed data and simulated baseline conditions.

Nonacho Lake is the largest lake in the Taltson River basin and has one of three man-made control structures within the basin. The other two control structures are at Tazin Lake and the Twin Gorges Facility. Outflow from Nonacho Lake occurs at two locations, the Nonacho dam control structure and Tronka Chua Gap. Discharge from Nonacho Lake to the Taltson River passes through the existing dam underflow gates, as leakage through the dam, or over the dam spillway. Tronka Chua Gap is a natural saddle in the south-west corner of the lake. Flow that passes through Tronka Chua Gap rejoins the Taltson River at Lady Grey Lake after passing through a series of lakes including Tronka Chua Lake and Thekulthili Lake. Prior to the construction of the Nonacho control structure in 1968, it is likely that all outflow from Nonacho Lake was naturally routed through the mainstem of the Taltson River. It is likely that discharge over the Tronka Chua Gap did not occur.

The reach between Nonacho Lake and the Twin Gorges Forebay is a complex series of slow-moving, low-gradient river reaches divided by a series of lakes, rapids, and waterfalls. The major lakes within the upper section of this reach include Taltson, King, and Lady Grey. In many cases, the backwaters from one lake extend almost as far upstream as the rapids near the outflow of the next upstream lake, such that flow through the system is primarily controlled by lake storage and flow restrictions at rapids and lake outlets.

Below Lady Grey Lake, the Taltson River regains more typical river characteristics to the Twin Gorges Forebay. In this reach, the river passes through a number of smaller lakes, including Benna Thy Lake. The Tazin River, the largest tributary of the Taltson River, joins the mainstem of the Taltson within this reach. Flow out of Tazin Lake is controlled by a dam constructed to divert water into the Charlot River system to operate hydroelectric projects that currently contribute to the Saskatchewan power grid. The diversion effectively removes approximately 9,400 km^2 of area from the Taltson Basin, or about 17% of the total potential drainage area at Twin Gorges. Flow over the Tazin Lake dam into the Taltson River basin is intermittent. Therefore, except during higher than normal runoff periods, discharge into the Taltson River basin is limited to the portion of the watershed downstream of Tazin Lake, including the Thoa River.



gis no. TAL-10-003DAR

TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Taltson River Watershed and Main Sub-watersheds**	**Figure 13.3.1**

Outflow from the Twin Gorges Forebay is either through the existing hydropower generating plant, or over the South Valley Spillway (SVS). Water passing through the generating station flows over Elsie Falls and into the Taltson River and continues toward Tsu Lake. Flow over the SVS is diverted through Trudel Creek, which flows in a broad loop to the south before returning to join the Taltson River below Elsie Falls. Currently, a substantial portion of the outflow from Twin Gorges enters Trudel Creek via the SVS, as the existing plant uses only about 25% of the basin runoff for power generation. Prior to construction of the Twin Gorges Power Facility in 1965, flow to Trudel Creek from the Taltson River would have been much lower and intermittent (Rescan 2006).

Below Elsie Falls, the Taltson River flows to Tsu Lake and on to Great Slave Lake. Within this reach a number of tributaries enter the Taltson River including the Konth, Rutledge, and Tethul River.

13.3.1.2 SUMMARY OF EXISTING AND PROPOSED TWIN GORGES HYDROELECTRIC FACILITIES

The existing 18 MW hydroelectric facility at Twin Gorges was originally developed in 1965 to supply power to the Pine Point Mine. In 1968 a dam with three underflow gates was constructed on Nonacho Lake to increase regulated storage capacity in the basin. The project provided power to the mine until its closure in 1986.

Since the closure of Pine Point Mine, the facility has supplied power to the communities of Hay River and Fort Fitzgerald, NWT, but at an output that is less than full capacity. Since 1986, the generating output has ranged from 8 MW to 12 MW. The decrease in power demand has resulted in the need for little regulation of releases from Nonacho Lake. Inflow to Twin Gorges that is not required for power production is allowed to spill over the SVS into Trudel Creek.

The Taltson Expansion Project would incorporate a new generation facility at Twin Gorges with an output capacity of between 36 MW and 56 MW, and upgrades and modifications to the control structures at the outlet of Nonacho Lake. The primary objective of the Expansion Project would be to maximize power generation from the existing and new plants, while maintaining basin environmental constraints and conditions as required. The existing Twin Gorges 18 MW plant currently operates at between 8 MW and 12 MW output, with the majority of the basin water spilled into Trudel Creek. Moving toward full generation at either of the total capacities proposed for the Expansion Project (54 MW or 74 MW) would thus require enhanced water management within the basin, particularly with respect to the current spill into Trudel Creek. These necessary water-management processes would tend to modify basin hydrological conditions from their current baseline in the basin between Nonacho Lake and Great Slave Lake, with varying departures from baseline in various basin zones.

Some indication of general response of the basin given the water management requirements of the Expansion Project can be ascertained from consideration of a few of the fundamental characteristics of the basin and the proposed plants. The basin flows at Twin Gorges are made up of two relatively independent flow sources: water from the upper Taltson River and Nonacho Lake system, and water from the Tazin River system. While the exact distribution of flows between these two sources is difficult to define with accuracy, best estimates are that each area contributes about 50% of the flows at Twin Gorges.

The Taltson River at Twin Gorges has a mean annual discharge of approximately 200 m^3/s, which has ranged from a low of about 100 m^3/s to as high as 285 m^3/s over the available period of record. Therefore, the mean annual discharge from the unregulated Tazin system and the Nonacho Lake branch are approximately 100 m^3/s each. The release flow from Nonacho Lake therefore needs to balance on average the difference between the design flow and a mean annual available flow of about 100 m^3/s.

The design flow for the 36 MW Expansion Project is 180 m^3/s, leaving an average release requirement of 80 m^3/s from Nonacho Lake, and 100 m^3/s from unregulated inflow. We can therefore expect that the Nonacho Lake system can successfully be used in average- to wetter-than-average years for storage of freshet flows and release of water into the system later in the year. In most years, the storage of freshet runoff would shift the higher-flow period from summer into winter in the river reach downstream of Nonacho Lake. The storage in Nonacho Lake allows for about one year of typical freshet storage. In dry years, and particularly in multiple-year dry periods, the storage would therefore have been used up, and releases from Nonacho Lake would be constrained. The plant output would need to be curtailed to keep inflows and generation flows in balance. The generation output would not be expected to achieve 100% on an average basis even though the design flow is less than the mean annual flow, due to the variation in flows from year to year, the limitation on storage, and the unregulated flows that would occur in the Tazin River system that would have to be spilled.

The design flow of the 56 MW Expansion Project is 240 m^3/s, well above the mean annual discharge at Twin Gorges over the available period of record (but below wet year annual discharges). In this case, only in wetter than average years would there be excess water that can be stored in Nonacho Lake, and released later in the season. In any year, the volume of water stored would be lower than for the 36 MW plant, and the associated winter releases possibly would also be lower. In an average year, all water coming into Nonacho Lake would be needed for release almost immediately to maintain power plant design flows. It would therefore not be expected that on average, high-flow months would shift from the summer baseline condition to winter conditions in the river reach between Nonacho Lake and Twin Gorges for this expansion scenario. On average, the flows and lake elevations in this scenario would therefore be expected to more resemble the baseline scenario where almost no controlled regulation is provided at Nonacho Lake, and flow routing is relatively natural.

Long-term power generation from the 56 MW Expansion Project cannot reach higher than the proportion of mean annual discharge to design flow (200/240), or 83%, and the benefits of installation of the larger system may not seem obvious. In fact, the water use for power generation on average rises from approximately 90% for the 36 MW expansion, to 97% for the 56 MW expansion, and results in a substantial increase in power generation for the larger plant.

To facilitate a quantitative assessment of the changes to flow and water levels in the Taltson Basin that may result from the Expansion Project, the Dezé Energy Corporation initiated and supported the creation of the Taltson Basin Flow Model (the Flow Model). The basis of the flow model is fully presented in Appendix 9.3A. The use of the model for prediction of basin response to the two expansion scenarios is presented in the following sections.

13.3.2 Taltson Basin Flow Model Expansion Scenarios for the Taltson River

The Flow Model is a numerical model created to simulate flows and water levels along the Taltson River between Nonacho Lake and Great Slave Lake and to predict changes in these parameters based on the proposed Expansion Project. Results provided by the model are considered for six zones (including Nonacho Lake) along this section of the Taltson River (Figure 13.3.2). The model set-up for the baseline scenario, which represents the current operational conditions of the Project (i.e. following the closure of the Pine Point Mine), is discussed in more detail in Section 9.3 (Taltson Basin Hydrology). The model set-up is fully presented for the baseline and expansion scenarios in Appendix 9.3A (2008 Taltson Basin Flow Model Report). The following discussion focuses on model specifics and results for Nonacho Lake and hydrological Zones 1 to 4 under the 36 MW and 56 MW expansion scenarios and compares these results to the baseline scenario. Model results for the two expansion scenarios for Trudel Creek, which comprises Zone 5, are presented in Section 14.3. (Trudel Creek — Alterations of Water Quantity).

To allow prediction of the flows and water levels within the model study area under the expansion scenarios, the physical representation and operations of the Twin Gorges Forebay and Nonacho Lake reservoir within the Flow Model were altered to reflect the Expansion Project description. The changes made to the Flow Model to represent the Expansion Project description at the Twin Gorges Forebay and Nonacho Lake are detailed in the following sections.

To allow comparison to the baseline scenario, model scenarios representing the 36 MW and 56 MW expansion options were given the same hydrological inputs (upstream inflow to Nonacho Lake and local inflows to the Taltson River below Nonacho Lake) as the baseline scenario. The hydrological inputs were estimated based on historic data available in the basin, and span the period from 1978 through 1990 (see Section 9.3.3, description of the Taltson Basin Flow Model).

The Flow Model was used to address "normal operations" (as summarized in Table 13.3.1 and Table 13.3.2) of the Project only. Outage scenarios were not considered. However outages would occur to allow for routine maintenance or as a result of accidents and malfunctions (Chapter 17). Section 6.6.7 (Plant Outages) provides details of the operating conditions during a scheduled and unscheduled plan outage. A discussion of scheduled outage scenarios and associated effects to flow and water levels in the Twin Gorges Forebay and the Taltson River below Twin Gorges is provided in Section 13.3.4 (Ramping from Annual Scheduled Outages). Section 13.3.4 incorporates flows at the power facilities simulated by the Flow Model but applies the outage scenario external to the model.

13.3.2.1 TWIN GORGES FOREBAY MODEL REPRESENTATION

Water exits the Twin Gorges Forebay either through the hydroelectric facility (Power Plants) or over the SVS to Trudel Creek. While the Project does include a bypass structure on the South Gorge with a capacity of up to 30 m^3/s, this release facility is not currently represented in the Flow Model. That structure would be primarily used for outage events, and as such is not part of typical continuous operations considered in this basin response analysis.

13.3.2.1.1 Power Plants (Existing and Proposed)

The Flow Model simulates flow through the hydroelectric facility based on physical parameters of the facility (i.e. generation capacity, plant efficiency, and head drop), a power demand curve, and water levels in the Forebay.

The existing power plant was modelled with an 18 MW maximum capacity and 74 m^3/s of maximum flow-through. For the baseline scenario, which represents operations of the facility following the closure of the Pine Point Mine in 1986 to present day, the power demand curve was specified so that the power plant operates at a seasonally variable capacity of 8 MW during the summer and 12 MW during the winter (Table 13.3.1).

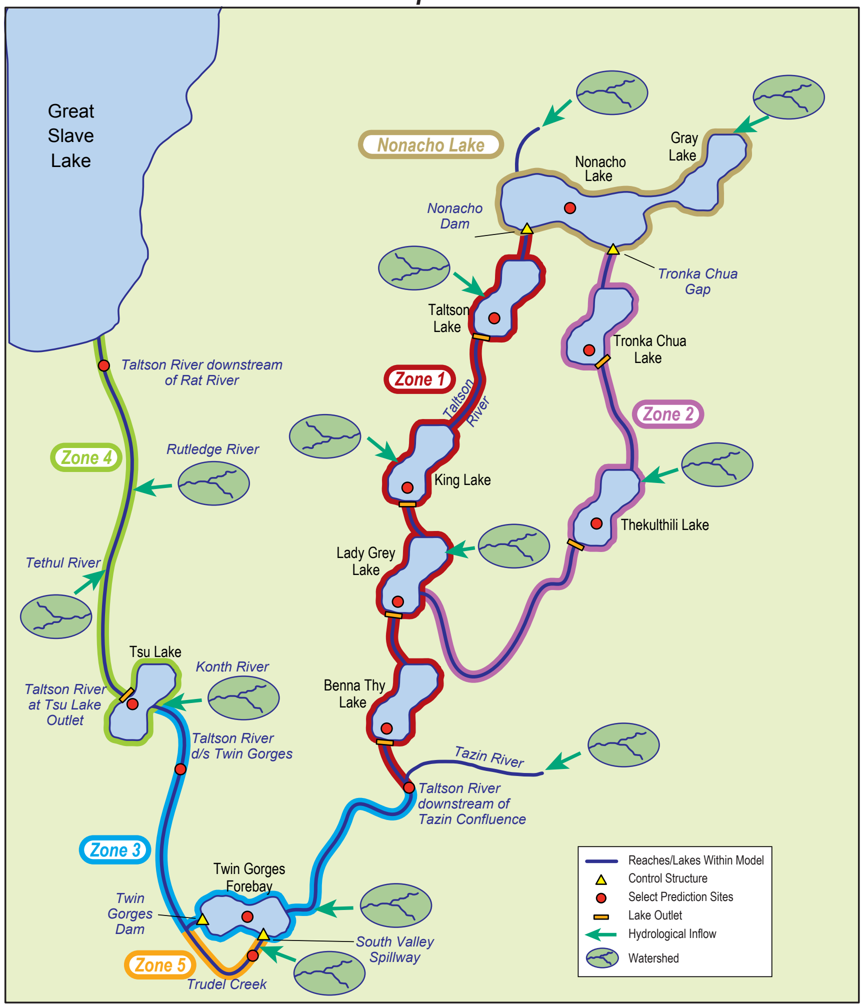
A main component of the Expansion Project is the construction of a new power facility at Twin Gorges, with a power production capacity of between 36 MW and 56 MW in addition to the existing 18 MW facility. These two expansion options were modelled separately within the Flow Model. The power demand curve was set for both expansion scenarios to maximize power production throughout the year, although the actual power production was controlled by water levels within the Twin Gorges Forebay. If the water availability in the Forebay drops, the flow through the existing power plant, which would be less efficient than the proposed plant, is decreased and turned off before the flow through the proposed plant is modified. Essentially, the proposed power plant is "first on, last off".

Table 13.3.1 — Proposed Power Plant Upgrades

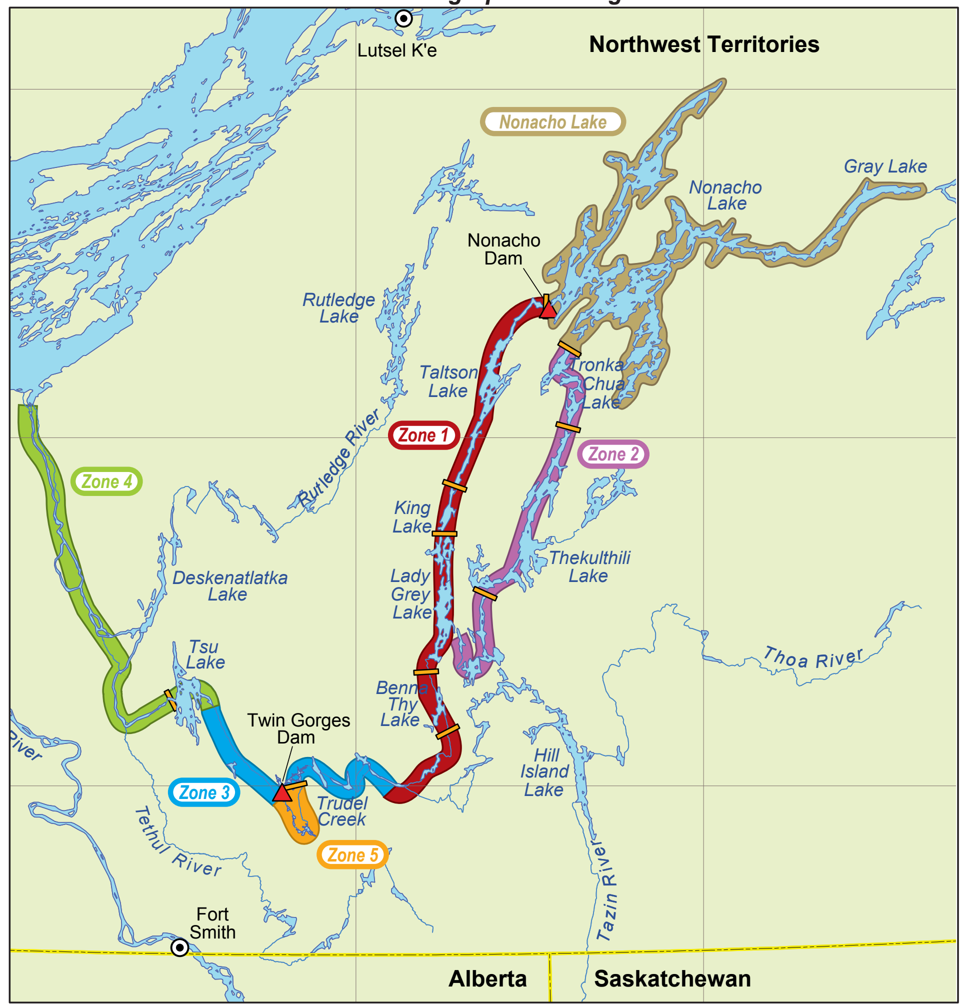
<table>
<tr><th rowspan="2">Model Scenario</th><th rowspan="2">Power Plants Modelled</th><th rowspan="2">Full Generation Flow (m³/s)</th><th colspan="2">OPERATIONAL TARGET</th></tr>
<tr><th>Power Production (MW)</th><th>Generation Flow (m³/s)</th></tr>
<tr><td>Baseline</td><td>18 MW</td><td>74.0</td><td>8 (summer)
12 (winter)</td><td>30 (summer)
50 (winter)</td></tr>
<tr><td rowspan="2">36 MW Expansion</td><td>18 MW</td><td>74.0</td><td rowspan="2">54</td><td rowspan="2">180.6</td></tr>
<tr><td>36 MW</td><td>106.6</td></tr>
<tr><td rowspan="2">56 MW Expansion</td><td>18 MW</td><td>74.0</td><td rowspan="2">74</td><td rowspan="2">240.0</td></tr>
<tr><td>56 MW</td><td>166.0</td></tr>
</table>

For the expansion scenarios, the target water level for the Forebay was specified at 247.6 masl (equal to the crest elevation of the SVS) to maximize power production and minimize spillage of excess water above the specified minimum release of 4 m^3/s to Trudel Creek.

A. Conceptual Sketch



B. Geographic Setting



TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report** **2009**	**Planar Schematic and Geographic Setting of the Taltson Basin Flow Model**	**Figure** **13.3.2**

13.3.2.1.2 South Valley Spillway

Water not used for power production flows from the Forebay to Trudel Creek via the South Valley Spillway (Plate 13.3.1). The main spillway is a concrete structure with a defined width of approximately 100 m constructed at a natural saddle that historically conveyed flow from the mainstem of the Taltson River to Trudel Creek during periods of high runoff. In addition to the main spillway, there are also two smaller, natural channel spillways located on one side of the main spillway.

Plate 13.3-1 — South Valley Spillway

The SVS is an uncontrolled spillway such that flow over the SVS is directly related to water level within the Forebay. No changes are proposed to the physical structure of the SVS for the expansion scenarios. However, to reflect the Project commitment to release a minimum of 4 m^3/s to Trudel Creek, this has been specified as a minimum release in the Flow Model for both of the expansion scenarios regardless of the water levels in the Forebay. This represents an additional controlled release from the Twin Gorges Forebay that would be physically incorporated into or near the SVS.

13.3.2.2 NONACHO LAKE

Within the Flow Model, outflow from Nonacho Lake is controlled by water level within the lake, rating equations for each of the reservoir outlets, and operational constraints set up for the controlled releases from the reservoir.

Under the baseline conditions, there are four outlets in Nonacho Lake, which include the Nonacho dam control structure and spillway, seepage through the dam, and uncontrolled flow over the natural topographic saddle at Tronka Chua Gap. Each outlet is represented by separate rating curves that relate the water level within the lake to flow rates at each of the outlets. Releases through the Nonacho Dam control structure are further controlled by operational specifications. Proposed alterations to each of the outlets are presented below.

13.3.2.2.1 Nonacho Dam Control Structure

Currently the Nonacho Dam control structure contains three identical underflow gates that allow flow to be discharged to the Taltson River. The maximum flow through the three gates is approximately 45 m^3/s to 60 m^3/s depending on water levels in the lake. The gates were constructed to provide some control of flows released to the Twin Gorges Forebay. After closure of the Pine Point Mine in 1986 the use of the gates to manage flows in the Taltson system has been limited. Typically the gates are opened for a four-month period each year (June through September) to mitigate rising levels within Nonacho Lake. This is the operational specification used for the baseline model scenario.

A main component of the Expansion Project would be a need to reintroduce regulation of flows from Nonacho Lake in order to maximize power production at Twin Gorges. This would be achieved by increasing the capacity of the underflow gates and reintroducing a structured management of releases.

For both expansion scenarios, the capacity of the underflow gates would be upgraded by replacing the current underflow gates with four new gates with a capacity at a minimum lake elevation of 30 m^3/s each, for a total capacity of 120 m^3/s. This capacity would increase under higher lake levels, such that the total capacity of the underflow gates would be approximately 140 m^3/s at the elevation of the upgraded Nonacho Dam spillway elevation.

To maximize power production at Twin Gorges under the expansion scenarios, releases from Nonacho Lake would be controlled such that water would be stored when flows from unregulated portions of the basin (including the Tazin River and other watersheds downstream of Nonacho Lake) are high and support the majority of flow requirements needed for full power generation. Water would be released when contributions from other watersheds are lower (i.e. late summer, fall, and winter). This operational scheme is represented in the Flow Model by specifying target monthly release rates (Table 13.3.2). The monthly release targets were set based on the difference between the full generation design flow for the proposed power plant upgrade and the estimated average monthly inflow from the Tazin River and other estimated average monthly lateral inflow from local watersheds between Nonacho Lake and Twin Gorges. Due to attenuation in the large lakes within the upper Taltson River basin, there is a lag time from when water released from Nonacho Lake enters the Twin Gorges Forebay. This lag is approximately 15 to 30 days depending on base flows within the system. Therefore, the target release from Nonacho Lake for any day in a specific month was based on the estimated average monthly flows from the unregulated portions of the basin estimated for the following month.

Under actual operational conditions this scheme would be overly simplistic and would not provide optimized use of available flows. Operations of the Nonacho control structure would in fact be reviewed on a daily basis, considering levels in the reservoir, upstream flows in the Taltson River, and unregulated flows at the mouth of the Tazin River, as outlined in Section 6.6.5 (Nonacho Lake Control).

Table 13.3.2 — Specified Target Releases from Nonacho Lake under the Expansion Scenarios

Month	FULL GENERATION FLOW AT TWIN GORGES (m^3/s)		RELEASE FROM NONACHO LAKE (m^3/s)		Average Flow from Unregulated Portion of the Basin for the Next Month (m^3/s)
	36 MW	56 MW	36 MW	56 MW	
January	180.6	240.0	139.1	198.5	41.5 (Feb)
February	180.6	240.0	146.8	206. 2	33.8 (Mar)
March	180.6	240.0	148.6	208.0	32.0 (Apr)
April	180.6	240.0	81.0	140.4	99.6 (May)
May	180.6	240.0	13.9	73.3	166.7 (Jun)
June	180.6	240.0	40.6	100.0	140.0 (Jul)
July	180.6	240.0	68.1	127.5	112.5 (Aug)
August	180.6	240.0	87.2	146.6	93.4 (Sep)
September	180.6	240.0	89.9	149. 3	90.7 (Oct)
October	180.6	240.0	91.6	151.0	89.0 (Nov)
November	180.6	240.0	106.6	166.0	74.0 (Dec)
December	180.6	240.0	126.3	185.7	54.3 (Jan)

Within the Flow Model, all releases from Nonacho Lake (i.e. underflow gates, Nonacho Dam spillway, and Tronka Chua Gap) are included as part of the specified monthly flow targets. Therefore, the underflow gates are typically not relied upon to supply the full release target during periods when water levels are high enough that flows also occur over the Nonacho Dam spillway and/or the Tronka Chua Gap.

Constraints on operations of the control structure under the expansion scenarios are included within the Flow Model in order to satisfy currently permitted water levels in Nonacho Lake and flows in the Taltson River below Nonacho Lake. The minimum water level for the reservoir is determined by the water license at 321.71 masl, and a nuisance high-water level in the model is set at 323.91 masl (the level at which local lodge owners register complaints). Additionally, a minimum release of 14 m^3/s was set for the underflow gates in the current model to comply with the minimum release to the Taltson River, specified in the existing water license.

An operational constraint that limits release from the control structure as water levels begin to approach the minimum permit level was also included in the model. This was required to ensure that both the minimum reservoir level and the minimum releases to the Taltson River would not be violated.

13.3.2.2.2 Nonacho Dam Spillway

The uncontrolled spillway at Nonacho Dam is approximately 60 m wide. Flow over the spillway is directly related to the water level within Nonacho Lake and is represented within the Flow Model using a broad-crested weir equation and discharge coefficient of 1.46.

The proposed upgrade to the dam at Nonacho Lake includes raising the existing spillway by 0.5 m. It was assumed that the spillway had a trapezoidal geometry such that a 0.5 m rise in the spillway crest would have an associated 2 m increase in the width of the crest. This increase in width was also represented within the model.

13.3.2.2.3 Leakage through Nonacho Dam

The existing Nonacho Lake dam leaks, allowing seepage through the dam to the Taltson River in the order of 5 to 10 m^3/s. One of the proposed upgrades to Nonacho Lake dam is to seal the existing dam to increase the control of releases from the lake. For the two expansion scenarios, the dam was "sealed" by setting the leakage term to 0 m^3/s for all time steps. In reality, the dam would not be fully sealed, and a small amount of leakage (i.e. less than 3 m^3/s) would likely still occur.

13.3.3 Expansion Scenario Model Results and Comparison to Baseline

During operations of the Expansion Project, release of water from Nonacho Lake would be regulated to maximize power production at Twin Gorges. As a result, the hydrologic regime of the Taltson River from Nonacho Lake to Great Slave Lake would be altered compared to baseline conditions. The Flow Model was run with the same 13-year time series of hydrological inputs as used for the baseline scenario (see Section 9.3, Taltson Basin Hydrology), but with the altered physical and operational characteristics of Nonacho Lake and the Twin Gorges Forebay as discussed above. The Flow Model was run for two different expansion scenarios, 36 MW expansion and 56 MW expansion. The only differences in model set-up between the two expansion scenarios were the monthly flow targets specified for Nonacho Lake releases and the full generation flow of the Twin Gorges power plants.

Within the model, results for flows are provided for seven locations in the basin:

1. Outflow from Nonacho Lake to Taltson River.
2. Outflow from Nonacho Lake at Tronka Chua Gap.
3. The Taltson River downstream of the confluence with the Tazin River.
4. Outflow from the Twin Gorges Forebay through the power plants.
5. Outflow from the Twin Gorges Forebay at the SVS.
6. The Taltson River downstream of Twin Gorges.
7. The Taltson River near Rat River.

These seven locations were chosen such that there is at least one set of flow predictions from each of the five zones within the Taltson Basin. Simulated flows for all available locations are presented in Appendix 9.3.A (2008 Basin Flow Model Report).

Model results for water levels are provided for all locations where a rating curve could be developed in the model. This includes the following nine lakes and reservoirs:

- Nonacho Lake.
- Taltson Lake.
- King Lake.

- Lady Grey Lake.
- Benna Thy Lake.
- Tronka Chua Lake.
- Thekulthili Lake.
- Twin Gorges Forebay.
- Tsu Lake.

and three river sections:

- Taltson River below the Tazin River.
- Taltson River below Twin Gorges.
- Trudel Creek at TRUDEL1 (presented in Section 14.3 Trudel Alterations of Water Quantity).

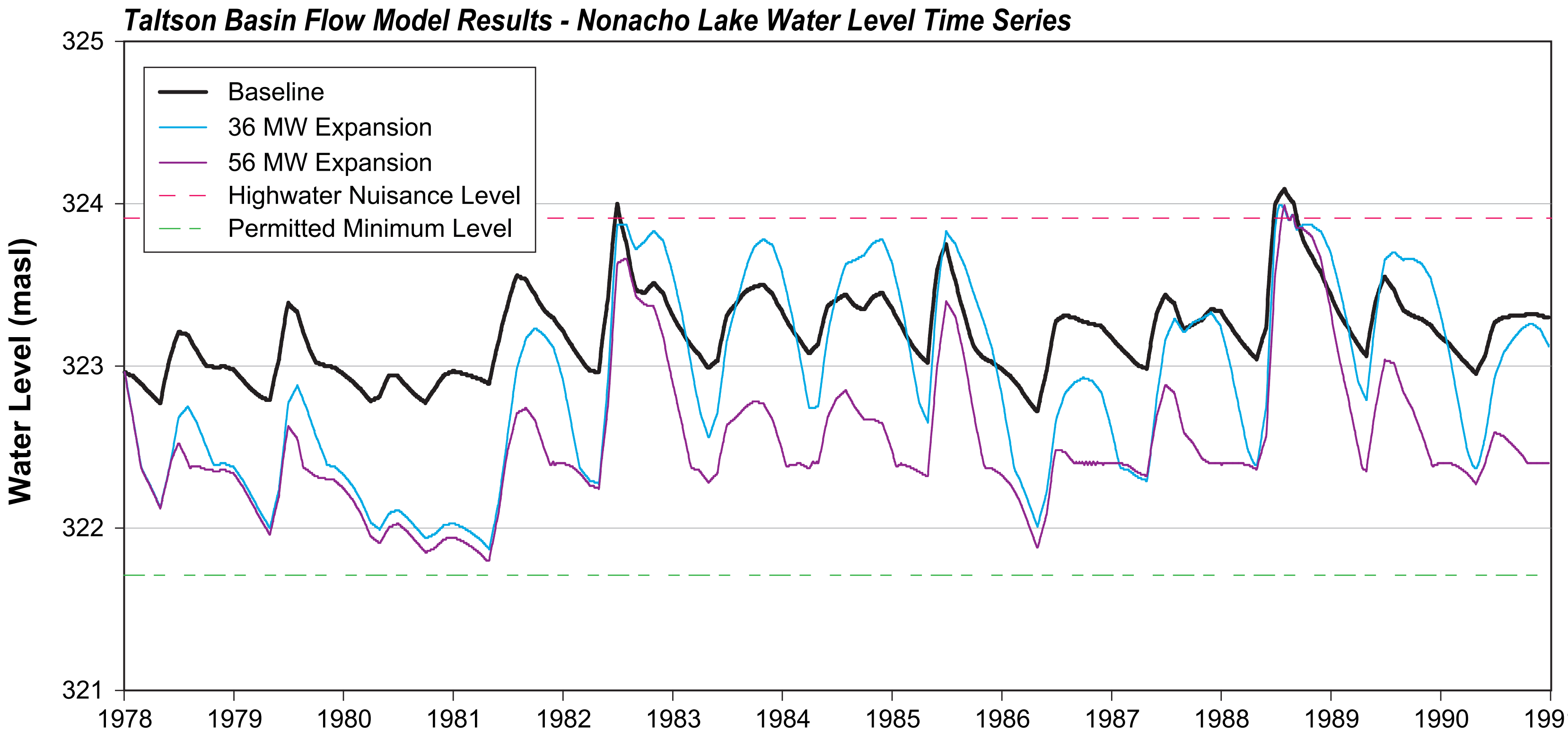
The Flow Model was used to address "normal operations" of the Project only. Outage scenarios were not considered. A discussion of potential outage scenarios and associated effects to flow and water levels in the Twin Gorges Forebay, Trudel Creek, and the Taltson River below Twin Gorges is provided in Section 6.7.2.

13.3.3.1 NONACHO LAKE

For the proposed expansion scenarios, releases from Nonacho Lake would be controlled to maximize power production at Twin Gorges. The general goal would be to store water in Nonacho Lake during the freshet and release it during the lower flow periods of summer, fall, and winter.

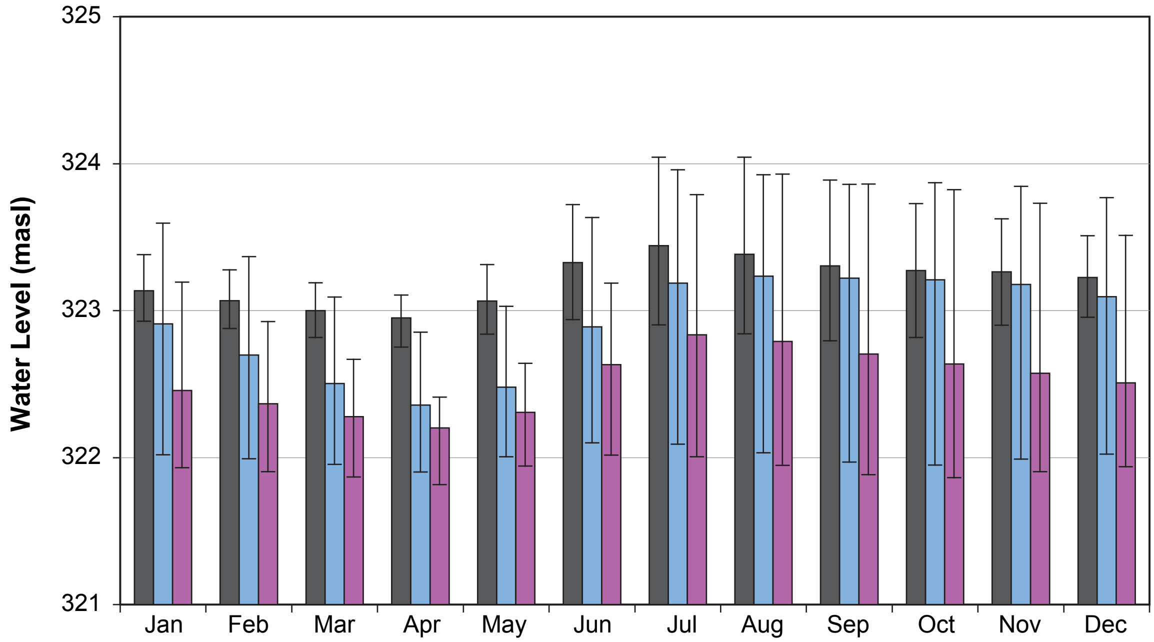
Due to the modified control of releases at Nonacho Dam, water levels within Nonacho Lake would also be altered from baseline conditions (Figure 13.3.3, Figure 13.3.4, and Table 13.3.3).

Under the 36 MW expansion scenario during average to wet years, water levels would be greater than baseline during the peak of freshet, summer and fall, when water would be stored within the reservoir. Water levels would be lower in the winter, when the stored water would be released to satisfy demand at Twin Gorges. During these periods, although water levels would be higher, they would be within the range of maximum peak water levels experienced under baseline conditions. During very wet periods, the greater capacity of releases at the control structure would improve the ability of the Project to mitigate against water levels approaching the nuisance high-water level. Therefore, for very large runoff events (i.e. spring freshet of 1982 and 1988), peak water levels would decrease compared to baseline conditions. During drier periods, water levels are expected to stay consistently lower than baseline for prolonged periods of multiple years in succession (i.e. 1978 through 1981). This is a result of the increased capacity of the underflow gates to facilitate a greater drawdown of storage in the reservoir. If freshet runoff for any year is not enough to replenish storage consumed the previous winter, then levels would remain low compared to baseline. On average, mean monthly water levels would be below baseline conditions throughout the year with a greater reduction in monthly levels during the winter than during the open-water period.



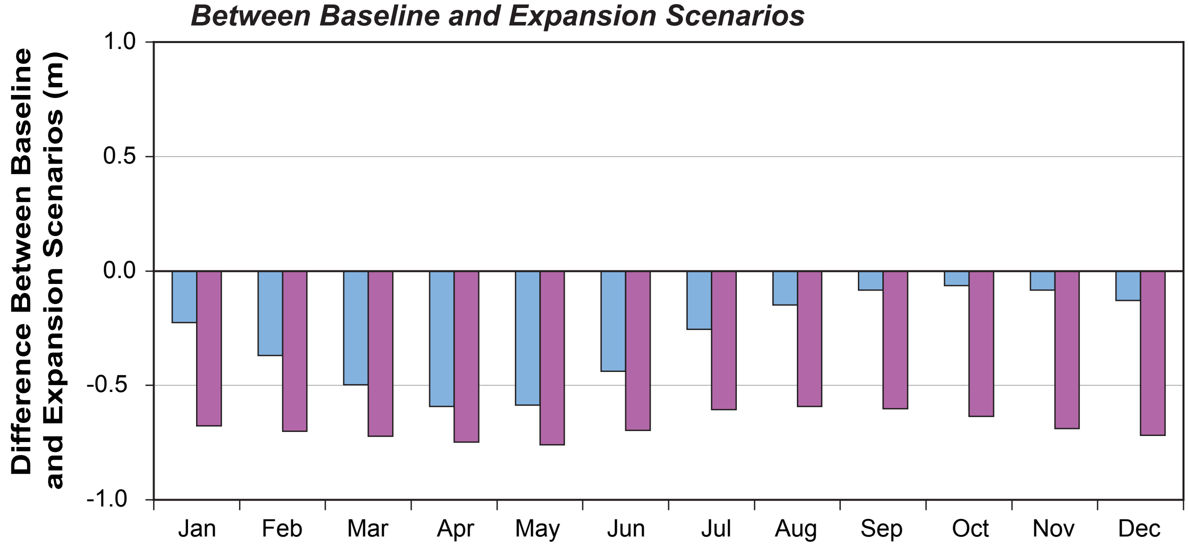
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Nonacho Lake Water Level Time Series (503-005 / a22067m)	Figure 13.3.3

A. Average Monthly Water Level



Note: Bars indicate maximum and minimum average monthly values over entire simulation period.

B. Difference in Average Monthly Water Level Between Baseline and Expansion Scenarios



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Taltson Basin Flow Model Results - Nonacho Lake Water Level Monthly Summary** (503-005 / a22068m)	**Figure 13.3.4**

Table 13.3.3 — Taltson Basin Flow Model Results: Nonacho Lake Water Levels

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Monthly Water Level (masl)												
Baseline	323.13	323.07	323.00	322.95	323.07	323.33	323.44	323.38	323.31	323.27	323.26	323.23
36 MW Expansion	322.91	322.70	322.50	322.36	322.48	322.89	323.19	323.23	323.22	323.21	323.18	323.10
56 MW Expansion	322.46	322.37	322.28	322.20	322.31	322.63	322.84	322.79	322.70	322.64	322.57	322.51
Change from Baseline (m)												
36 MW Expansion	-0.23	-0.37	-0.50	-0.59	-0.59	-0.44	-0.26	-0.15	-0.08	-0.06	-0.08	-0.13
56 MW Expansion	-0.68	-0.70	-0.72	-0.75	-0.76	-0.70	-0.61	-0.59	-0.60	-0.64	-0.69	-0.72

Under the 56 MW expansion scenario much of the inflow to the reservoir would be released to meet the increased power production capacity downstream, even during periods of high runoff, such that water levels remain consistently below baseline conditions. Similar to the 36 MW scenario, this would be result of freshet runoff not being able to replace storage that was consumed the previous winter to maximize power production at Twin Gorges. However, this would be exacerbated in the 56 MW scenario as target releases throughout the year would be greater than in the 36 MW scenario, resulting in greater consumption of stored water in the winter and less ability to accumulate storage within the reservoir. Therefore, under the 56 MW scenario water levels would remain below baseline levels perpetually.

Due to the greater regulation of releases from Nonacho Lake, there would be the potential to have greater annual variation in water levels under the expansion scenarios. Table 13.3.4 compares the annual baseline variation of estimated monthly average water levels to those of the upgrade scenario runs. Under the 36 MW expansion scenario there would be on average, an increase in the annual variation. Although there would also be an increase in the annual variation under the 56 MW scenario, it would be of a lesser magnitude than for the 36 MW scenario. This is because under the same scenario, water levels would be consistently closer to the permitted minimum levels such that releases would often have to be limited to ensure the levels and releases do not drop below the permitted minimums.

Table 13.3.4 — Estimated Annual Variation in Mean Monthly Nonacho Lake Water Level

Scenario	Annual Variation in Mean Monthly Level (m)
Baseline	0.49
36 MW Expansion	0.88
56 MW Expansion	0.63

13.3.3.2 ZONE 1 – TALTSON RIVER FROM THE NONACHO DAM TO THE TAZIN RIVER

13.3.3.2.1 Outflow from Nonacho Lake to the Taltson River (Zone 1)

The comparison of baseline and expansion scenario flows from Nonacho Lake to Taltson River is illustrated in Figure 13.3.5 to Figure 13.3.7 and Table 13.3.5. Due to the increased capacity of the new upgraded underflow gates, a greater total flow through the Nonacho Dam control structure would be possible throughout the year. However, because water levels in Nonacho Lake would be lower on average during the expansion scenarios compared to baseline conditions, there would be a substantial reduction in flow over the spillway and Tronka Chua Gap (which is discussed in Section 13.3.3.3). Under the baseline scenario, flow would occur continuously over the spillway throughout the simulation period. Under the expansion scenarios the spillway would not carry any flow for substantial periods. Under the 36 MW expansion, flow over the spillway would occur approximately 45% of the time, based on the 13 year simulation period, and only 13% of the time under the 56 MW scenario (Figure 13.3.8).

For the 36 MW expansion scenario, releases from Nonacho Lake would be generally reduced compared to baseline conditions from May through September, indicating storage of the freshet runoff in Nonacho. This stored water would be released in the winter, generally beginning in October or December, which would result in greater winter flows compared to baseline conditions.

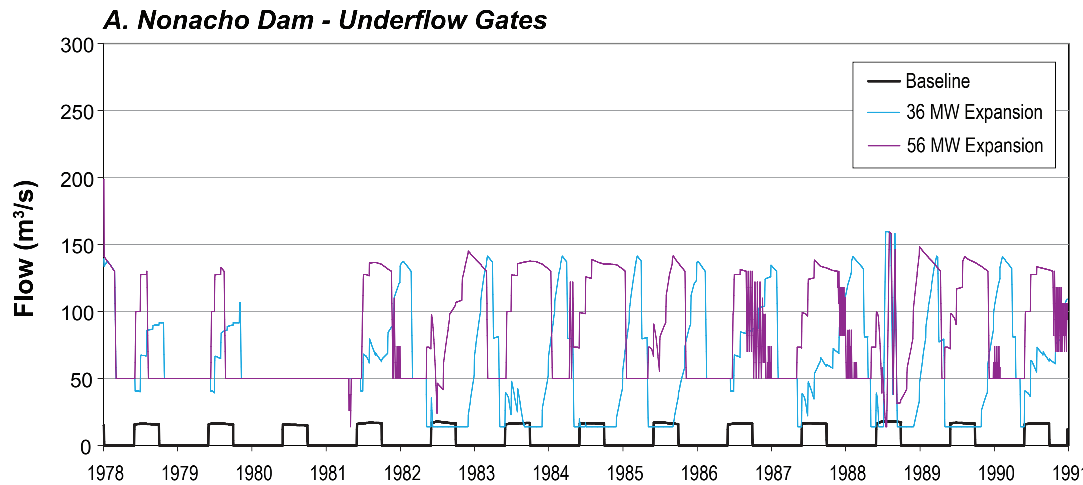
For the 56 MW expansion scenario, even during the freshet period, releases would be generally near baseline conditions due to the higher flow requirements at Twin Gorges. Although average releases under the 56 MW expansion scenario would be lower in during the peak freshet period of June and July, substantial storage would only occur during wetter than average years (i.e. 1982, 1985, and 1988). Generally, the storage within Nonacho Lake would be consumed by early winter and releases would have to be limited to ensure that water levels do not drop below the permitted minimum. Based on the 13-year simulation period, this would occur every year and would result in power production at Twin Gorges generally falling below the full generation target during the months of December to May (see Section 13.3.3.4).

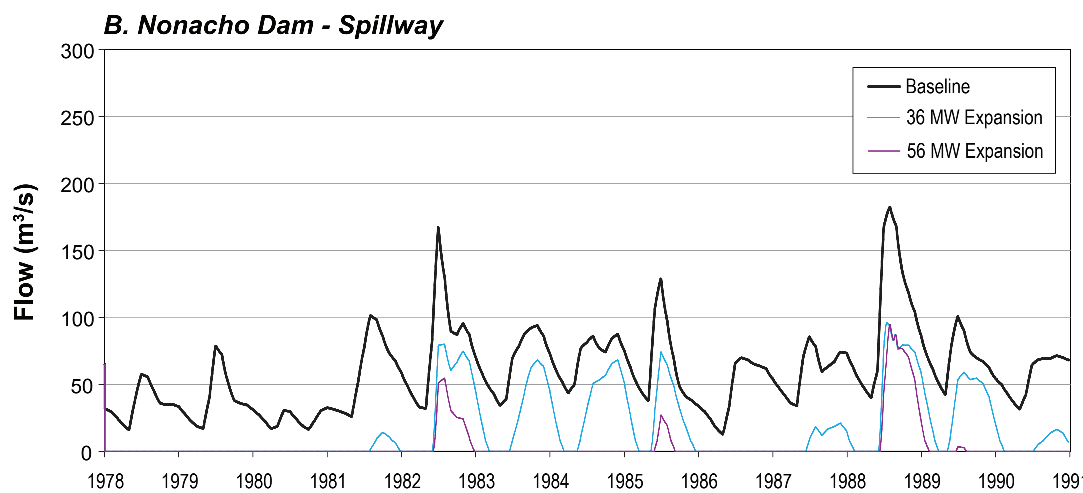
For the 36 MW expansion scenario, the peak annual flow would shift to the winter (January or February) from July under baseline conditions, and by one month to August under the 56 MW expansion scenario. Generally, peak flows to the Taltson River would be greater during wet years under the expansion scenarios and lower during dry years.

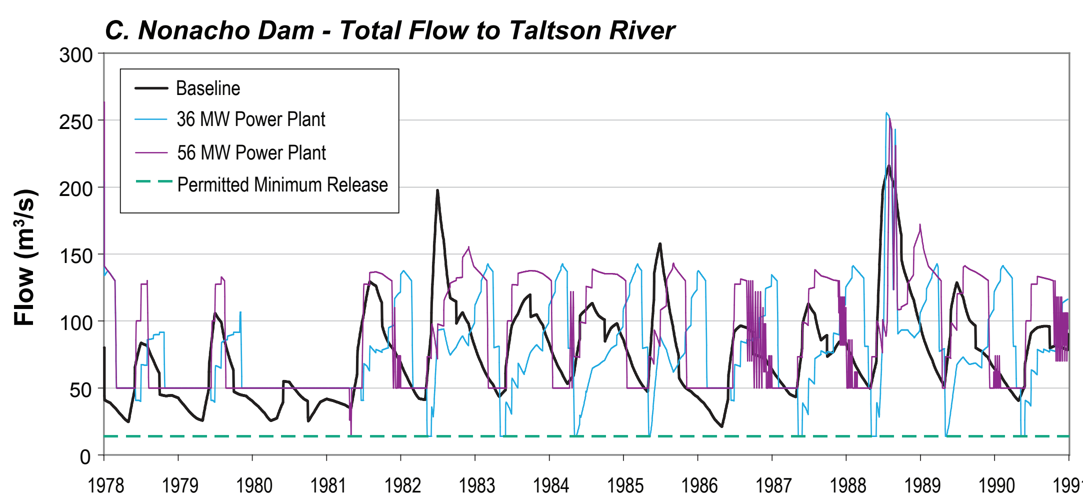
The timing of annual minimum flow would shift on average by one month from April to May for the 36 MW scenario, compared to baseline, while no substantial shift in timing would occur for the 56 MW scenario. The shift in timing of the annual low flow is a result of the monthly target releases from Nonacho Lake outlined in Table 13.3.2. Generally, annual minimum flows would be reduced under the 36 MW expansion compared to baseline, while minimum flows would be similar or slightly increased under the 56 MW expansion.

On average, the annual hydrograph based on monthly mean flows for the 36 MW scenario would be substantially different than baseline, while the annual hydrograph for the 56 MW scenario would be more similar to baseline conditions, with the highest flow months occurring in the open water season (i.e. July through October) and lowest flow period occurring in late winter (i.e. March though May).

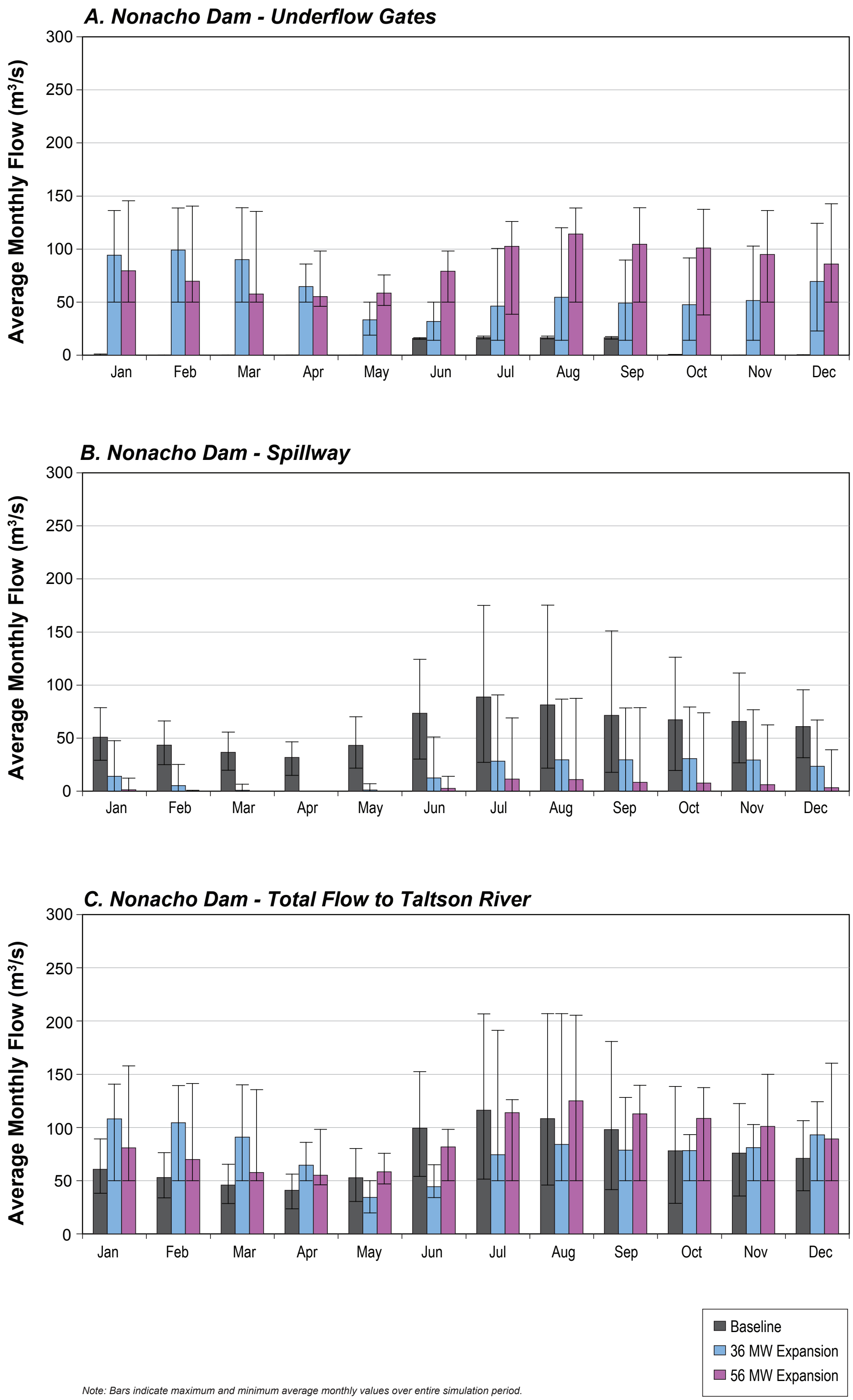
There are numerous rapid fluctuations in gate releases that are observable in Figure 13.3.5B (e.g., Fall 1986) specifically for the 56 MW scenario. This is an artifact of the model as the gates would be opened and closed on a daily basis, following pre-set rules that do not have any “forward-looking” abilities. For example, in the fall of 1986 under the 56 MW scenario, the gate releases would be initially reduced as water levels would drop to the defined conservation pool elevation; during the next model time step (one day), the pool elevation would respond positively due to the reduction in outflow such that the gates would open on the next time step. This in turn would drop the pool elevation to the conservation level again and the releases would be reduced. This would continue until inflow into Nonacho Lake drops sufficiently such that water levels do not respond positively to the reduction in releases. In reality, real-time operations personnel would produce a more constant release rate during these periods by projecting trends into the future (i.e. number of days or weeks).





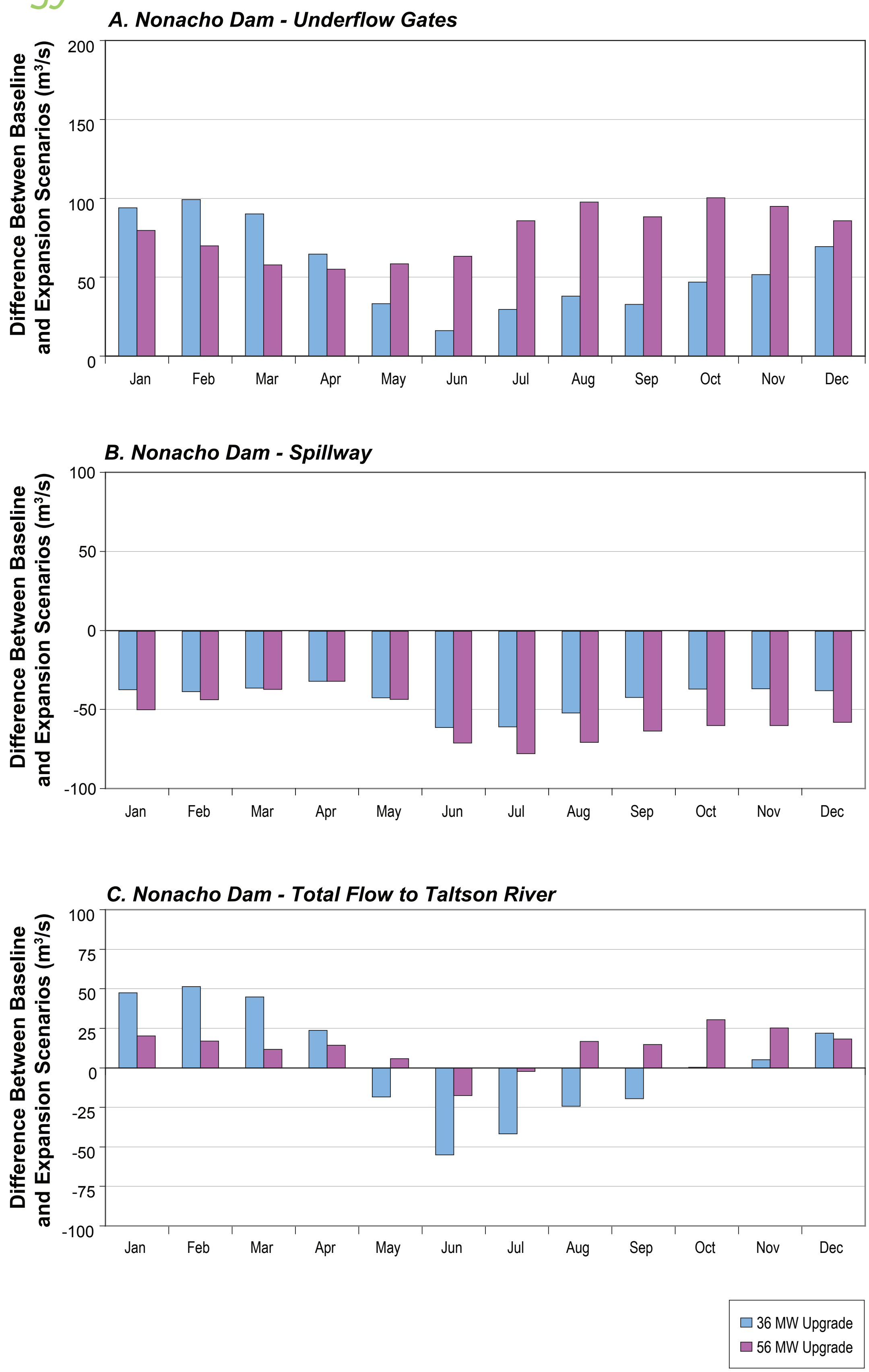


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Low Model Results, Zone 1: Nonacho Dam Outflow to Taltson River Time Series	Figure 13.3.5

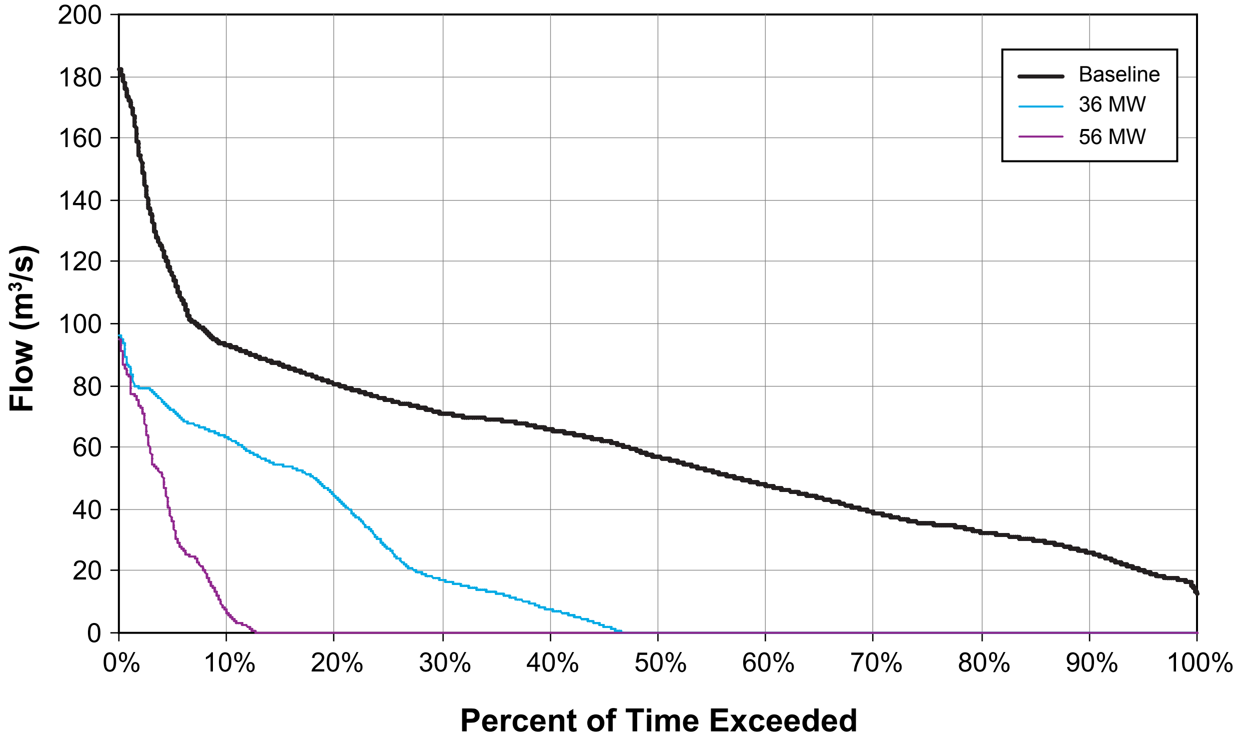


Note: Bars indicate maximum and minimum average monthly values over entire simulation period.

TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results, Zone 1: Nonacho Dam Outflow to Taltson River Monthly Summary	Figure 13.3.6



TALTSON HYDROELECTRIC EXPANSION PROJECT	Developer's Assessment Report 2009	Taltson Basin Flow Model Results, Zone 1: Nonacho Dam Outflow to Taltson River Monthly Difference Summary	Figure 13.3.7



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Nonacho Dam Spillway Flow Exceedance Curves (503-005 / a22100f)	Figure 13.3.8

Table 13.3.5 — Taltson Basin Flow Model Results, Zone 1: Nonacho Dam Outflow to Taltson River

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Underflow Gates: Average Monthly Flow (m^3/s)												
Baseline	0.00	0.00	0.00	0.00	0.00	15.71	16.66	16.53	16.36	0.67	0.00	0.00
36 MW Expansion	94.14	99.10	90.10	64.55	33.23	31.83	46.19	54.53	49.16	47.63	51.58	69.54
56 MW Expansion	79.61	69.79	57.68	55.16	58.42	79.06	102.47	114.15	104.62	100.97	94.79	85.91
Underflow Gates: Change from Baseline (m^3/s)												
36 MW Expansion	94.14	99.10	90.10	64.55	33.23	16.12	29.53	38.00	32.80	46.96	51.58	69.54
56 MW Expansion	79.61	69.79	57.68	55.16	58.42	63.35	85.82	97.62	88.27	100.31	94.79	85.91
Spillway: Average Monthly Flow (m^3/s)												
Baseline	50.90	43.44	36.69	31.74	43.20	73.36	88.77	81.22	71.46	67.23	65.76	61.01
36 MW Expansion	13.93	5.28	0.77	0.00	1.08	12.46	28.24	29.55	29.49	30.72	29.43	23.51
56 MW Expansion	1.28	0.06	0.00	0.00	0.00	2.68	11.40	10.94	8.26	7.58	6.17	3.33
Spillway: Change from Baseline (m^3/s)												
36 MW Expansion	-36.97	-38.15	-35.92	-31.74	-42.12	-60.90	-60.53	-51.67	-41.97	-36.51	-36.33	-37.50
56 MW Expansion	-49.62	-43.37	-36.69	-31.74	-43.20	-70.68	-77.37	-70.28	-63.20	-59.65	-59.59	-57.69
Total Dam Outflow to Taltson River: Average Monthly Flow (m^3/s)												
Baseline	60.65	52.93	45.97	40.87	52.67	99.37	116.20	108.33	98.06	78.04	75.87	71.03
36 MW Expansion	108.07	104.38	90.87	64.55	34.31	44.29	74.43	84.08	78.65	78.35	81.01	93.05
56 MW Expansion	80.89	69.85	57.68	55.16	58.42	81.74	113.88	125.10	112.88	108.56	100.96	89.24
Total Dam Outflow to Taltson River: Change from Baseline (m^3/s)												
36 MW Expansion	47.43	51.45	44.90	23.68	-18.36	-55.08	-41.77	-24.26	-19.42	0.31	5.14	22.02
56 MW Expansion	20.25	16.93	11.71	14.29	5.75	-17.63	-2.32	16.76	14.82	30.51	25.09	18.20

The changes to flow estimated at the Nonacho Dam would continue downstream through Zone 1 until Lady Grey Lake where Zone 2 would return flow back into the mainstem of the Taltson River. However, this would not alter the hydrograph substantially below Lady Grey as flow in Zone 2 would be relatively low compared to the releases of flow from the Nonacho Dam. The next downstream location that would have substantial control on the shape of the Taltson River hydrograph is the confluence of the Tazin River, which marks the upstream boundary of Zone 3.

13.3.3.2.2 Taltson Lake and King Lake

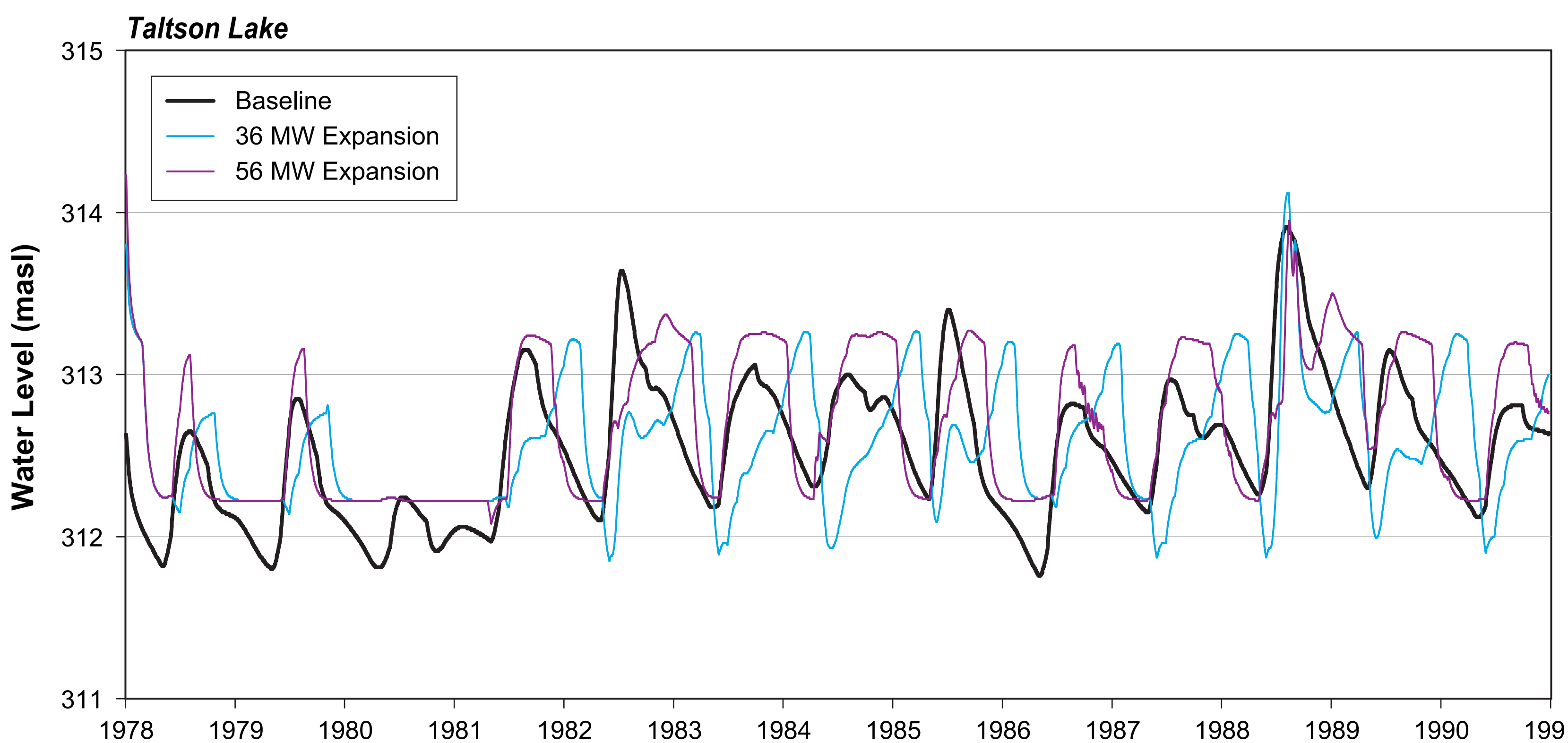
Changes to the water levels within Taltson Lake and King Lake would directly reflect the changes in Nonacho Dam releases under the expansion scenarios. Although each lake has a local watershed, contributions in the form of runoff from these areas would be much less than the flow from Nonacho Dam.

Simulated water levels under the expansion scenarios are presented and compared to baseline levels in Figure 13.3.9 to Figure 13.3.12 and Table 13.3.6. The trend in change from baseline conditions under the two expansion scenarios would be the same for both lakes, although the magnitude of change would be slightly different due to the difference in size and outlet geometries of the lakes.

For the 36 MW expansion scenario, water levels in Taltson Lake and King Lake from May through October would be consistently lower than the baseline conditions, as water that is not necessary for power production downstream would be stored in Nonacho Lake. From November through April, this excess water would be released and water levels in Taltson and King lakes would increase above baseline conditions. From the daily water-level time series, it is apparent that the annual peak and minimum levels would be delayed compared to baseline by approximately six months and one month, respectively. Generally, the peak annual levels would be higher than baseline, although they would be within the range of levels experienced under baseline conditions. During extremely high flow events (i.e. spring of 1988) peak levels are estimated to be somewhat higher than during baseline conditions by approximately 0.2 m. This is because releases from Nonacho Lake would be increased above baseline releases for this flow event to maintain water levels near the nuisance high water level. This occurrence could be mitigated by real-time operational decisions that are not represented within the Flow Model. For example, releases from the Nonacho Lake could be increased during the winter to increase storage within the reservoir if local snow pack conditions indicate the probability of a large freshet occurring. In general annual minimum levels would decrease from baseline levels by approximately 0.2 m to 0.5 m.

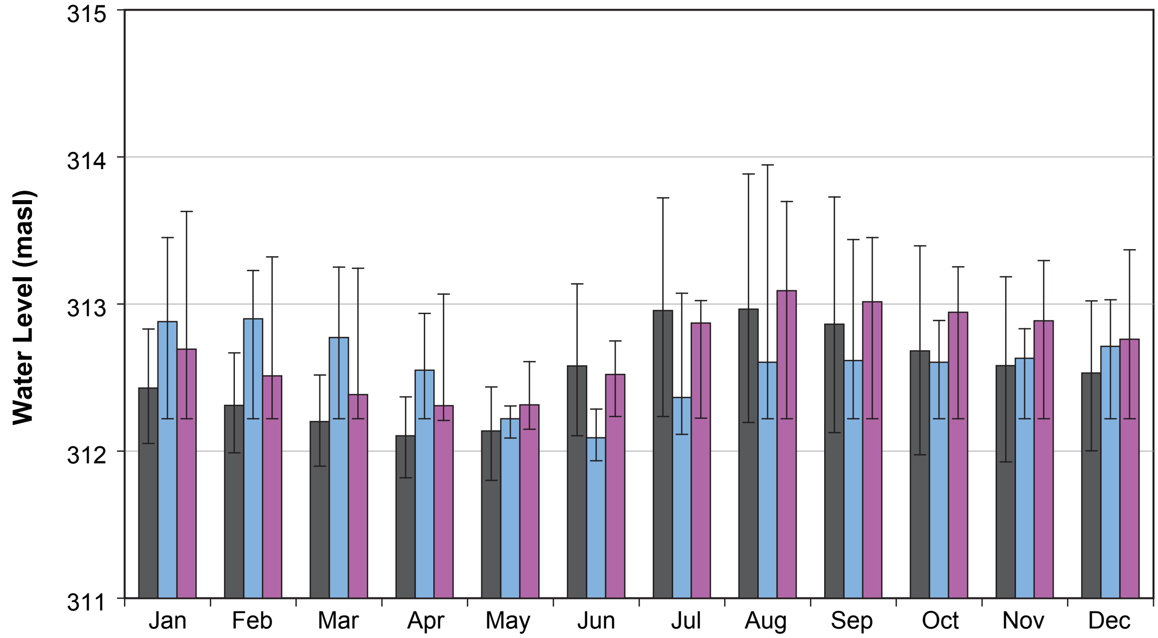
Water levels in Taltson and King lakes under the 56 MW expansion scenario would be relatively similar to the baseline conditions, compared to the 36 MW expansion scenario. During average runoff years, higher water levels would be more constant through the open water season compared to baseline; however, the peak annual level would still occur within the open water period rather than in the winter as would occur on average under the 36 MW expansions. On average, water levels would be higher than baseline throughout the year, except for June and July when freshet storage (if any) within Nonacho Lake would occur.

Water levels would be higher on average throughout the year despite relatively little increased storage in Nonacho Lake under this expansion scenario, because a greater proportion of the annual releases from Nonacho Lake would occur to the Taltson River at the expense of lower releases at Tronka Chua Gap into Zone 2. Although peak annual levels are higher than baseline, they would remain within the range of levels experienced under baseline conditions. Annual minimum water levels would not change substantially from baseline conditions in timing or magnitude.



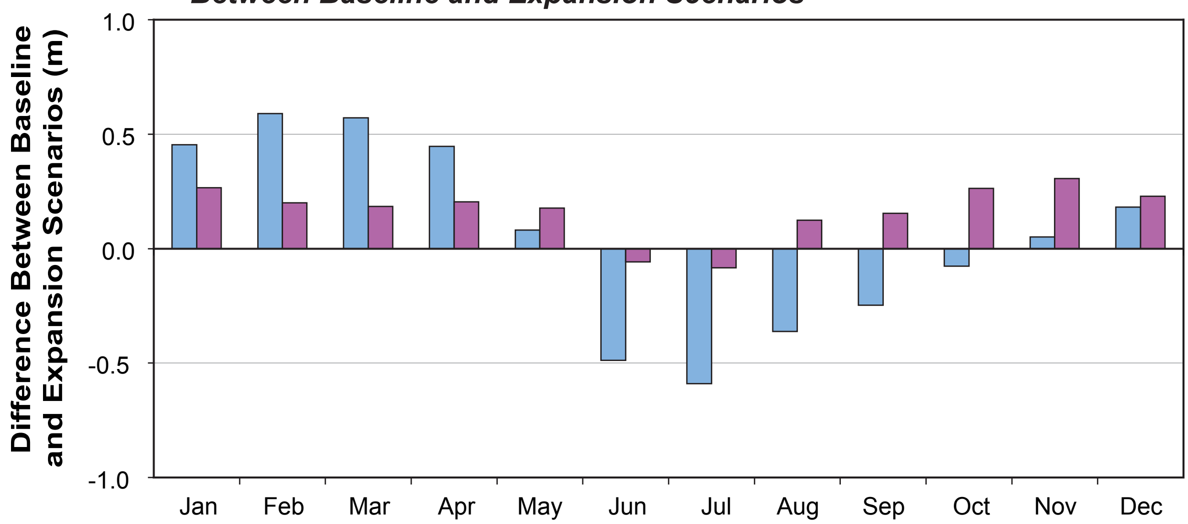
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Zone 1: Taltson Lake Water Level Time Series (503-005 / a22069m)	Figure 13.3.9

A. Average Monthly Water Level

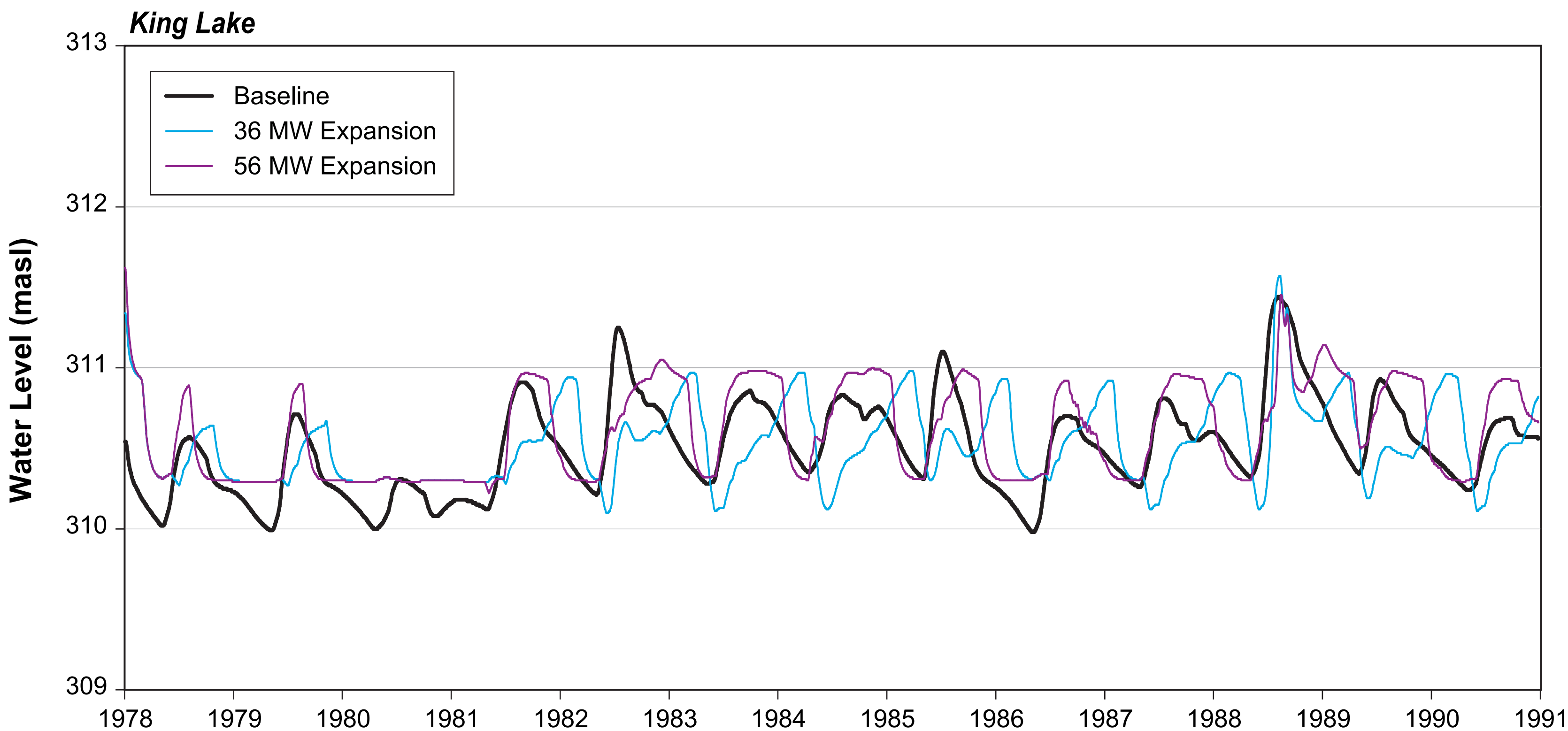


Note: Bars indicate maximum and minimum average monthly values over entire simulation period.

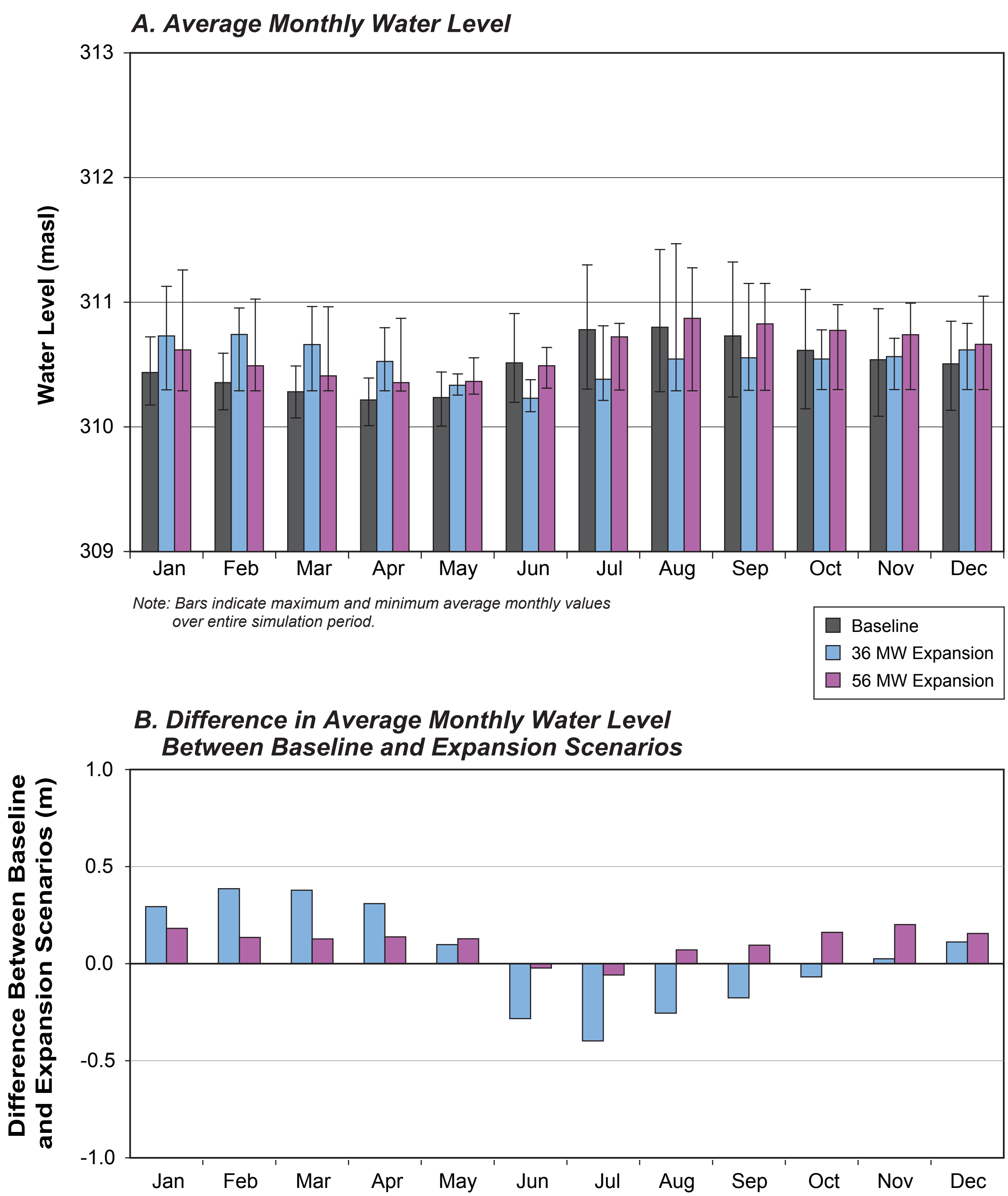
B. Difference in Average Monthly Water Level Between Baseline and Expansion Scenarios



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Taltson Basin Flow Model Results Zone 1 - Taltson Lake Water Level Monthly Summary** (503-005 / a22070m)	**Figure 13.3.10**



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 1 - King Lake Water Level Time Series (503-005 / a22071m)	Figure 13.3.11



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 1 - King Lake Water Level Monthly Summary (503-005 / a22072m)	Figure 13.3.12

Table 13.3.6 — Taltson Basin Flow Model Results, Zone 1: Water Levels

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Taltson Lake: Average Monthly Water Level (masl)												
Baseline	312.43	312.31	312.20	312.10	312.14	312.58	312.95	312.97	312.86	312.68	312.58	312.53
36 MW Expansion	312.88	312.90	312.77	312.55	312.22	312.09	312.36	312.60	312.62	312.60	312.63	312.71
56 MW Expansion	312.69	312.51	312.38	312.31	312.32	312.52	312.87	313.09	313.02	312.94	312.89	312.76
Taltson Lake: Change from Baseline (m)												
36 MW Expansion	0.45	0.59	0.57	0.45	0.08	-0.49	-0.59	-0.36	-0.25	-0.08	0.05	0.18
56 MW Expansion	0.27	0.20	0.18	0.20	0.18	-0.06	-0.08	0.12	0.15	0.26	0.31	0.23
King Lake: Average Monthly Water Level (masl)												
Baseline	310.44	310.36	310.28	310.22	310.24	310.51	310.78	310.80	310.73	310.61	310.54	310.51
36 MW Expansion	310.73	310.74	310.66	310.53	310.33	310.23	310.38	310.54	310.55	310.55	310.56	310.62
56 MW Expansion	310.62	310.49	310.41	310.35	310.36	310.49	310.72	310.87	310.83	310.77	310.74	310.66
King Lake: Change from Baseline (m)												
36 MW Expansion	0.29	0.39	0.38	0.31	0.10	-0.28	-0.40	-0.25	-0.18	-0.07	0.03	0.11
56 MW Expansion	0.18	0.13	0.13	0.14	0.13	-0.02	-0.06	0.07	0.10	0.16	0.20	0.16
Lady Grey Lake: Average Monthly Water Level (masl)												
Baseline	308.68	308.58	308.48	308.39	308.37	308.62	308.98	309.08	309.02	308.91	308.81	308.76
36 MW Expansion	308.96	308.97	308.88	308.71	308.51	308.40	308.50	308.73	308.78	308.78	308.81	308.85
56 MW Expansion	308.80	308.64	308.53	308.44	308.44	308.57	308.81	309.04	309.03	308.97	308.93	308.85
Lady Grey Lake: Change from Baseline (m)												
36 MW Expansion	0.29	0.39	0.40	0.32	0.14	-0.22	-0.48	-0.35	-0.24	-0.13	0.00	0.09
56 MW Expansion	0.12	0.06	0.04	0.05	0.06	-0.05	-0.16	-0.04	0.01	0.06	0.12	0.09
Benna Thy Lake: Average Monthly Water Level (masl)												
Baseline	280.84	280.77	280.71	280.64	280.63	280.79	281.04	281.12	281.09	281.01	280.93	280.90
36 MW Expansion	281.04	281.05	280.98	280.87	280.73	280.65	280.70	280.87	280.91	280.91	280.93	280.96

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
56 MW Expansion	280.93	280.81	280.73	280.67	280.66	280.75	280.93	281.09	281.09	281.04	281.02	280.96
Benna Thy Lake: Change from Baseline (m)												
36 MW Expansion	0.20	0.27	0.28	0.22	0.10	-0.14	-0.34	-0.26	-0.18	-0.10	0.00	0.06
56 MW Expansion	0.09	0.04	0.02	0.02	0.03	-0.03	-0.12	-0.03	0.01	0.03	0.08	0.06

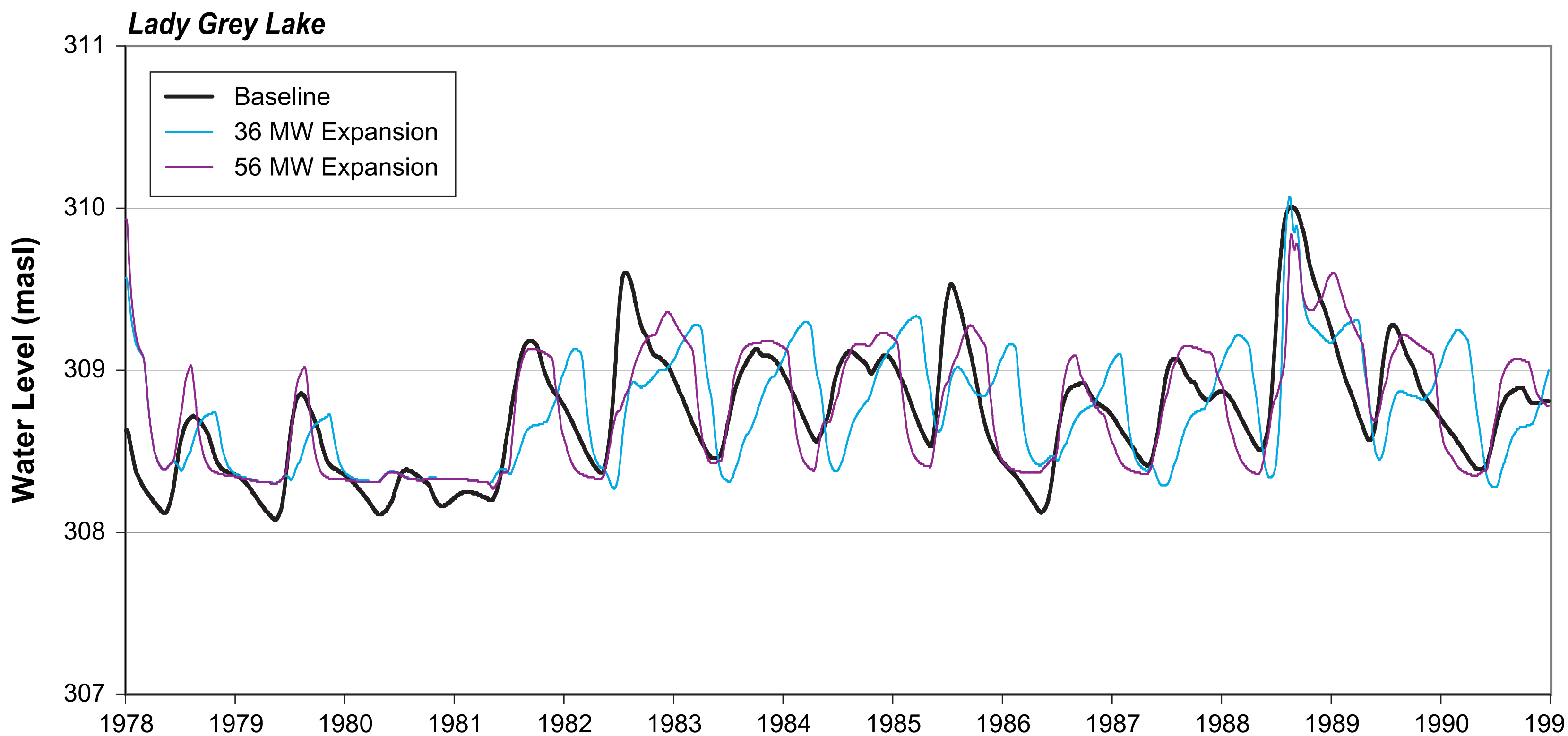
For years with average runoff, annual variation would increase for the expansion scenarios compared to baseline conditions. However, during years of above or below average runoff, water levels would vary less under the expansion scenarios compared to baseline. This reduced variation would be due to the greater regulation of releases from Nonacho Lake allowing for the Nonacho Lake reservoir being able to buffer downstream environments from anomalous runoff conditions. Therefore, the annual variation, based on monthly mean water levels would be similar to, but lower than, baseline fluctuations (Table 13.3.7).

Table 13.3.7 — Estimated Annual Variation in Mean Monthly Water Levels in Zone 1

Location	Baseline (m)	SCENARIO	
		36 MW Expansion (m)	56 MW Expansion (m)
Taltson Lake	0.86	0.81	0.78
King Lake	0.58	0.51	0.52
Lady Grey Lake	0.70	0.58	0.60
Benna Thy Lake	0.49	0.40	0.43

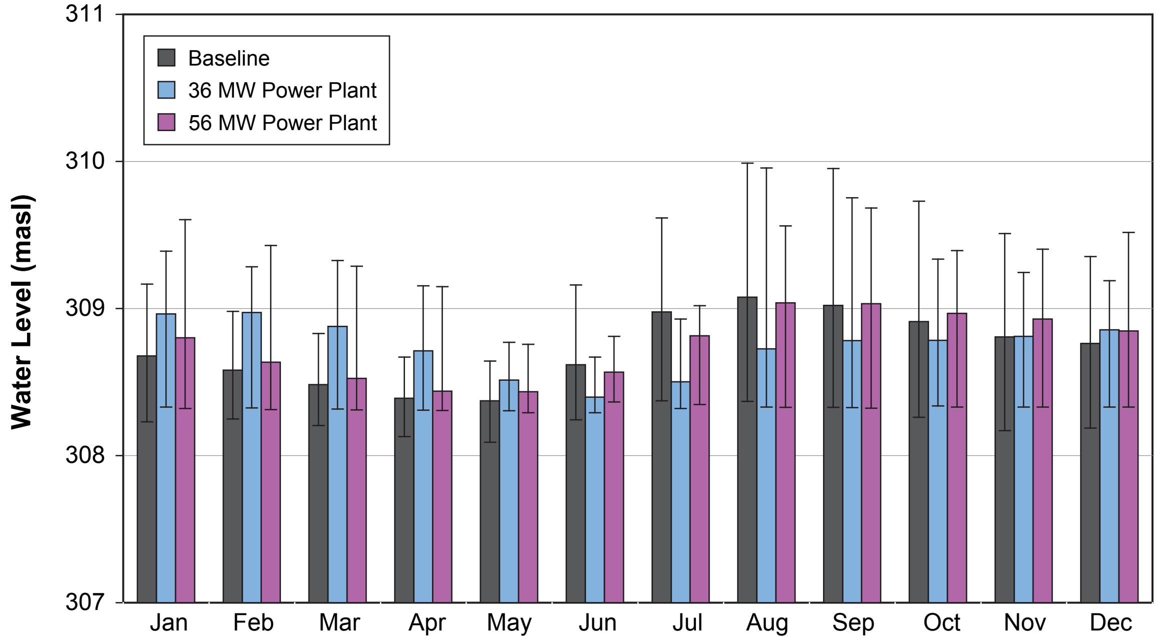
13.3.3.2.3 Lady Grey Lake and Benna Thy Lake

Estimated changes to water levels within Lady Grey Lake and Benna Thy Lake would be generally consistent with those observed upstream in Taltson Lake and King Lake. However, inflow from Zone 2 would enter the Taltson River at Lady Grey Lake. Therefore, the predicted effects on water levels in Lady Grey Lake and Benna Thy Lake under the expansion scenarios would be slightly different than those simulated in the upper portion of Zone 1 (i.e. Taltson Lake and King Lake). Under the 36 MW scenarios, flow would increase to Zone 2 over baseline conditions whenever water levels within Nonacho Lake are greater than baseline conditions (see discussion below in *Zone 2 – Tronka Chua Gap to Lady Grey Lake*). This would occur during the summer and fall in average to wet runoff years and would coincide with reduced releases to Zone 1 at Nonacho Dam. Likewise, periods of higher releases under the 36 MW expansion scenario to Zone 1 at Nonacho Dam would generally coincide with lower than baseline flow to Zone 2. Therefore, the return of flow to Zone 1 at Lady Grey Lake via Zone 2 would slightly reduce the 36 MW expansion scenario effects to water levels in Lady Grey Lake and Benna Thy Lake compared to Taltson Lake and King Lake (Figure 13.3.13 to Figure 13.3.16; Tables 13.3.6 and 13.3.7). Although estimated water levels would be lower than baseline conditions from June through October and higher in the winter (i.e. January though April), consistent with effects predicted upstream of Lady Grey Lake, the magnitude of change would be less.



TALTSON **Hydroelectric Expansion Project**	**Developer's Assessment Report 2009**	**Taltson Basin Flow Model Results Zone 1 - Lady Grey Lake Water Level Time Series** (503-005 / a22073m)	**Figure 13.3.13**

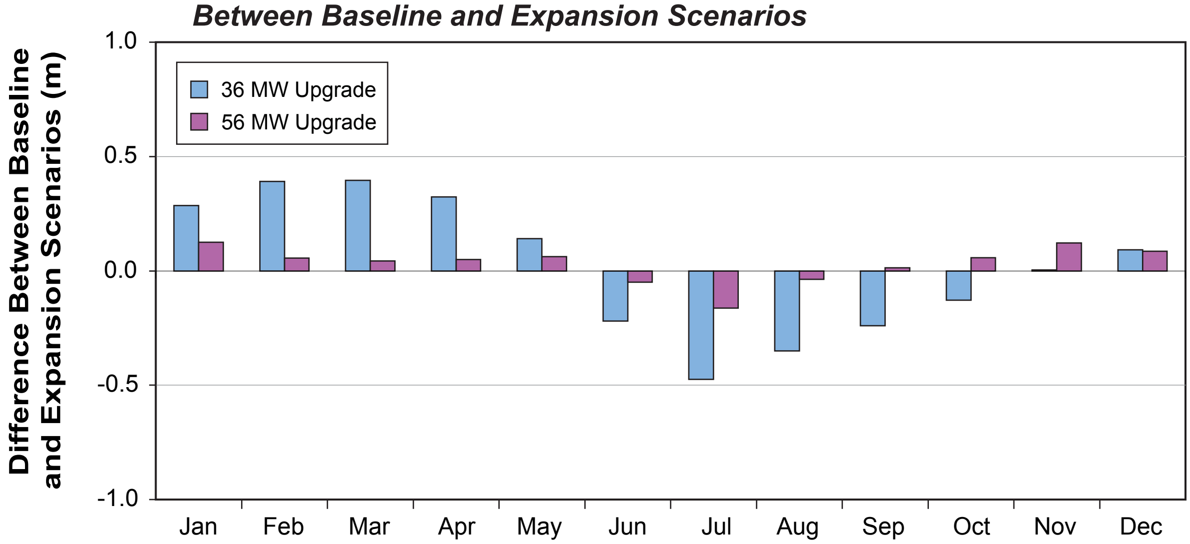
A. Average Monthly Water Level



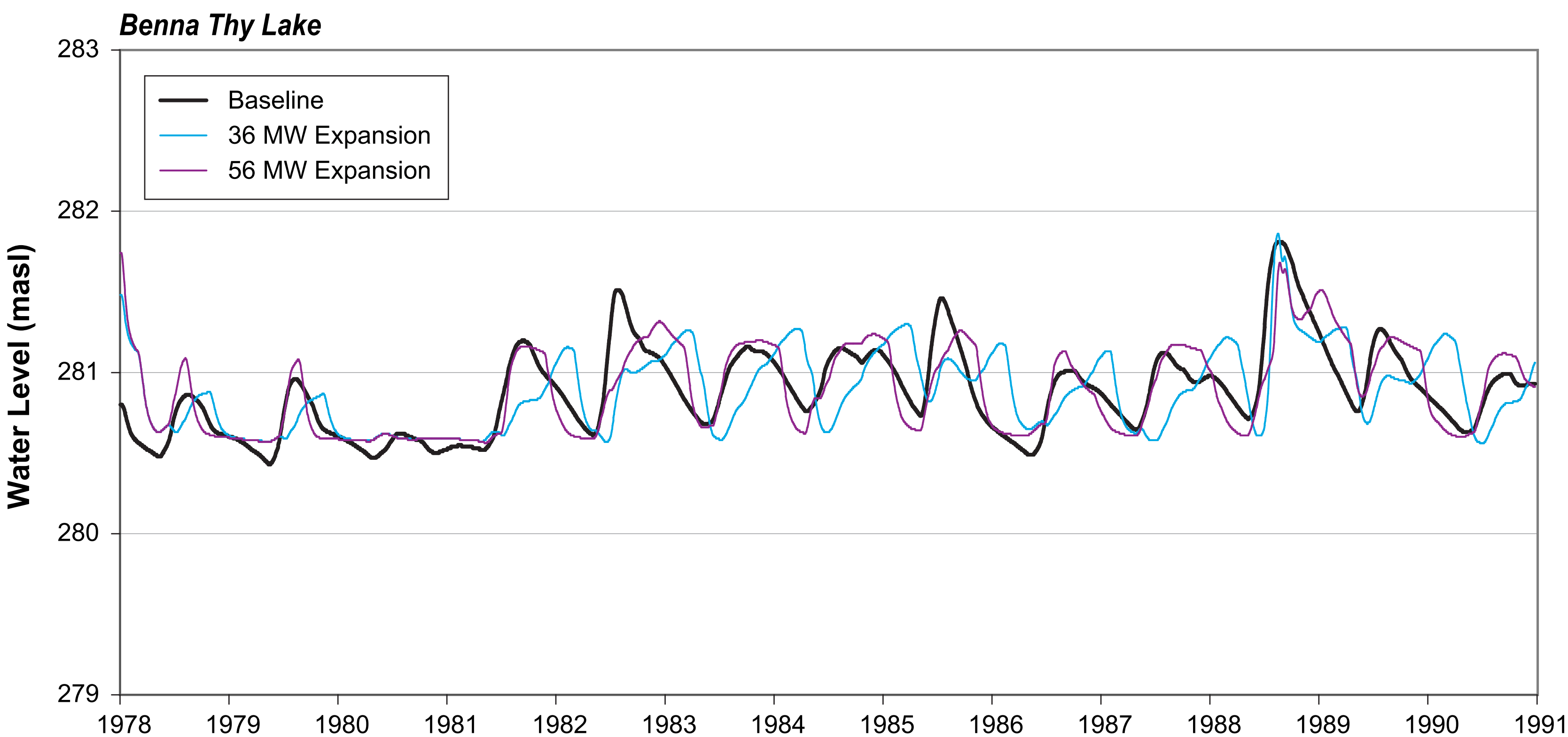
Note: Bars indicate maximum and minimum average monthly values over entire simulation period.

Baseline
36 MW Expansion
56 MW Expansion

B. Difference in Average Monthly Water Level Between Baseline and Expansion Scenarios

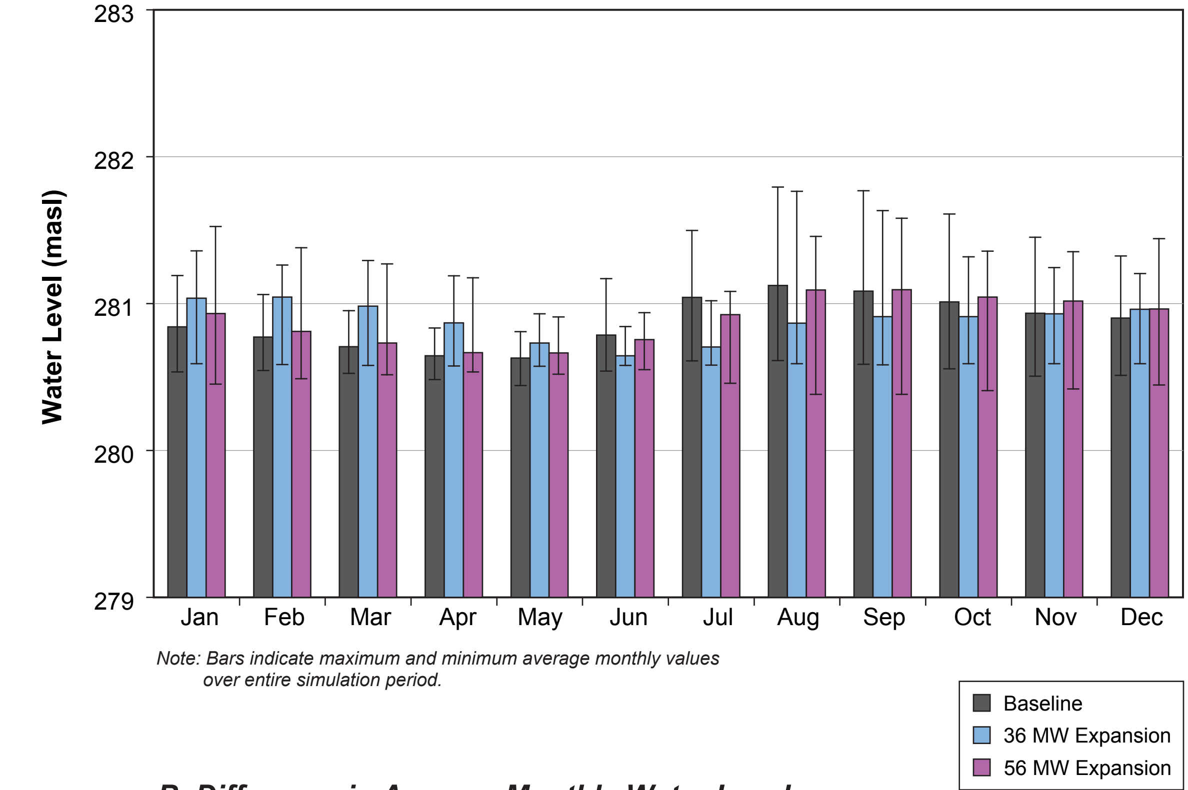


TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Taltson Basin Flow Model Results Zone 1 - Lady Grey Lake Water Level Monthly Summary** (503-005 / a22074m)	**Figure 13.3.14**

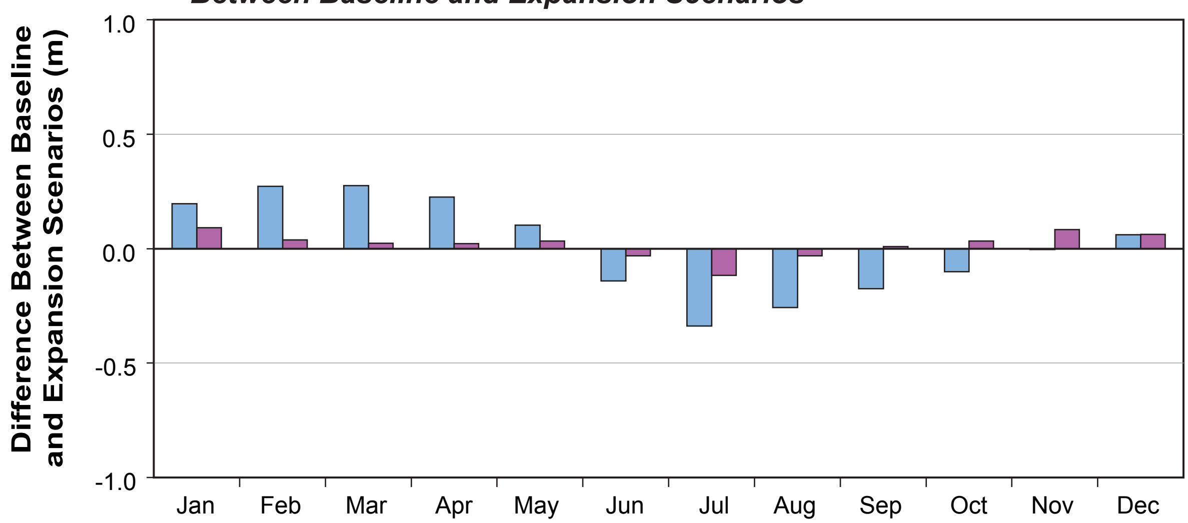


TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report** **2009**	**Taltson Basin Flow Model Results Zone 1 -** **Benna Thy Lake Water Level Time Series** (503-005 / a22075m)	**Figure** **13.3.15**

A. Average Monthly Water Level



B. Difference in Average Monthly Water Level Between Baseline and Expansion Scenarios



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 1 - Benna Thy Lake Water Level Monthly Summary (503-005 / a22076m)	Figure 13.3.16

Under the 56 MW expansion scenario, flow to Zone 2 at Tronka Chua Gap would be consistently less than baseline conditions and would be very low compared to flow to the upper portion of Zone 1. Therefore, effects to water levels within Lady Grey Lake and Benna Thy Lake under the 56 MW expansion would be largely driven by changes in flow at Nonacho Dam. Trends that are predicted in the upper portion of Zone 1 would continue through Lady Grey Lake and Benna Thy Lake with negligible influence by the return flow from Zone 2.

13.3.3.3 Zone 2 – Tronka Chua Gap to Lady Grey Lake

13.3.3.3.1 Outflow from Nonacho Lake at Tronka Chua Gap (Zone 2)

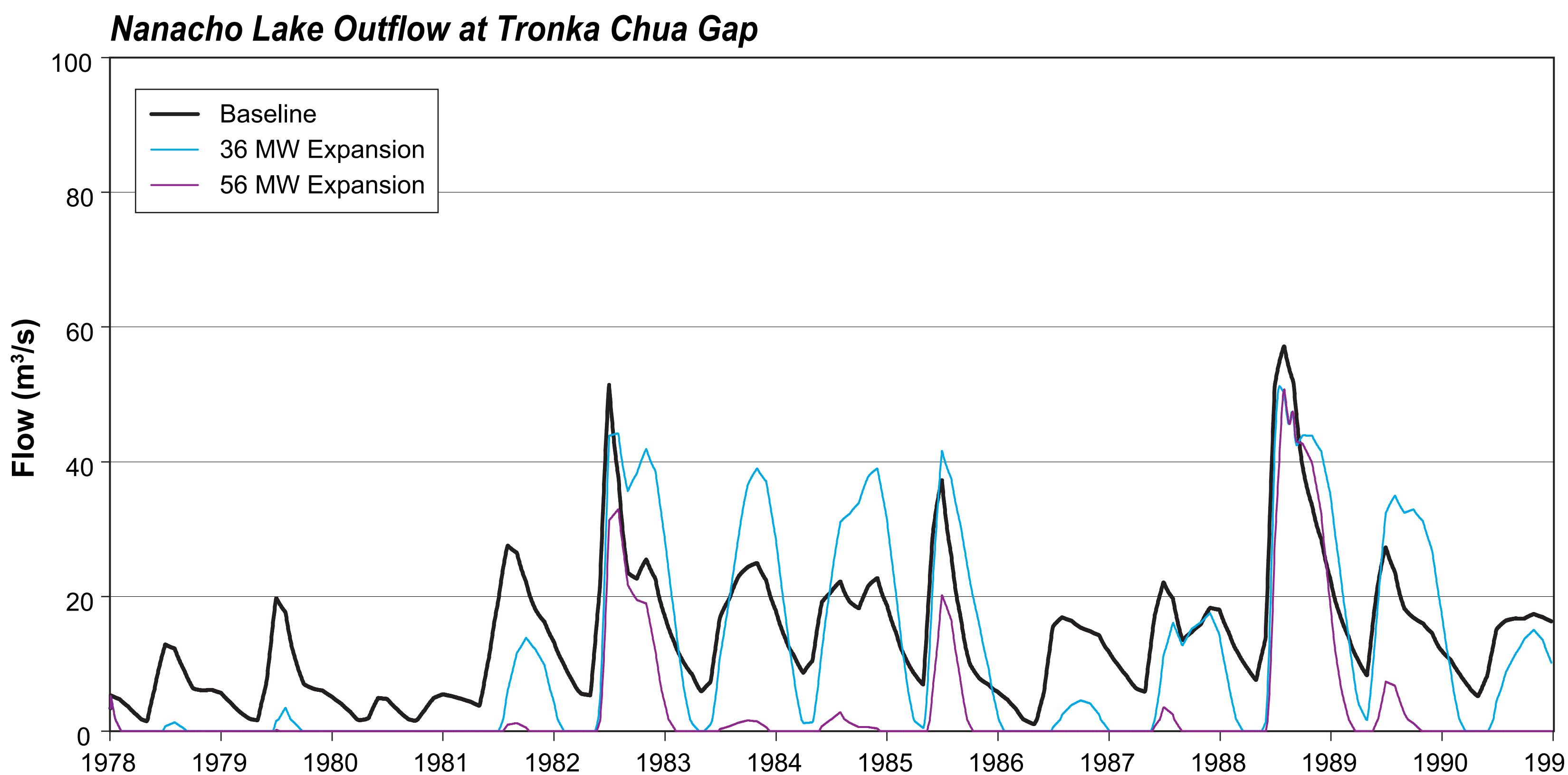
Historically, there was likely little connectivity between Nonacho Dam and Zone 2. However, following the construction of the Nonacho Dam in 1968, flow regularly began passing over the natural topographic saddle of the Tronka Chua Gap. Although outflow from Nonacho Lake at the Tronka Chua Gap is relatively low (about 15% of total annual outflow under baseline condition) compared to that at Nonacho Dam, flow over Tronka Chua Gap is the primary input of flow to Zone 2.

Tronka Chua Gap is an uncontrolled spillway with no proposed upgrades under the expansion scenarios. As a result, periods when Nonacho Lake would have higher water levels than baseline conditions would result in increased flows through Tronka Chua Gap. Periods where there are lower water levels in Nonacho Lake compared to baseline conditions would result in lower flows through Tronka Chua Gap (Figure 13.3.17, Figure 13.3.18, and Table 13.3.8).

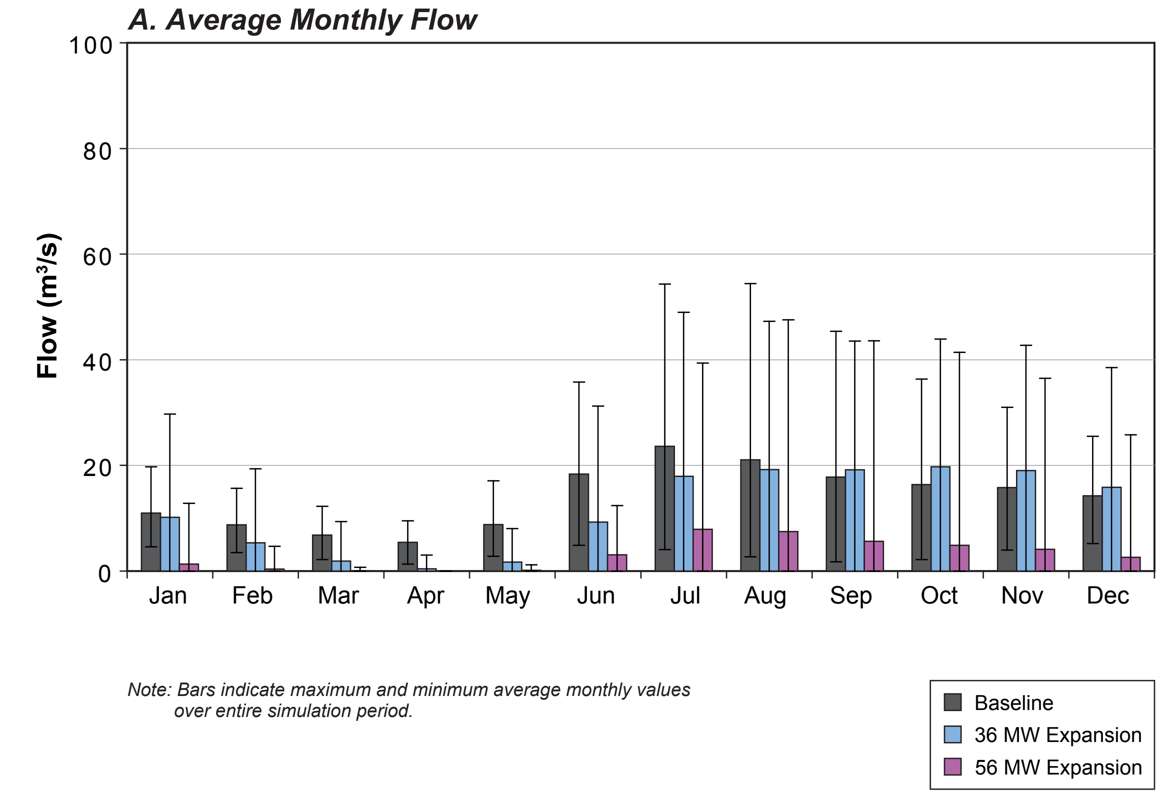
Under the 36 MW expansion scenario during average to wet years, flows would be greater than baseline during the peak of freshet, summer and fall as water is stored within the reservoir, and lower in the winter as stored water is released to satisfy demand at Twin Gorges. During these periods, although flow would be higher, it would be within the range of maximum peak flows experienced under baseline conditions. During drier periods when Nonacho Lake water levels would be lower than baseline, flow at Tronka Chua Gap would also be lower. Tronka Chua Gap would regularly cease to conduct flow. Under baseline conditions, Tronka Chua Gap always carries some flow. However, based on the full 13-year simulation period, flow would only occur approximately 65% of the time (Figure 13.3.19). Despite prolonged periods of up to multiple years of no flow, on average, there would be a small increase in flow compared to baseline conditions during the late-summer, fall, and early winter (i.e. September to December).

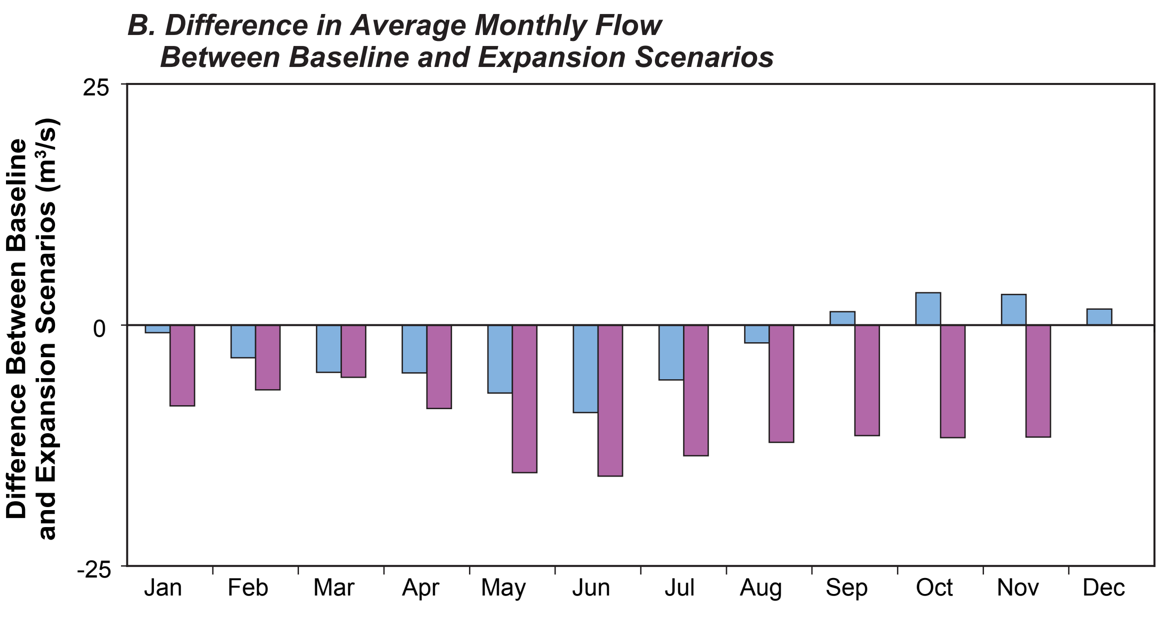
Under the 56 MW expansion scenario, due to the consistently lower water levels in Nonacho Lake, flow at Tronka Chua Gap would also be consistently lower than baseline. Under this scenario, flow would only be expected to occur during wetter than average years. Based on the full 13-year simulation period flow would only occur at Tronka Chua Gap approximately 30% of the time. Flow rates at Tronka Chua Gap would approach those under the baseline conditions only during extremely high runoff events.

The changes to flow predicted at Tronka Chua Gap would continue downstream through Zone 2 until Lady Grey Lake where Zone 2 would return flow back into the mainstem of the Taltson River.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Zone 2: Nonacho Lake Outflow to Tronka Chua Gap Time Series (503-005 / a22013m)	Figure 13.3.17

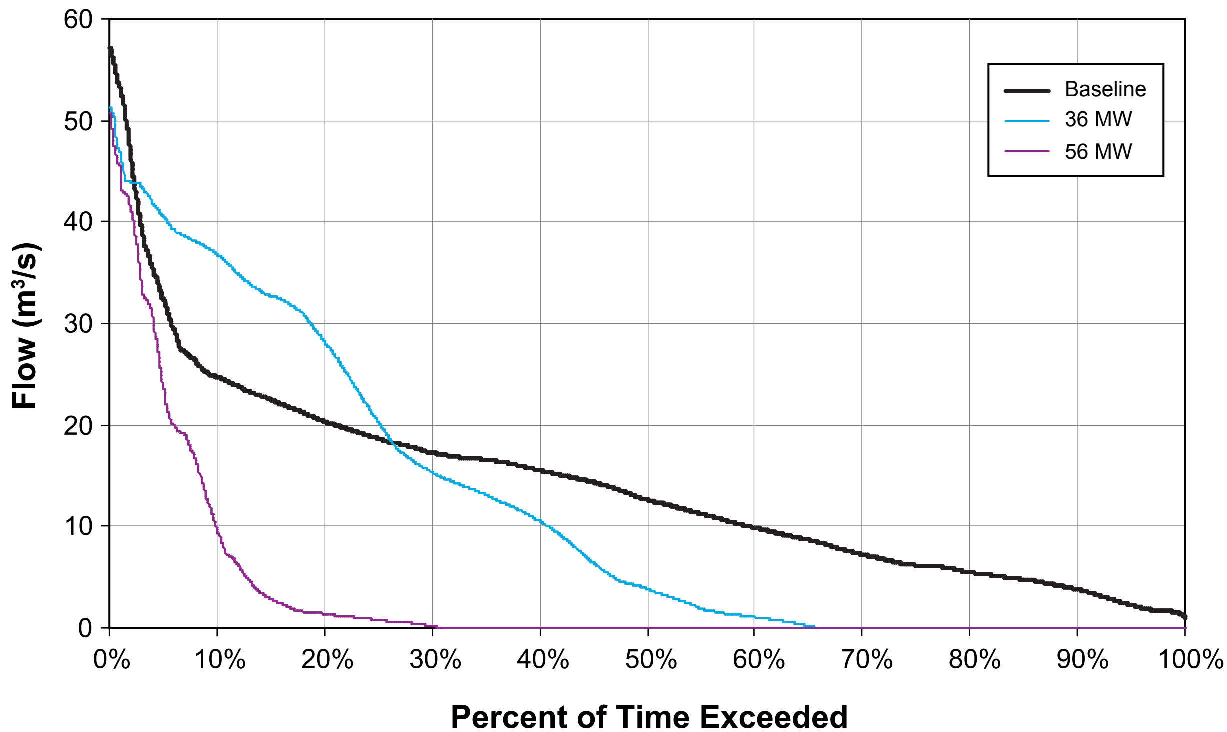




TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Taltson Basin Flow Model Results - Zone 2: Nonacho Lake Outflow at Tronka Chua Gap Monthly Summary** (503-005 / a22014m)	**Figure 13.3.18**

Table 13.3.8 — Taltson Basin Flow Model Results, Zone 2: Nonacho Lake Outflow at Tronka Chua Gap

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Monthly Flow (m^3/s)												
Baseline	10.99	8.77	6.80	5.43	8.78	18.39	23.61	21.04	17.79	16.37	15.83	14.23
36 MW Expansion	10.18	5.36	1.88	0.45	1.72	9.29	17.92	19.19	19.18	19.71	19.00	15.87
56 MW Expansion	1.33	0.37	0.06	0.00	0.13	3.07	7.93	7.48	5.63	4.90	4.14	2.61
Change from Baseline (m^3/s)												
36 MW Expansion	-0.81	-3.41	-4.92	-4.98	-7.06	-9.09	-5.69	-1.85	1.38	3.34	3.17	1.64
56 MW Expansion	-9.66	-8.40	-6.74	-5.43	-8.65	-15.31	-15.69	-13.56	-12.17	-11.47	-11.69	-11.62



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Tronka Chua Gap Flow Exceedance Curves (503-005 / a22101f)	Figure 13.3.19

13.3.3.3.2 Tronka Chua Lake and Thekulthili Lake

Compared to baseline conditions, water levels in Zone 2 under the expansion scenarios largely reflect trends predicted in flows at Tronka Chua Gap. Although there are local watersheds that provide some inflow to the lakes with this zone, outflow from Nonacho Lake at Tronka Chua Gap is the dominant source of flow.

Similarly, the trend in changes between Project expansion and baseline is consistent between the two lakes within Zone 2 where water levels were simulated. However, the magnitude of change varies between the lakes based on their respective size and outlet geometries. Tronka Chua Lake is substantially smaller than Thekulthili Lake and directly receives outflow from Nonacho Lake via Tronka Chua Gap. Therefore, the magnitude of change in water levels in Tronka Chua Lake is more pronounced than in Thekulthili Lake.

In general, levels would be lower than baseline conditions under both expansion scenarios (Figure 13.3.20 to Figure 13.3.23, and Table 13.3.9). The exception would be under the 36 MW expansion scenario in Zone 2, where water levels would be higher than baseline during the open water season for relatively wet years. The higher water levels estimated under the 36 MW expansion scenario would remain within the range of peak water levels experienced under the baseline condition.

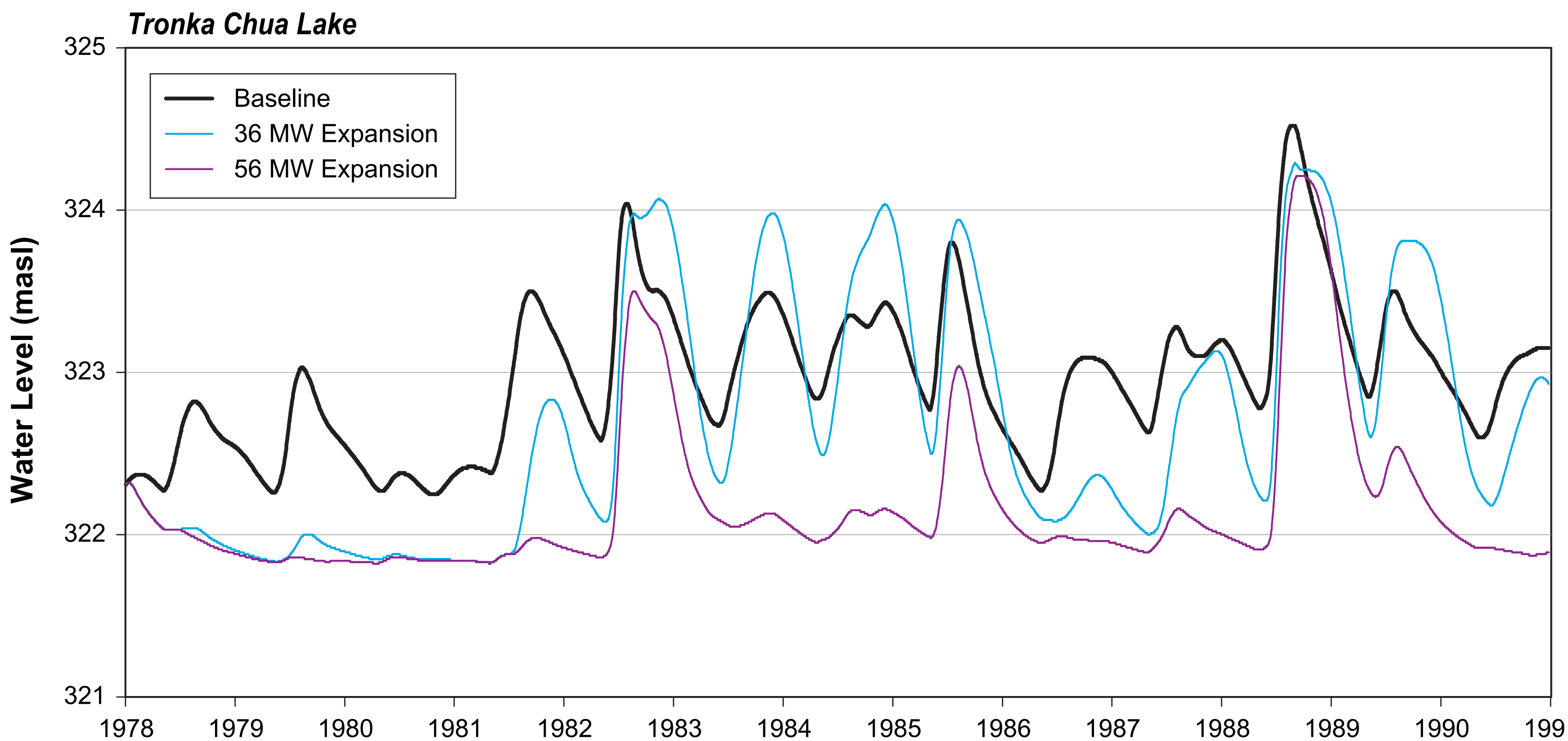
The average annual variation in water levels within Zone 2 would increase under the 36 MW expansion and decrease under the 56 MW expansion (Table 13.3.10). For the 36 MW expansion scenario the variation would increase as average peak levels are similar to baseline; however, average annual minimum levels would decrease compared to baseline. On the other hand, variation would decrease under the 56 MW expansion as total flow to Zone 2 would be reduced to such low levels that annual variation would be driven primarily by variation in local surface runoff, which is substantially less than the baseline inflow to Zone 2 from Tronka Chua Gap.

During years with flow at Tronka Chua Gap under the 36 MW expansion, the timing of peak water levels would shift to later in the year compared to baseline conditions (i.e. November or December rather than August). However, the timing of annual minimum flows would not change. Under the 56 MW expansion, no shift in timing is expected for annual maximum or minimum levels.

13.3.3.4 ZONE 3 – TALTSON RIVER FROM TAZIN RIVER TO TSU LAKE

13.3.3.4.1 Taltson River Downstream of Tazin River Confluence

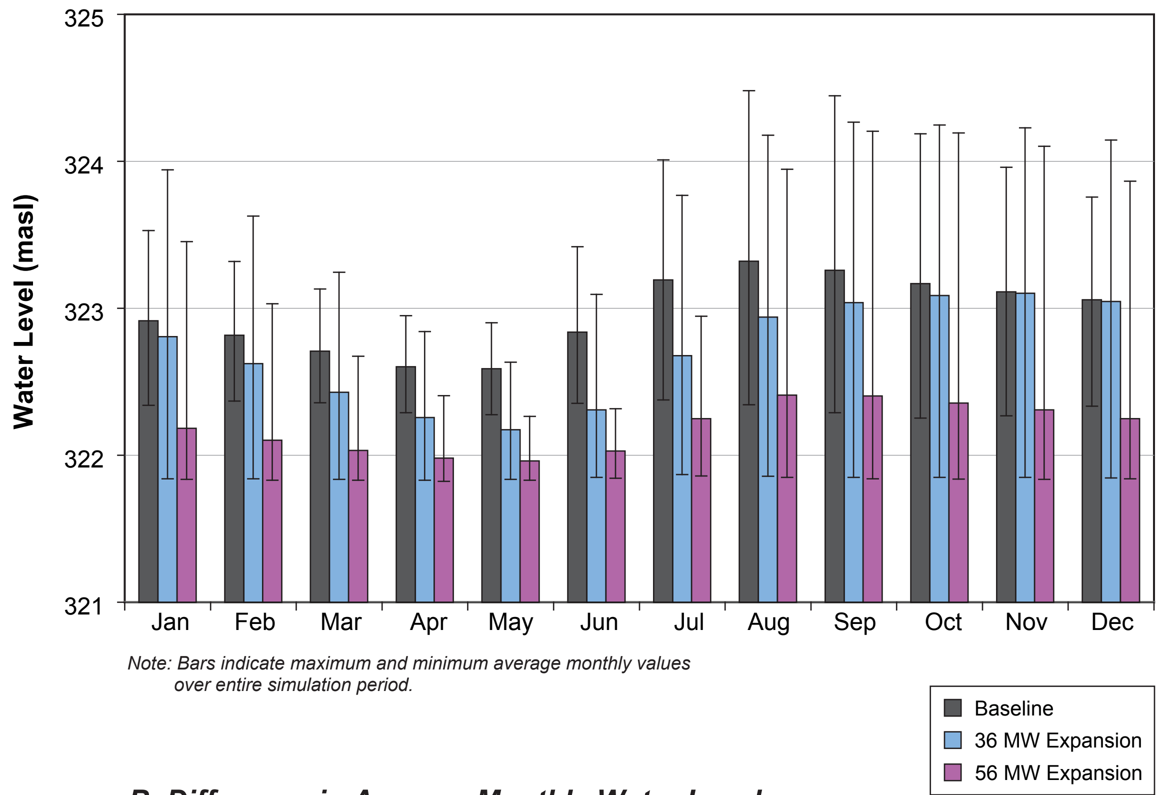
Releases from Nonacho Lake under the expansion scenarios would be timed so that the combined flow from Nonacho Lake and the unregulated portion of the Taltson Basin between Nonacho Lake and Twin Gorges would meet the flow requirement for full power production at Twin Gorges. The Tazin River drainage area comprises the majority (about 65%) of the unregulated area and therefore contributes the greatest amount of unregulated flow. As a result, the combination of the altered hydrograph in the Taltson River from operations at Nonacho Lake and the unregulated hydrograph from the Tazin River would produce a relatively “flattened” hydrograph below the Tazin River (Figure 13.3.24, Figure 13.3.25, and Table 13.3.11). This “flattening” is most evident in the average monthly flows under the expansion scenarios compared to the baseline scenario. On average, flows would be lower for the majority of the open-water season (i.e. June to September) and higher during the winter (i.e. December to May), and would occur under both expansion scenarios. The flattening would be more pronounced under the 36 MW expansion than the 56 MW expansion due to the greater use of the available Nonacho Lake storage under the 36 MW expansion scenario.



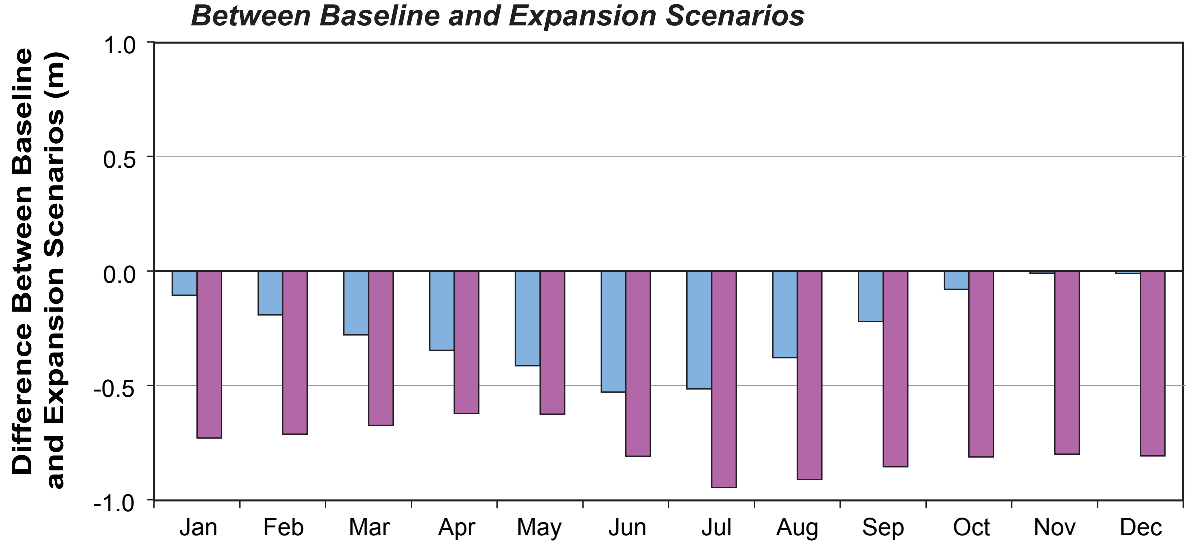
TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Taltson Basin Flow Model Results Zone 2 - Tronka Chua Lake Water Level Time Series** (503-005 / a22077m)	**Figure 13.3.20**

Dezé energy

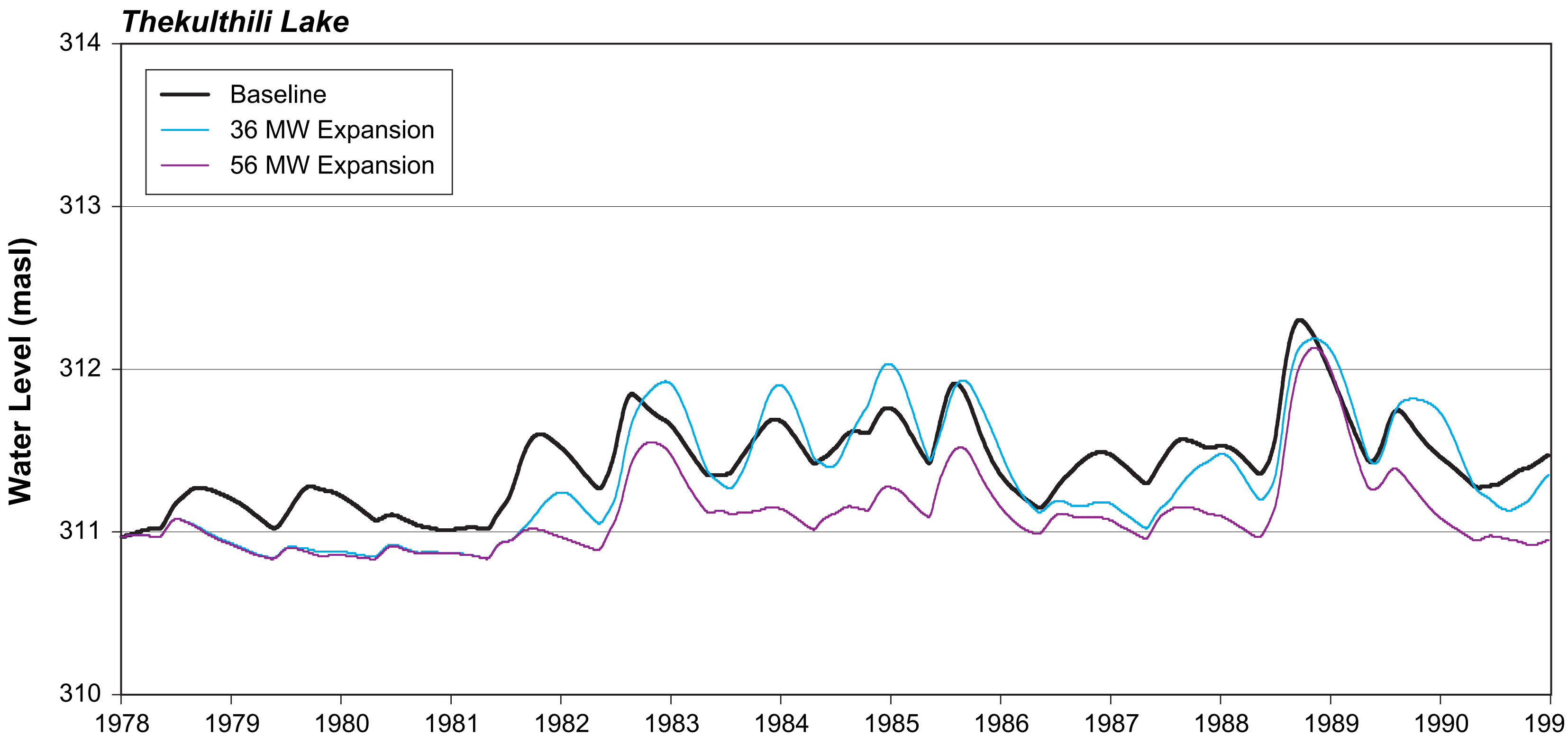
A. Average Monthly Water Level



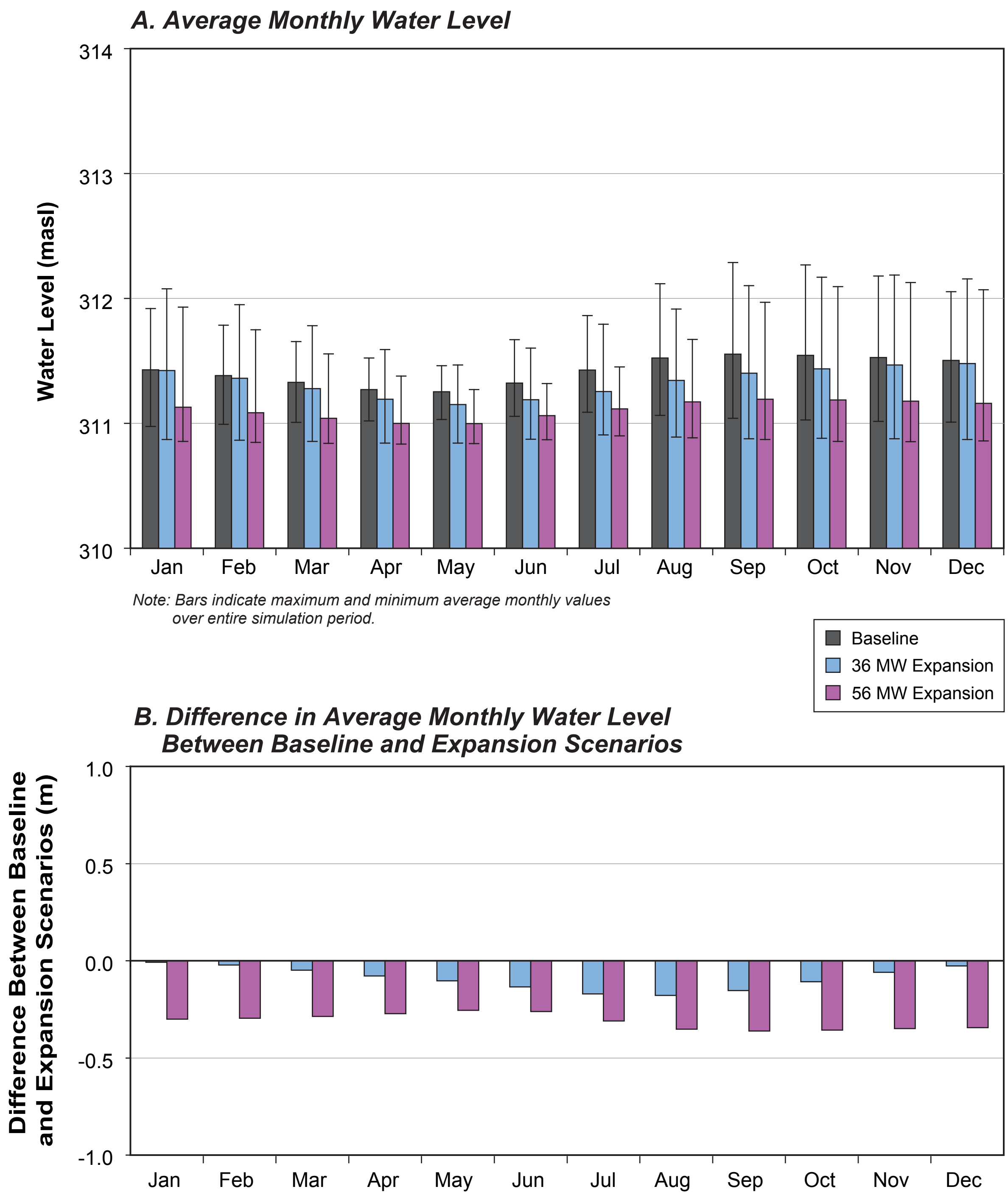
B. Difference in Average Monthly Water Level Between Baseline and Expansion Scenarios



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 2 - Tronka Chua Lake Water Level Monthly Summary (503-005 / a22078m)	Figure 13.3.21



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 2 - Thekulthili Lake Water Level Time Series (503-005 / a22079m)	Figure 13.3.22



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 2 - Thekulthili Lake Water Level Monthly Summary (503-005 / a22080m)	Figure 13.3.23

Table 13.3.9 — Taltson Basin Flow Model Results, Zone 2: Water Levels

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tronka Chua Lake: Average Monthly Water Level (masl)												
Baseline	322.91	322.82	322.71	322.60	322.59	322.84	323.19	323.32	323.26	323.17	323.11	323.06
36 MW Expansion	322.81	322.62	322.43	322.26	322.17	322.31	322.68	322.94	323.04	323.09	323.10	323.05
56 MW Expansion	322.18	322.10	322.03	321.98	321.96	322.03	322.25	322.41	322.40	322.36	322.31	322.25
Tronka Chua Lake: Change from Baseline (m)												
36 MW Expansion	-0.11	-0.19	-0.28	-0.35	-0.41	-0.53	-0.52	-0.38	-0.22	-0.08	-0.01	-0.01
56 MW Expansion	-0.73	-0.71	-0.67	-0.62	-0.63	-0.81	-0.95	-0.91	-0.86	-0.81	-0.80	-0.81
Thekulthili Lake: Average Monthly Water Level (masl)												
Baseline	311.43	311.38	311.33	311.27	311.25	311.32	311.43	311.52	311.55	311.54	311.53	311.50
36 MW Expansion	311.42	311.36	311.28	311.19	311.15	311.19	311.26	311.34	311.40	311.44	311.47	311.48
56 MW Expansion	311.13	311.09	311.04	311.00	311.00	311.06	311.12	311.17	311.19	311.19	311.18	311.16
Thekulthili Lake: Change from Baseline (m)												
36 MW Expansion	-0.01	-0.02	-0.05	-0.08	-0.10	-0.13	-0.17	-0.18	-0.15	-0.11	-0.06	-0.03
56 MW Expansion	-0.30	-0.30	-0.29	-0.27	-0.26	-0.26	-0.31	-0.35	-0.36	-0.36	-0.35	-0.34

Table 13.3.10 — Estimated Annual Variation in Mean Monthly Water Levels in Zone 2

Location	SCENARIO		
	Baseline (m)	36 MW Expansion (m)	56 MW Expansion (m)
Tronka Chua Lake	0.73	0.93	0.45
Thekulthili Lake	0.30	0.33	0.19

The flattening of the hydrograph at this location can also be seen in the daily flow time series. On an annual basis, peak flows would be lower under the 36 MW expansion and annual minimum flows would be higher. For many years a secondary peak beginning in the fall or winter would occur resulting from the release of water stored within Nonacho Lake during the freshet. The daily hydrograph under the 56 MW expansion would more closely follow the baseline hydrograph.

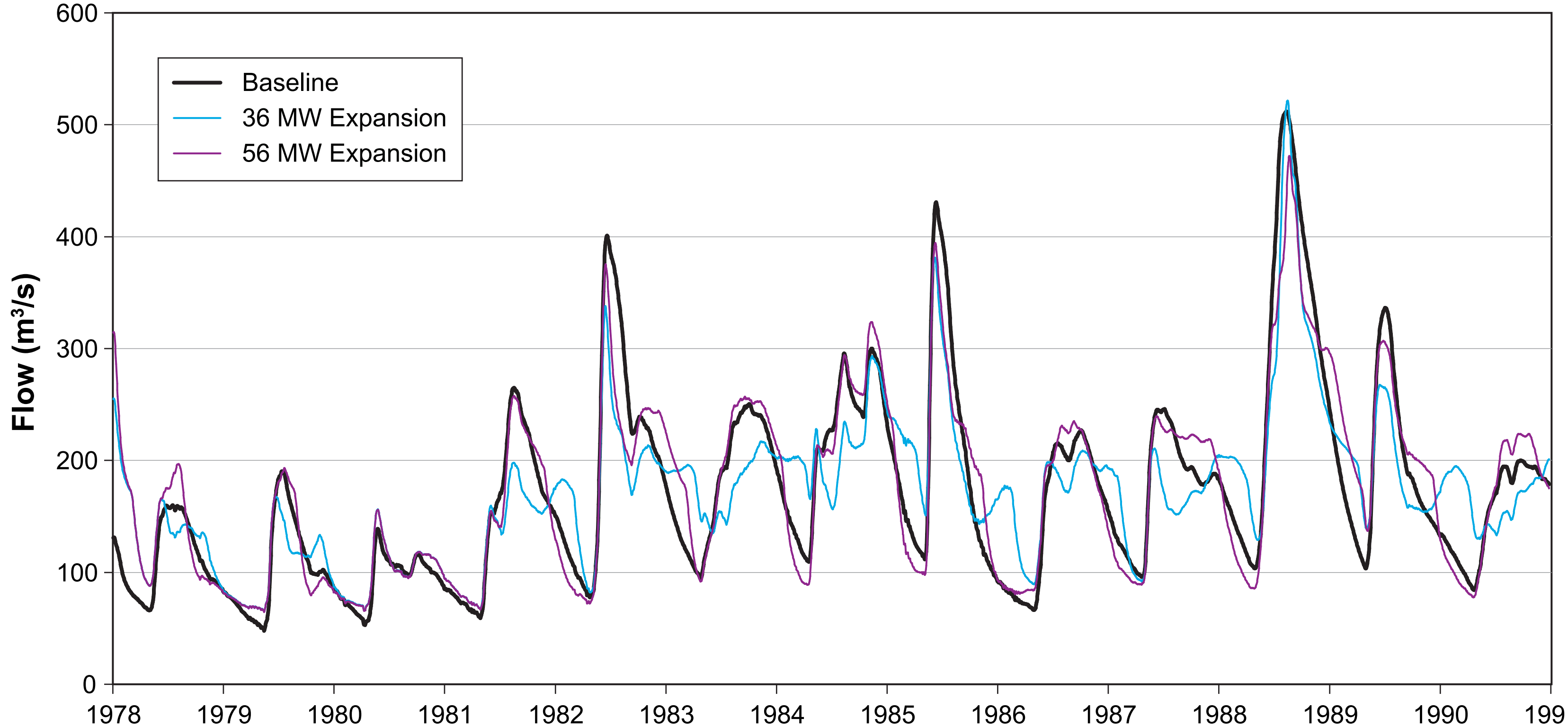
The alteration to the baseline hydrograph downstream of the Tazin River under the expansion scenarios would be reflected in water levels at this location (Figure 13.3.26, Figure 13.3.27, and Table 13.3.12). On average, annual peak levels would decrease under the expansion scenario and minimum levels would be greater. The flattened hydrograph would result in a substantial reduction in the seasonal variation in water levels throughout Zone 3 (Table 13.3.13).

13.3.3.4.2 Twin Gorges Forebay

Outflow from the Twin Gorges Forebay occurs either through the power facilities to the Taltson River as a continuation of Zone 3, or as inflow to Zone 5 (Trudel Creek) at the SVS.

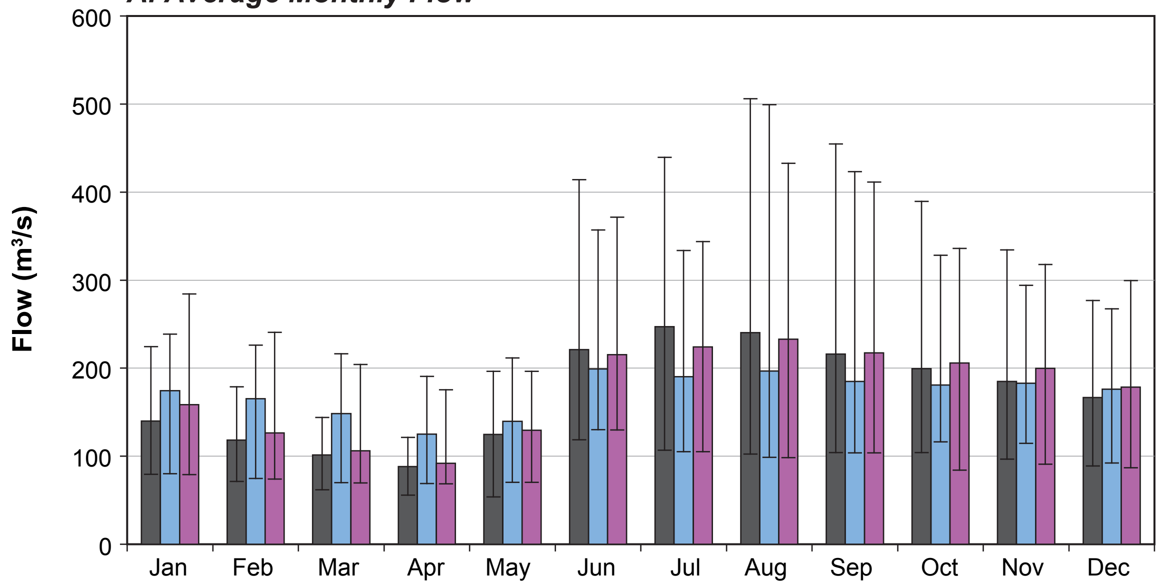
Under the expansion scenarios target flows through the Twin Gorges power facilities would be 180 m^3/s and 240 m^3/s for the 36 MW and 56 MW expansions, respectively. These generated targets are a substantial increase over the baseline power plant flow of between 30 m^3/s and 50 m^3/s, which corresponds to the current power production of 8 MW in the summer and 12 MW in the winter. To achieve this increase in flow through the power facilities, operations of the facilities would be set such that water level in the Forebay would be maintained slightly below the elevation of the crest of the SVS. This operational guide would maximize power production by minimizing the amount of water spilled into Trudel Creek above a specified minimum release of 4 m^3/s. Although plant flow would be greater than baseline on a consistent basis, there would be periods when the full target flows would not be met (Figure 13.3.28, Figure 13.3.29). The duration and extent of these flow deficit periods would be greater under the 56 MW expansion scenario than the 36 MW expansion scenario.

Taltson River Downstream of Tazin River Confluence

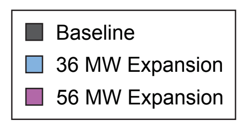


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Zone 3: Taltson River Downstream of Tazin River Confluence Flow Time Series (503-005 / a22015m)	Figure 13.3.24

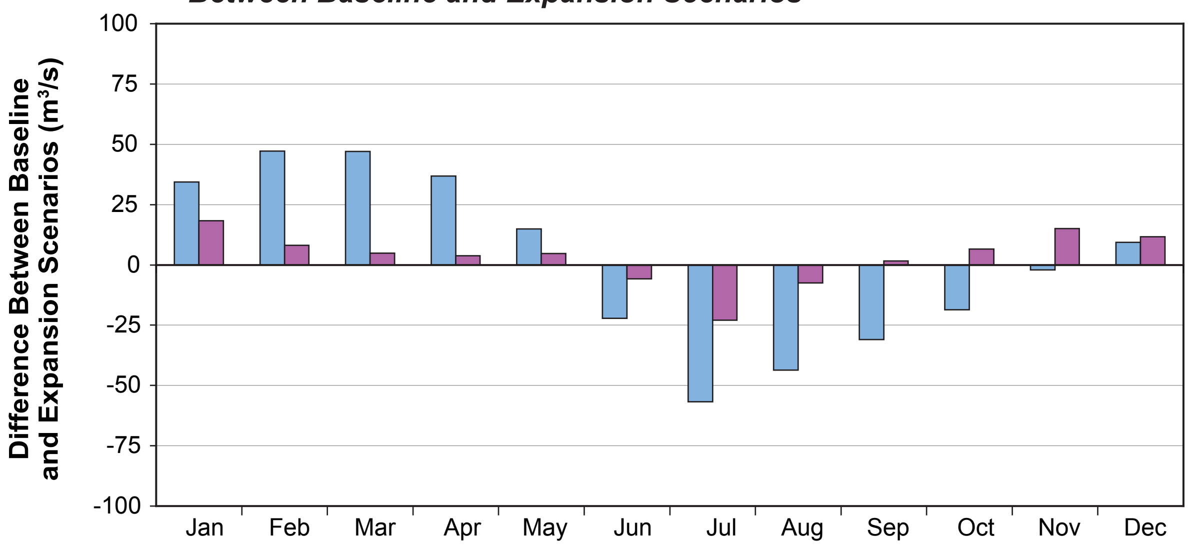
A. Average Monthly Flow



Note: Bars indicate maximum and minimum average monthly values over entire simulation period.



B. Difference in Average Monthly Flow Between Baseline and Expansion Scenarios

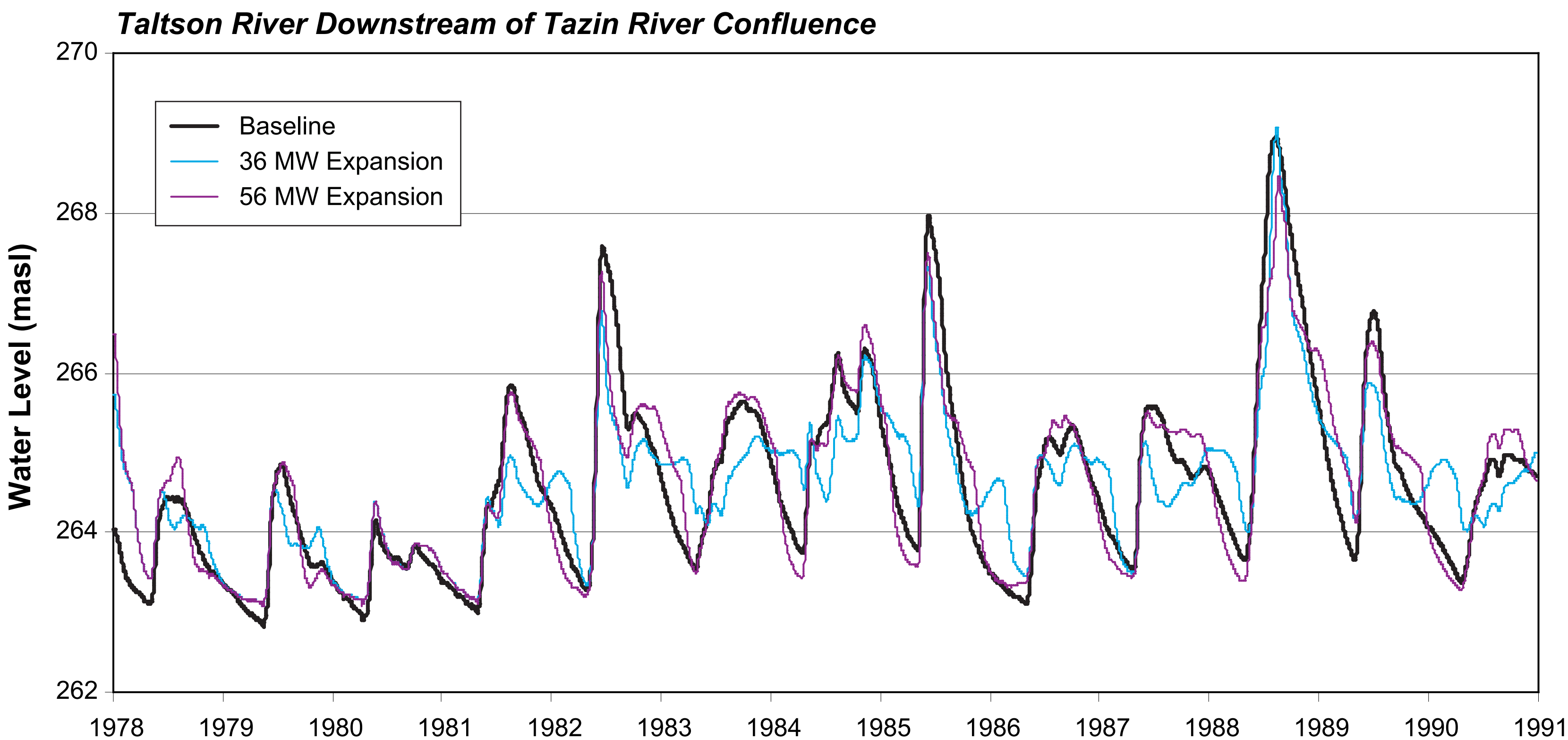


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Zone 3: Taltson River Downstream of Tazin River Confluence Flow Monthly Summary (503-005 / a22016m)	Figure 13.3.25

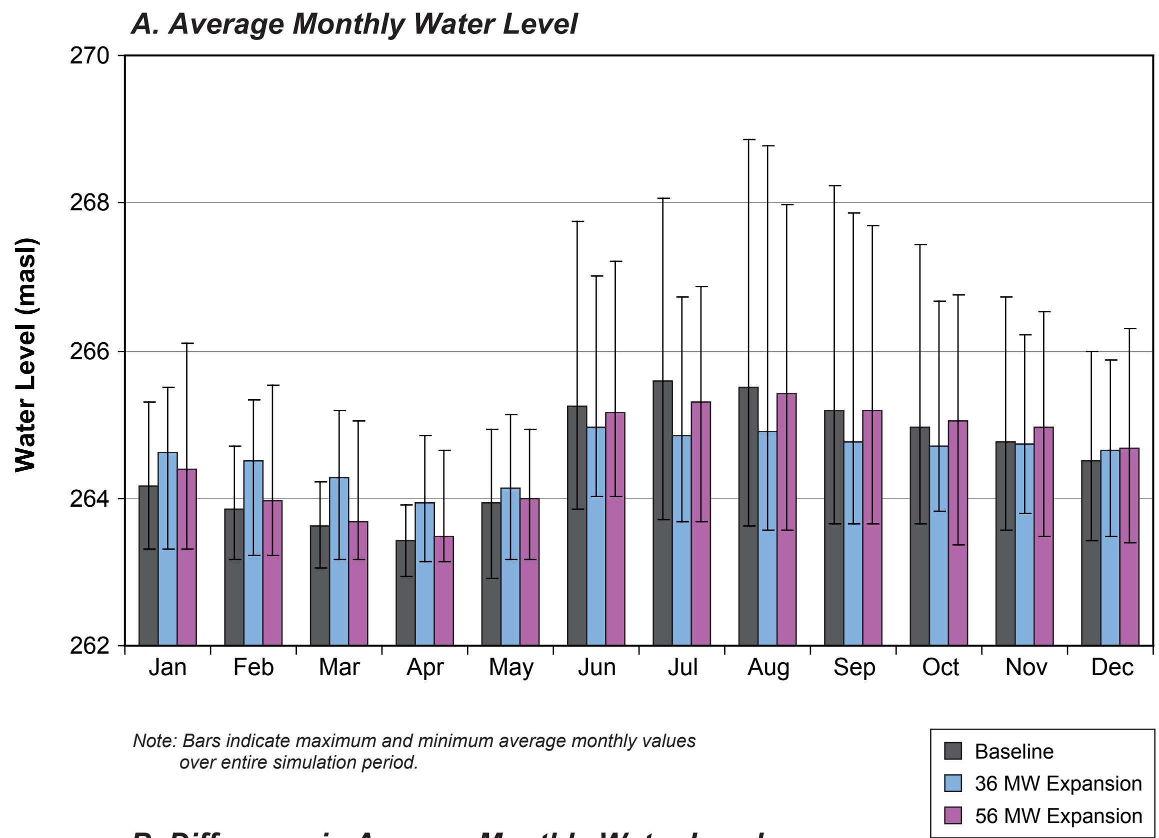
Table 13.3.11 — Taltson Basin Flow Model Results, Zone 3: Flow

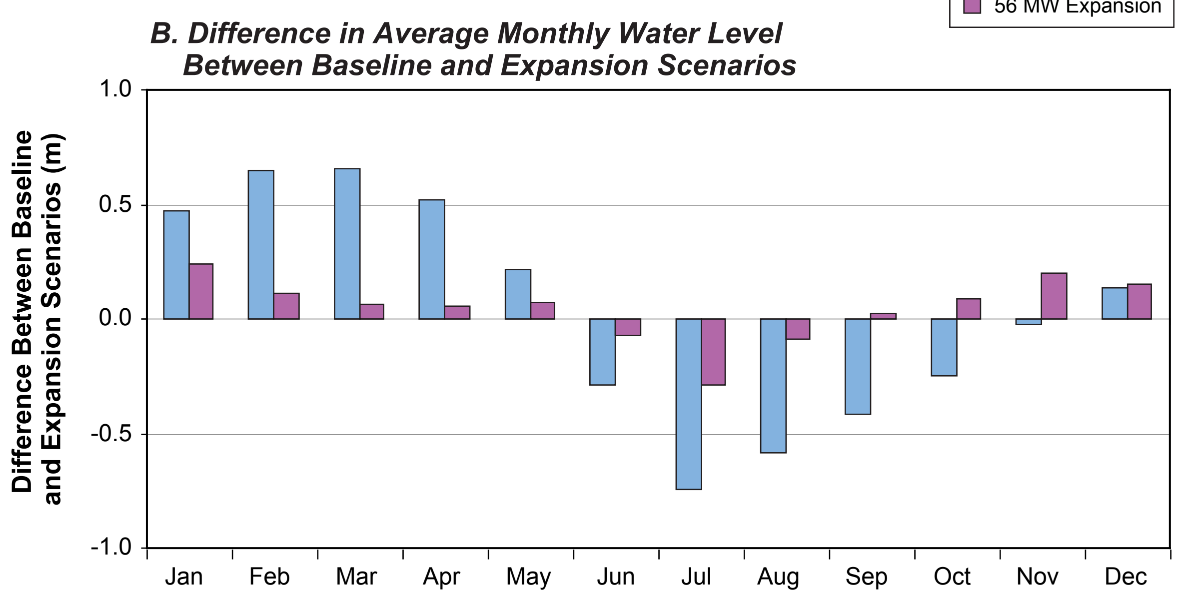
Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Taltson River Downstream of Tazin River: Average Monthly Flow (m^3/s)												
Baseline	140.03	118.18	101.27	88.27	124.66	221.15	246.99	240.44	215.85	199.40	184.90	166.65
36 MW Expansion	174.37	165.34	148.23	125.04	139.62	198.97	190.21	196.81	184.94	180.75	182.78	176.05
56 MW Expansion	158.37	126.30	106.21	92.10	129.41	215.35	224.02	232.98	217.51	205.92	199.92	178.32
Taltson River Downstream of Tazin River: Change from Baseline (m^3/s)												
36 MW Expansion	34.34	47.16	46.95	36.77	14.96	-22.18	-56.78	-43.63	-30.91	-18.66	-2.12	9.40
56 MW Expansion	18.34	8.11	4.94	3.83	4.75	-5.79	-22.97	-7.47	1.66	6.52	15.02	11.67
Twin Gorges Power Plant(s): Average Monthly Flow (m^3/s)												
Baseline	50.00	50.00	50.00	50.00	50.00	30.52	30.00	30.00	30.00	49.50	50.00	50.00
36 MW Expansion	156.04	153.52	139.14	122.74	129.71	163.74	158.40	160.52	160.57	159.25	158.57	156.61
56 MW Expansion	152.34	125.79	105.26	90.11	122.46	190.34	202.98	213.12	200.85	194.40	186.81	170.94
Twin Gorges Power Plant(s): Change from Baseline (m^3/s)												
36 MW Expansion	106.04	103.52	89.14	72.74	79.71	133.22	128.40	130.52	130.57	109.75	108.57	106.61
56 MW Expansion	102.34	75.79	55.26	40.11	72.46	159.81	172.98	183.12	170.85	144.90	136.81	120.94
SVS: Average Monthly Flow (m^3/s)												
Baseline	94.62	71.92	54.20	40.53	71.65	191.34	222.05	217.05	191.01	154.86	139.83	121.71
36 MW Expansion	21.03	14.86	12.31	6.37	9.50	40.06	37.84	41.41	28.75	24.54	28.03	23.05
56 MW Expansion	10.89	4.62	4.00	4.00	4.72	27.77	26.38	24.75	21.76	15.16	17.79	12.94
SVS: Change from Baseline (m^3/s)												
36 MW Expansion	-73.59	-57.06	-41.89	-34.16	-62.15	-151.28	-184.21	-175.64	-162.27	-130.31	-111.80	-98.66
56 MW Expansion	-83.73	-67.29	-50.20	-36.53	-66.93	-163.57	-195.68	-192.30	-169.25	-139.69	-122.04	-108.77
Taltson River downstream of Twin Gorges: Average Monthly Flow (m^3/s)												

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline	145.47	122.63	104.73	90.83	119.12	219.49	251.91	247.88	221.71	205.28	190.39	172.43
36 MW Expansion	177.34	168.67	151.84	129.63	138.17	203.26	196.50	202.21	189.73	183.81	186.76	179.90
56 MW Expansion	163.85	130.92	109.58	94.24	125.93	217.18	229.61	237.97	223.14	209.74	204.90	184.45
Taltson River downstream of Twin Gorges: Change from Baseline (m^3/s)												
36 MW Expansion	31.88	46.05	47.11	38.80	19.05	-16.23	-55.41	-45.67	-31.98	-21.47	-3.62	7.48
56 MW Expansion	18.39	8.29	4.85	3.41	6.81	-2.31	-22.30	-9.91	1.43	4.46	14.51	12.02



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 3 - Taltson River Downstream of Tazin River Water Level Time Series (503-005 / a22081m)	Figure 13.3.26





TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 3 - Taltson River Downstream of Tazin River Water Level Monthly Summary (503-005 / a22082m)	Figure 13.3.27

Table 13.3.12 — Taltson Basin Flow Model Results, Zone 3: Water Levels

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Taltson River downstream of Tazin River - Average Monthly Water Level (masl)												
Baseline	264.15	263.85	263.61	263.43	263.94	265.24	265.58	265.50	265.18	264.96	264.76	264.52
36 MW Expansion	264.62	264.50	264.26	263.94	264.15	264.96	264.84	264.92	264.76	264.71	264.74	264.65
56 MW Expansion	264.40	263.96	263.68	263.48	264.01	265.17	265.29	265.41	265.20	265.05	264.97	264.67
Taltson River downstream of Tazin River - Change from Baseline (m)												
36 MW Expansion	0.47	0.65	0.65	0.52	0.21	-0.29	-0.75	-0.58	-0.41	-0.24	-0.02	0.13
56 MW Expansion	0.24	0.11	0.07	0.06	0.07	-0.07	-0.29	-0.09	0.02	0.09	0.20	0.16
Twin Gorges Forebay - Average Monthly Water Level (masl)												
Baseline	248.02	247.97	247.92	247.88	247.96	248.22	248.28	248.27	248.22	248.15	248.12	248.08
36 MW Expansion	247.69	247.66	247.64	247.56	247.55	247.72	247.70	247.71	247.66	247.66	247.67	247.69
56 MW Expansion	247.57	247.51	247.50	247.50	247.51	247.64	247.65	247.64	247.61	247.60	247.62	247.58
Twin Gorges Forebay - Change from Baseline (m)												
36 MW Expansion	-0.33	-0.30	-0.28	-0.32	-0.41	-0.50	-0.58	-0.56	-0.57	-0.49	-0.44	-0.39
56 MW Expansion	-0.45	-0.45	-0.42	-0.38	-0.45	-0.58	-0.63	-0.62	-0.61	-0.55	-0.50	-0.50
Taltson River downstream of Twin Gorges - Average Monthly Water Level (masl)												
Baseline	203.71	203.51	203.32	203.14	203.44	204.25	204.45	204.43	204.29	204.18	204.05	203.92
36 MW Expansion	203.98	203.91	203.76	203.54	203.66	204.17	204.12	204.13	204.06	204.05	204.06	204.00
56 MW Expansion	203.83	203.56	203.35	203.19	203.53	204.26	204.35	204.41	204.30	204.21	204.16	204.01
Taltson River downstream of Twin Gorges - Change from Baseline (m)												
36 MW Expansion	0.26	0.40	0.44	0.40	0.22	-0.08	-0.33	-0.30	-0.23	-0.13	0.01	0.08
56 MW Expansion	0.11	0.05	0.04	0.05	0.09	0.01	-0.10	-0.02	0.02	0.03	0.11	0.09

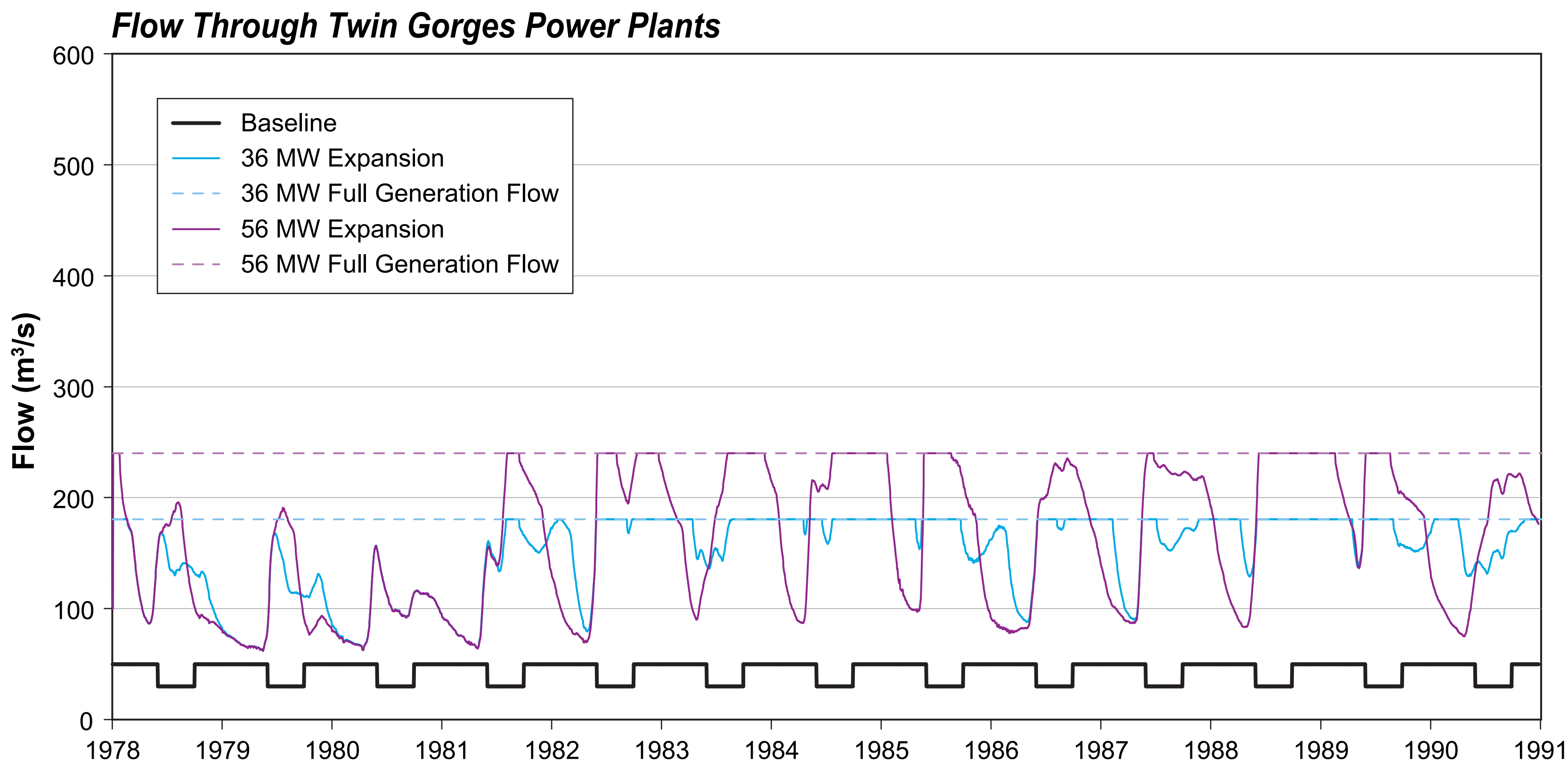
Table 13.3.13 — Estimated Annual Variation in Mean Monthly Water Levels in Zone 3

Location	SCENARIO		
	Baseline (m)	36 MW Expansion (m)	56 MW Expansion (m)
Taltson River downstream of Tazin River	2.16	1.01	1.93
Twin Gorges Forebay	0.40	0.16	0.15
Taltson River downstream of Twin Gorges	1.31	0.63	1.22

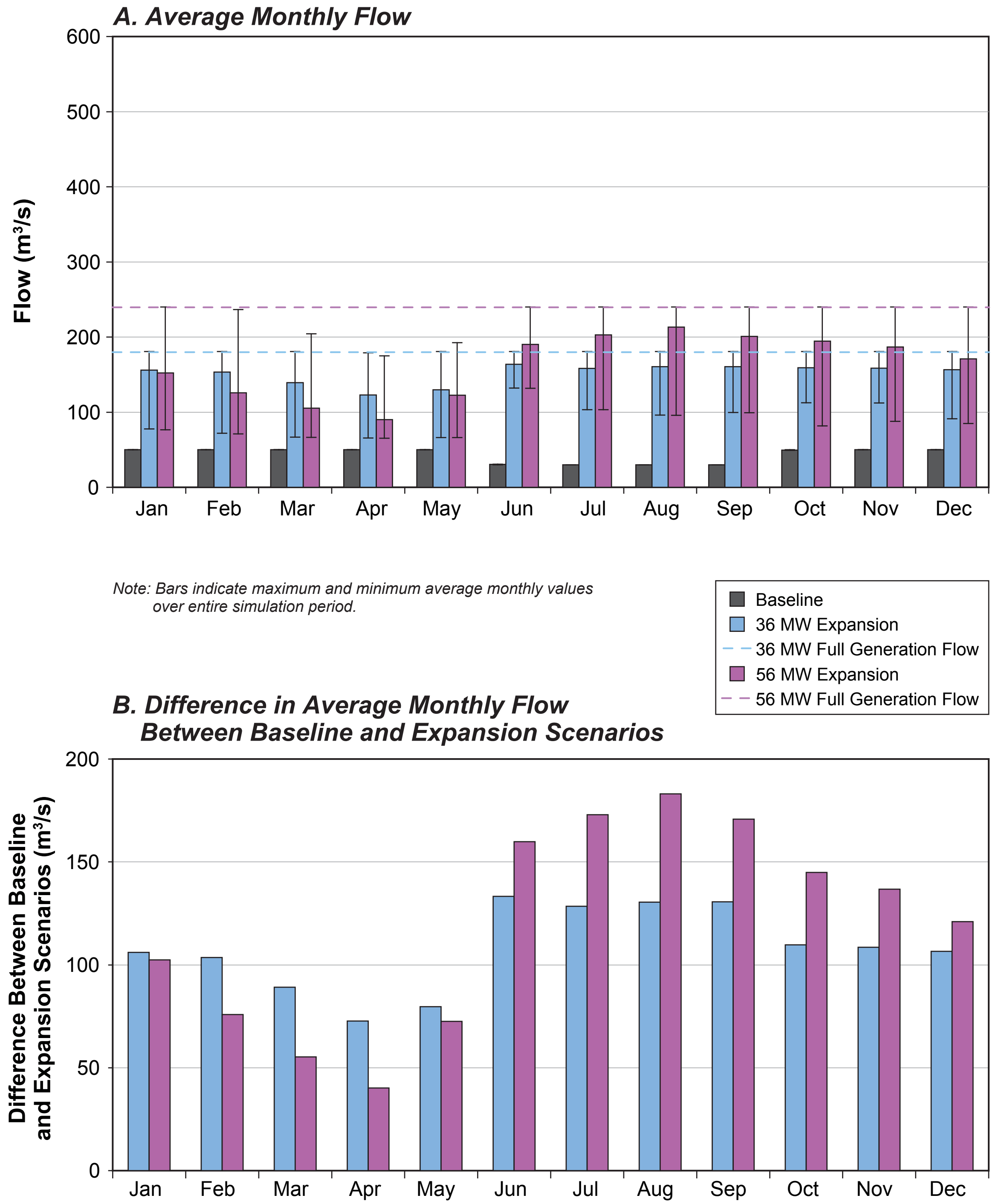
It must be noted that this model was not developed to assess whether there is sufficient water for power production. This is addressed by the Generation Model described in the Development Description (Chapter 6).

Due to the target water level set for the Forebay within the Flow Model, water levels in the Forebay would be lower under the expansion scenarios than baseline conditions (Figure 13.3.30, Figure 13.3.31, and Table 13.3.12). Additionally, average water levels would be less variable under the expansion scenarios than baseline conditions (Table 13.3.13). Although operational reservoirs can often be subjected to greater water level fluctuations than natural lakes would experience, due to the low storage available at Twin Gorges (e.g., less than two days of storage at the 36 MW expansion plant flow capacity) the Forebay would not be operated as a traditional reservoir. Thus flows from Nonacho Lake would require regulation. Under the expansion scenarios, water levels would only exceed the target Forebay level during periods of high runoff from the unregulated catchments, including the Tazin River. This would generally occur during the freshet period for average to wet years under the 36 MW expansion and only during wet years under the 56 MW expansion.

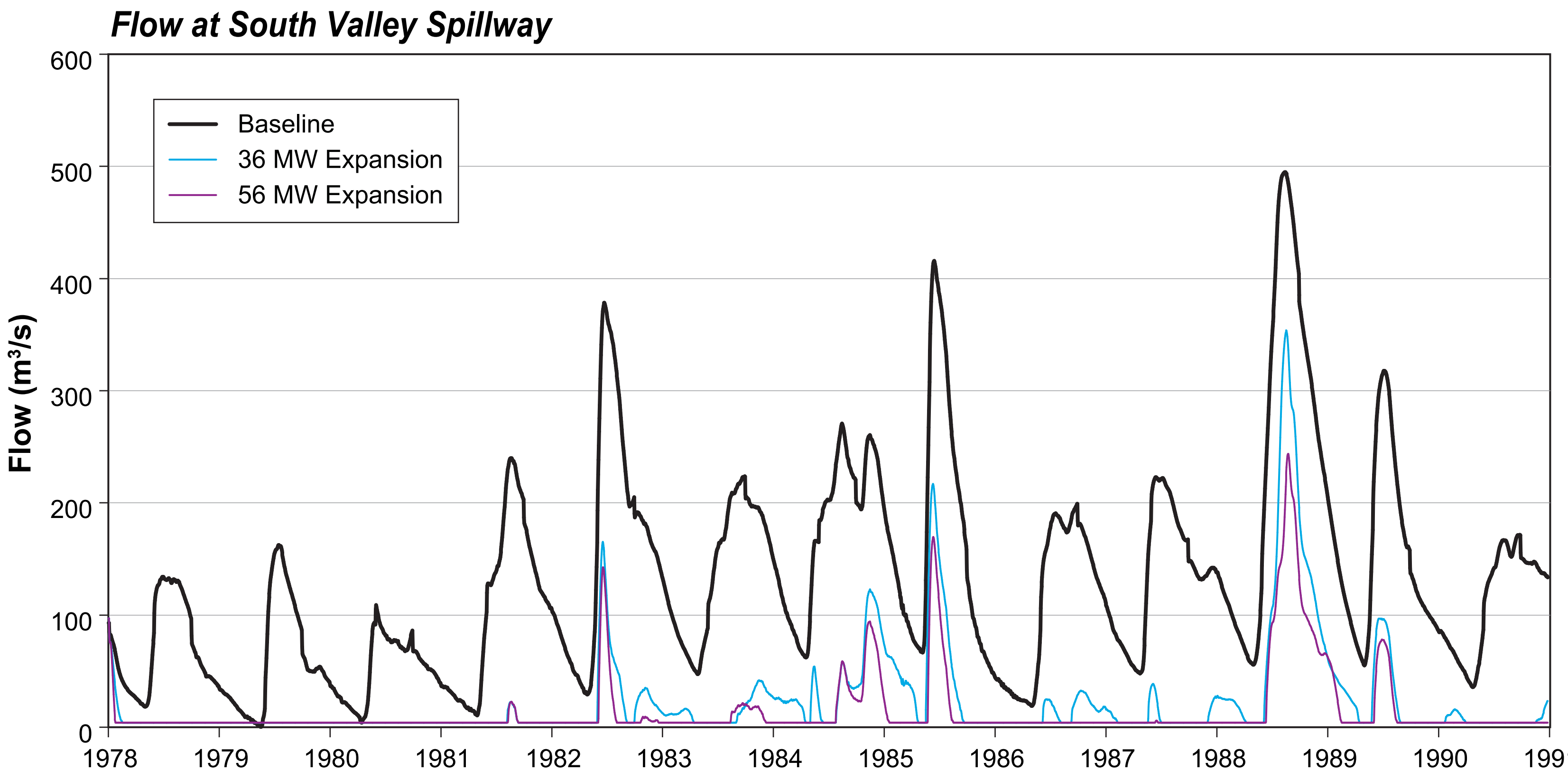
The increase in flow through the power facilities would result in a corresponding decrease in flow at the SVS to Zone 5, Trudel Creek (Figure 13.3.32, Figure 13.3.33, and Table 13.3.11). The SVS is an uncontrolled spillway; flow over the SVS (other than during periods of specified minimum release) is directly related to water level within Twin Gorges. Within the Flow Model, because the target water level of the Forebay would be set at the elevation of the crest of the SVS, outflow at the SVS above the specified minimum release would only occur during periods when inflow to Twin Gorges is in excess of what can be used at the power facilities. Overall, both of the expansion scenarios would result in less flow entering Trudel Creek. For the majority of the 13-year model simulation period, flow over the SVS would be restricted to the minimum release level of 4 m^3/s under both of the expansion scenarios. However, due to the low storage volume in Twin Gorges and uncontrolled flows from Tazin River, as well as other local watersheds between Nonacho Lake and Twin Gorges, there would be periods when high flows experienced at the SVS although at lower magnitudes compared to baseline peak flow levels. Although not included in this modeling study, additional release over SVS to Trudel Creek would occur during outage conditions at the power facility. Changes to water level and flow within Trudel Creek, which would be directly related to flow at the SVS, are further discussed in Section 14.3 (Alterations of Water Quantity in Trudel Creek).



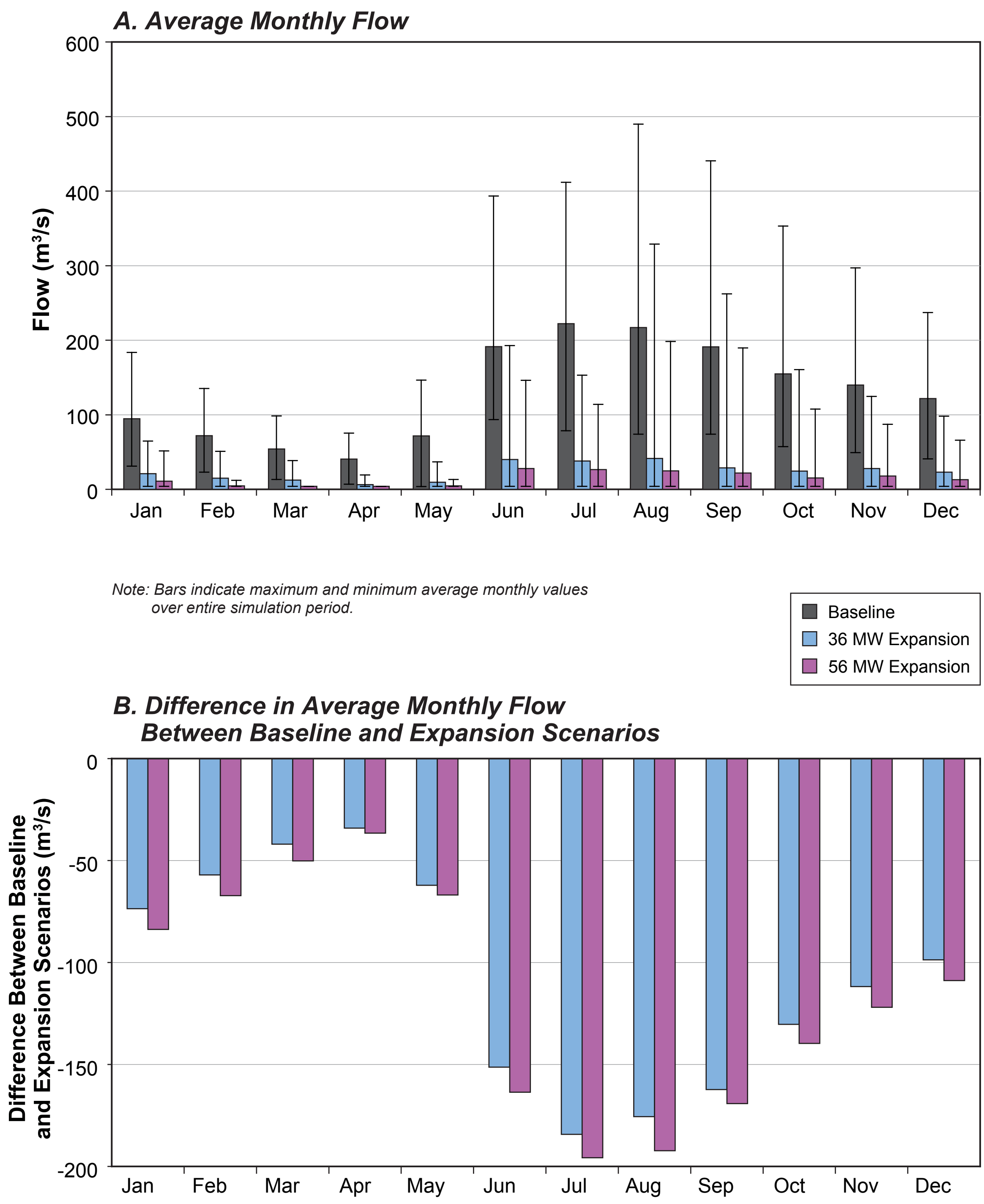
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Zone 3: Flow Through Twin Gorges Power Plants Time Series (503-005 / a22017m)	Figure 13.3.28



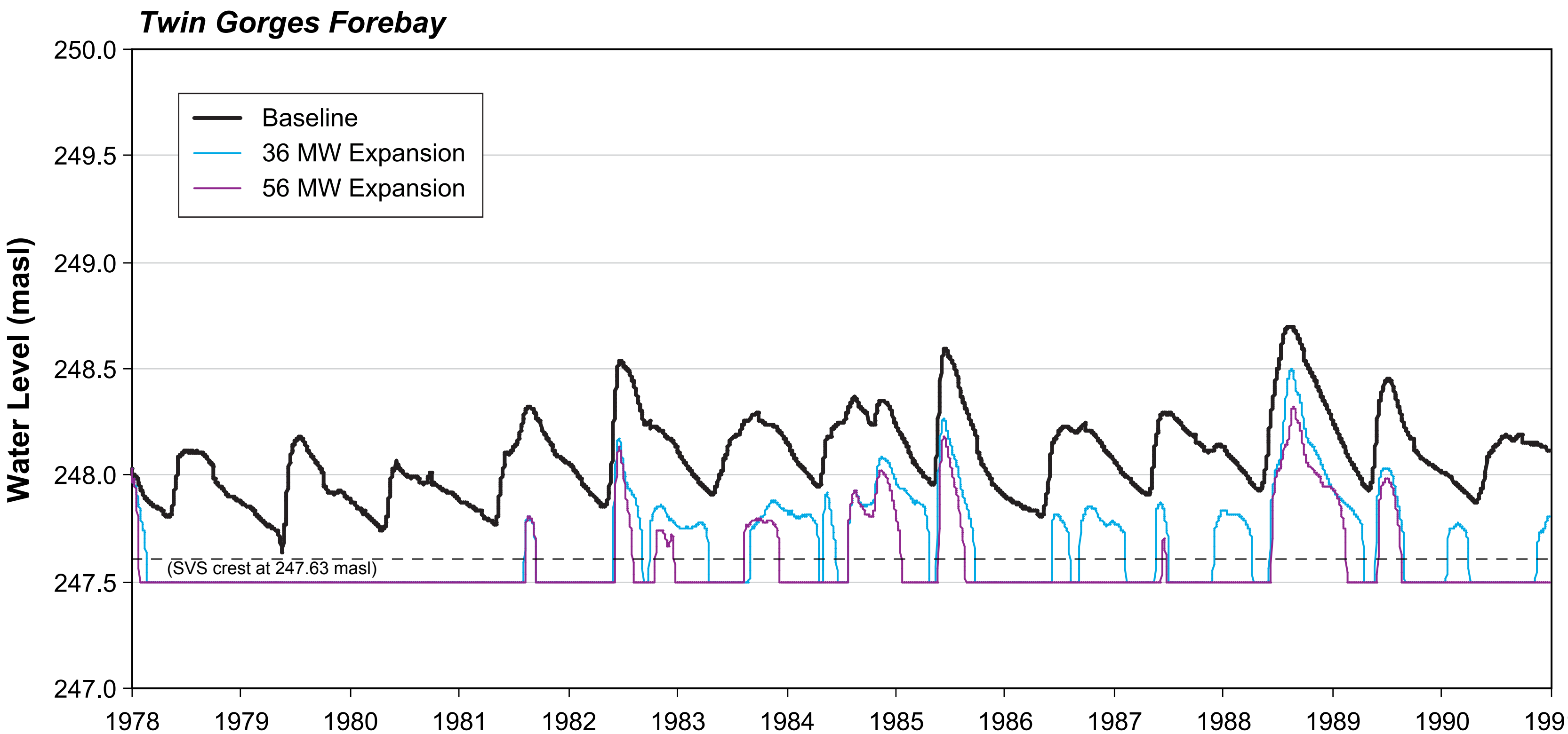
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Zone 3: Flow Through Twin Gorges Power Plants Monthly Summary (503-005 / a22018m)	Figure 13.3.29



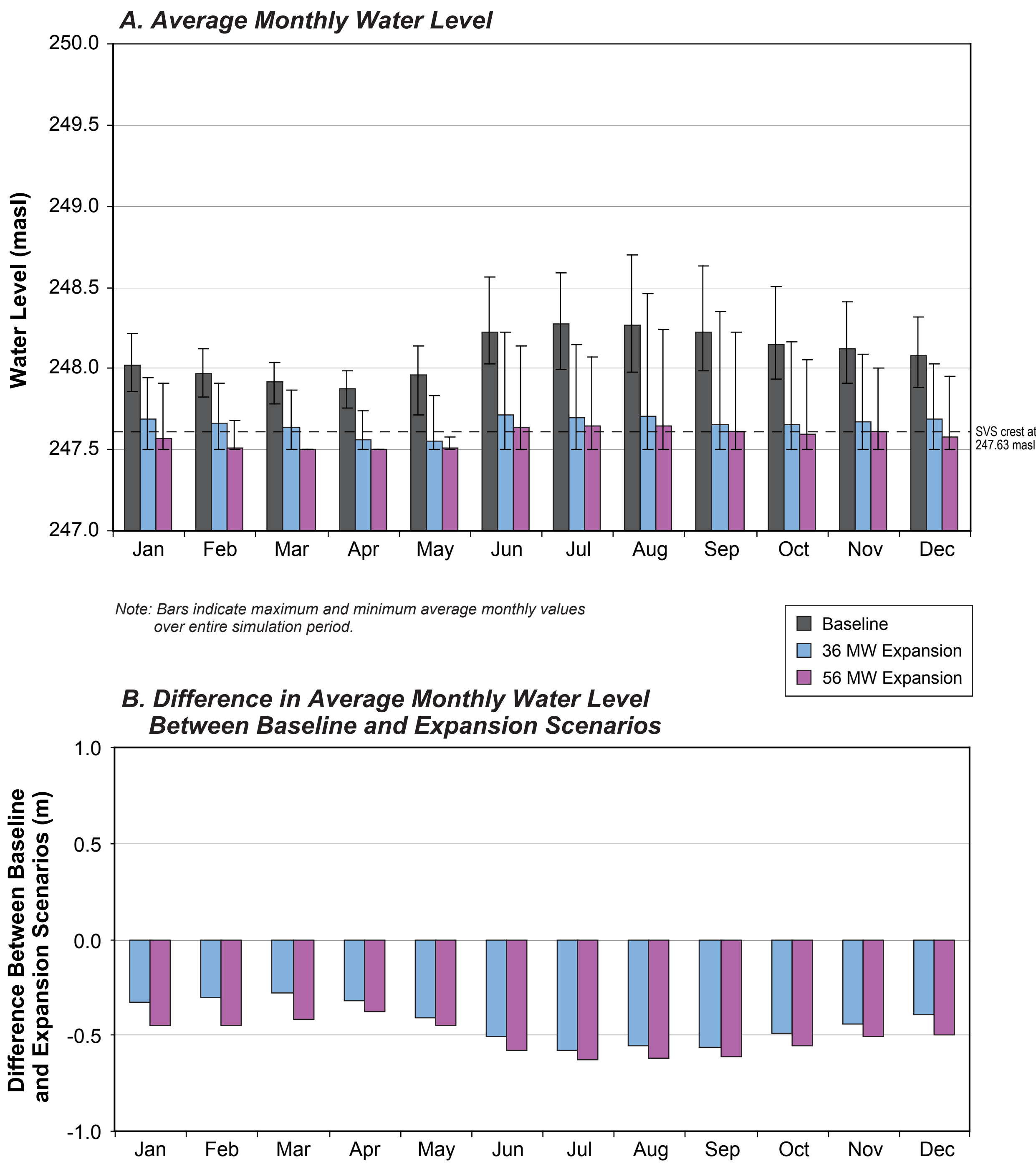
TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Taltson Basin Flow Model Results - Zone 5: South Valley Spillway Flow Time Series** (503-005 / a22023m)	**Figure 13.3.30**



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Zone 5: South Valley Spillway Flow Monthly Summary (503-005 / a22024m)	Figure 13.3.31



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 3 - Twin Gorges Forebay Water Level Time Series (503-005 / a22083m)	Figure 13.3.32



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 3 - Twin Gorges Forebay Water Level Monthly Summary (503-005 / a22084m)	Figure 13.3.33

13.3.3.4.3 Taltson River downstream of Twin Gorges

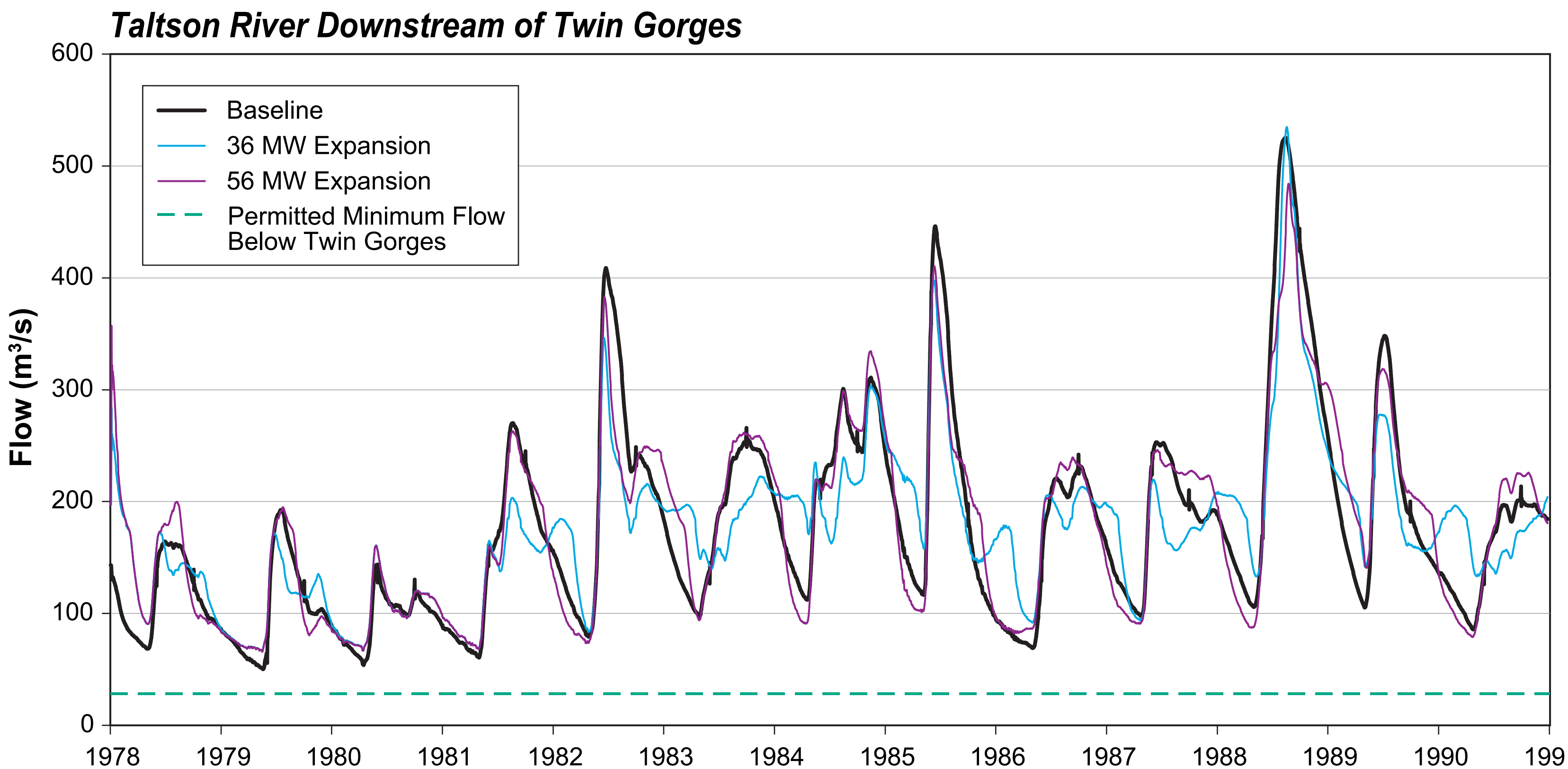
Just below Twin Gorges and Elsie Falls, Trudel Creek enters the Taltson River mainstem and returns all outflow from Twin Gorges at the SVS back to the Taltson River. The change in operations at Nonacho Lake and Twin Gorges under the Expansion Project would have a similar effect on flows and water levels at this location as in the Taltson River downstream of the confluence with the Tazin River (discussed previously). Under both of the expansion scenarios, flows and levels, on average, would be lower compared to baseline conditions during the open-water season (i.e. June to September) and higher during the winter (i.e., December to May) (Figure 13.3.34 to Figure 13.3.37; Tables 13.3.11 and 13.3.12). On average, seasonal variation in water levels would decrease under the expansion scenarios at a similar magnitude to the Taltson River downstream of the Tazin River (Table 13.3.13).

On average, annual peak flows below Twin Gorges would decrease from baseline under the 36 MW expansion and increase under the 56 MW expansion (Table 13.3.14). However, based on the available historic Water Survey of Canada (WSC) record from the hydrometric station downstream of Twin Gorges, this change is negligible in terms of the range of return period peak flows observed for this location. For example, the relative change in annual peak flows from baseline is -6% and +2% for the 36 MW and 56 MW expansions, respectively. This is a small change compared to the difference (+46%) between the return period flows that are expected on average once every two (Q_2) and ten (Q_{10}) years estimated from the WSC record. Similarly for the maximum daily peak flow predicted over the 13-year simulation period, the peak flow would be greater under the 36 MW expansion compared to baseline and lower under the 56 MW expansion. However, compared to the return period flow estimates these would be relatively small changes. The predicted maximum flow under the 36 MW expansion would fall between the peak flow expected on average currently once every 20 years (Q_{20}) and every 50 years (Q_{50}), which is consistent with the peak flow simulated under baseline conditions. The increase in maximum peak flow under the 36 MW expansion compared to baseline is due to increased release of flows at Nonacho Lake during this event to maintain water levels in Nonacho Lake near the nuisance high-water level (Section 13.3.3.1). The predicted maximum flow under the 56 MW expansion would fall between the peak flow expected on average currently once every 10 (Q_{10}) and 20 years (Q_{20}).

13.3.3.5 Zone 4 – Tsu Lake to Great Slave Lake

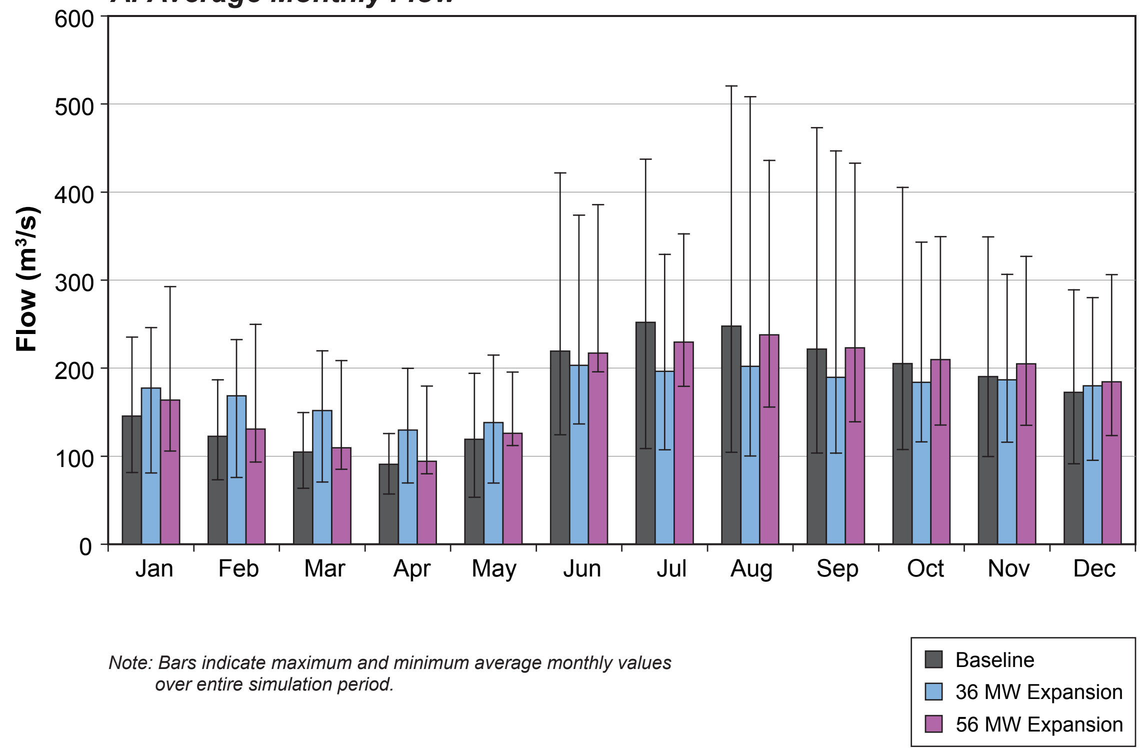
13.3.3.5.1 Tsu Lake and Taltson River downstream of Rat River

Zone 4 includes Tsu Lake and extends along the Taltson River mainstem to its outlet at Great Slave Lake and is the farthest downstream reach of the Taltson basin included in the Flow Model. Simulated flows in Zone 4 are presented for the Taltson River downstream of Rat River (Figure 13.3.38, Figure 13.3.39, and Table 13.3.15), which are considered representative of the Taltson River prior to its discharge into Great Slave Lake. Simulated water levels are available for Tsu Lake (Figure 13.3.40, Figure 13.3.41, and Table 13.3.16), but are not available in the Taltson River downstream of Rat River due to limited observed data.

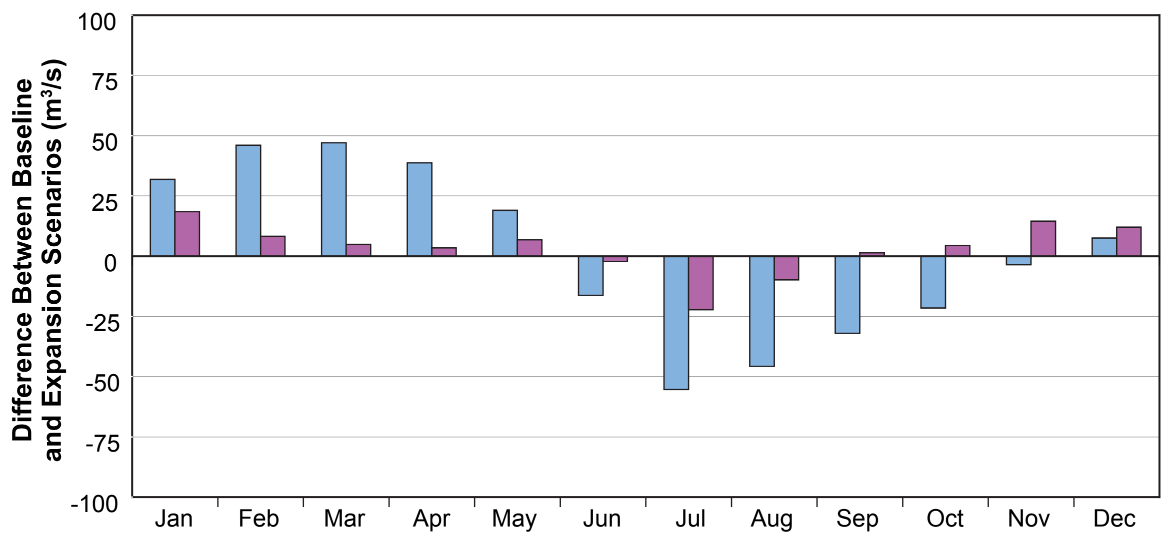


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Zone 3: Taltson River Downstream of Twin Gorges Flow Time Series (503-005 / a22019m)	Figure 13.3.34

A. Average Monthly Flow

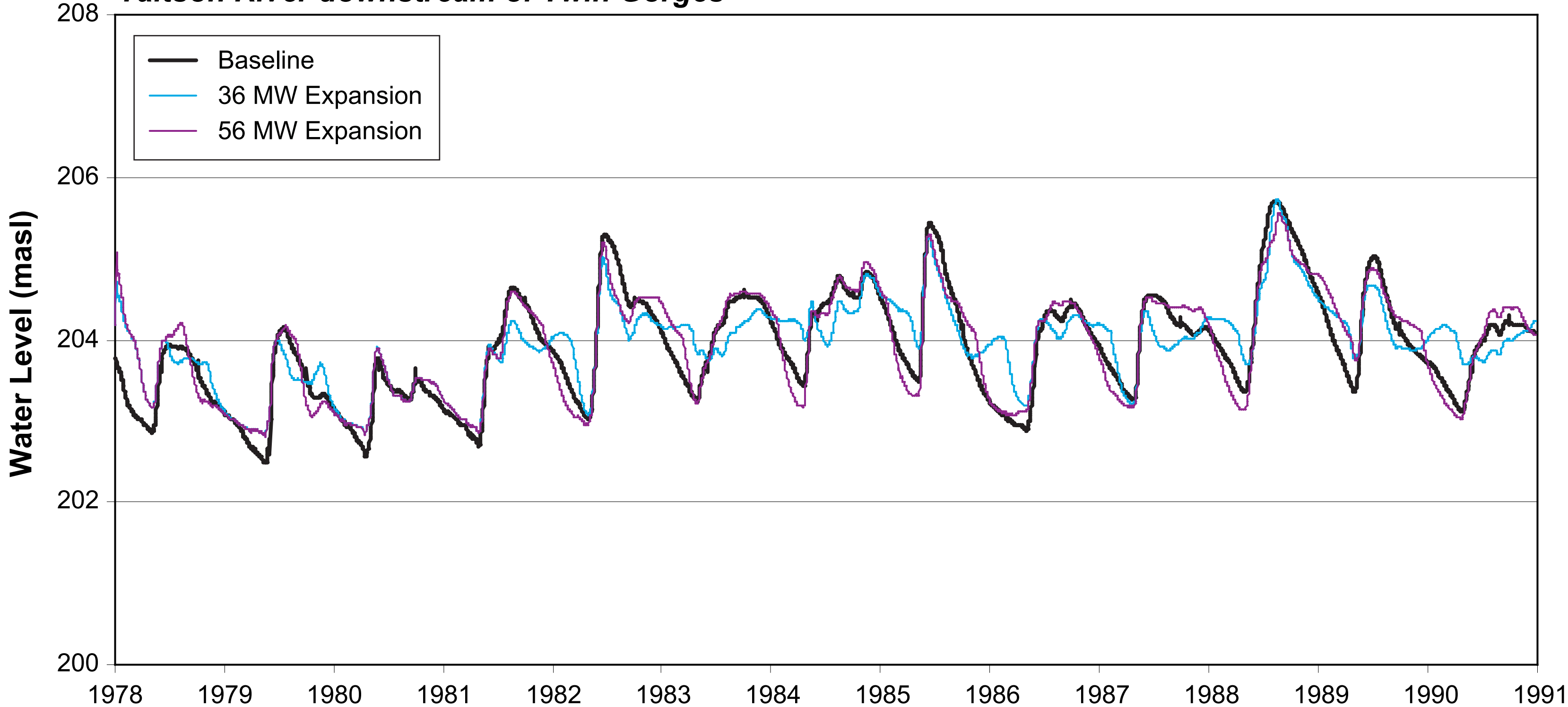


B. Difference in Average Monthly Flow Between Baseline and Expansion Scenarios

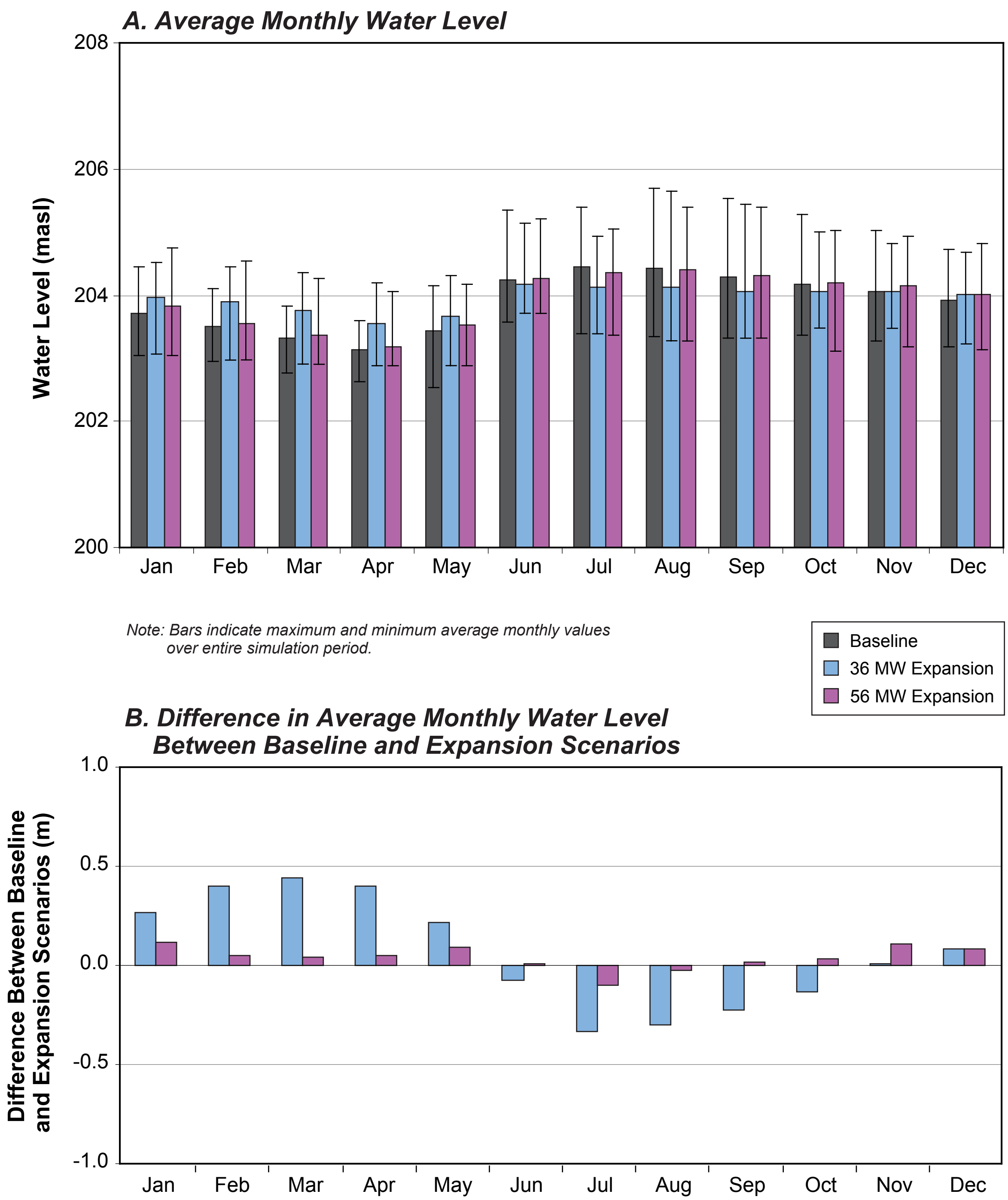


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Zone 3: Taltson River Downstream of Twin Gorges Flow Monthly Summary (503-005 / a22020m)	Figure 13.3.35

Taltson River downstream of Twin Gorges



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 3 - Taltson River Downstream of Twin Gorges Water Level Time Series (503-005 / a22085m)	Figure 13.3.36



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 3 - Taltson River Downstream of Twin Gorges Water Level Monthly Summary (503-005 / a22086m)	Figure 13.3.37

Table 13.3.14 — Estimated Peak Flows within Taltson River Downstream of Twin Gorges

Peak Flow	Baseline (m^3/s)	36 MW Expansion (m^3/s)	56 MW Expansion (m^3/s)	WSC Historic Record
Daily Flow over 13 year Simulation Period				
Mean Annual	291	272	298	n/a
Maximum	525	535	484	n/a
Return Period Flows				
Q_2	n/a	n/a	n/a	320
Q_{10}	n/a	n/a	n/a	470
Q_{20}	n/a	n/a	n/a	510
Q_{50}	n/a	n/a	n/a	550
Q_{100}	n/a	n/a	n/a	580

Notes: QT is the Daily peak flow (Q) expected on average, once every (T) years

Presentation and discussion of the WSC data in Taltson Basin is provided in Section 9.3 - Taltson Basin Hydrology.

n/a – Not applicable; return period flows not estimated for model results and simulated flows not relevant to WSC historic record

Changes within this zone under the Expansion Project would be a continuation of effects experienced upstream. The trends in flows and water levels between baseline and expansion scenarios which were discussed previously for Zone 3 would be applicable throughout Zone 4. Under both of the expansion scenarios, flows and levels, on average, would be lower compared to baseline during the majority of the open water season (i.e. July to September) and higher during the winter (i.e. December to May). On average, seasonal variation in water levels would decrease under the expansion scenarios at a similar magnitude to the Taltson River downstream of the Tazin River (Table 13.3.17). However, the relative change in flow would decrease with distance from Twin Gorges, as additional unregulated flows (i.e. Rutledge River, Konth River) join the Taltson River.

13.3.4 Ramping from Annual Scheduled Outages

Outages at the Twin Gorges power facility would be scheduled on an annual basis to conduct routine maintenance. This section discusses the associated ramping of flow and water levels in the Twin Gorges Forebay and the Taltson River below Twin Gorges; ramping in Trudel Creek is discussed in Section 14.3.3 (Ramping from Annual Scheduled Outages – Trudel Creek). Outages would also occur as a result of accidents and malfunctions. Ramping resulting from unplanned and unscheduled events is discussed in Chapter 17 (Accidents and Malfunctions), Sections 17.4 (Ramping Trudel Creek) and 17.5 (Taltson Basin).

Scheduled shutdowns would occur once a year for each turbine for regular maintenance. Each turbine would be inoperative for approximately one week. Maintenance of the turbines would be completed sequentially rather than simultaneously, such that as one turbine is brought back on-line another turbine would be taken off-line. Thus, a scheduled partial shutdown of the existing 18 MW and two proposed 18 MW turbines for a 36 MW expansion or two 28 MW turbines for a 56 MW expansion would last approximately three consecutive weeks. The preferred timing of the annual outages would be to occur just prior to the onset of freshet, which generally occurs in April or May.

During the annual outages, the aim would be to reduce any resulting ramping of flow and levels in the Forebay, the Taltson River below Twin Gorges, or in Trudel Creek. If full generation flow (180.6 m^3/s and 240 m^3/s for the 36 MW and 56 MW expansions, respectively) was not occurring at the power plants at the time of the outage, then the flow that had been conveyed through a turbine being taken off-line would be passed to the remaining two turbines. If the pre-outage flow in the Forebay was greater than the combined capacity of any two of the turbines, the South Gorge by-pass spillway would be operated to allow the excess flow, up to 30 m^3/s, to continue to pass to the Taltson River below Twin Gorges, rather than having it re-routed through Trudel Creek. In the event the pre-outage flow was greater than the combined capacity of two of the turbines and the South Gorge spillway, staging of levels would occur in the Forebay and ramping of flows would occur in the Taltson River below Twin Gorges and in Trudel Creek.

The greatest ramping of levels and flows would occur if all turbines were running at full capacity when the outage commenced. Based on the Flow Model results, this was estimated to occur six times in April or May during the 13-year model simulation period for the 36 MW expansion scenario, and once out of 13 years for the 56 MW expansion scenario. The 13-year model period represents historical runoff in the Taltson Basin for the period of 1978 to 1990 and is a subset of a longer period of record (see Section 9.3.3 Taltson Basin Hydrology) available below Twin Gorges. Although the model period was limited to 13 years, it contained the highest recorded annual flow as well as the second and fourth lowest annual flow on record. Therefore, the period represents a wide range of expected hydrological conditions in the area.

Assuming full generation flow was occurring at the time of an outage, upon initial shutdown of a turbine, the level would rise in the Forebay increasing discharge over the SVS to Trudel Creek and simultaneously decreasing flow in the Taltson River below Twin Gorges. The South Gorge Spillway would be operated and 30 m^3/s would pass to the Taltson River below Twin Gorges, reducing the initial drop of flow in the Taltson River and the increase to Trudel Creek. Flow would remain depressed in the Taltson River below Twin Gorges until the additional spill at the SVS routes through Trudel Creek and returns to the Taltson River, which would require approximately 10 to 16 hours, and return to pre-outage flow.

Through the successive re-start and shut down of the three turbines, ramping to a lesser degree would occur as the maintenance routine shifts from an expansion turbine to the existing turbine and vice versa, depending on the order that the turbines are serviced. Additional ramping would not occur between the re-start of one expansion turbine and shut-down of another, as the expansion turbines would have the same flow-through capacity.

Upon the re-start of the final turbine, the South Gorges Spillway would be closed and flow over the SVS would decrease. Flow and levels in the Taltson River below Twin Gorges would temporarily increase above pre-outage levels until flow through Trudel Creek has completely responded to the decrease in flow at the SVS, which would require approximately 10 hours.

The change in flow and levels in the Forebay and the Taltson River below Twin Gorges as a result of a scheduled outage would depend on the pre-outage flow in the basin as well as the final size of the Expansion Project turbines. Tables 13.3.18 and 13.3.19 present the estimated change in flow and water levels assuming that full generation is occurring prior to the outage. The estimated pre-outage flows in Trudel Creek were based on average daily Flow Model results in April and May when full generation was occurring at the power plants.

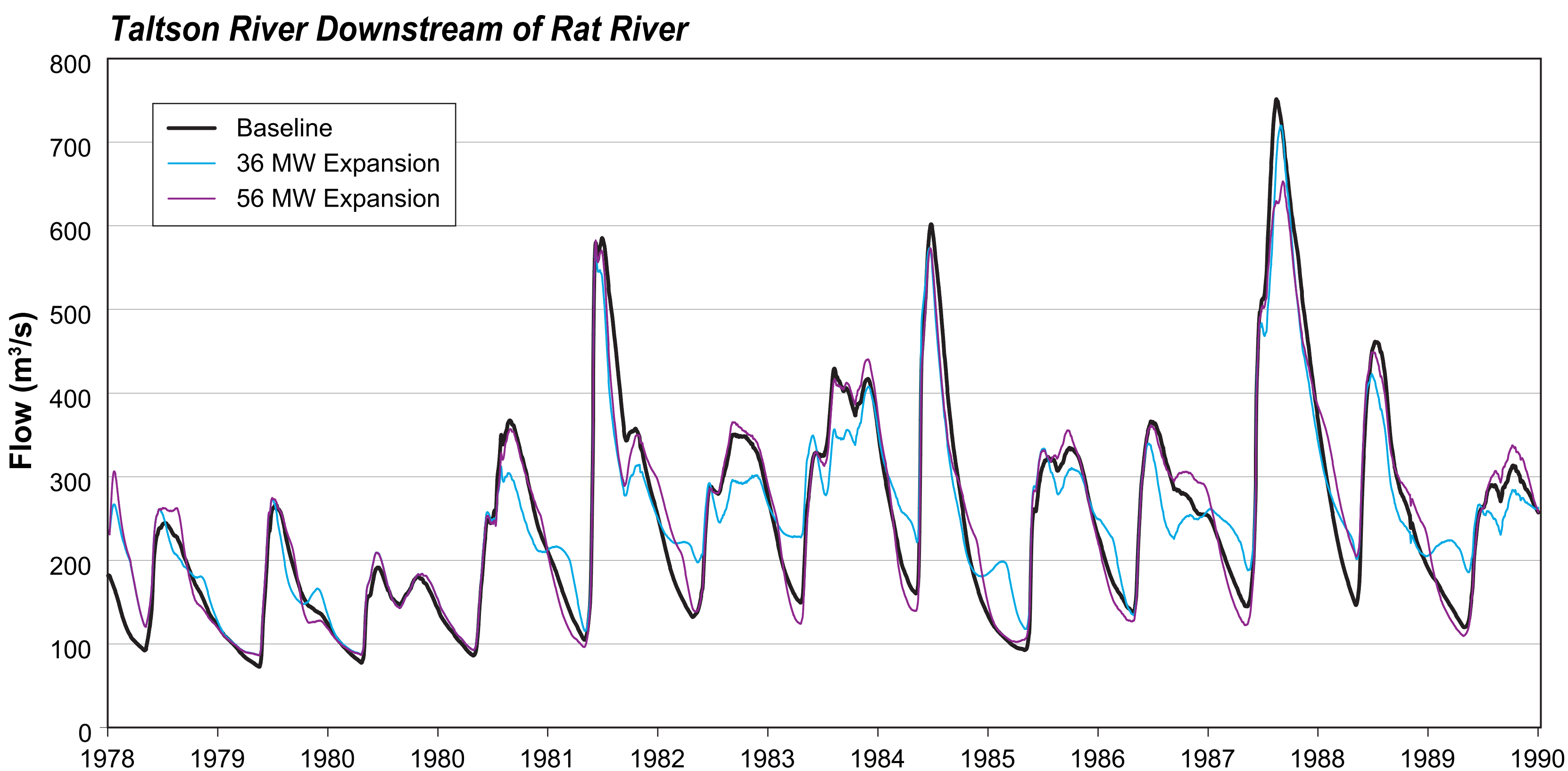
Flow in Taltson River below Twin Gorges would change by 44 m^3/s (for the existing turbine) and 20 m^3/s (new 18 MW turbines) from estimated pre-outage conditions for the 36 MW expansion and by up to 53 m^3/s (for an expansion turbine) for the 56 MW scenario. Based on average April and May background flow in Trudel Creek during periods of full generation flow at the power plants, the resulting changes in water level would be up to 0.34 m (decrease during initial shutdown and increase upon restart) for the 36 MW expansion and up to 0.32 m (decrease during initial shutdown and increase upon restart) for the 56 MW expansion.

13.3.5 Summary

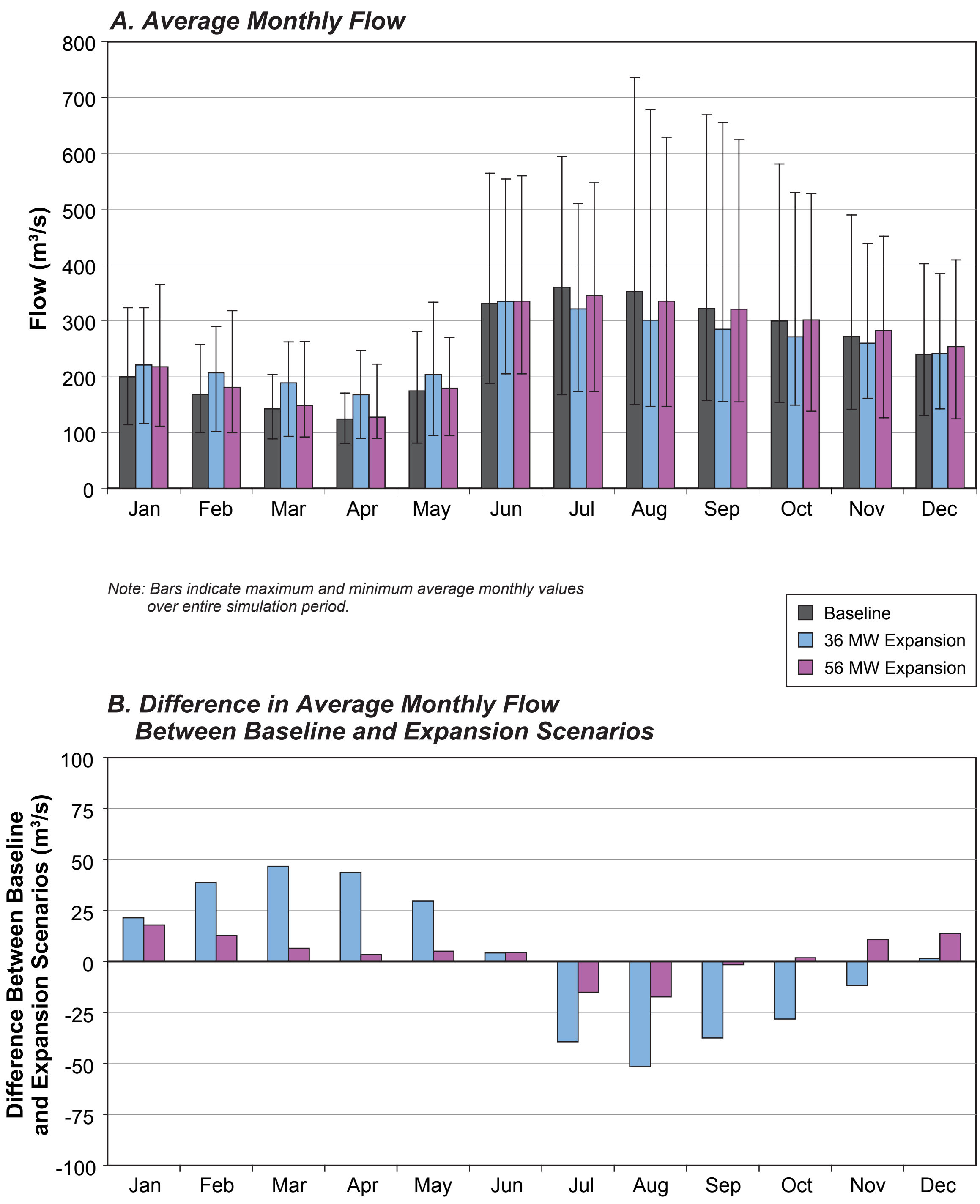
The proposed upgrades to the Twin Gorges facility and the dam at Nonacho Lake have the potential to alter the timing and magnitude of flows and water levels throughout the Taltson River from Nonacho Lake to Great Slave Lake.

The greatest changes under the Expansion Project would be realized in Nonacho Lake, the Taltson River from Nonacho Lake to the Tazin River (Zone 1), from Tronka Chua Gap to Lady Grey Lake (Zone 2), and Trudel Creek (Zone 5) which is discussed in detail in Section 14.3 (Trudel Alterations of Water Quantity).

In general, under the expansion scenarios more flow that enters into Nonacho Lake would be routed through the mainstem of the Taltson River via the Nonacho Dam at the expense of reduced flow over the Tronka Chua Gap to Zone 2. Within Zone 1, the 36 MW expansion would substantially alter the shape of the annual hydrograph as freshet runoff would be stored within Nonacho Lake and released over the fall and winter. Under the 56 MW expansion the alteration in shape of the annual hydrograph would not be as severe as there would be less opportunity to store freshet runoff within Nonacho Lake, due to the high demand of flow at Twin Gorges throughout the year. On average, the 56 MW expansion would only approach maximum power production during the summer freshet period. Full power production would be obtained for wet years only. Thus, the hydrograph under the 56 MW expansion would be more similar to the baseline than the 36 MW expansion hydrograph. Although the alteration to the hydrograph in Zone 1 would not be as severe under the 56 MW expansion as the 36 MW expansion, the reduction in flow in Zone 2 would be more severe under the 56 MW expansion.



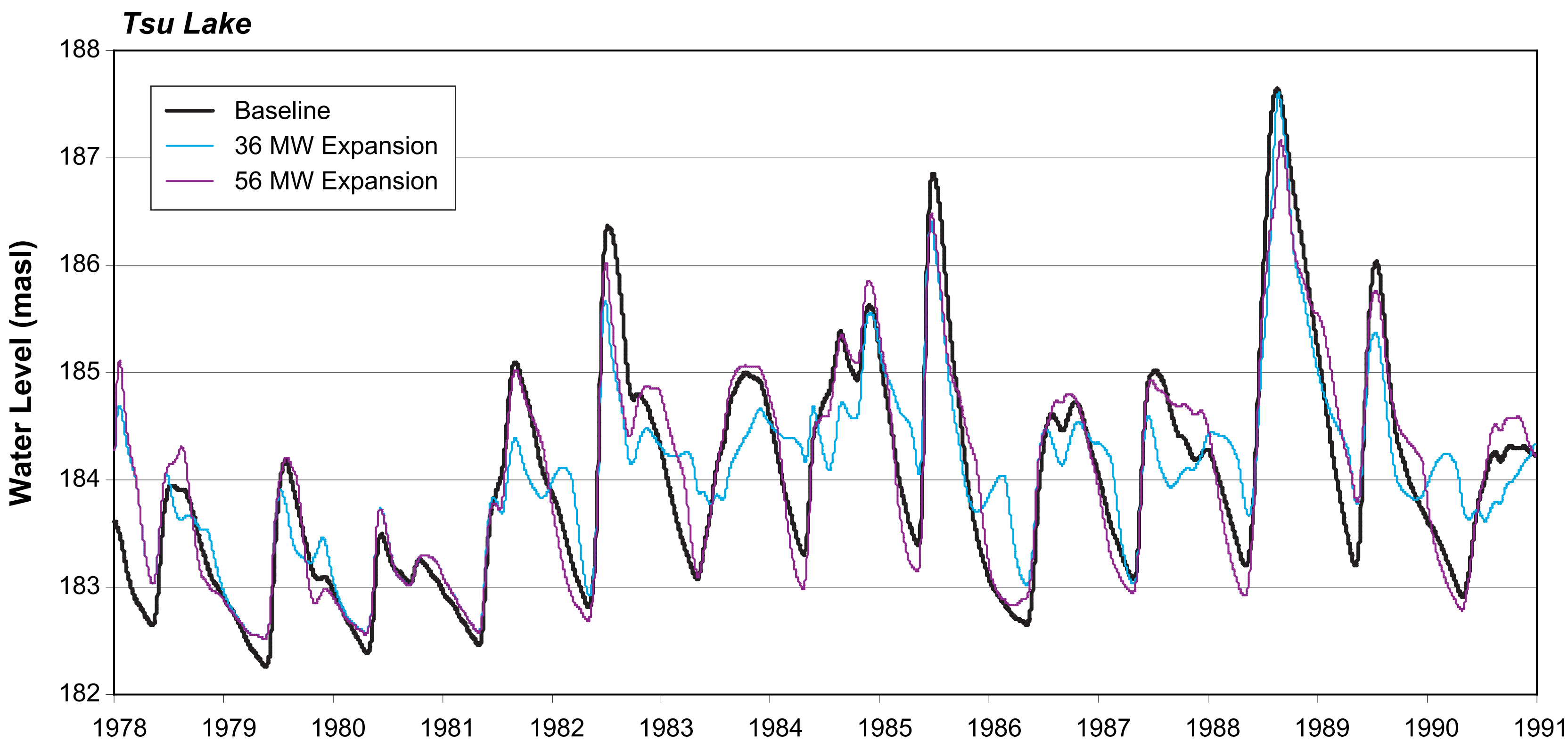
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Zone 4: Taltson River Downstream of Rat River Flow Time Series (503-005 / a22021m)	Figure 13.3.38



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results - Zone 4: Taltson River Downstream of Rat River Flow Monthly Summary (503-005 / a22022m)	Figure 13.3.39

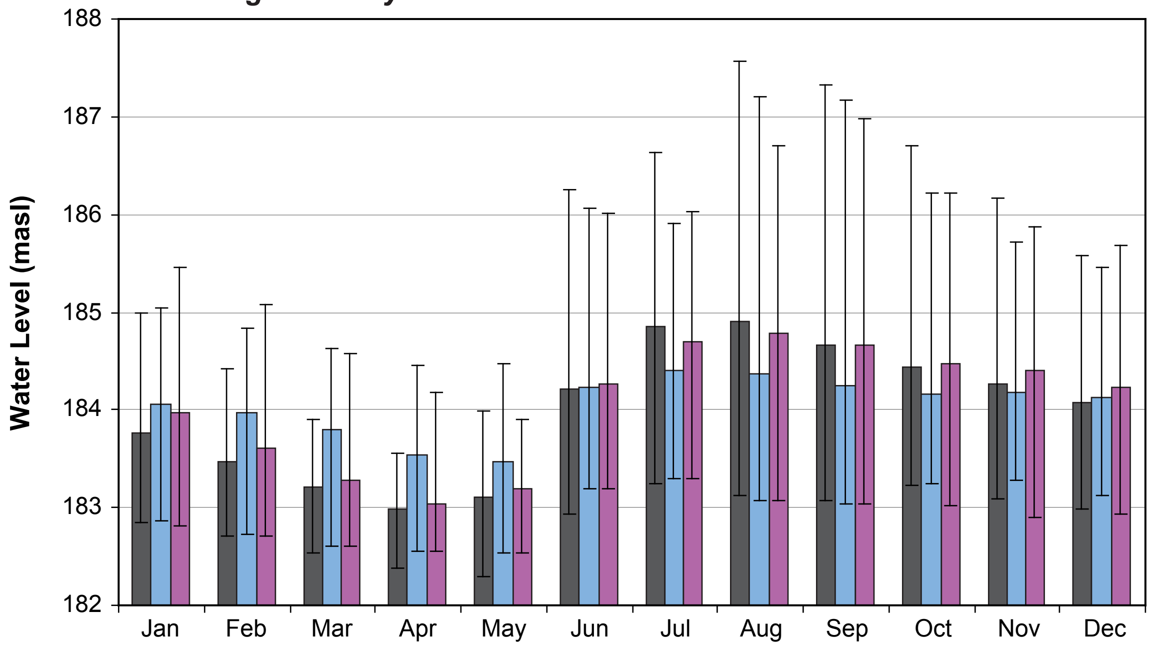
Table 13.3.15 — Taltson Basin Flow Model Results, Zone 4: Flow

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Taltson River at Outlet of Tsu Lake: Average Monthly Flow (m^3/s)												
Baseline	161.29	137.37	116.79	100.65	110.23	201.40	259.96	264.92	240.09	220.25	205.07	188.20
36 MW Expansion	185.42	177.98	163.55	143.02	137.46	200.25	215.83	215.15	204.17	193.69	195.60	191.22
56 MW Expansion	179.41	148.85	122.78	103.88	115.76	204.15	242.45	249.67	239.65	222.68	216.85	201.64
Taltson River at Outlet of Tsu Lake: Change from Baseline (m^3/s)												
36 MW Expansion	24.13	40.61	46.76	42.37	27.22	-1.15	-44.14	-49.77	-35.92	-26.56	-9.47	3.02
56 MW Expansion	18.12	11.48	5.99	3.23	5.53	2.76	-17.52	-15.25	-0.44	2.43	11.78	13.44
Taltson River Downstream Rat River: Average Monthly Flow (m^3/s)												
Baseline	199.69	168.05	142.11	124.04	174.37	330.88	360.39	352.77	322.49	299.65	271.77	239.99
36 MW Expansion	221.08	206.83	188.78	167.69	203.97	335.07	321.11	301.18	285.03	271.50	260.06	241.42
56 MW Expansion	217.54	180.90	148.61	127.37	179.40	335.24	345.30	335.36	320.95	301.47	282.44	253.82
Taltson River Downstream Rat River: Change from Baseline (m^3/s)												
36 MW Expansion	21.39	38.78	46.67	43.65	29.60	4.19	-39.28	-51.59	-37.46	-28.15	-11.72	1.43
56 MW Expansion	17.85	12.85	6.50	3.33	5.03	4.36	-15.09	-17.40	-1.55	1.81	10.67	13.82



TALTSON **Hydroelectric Expansion Project**	**Developer's Assessment Report** **2009**	**Taltson Basin Flow Model Results Zone 4 -** **Tsu Lake Water Level Time Series** (503-005 / a22087m)	**Figure** **13.3.40**

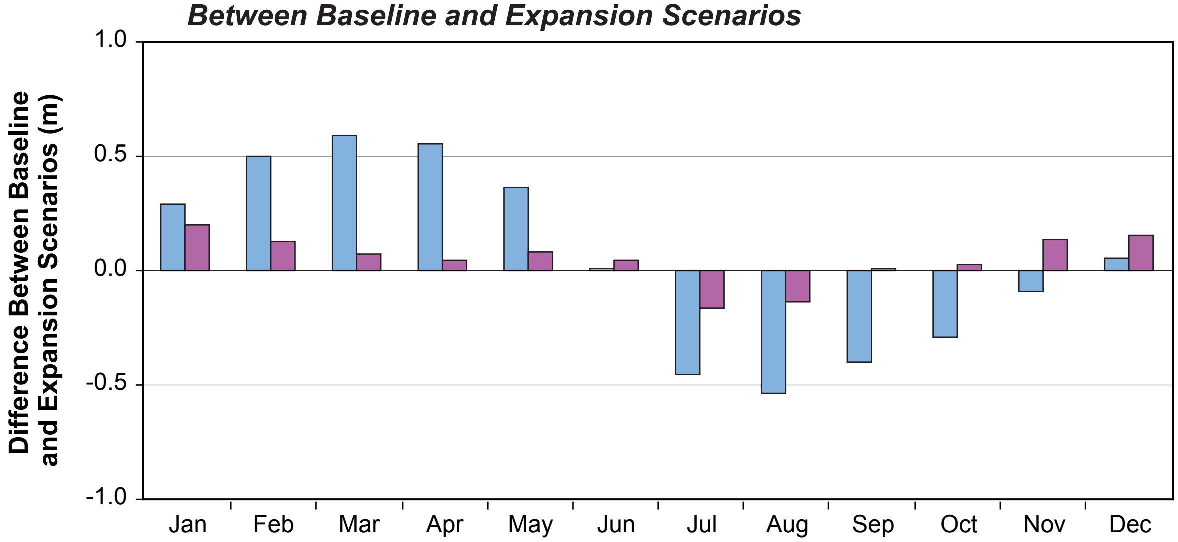
A. Average Monthly Water Level



Note: Bars indicate maximum and minimum average monthly values over entire simulation period.

Baseline
36 MW Expansion
56 MW Expansion

B. Difference in Average Monthly Water Level Between Baseline and Expansion Scenarios



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 4 - Tsu Lake Water Level Monthly Summary (503-005 / a22088m)	Figure 13.3.41

Table 13.3.16 — Taltson Basin Flow Model Results, Zone 4: Water Levels

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tsu Lake: Average Monthly Water Level (masl)												
Baseline	183.77	183.48	183.21	182.98	183.11	184.22	184.86	184.91	184.66	184.45	184.27	184.08
36 MW Expansion	184.07	183.97	183.79	183.53	183.48	184.23	184.40	184.38	184.26	184.16	184.18	184.13
56 MW Expansion	183.97	183.60	183.28	183.03	183.19	184.27	184.70	184.78	184.66	184.48	184.41	184.23
Tsu Lake: Change from Baseline (m)												
36 MW Expansion	0.30	0.50	0.59	0.55	0.37	0.01	-0.45	-0.54	-0.40	-0.29	-0.09	0.05
56 MW Expansion	0.20	0.13	0.07	0.05	0.09	0.05	-0.16	-0.13	0.01	0.03	0.14	0.15
Taltson River Downstream Rat River: Average Monthly Water Level (masl)												
Baseline	Not available[1]											
36 MW Expansion												
56 MW Expansion												
Taltson River Downstream Rat River: Change from Baseline (m)												
36 MW Expansion	Not available[1]											
56 MW Expansion												

[1] Water levels were not modelled for Taltson River downstream of Rat River due to limited observed data

Table 13.3.17 — Estimated Annual Variation in Mean Monthly Water Levels in Zone 4

Location	SCENARIO		
	Baseline (m)	36 MW Expansion (m)	56 MW Expansion (m)
Tsu Lake	1.93	0.93	1.75
Taltson River downstream of Rat River	n/a	n/a	n/a

n/a – Water levels not simulated due to limited observed data.

Below the Tazin River (excluding Trudel Creek), changes would be less due to the large amount of unregulated flow that would be provided by the Tazin River. The unregulated flows from Tazin River combined with the altered hydrograph in Zone 1, would result in a "flattened" hydrograph from the Tazin River to Great Slave Lake. In general, flows would be lower during high flow periods (e.g., spring freshet) and higher during low flow periods (e.g., winter).

Table 13.3.18 — Estimated Flows during a Scheduled Outage in the Twin Gorges Forebay and the Taltson River below Trudel Creek

Scheduled Outage Scenario	FLOW (m^3/s)		CHANGE FROM PRE-OUTAGE (m^3/s)	
	Twin Gorges Forebay[1]	Taltson below Twin Gorges	Twin Gorges Forebay	Taltson below Twin Gorges
36 MW — Simulated to occur in April or May: 6 out of 13 years				
Pre-Outage	202.14	202.14		
Outage Maximum: Expansion Turbine	202.14	225.14	0.00	23.00
Outage Minimum: Expansion Turbine	202.14	179.14	0.00	-23.00
Outage Maximum: Existing Turbine	202.14	246.14	0.00	44.00
Outage Minimum: Existing Turbine	202.14	158.14	0.00	-44.00
56 MW — Simulated to occur in April or May: 1 out of 13 years				
Pre-Outage	269.92	269.92		
Outage Maximum: Expansion Turbine	269.92	322.92	0.00	53.00
Outage Minimum: Expansion Turbine	269.92	216.92	0.00	-53.00
Outage Maximum: Existing Turbine	269.92	313.92	0.00	44.00
Outage Minimum: Existing Turbine	269.92	225.92	0.00	-44.00

[1] Total flow through Twin Gorges, includes flow through the power plants and over the SVS

Table 13.3.19 — Estimated Water Levels during a Scheduled Outage in the Twin Gorges Forebay and the Taltson River below Trudel Creek

Scheduled Outage Scenario	WATER LEVEL (masl)		CHANGE FROM PRE-OUTAGE (m)	
	Twin Gorges Forebay	Taltson below Twin Gorges	Twin Gorges Forebay	Taltson below Twin Gorges
36 MW — Simulated to occur in April or May: 6 out of 13 years				
Pre-Outage	247.81	204.28		
Outage Maximum: Expansion Turbine	247.89	204.44	0.08	0.15
Outage Minimum: Expansion Turbine	247.81	204.12	0.00	-0.17
Outage Maximum: Existing Turbine	247.95	204.56	0.14	0.28
Outage Minimum: Existing Turbine	247.81	203.95	0.00	-0.34
56 MW — Simulated to occur in April or May: 1 out of 13 years				
Pre-Outage	247.84	204.70		
Outage Maximum: Expansion Turbine	248.00	204.97	0.15	0.27
Outage Minimum: Expansion Turbine	247.84	204.38	0.00	-0.32
Outage Maximum: Existing Turbine	247.97	204.92	0.13	0.23
Outage Minimum: Existing Turbine	247.84	204.44	0.00	-0.26

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

13. WATER FLUCTUATIONS IN THE TALTSON RIVER WATERSHED

13.4 ALTERATION OF WATER QUALITY

13.4.1 Introduction

Surface water in the Taltson Basin is an intrinsic component of the biological and physical environment. It is an indicator of environmental health because it is linked to other key ecosystem components such as fish and fish habitat, aquatic resources (benthos, zooplankton, phytoplankton, and periphyton), soil, vegetation, and wildlife.

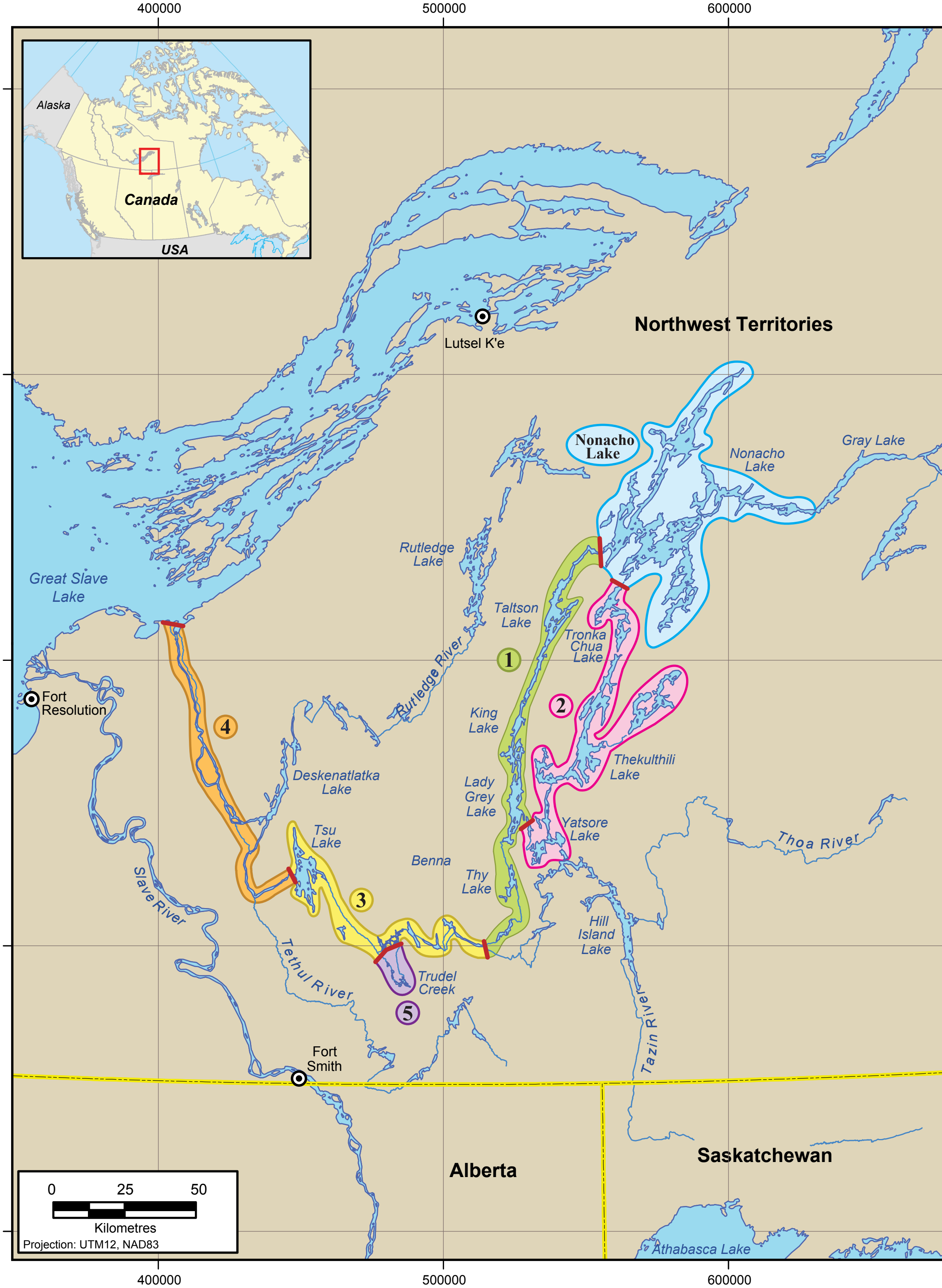
This section provides the following:

- a summary of the current water quality within the Taltson Basin (excluding Trudel Creek);
- an overview of typical hydroelectric project pressures on water quality; and
- a qualitative assessment of how alterations to the water levels and flows in the Taltson Basin lakes and streams may result in changes to water quality.

The Taltson Basin has been divided into six watershed zones (Figure 13.4.1). The main water control and release structure is at the Nonacho Lake dam. Proposed changes in water retention and release of Nonacho Lake water would ultimately affect downstream water levels and flow rates. Water flowing from the Nonacho Lake dam enters Zone 1, which includes a series of lakes (Taltson, King, Lady Grey, and Benna Thy) connected by the Taltson River. When water levels exceed the capacity of Nonacho Lake, water flows over the Tronka Chua Gap into Zone 2 and into a series of lakes (Tronka Chua, Thekulthili, and Yatsore), which enters Lady Grey Lake and continues downstream into Zone 3. Zone 3 is the location of the main hydropower facility in the Twin Gorges Forebay. The zone is divided into three subzones: upstream of the Twin Gorges Forebay in the Taltson River downstream from the Tazin River confluence, the Twin Gorges Forebay itself, and immediately downstream from the hydropower facility. The released water continues along the Taltson River into Zone 4, where it enters Tsu Lake. Zone 4 includes Tsu Lake, the Rat River confluence, and its outflow into the Taltson River to Great Slave Lake.

Water fluctuations and alterations to water quality in Zone 5 were assessed separately in Section 14.4. Zone 5 includes Trudel Creek and a series of small lakes. When the water level in the Twin Gorges Forebay reaches its capacity, water flows over the South Valley Spillway into Zone 5 and merges with Zone 3, downstream from the hydropower facility.

The proposed upgrade scenarios would generate additional hydroelectric power in the range of 36 MW to 56 MW. These upgrades would require greater water volumes at the Twin Gorges hydropower facility. Under the proposed upgrades, water in Nonacho Lake would be retained during spring freshet to supply the Twin Gorges facility with water during low-flow winter months. The change in water management within the Taltson Basin would ultimately change the patterns of flows and water levels. In this section, the potential effects of these water level changes are assessed per zone for changes in general water chemistry, total mercury, temperature, dissolved oxygen, eutrophication, erosion, and deposition for the 36 MW and 56 MW upgrade scenarios.



TALTSON
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Hydrological Zones in Taltson Basin

Figure 13.4.1

13.4.2 Existing Environment

This section describes the existing water quality within the Taltson Basin. Nonacho Lake and Zone 3 are the sites of the main water reservoir and hydropower facility, respectively. These sites were the focus of the baseline water quality monitoring. The water quality of the existing environment is the result of natural environmental characteristics (e.g., local geology, soil type, rainfall) and anthropogenic effects from the existing project (e.g., management of water from Nonacho Lake).

13.4.2.1 Water Quality Parameters

A range of water quality parameters was measured in Nonacho Lake and Zone 3 to establish the existing water quality of these water bodies. Water from the study area was sampled and analyzed for physical parameters and general chemistry (dissolved anions, nutrients, total and dissolved metals, and total organic carbon). These parameters were compared to the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life (CCME 2007). When a parameter was below the laboratory detection limit, a value of half the detection limit was used to calculate average concentrations. The Northwest Territories (NWT) does not have its own provincial guidelines and has adopted the CCME guidelines for the protection of aquatic life. The rationale for measuring specific parameters is described below.

13.4.2.1.1 Hardness

Hardness is a measure of the concentration of calcium and magnesium ions in the water, although laboratory measurements are standardized as calcium ion equivalents. Water hardness can affect the accumulation and toxicity of numerous metals to aquatic biota (i.e. metals such as copper and cadmium are less toxic to aquatic life in harder waters because of reduced uptake from competition with calcium). Consequently, the CCME guidelines for some water quality parameters are dependent on water hardness. Hardness is a reflection of the type of soil minerals and bedrock in the local environment, as well as the hydrological characteristics of the area. In general, soft water (low hardness) occurs in watersheds characterized by igneous rock, whereas hard water occurs in systems draining through carbonate rock (Williamson & Ralley 1993).

13.4.2.1.2 Turbidity and Total Suspended Solids

Water clarity can be described using measures of turbidity, which are indicators of the scattering of light by suspended particles in water. Turbidity and total suspended solids (TSS) are relevant to the suitability of water used for drinking and recreation and affect the aesthetic quality of aquatic ecosystems. In river systems, TSS concentrations generally vary with river discharge, because settling of suspended solids out of the water column increases when water velocity decreases. Thus, TSS can increase during periods of increased flow. In lake systems, TSS and turbidity are less susceptible to seasonal changes in flow and are dependent on the surrounding environmental characteristics.

13.4.2.1.3 Total Dissolved Solids and Conductivity

Total dissolved solids (TDS) and conductivity are measures of the amount of minerals and organic matter dissolved in water. Both natural conditions, such as local geology, and anthropogenic activities can increase these substances in water. Hard waters are typically associated with higher TDS and conductivity, although water clarity and turbidity may remain unchanged.

13.4.2.1.4 pH

This is a measure of the acidity of water. Fairly wide ranges of pH in surface waters are suitable for aquatic life and wildlife. The CCME guideline range for pH is 6.0 to 9.0. However, pH can also affect the toxicity of substances such as ammonia and metals to aquatic biota. Changes in water pH may directly affect aquatic biota (i.e. highly acidic or alkaline conditions can threaten aquatic life). Changing water or sediment pH can also alter bioavailability of metals in sediment.

13.4.2.1.5 Alkalinity

Alkalinity is a measure of the water's acid-neutralizing capacity, which is largely dependent upon the concentration of hydroxides, bicarbonates, and carbonates in the water. It is generally a reflection of the local geology and bicarbonates being leached from the soil. Lakes and rivers with low buffering capacity are more susceptible to pH changes caused by flooding of acidic or alkaline soils. The soils in the Taltson Basin are slightly to moderately acidic.

13.4.2.1.6 Nutrients

Dissolved and suspended forms of nitrogen, phosphorus, and organic carbon are the major nutrients in surface waters that support the growth of aquatic plants, benthic algae (periphyton), and algae (phytoplankton) in the water column. Sources of nutrients in surface waters include the breakdown of organic matter, excretion by organisms, erosion and run-off from nutrient-rich soils, and atmospheric deposition. Aquatic systems that have low nutrient content are described as oligotrophic, supporting minimal primary productivity from photosynthetic organisms. Undisturbed arctic and subarctic Canadian lakes are typically oligotrophic. Nutrient enrichment (i.e., eutrophication) can stimulate excessive growth of plants and algae, which can subsequently lead to the degradation of aquatic habitat through physical changes and changes to water quality.

13.4.2.1.7 Major Ions and Trace Elements

Major ions, metals, and metalloids are typically present in surface waters. They are introduced to surface waters through erosion and weathering of soils and rock and atmospheric deposition. High metal levels may occur naturally in some water bodies. Metals can also become elevated from anthropogenic activities. At sufficient concentrations, metals such as nickel, cadmium, lead, copper, arsenic, and mercury can be harmful to fish, wildlife, and humans. For hydroelectric projects, the flooding of soils may release soil-bound metals into the water, particularly if the water is acidic. In this scenario, metal concentrations increase post-impoundment for several years and return to pre-impoundment levels as the flooded land makes the transition from a terrestrial to aquatic environment. However, the proposed Project activities predict that water levels in the Nonacho Lake reservoir would not exceed baseline levels, so no soils would be flooded in the area, but water level variation may redistribute existing elements from sediments into the water.

13.4.2.1.8 Water Temperature

Water temperature is dependent on ambient temperatures. The specific heat capacity of water (i.e. the energy required to increase water temperature by 1ºC) is high; thus, water temperatures are lower than ambient temperatures. For example, the highest temperature recorded in July 2008 in the region was 26.9ºC (The Weather Network 2008). Surface water temperatures measured in Nonacho Lake during this month showed a maximum temperature of 17.4ºC and 15.6ºC at a depth of 1 m collected during the same time. Water temperature is also dependent on depth. In the summer, surface waters experience higher water temperatures because of thermal absorption of sunlight, while water at lower depths is colder. In the winter, ice formation at the surface results in colder surface waters with warmer deep water. The depth-dependence temperature is due to stratification, which typically occurs in deep lakes. In the spring and fall, water bodies are in transition between summer and winter stratification, resulting in water turnover. During spring and fall turnover, water temperatures are more homogenous with depth. Temperature stratification typically does not occur in rivers and streams with constant flow because of water turbulence and constant mixing.

13.4.2.1.9 Dissolved Oxygen

The solubility of oxygen in water is dependent on temperature, partial pressure of oxygen in the atmosphere, and salinity of the water. Higher concentration of dissolved oxygen in the water is associated with low temperature, high partial pressure, and low salinity. Most of the dissolved oxygen in the Taltson Basin comes from the atmosphere; therefore, the water-air interface is the primary means of re-oxygenation. Winter ice formation in lakes and rivers prevents re-oxygenation during winter months, and existing dissolved oxygen levels may decrease as a result of biological processes. For example, oxygen may be used by fish or other aquatic organisms for respiration. Waters with high detritus or organic carbon content may undergo aerobic decomposition, depleting the water of up to 80% of its dissolved oxygen under winter ice formation, but return to normal saturation concentrations after the ice breaks up (Whitfield & McNaughton 1986). Small lakes with shallow depths and no water inflows would increase the likelihood of lake waters becoming hypoxic (low in oxygen) during winter ice cover.

Natural oligotrophic freshwaters with temperatures ranging from 0ºC to 17 °C typically contain 10 mg/L to 14 mg/L dissolved oxygen. Dissolved oxygen content is not measurable in sub-zero temperatures because of ice formation. Stratification of dissolved oxygen may occur in deep lakes, where surface waters exposed to the atmosphere have saturated oxygen concentrations, while deeper waters contain lower concentrations because of potential aerobic decomposition of detritus and organic carbon in the sediments, and lack of re-oxygenation from the atmosphere. Dissolved oxygen stratification may not occur in deep lakes with minimal organic carbon in the benthos. Stratification also does not occur in rivers or streams with constant flow because of low water depth, high water turbulence, and constant mixing.

13.4.2.2 Nonacho Lake

The Nonacho Lake reservoir is the most upstream water body in the Taltson Basin. Water from Nonacho Lake flows through the control structure and over a spillway into Zone 1. If the reservoir capacity is exceeded, excess water flows over the Tronka Chua Gap into Zone 2.

Water samples were collected from three pairs of shallow and deep stations in Nonacho Lake in both 2003 and 2004 (Figure 13.4.2). In 2003, 12 water samples were analyzed for all water quality parameters described in Section 13.4.2.1. In some samples, dissolved ortho-phosphate and total Kjeldahl nitrogen were not measured. In 2004, 24 samples were analyzed for alkalinity and nutrients. Table 13.4.1 presents a summary of the results. Temperature and dissolved oxygen depth profiles were also surveyed for stratification at three sites in Nonacho Lake in 2008 (Cambria Gordon Ltd 2008).

Nonacho Lake surface waters were clear (i.e. low turbidity), soft, slightly alkaline, and had very low concentrations of nutrients and total metals. Water samples were similar among all stations and depths. The lake is oligotrophic, with most nutrients near the laboratory detection limit, and a low buffering capacity, typical of many northern water bodies. Total metal concentrations were similar among sites, and all of the measured water variables had concentrations well below the CCME guidelines for the protection of aquatic life. In Nonacho Lake the water temperature averaged 15ºC to 16ºC in July 2008, at depths up to 11 m. At 15 m, a mild thermocline was noted where temperatures were 5ºC. Dissolved oxygen content ranged between stations, from 10 mg/L to 14 mg/L but did not change with respect to depth. The potential for dissolved oxygen stratification in Nonacho Lake is low.

13.4.2.3 Zone 3

Zone 3 is downstream from Zones 1 and 2 after the two zones merge (Figure 13.4.1).

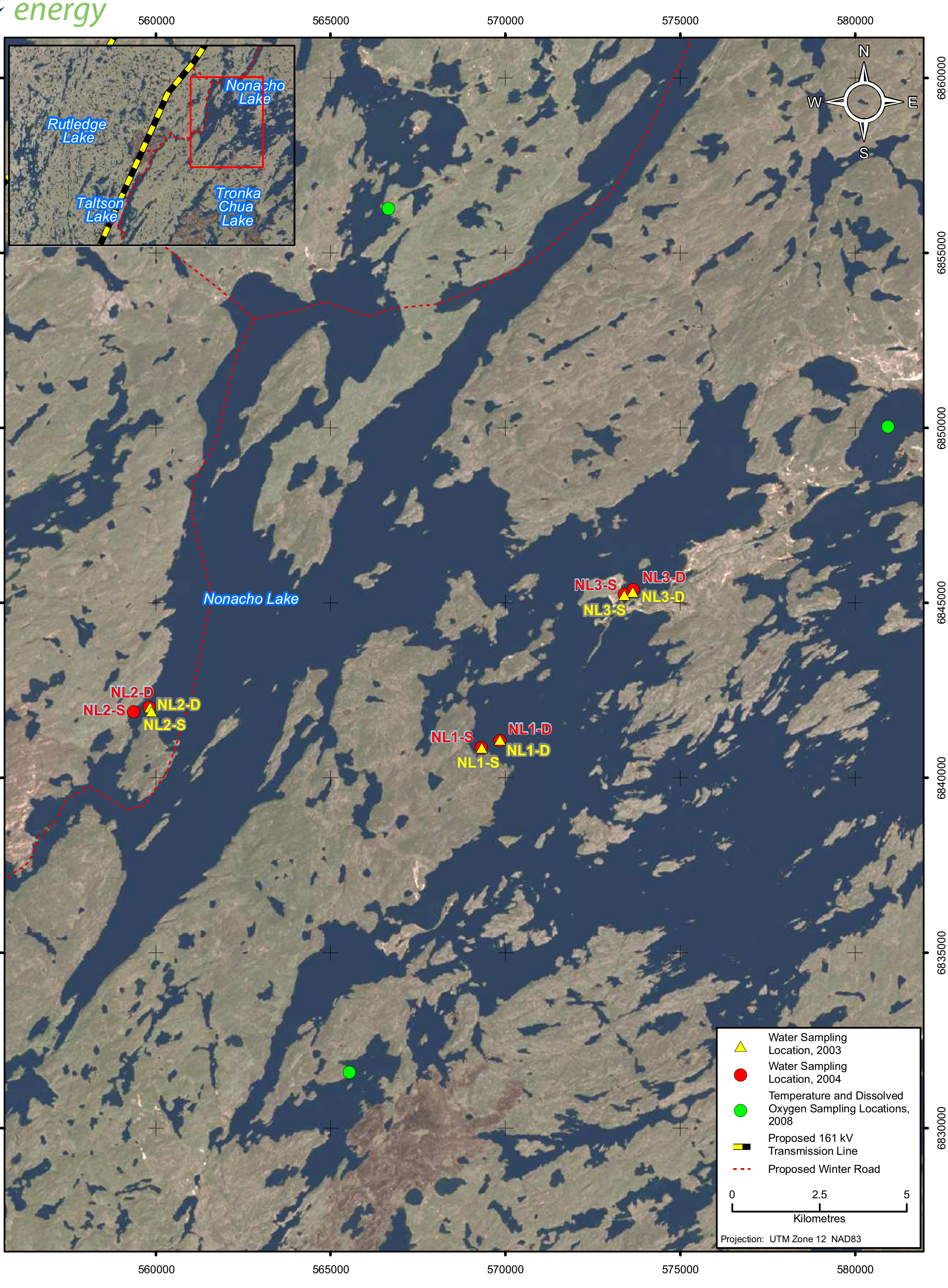
13.4.2.3.1 Twin Gorges Forebay

Water samples were collected at three pairs of shallow (along the shoreline) and deep (open lake) stations in the Twin Gorges Forebay area in August 2004 (Figure 13.4.3). Four samples were collected in three shallow stations and two in deep stations (13 to 17 m). A total of 18 samples were analyzed for physical parameters, dissolved anions, nutrients, and organic carbon. Table 13.4.2 presents a summary of the results.

Twin Gorges Forebay water was clear, soft, and slightly alkaline, with low concentrations of nutrients. The Forebay is oligotrophic with a low buffering capacity, and overall has similar ranges of measured parameters to Nonacho Lake. Total metal concentrations in the Twin Gorges Forebay were not assessed, but they are assumed to be similar to Nonacho Lake.

13.4.2.3.2 Downstream of Twin Gorges Forebay (Taltson River Downstream of Twin Gorges)

Water samples were collected in May 2007 at three locations immediately downstream of the existing hydropower facility (Figure 13.4.3). One sample location was at Elsie Falls, immediately downstream from the Twin Gorges dam and before the confluence with Trudel Creek. A second site was on the Taltson River immediately after the Trudel Creek confluence, and a third site was downstream along the Taltson River at the inflow to Tsu Lake. The sites were selected to assess the clarity of the water during freshet. The samples were analyzed for turbidity and TSS.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Nonacho Lake Water Quality Monitoring Locations	Figure 13.4.2

gis no. TAL-01-003DAR

Table 13.4.1 — Summary of Nonacho Lake Water Quality

Parameter	Number of Samples	Min-Max	Average	CCME Guidelines[1]	Parameter	Number of Samples	Min-Max	Average	CCME Guidelines[1]
Physical Variables					**Total Metals**				
Conductivity (μS/cm)	36	34 to 41	37	NG	Barium	12	0.00434 to 0.00464	0.0045	NG
Total Dissolved Solids	36	18.9 to 31.0	24	NG	Beryllium	12	<0.0005	<0.0005	NG
Hardness ($CaCO_3$)	12	14.4 to 15.8	15	NG	Bismuth	12	<0.0005	<0.0005	NG
pH (pH units)	36	6.7 to 7.7	7.2	6.5 to 9.0	Boron	12	<0.01	<0.01	NG
Total Suspended Solids	36	<1 to 5.3	2.1	> 25 ambient	Cadmium	12	<0.00005	<0.00005	0.000017
Turbidity (NTU)	36	0.3 to 0.9	0.4	NG	Calcium	12	4.1 to 4.7	4.3	NG
Dissolved Anions					Chromium	12	<0.0005	<0.0005	0.001 Cr IV
Acidity (to pH 8.3)	12	<1 to 6	1.9	NG					0.0089 Cr III
Total Alkalinity	36	<1 to 16.6	9	NG	Cobalt	12	<0.0001	<0.0001	NG
Bromide	36	14 to 16.6	14.7	NG	Copper	12	0.0002 to 0.0006	0.0003	0.002
Chloride	36	<0.02 to 1.07	0.5	NG	Iron	12	<0.03	<0.03	0.3
Fluoride	12	<0.02 to 0.10	0.08	NG	Lead	12	<0.00005 to 0.00055	0.00009	0.001
Silicate	12	2.2 to 2.7	2.5	NG	Lithium	12	<0.005	<0.005	NG
Sulphate	36	<1 to 1.3	1.1	NG	Magnesium	12	1.1 to 1.2	1.1	NG
Nutrients					Manganese	12	0.0015 to 0.0027	0.0019	NG

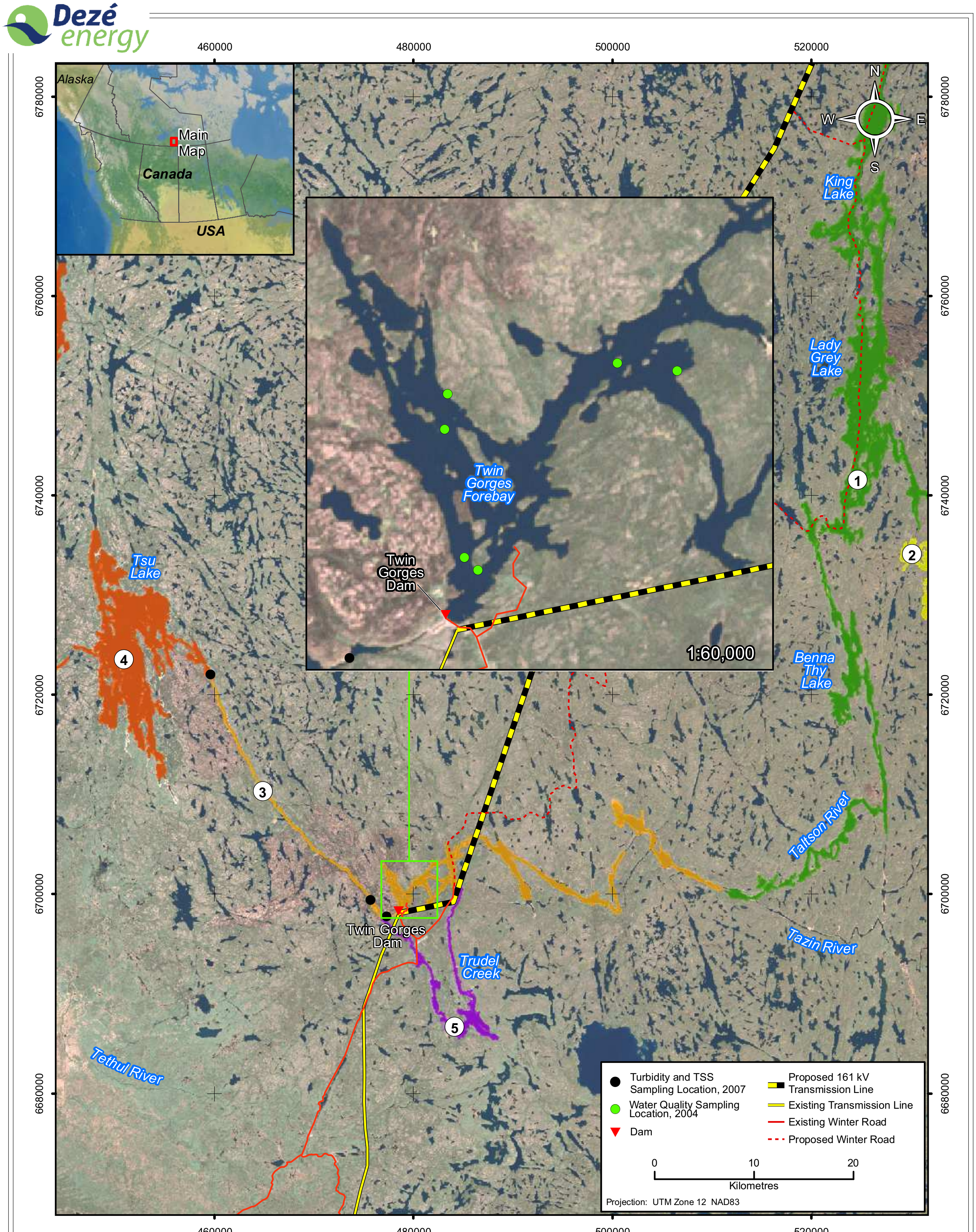
Parameter	Number of Samples	Min-Max	Average	CCME Guidelines[1]	Parameter	Number of Samples	Min-Max	Average	CCME Guidelines[1]
Total Ammonia	36	0.012 to 0.033	0.02	2.43	Mercury	12	<0.00001	<0.00001	0.000026
Total Kjeldahl Nitrogen	9	0.21 to 0.24	0.2	NG	Molybdenum	12	0.00018 to 0.00021	0.00019	0.073
Nitrate	36	<0.005 to 0.050	0.014	2.93	Nickel	12	<0.0005	<0.0005	0.025
Nitrite	36	<0.001 to 0.0017	0.001	0.06	Phosphorus	12	<0.3	<0.3	NG
Total Nitrogen	36	0.06 to 0.28	0.2	NG	Potassium	12	<2	<2	NG
Dissolved Nitrogen	12	<0.05 to 0.11	0.07	NG	Selenium	12	<0.001	<0.001	0.001
Dissolved Ortho-phosphate	9	<0.001	<0.001	NG	Silicon	12	1.0 to 1.2	1.1	NG
Total Dissolved Phosphate	36	<0.002 to 0.004	0.002	NG	Silver	12	<0.00001	<0.00001	0.0001
Total Phosphate	36	0.002 to 0.006	0.004	NG	Sodium	12	<2	<2	NG
Organic Parameters					Strontium	12	0.024 to 0.026	0.024	NG
Dissolved Organic Carbon	36	3.3 to 4.9	4.1	NG	Thallium	12	<0.0001	<0.0001	0.0008
Total Organic Carbon	36	3.3 to 6	4.2	NG	Tin	12	<0.0001	<0.0001	NG
Total Metals					Titanium	12	<0.01	<0.01	NG
Aluminum	12	0.005 to 0.012	0.009	0.1	Uranium	12	0.00005 to 0.00006	0.00005	NG
Antimony	12	<0.0001	<0.0001	NG	Vanadium	12	<0.001	<0.001	NG

Parameter	Number of Samples	Min-Max	Average	CCME Guidelines[1]	Parameter	Number of Samples	Min-Max	Average	CCME Guidelines[1]
Arsenic	12	<0.0001 to 0.0001	5E-05	0.005	Zinc	12	<0.001 to 0.001	0.0006	0.03

[1] CCME Guidelines for the Protection of Aquatic Life (2007).

NG = No guideline.

Units in mg/L unless noted.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Zone 3 Water Quality Monitoring Locations	Figure 13.4.3

gis no. TAL-01-002DAR

Table 13.4.2 — Summary of Zone 3 Water Quality in the Twin Gorges Forebay

Parameters	Number of Samples	Minimum to Maximum	Average	CCME Guidelines[1]
Physical Variables				
Conductivity (μS/cm)	18	40.4 to 42.8	41.2	NG
Total Dissolved Solids	18	22.2 to 23.5	22.7	NG
pH (pH units)	18	7.1 to 7.2	7.2	6.5 to 9.0
Total Suspended Solids	18	<3	<3	>25 ambient
Turbidity (NTU)	18	0.4 to 0.8	0.5	NG
Dissolved Anions				
Alkalinity-Total ($CaCO_3$)	18	15.3 to 17.0	16.3	NG
Alkalinity-Bicarbonate ($CaCO_3$)	18	15.3 to 17.0	16.3	NG
Alkalinity-Carbonate ($CaCO_3$)	18	<1	<1	NG
Alkalinity-Hydroxide ($CaCO_3$)	18	<1	<1	NG
Chloride-Cl	18	1.2	1.2	NG
Sulphate-SO_4	18	1.1 to 1.2	1.1	NG
Nutrients				
Total Ammonia (N)	18	0.01 to 0.02	0.02	2.43
Total Kjeldahl Nitrogen (N)	18	0.22 to 0.28	0.25	NG
Nitrate (N)	18	0.005 to 0.070	0.02	2.93
Nitrite (N)	18	<0.001 to 0.002	0.001	0.06
Total Nitrogen	18	0.26 to 0.30	0.27	NG
Dissolved Ortho-phosphate	18	<0.001	<0.001	NG
Total Dissolved Phosphate	18	<0.002 to 0.002	0.002	NG
Total Phosphate	18	<0.002 to 0.006	0.004	NG
Organic Parameters				
Dissolved Organic Carbon	18	4.68 to 5.77	5.16	NG
Total Organic Carbon	18	4.89 to 7.36	5.51	NG

[1] CCME Guidelines for the Protection of Aquatic Life (2007).

Units in mg/L unless noted.

NG = No Guideline.

Table 13.4.3 presents the turbidity and TSS monitoring results. The water at the Elsie Falls station was clear (<3.0 nephelometric turbidity units (NTU)), and contained lower TSS (0.81 mg/L) than the Twin Gorges Forebay. Overall, water flowing through the hydropower facility experiences no changes in turbidity or TSS. At the confluence with Trudel Creek, turbidity and TSS were slightly higher (6.5 NTU and 3.83 mg/L, respectively), indicating some influx of these parameters from Trudel Creek. Farther downstream along Taltson River, at the inflow to Tsu Lake, turbidity and TSS were similar to the confluence with Trudel Creek. Turbidity increased to 7.2 NTU and the TSS was 3.86 mg/L. The sampling month also corresponds to spring freshet in the region, and represents the highest levels during the year. The water was relatively clear at all stations along Zone 3.

Table 13.4.3 — Zone 3 Turbidity and Suspended Solids Monitoring

Sample ID	Location	Turbidity (NTU)	Total Suspended Solids (mg/L)
Elsie Falls	Immediately downstream of Twin Gorges Dam	<3.0	0.81
Downstream Taltson	At the point where Trudel and Taltson have mixed	6.5	3.83
Upstream Tsu Lake	Immediately upstream of Tsu Lake	7.2	3.86

13.4.2.3.3 Upstream of Hydropower Facility (Taltson River Downstream of the Tazin River Confluence)

No water quality monitoring has been conducted in the Taltson River between the Tazin River confluence of the Twin Gorges Forebay. Water in this subzone originates from the Tazin River and Zones 1 and 2, which receive water from Nonacho Lake. Between Nonacho Lake and the river confluence, water flows through several slow-moving lakes and has not experienced any anthropogenic inputs since the years following the original impoundment in 1965.

Upstream, in the Tazin River, there is a small hydroelectric facility independent from the Taltson hydroelectric project. The effect of this hydroelectric dam on water quality in Zone 3 is uncertain. However, it is anticipated that this water is oligotrophic with low levels of metals, similar to most water bodies in the subarctic. Subsequently, this sub-zone is expected to have water quality similar to Nonacho Lake.

13.4.2.4 Zones 1 and 2

Zones 1 and 2 are downstream from the Nonacho dam and Tronka Chua Gap, respectively. No water quality monitoring has been conducted in Zones 1 and 2. No Project-related facilities exist within these zones and Nonacho Lake is the primary water source for these lakes and streams. Thus, water quality in these areas is expected to have similar water characteristics to Nonacho Lake (i.e. clear, soft, slightly alkaline, and with low concentrations of nutrients and metals) and are likely oligotrophic with low buffering capacity.

13.4.2.5 Zone 4

Zone 4 is the most downstream section of the Taltson Basin, which includes Tsu Lake to Great Slave Lake. The assessed section of Zone 4 is in the Taltson River downstream from Rat River. The proposed Project upgrades would not redirect any water into or out of the Taltson Basin and all of the water originating from Nonacho Lake eventually passes through Zone 4. Although water level and flow patterns may change as a result of the proposed upgrades, the total water volume passing through Zone 4 annually would remain unchanged.

Water quality monitoring was not conducted in Zone 4. Zone 4 also receives inflows from Tethul and Rat River, and Deskenatlata Lake, which may have different water quality characteristics.

Rutledge Lake, a reference lake upstream of Deskenatlata Lake, was sampled in 2003. Water quality in Rutledge Lake (a reference lake) was compared with the water quality in Nonacho Lake (Table 13.4.4). The two lakes share similar ranges of measured parameters. This suggests that water flowing into Deskenatlata Lake and Zone 4 would be comparable to Nonacho Lake water quality. Based on the minimal water quality changes between Nonacho Lake and Zone 3, and the comparable water quality between Rutledge Lake and Nonacho Lake, Zone 4 is expected to have similar characteristics for all water parameters.

Table 13.4.4 — Comparison of Nonacho Lake and Rutledge Lake Water Quality

Parameter	NONACHO LAKE Min - Max	Rutledge Lake 2003[1]	Parameter	NONACHO LAKE Min - Max	Rutledge Lake 2003[1]
Physical Variables			**Total Metals**		
Conductivity (μS/cm)	34 to 41	48 to 51	Barium	0.00434 to 0.00464	0.00350 to 0.00413
Total Dissolved Solids	18.9 to 31.0	27 to 43	Beryllium	<0.0005	<0.0005
Hardness ($CaCO_3$)	14.4 to 15.8	20.4 to 22.0	Bismuth	<0.0005	<0.0005
pH (pH units)	6.7 to 7.7	6.9 to 7.5	Boron	<0.01	<0.01
Total Suspended Solids	<1 to 5.3	<1.0 to 1.0	Cadmium	<0.00005	<0.00005
Turbidity (NTU)	0.3 to 0.9	0.3 to 0.5	Calcium	4.1 to 4.7	5.64 to 6.23
Dissolved Anions			Chromium	<0.0005	<0.0005
Acidity (to pH 8.3)	<1 to 6	<1 to 3			
Total Alkalinity	<1 to 16.6	20.0 to 21.0	Cobalt	<0.0001	<0.0001
Bromide	14 to 16.6	<0.05	Copper	0.0002 to 0.0006	0.0002 to 0.0005
Chloride	<0.02 to 1.07	<2.37	Iron	<0.03	<0.03
Fluoride	<0.02 to 0.10	0.10 to 0.11	Lead	<0.00005 to 0.00055	<0.00005 to 0.00037
Silicate	2.2 to 2.7	0.3 to 0.7	Lithium	<0.005	<0.005
Sulphate	<1 to 1.3	1	Magnesium	1.1 to 1.2	1.6 to 1.7
Nutrients			Manganese	0.0015 to 0.0027	0.00056 to 0.00286
Total Ammonia	0.012 to 0.033	0.013 to 0.020	Mercury	<0.00001	<0.00001 to 0.00006
Total Kjeldahl Nitrogen	0.21 to 0.24	-	Molybdenum	0.00018 to 0.00021	0.00005 to 0.00011
Nitrate	<0.005 to 0.050	<0.005 to 0.032	Nickel	<0.0005	<0.0005
Nitrite	<0.001 to 0.0017	<0.001	Phosphorus	<0.3	<0.3

Parameter	NONACHO LAKE Min - Max	Rutledge Lake 2003[1]	Parameter	NONACHO LAKE Min - Max	Rutledge Lake 2003[1]
Total Nitrogen	0.06 to 0.28	0.10 to 0.20	Potassium	<2	<2
Dissolved Nitrogen	<0.05 to 0.11	0.08 to 0.17	Selenium	<0.001	<0.001
Dissolved Ortho-phosphate	<0.001	-	Silicon	1.0 to 1.2	0.2 to 0.3
Total Dissolved Phosphate	<0.002 to 0.004	<0.002 to 0.003	Silver	<0.00001	<0.00001
Total Phosphate	0.002 to 0.006	<0.002 to 0.007	Sodium	<2	<2
Organic Parameters			Strontium	0.024 to 0.026	0.026 to 0.029
Dissolved Organic Carbon	3.3 to 4.9	4.1 to 5.7	Thallium	<0.0001	<0.0001
Total Organic Carbon	3.3 to 6	4.4 to 5.9	Tin	<0.0001	<0.0001
Total Metals			Titanium	<0.01	<0.01
Aluminum	0.005 to 0.012	0.004 to 0.009	Uranium	0.00005 to 0.00006	0.00008 to 0.00013
Antimony	<0.0001	<0.0001	Vanadium	<0.001	<0.001
Arsenic	<0.0001 to 0.0001	0.0002	Zinc	<0.001 to 0.001	<0.001

[1] Rescan 2004

13.4.3 Typical Hydro Project Effects on Water Quality

This section presents an overview of typical effects on water quality from hydro projects, including the following categories:

- changes in general water chemistry,
- increased mercury levels,
- changes in temperature and stratification,
- eutrophication, and
- alteration of erosion and deposition rates.

Some of these effects are relevant only to new hydroelectric projects, and are not applicable to the proposed expansion upgrades. Section 13.4.4 assesses the effects specific to the Expansion Project.

13.4.3.1 General Chemistry Changes

General chemistry changes in newly-formed reservoirs include altered nutrient levels and dynamics, modified water column and sediment oxygen regimes, nitrogen super-saturation in downstream waters, and increased mobilization of certain metals (Environment Canada 2004). Newly formed reservoirs can also cause the release of metals, nutrients, and organic matter from the newly-flooded terrestrial areas.

In newly-flooded reservoirs, water levels may increase by metres to store water for power generation during specific time periods. The inundation of these soils may introduce sediment-bound metals and organic matter into the water column. Fine soils can also increase water turbidity. These effects typically last for several years following the initial impoundment. After the increases in general chemistry concentrations reach a maximum, levels slowly return to those experienced at pre-impoundment levels, typically within 10 to 20 years depending on the environment.

Flow management may also potentially alter general water chemistry. During low-flow months, suspended solids and metals would deposit river and stream sediments that are re-suspended in the water column during freshet or high flow periods. Permanently decreased flows would improve general water chemistry and may also increase the potential for large increases in these parameters during rare years with high precipitation or high flow rates.

13.4.3.2 Mercury

Newly constructed hydroelectric reservoirs are commonly associated with increased mercury levels in water because of mercury release from flooded soils into the aquatic environment. Also, variations in reservoir water levels, particularly lower drawdown levels, may disturb sediments and redistribute sediment-sequestered mercury into the water column.

Mercury level alterations from new hydroelectric reservoirs are generally predictable (Rosenberg et al. 1997). In pristine arctic and subarctic environments, mercury is introduced from long-distance atmospheric transport that deposits it onto water and soil surfaces as inorganic or metallic mercury. Mercury is not produced from hydroelectric reservoirs, but it is present in terrestrial soils and released during flooding. Mercury exists in various chemical forms or species. Speciation of mercury largely determines its fate in the environment and its toxicity to organisms. Different mercury species behave differently based on their physical and chemical characteristics and interactions with soil and water. Inorganic and metallic mercury is generally biologically unavailable to organisms and has low water solubility. Inorganic mercury tends to associate with sediments with trace levels in the water column that are usually below the laboratory detection limits.

Methylmercury, which is produced by anaerobic bacterial conversion of inorganic mercury in aquatic sediments, is the primary toxic form to organisms and has the potential to bioaccumulate up the food chain. However, methylmercury also has low water solubility and is often below the laboratory detection limits in the water column. It tends to associate with sediments and the fat tissues in animals, subsequently accumulating at small concentrations in benthic organisms. The magnitude of bioaccumulation increases up the food chain and top aquatic predators may have tissue concentrations thousands or millions of times higher than ambient water concentrations. Methylmercury effects on organisms, specifically piscivorous fish species, are discussed in Section 13.5. With respect to water quality, only mercury in the water column and associated sediments are discussed.

Typically, methylmercury represents less than 10% of the total mercury in surface waters but can exceed 30% in disturbed systems (CCME 2003). Waters draining from wetlands tend to have a higher percentage of methylmercury concentrations than other sources because of higher levels of organic material present in wetland sediments needed for bacterial methylation. There are wetlands in the study area and changes in water level may affect mercury in these regions.

In undisturbed Canadian surface waters, total mercury concentrations typically range between 0.00005 and 0.00025 mg/L (Reeder et al. 1979 and National Water Quality Data Bank [NAQUADAT] 1985). In disturbed watersheds, such as newly-formed reservoirs, the proportion of methylmercury increases, but the overall total concentration remains relatively constant. The CCME water quality guideline for the protection of aquatic life for total inorganic mercury is 0.000026 mg/L. Because of the range of factors contributing to methylmercury production, there is no established relationship between inorganic and methylmercury concentrations in water bodies. The CCME guideline assumes no methylmercury is present in the water.

The methylmercury guideline for the protection of aquatic life is 0.000004 mg/L, which is 6.5 times lower than the total mercury guideline. The current commercial laboratory detection limit for total mercury is 0.00001 mg/L. Thus, the guideline for methylmercury is lower than what can be detected and concentrations below this level are uncertain.

13.4.3.3 TEMPERATURE AND DISSOLVED OXYGEN STRATIFICATION

Reservoir operating procedures affect the water temperature both in the reservoir and downstream areas. Lower water levels are associated with higher water temperatures in lakes and rivers and also allow for shallow water body freezing during winter periods. Temperature changes relate to the reservoir's thermal mass and surface area for radiant exchange, retention time, thermocline development, and whether release water originates from the surface or at depth (Environment Canada 2004). Epilimnetic discharge reservoirs (which tend to be shallower) produce elevated downstream water temperatures caused by the thermal warming of surface waters. These types of alterations in thermal regimes can have profound consequences on the type and complexity of biological communities that can be sustained downstream (Environment Canada 2004).

13.4.3.4 EUTROPHICATION

In newly-formed reservoirs, inundating terrestrial soils could potentially release vast quantities of nutrients into the water if the soils are fertile and rich. Reservoirs with excess nutrient levels could be subject to eutrophication, a condition where water bodies become oversaturated with nutrients such as nitrates and phosphates that can cause excessive algae production. Decomposing algae can cause low oxygen levels and harm other aquatic organisms such as benthic invertebrates and fish (Canadian Dam Association 2007).

13.4.3.5 EROSION AND DEPOSITION

Erosion is the process by which soil and weathered rock particles (sediment: gravel, sand, silt, and clay) are transported, or moved from one place to another. Increasing water levels and flows can erode soil and sediment through abrasion, dissolution, and scouring. Shoreline erosion can increase the sediment load and increase the turbidity of the water and potentially add heavy metals. Soil that is eroded and transported by streams would eventually be deposited as sandbars in streams, as point-bars on the inside curve of a meandering stream, on floodplains and levees, or at the mouth of the river in a delta.

13.4.4 Screening Potential Effects in Taltson Basin

13.4.4.1 INTRODUCTION

Because the Project is an operating hydroelectric facility, typical water quality effects associated with newly-constructed facilities that were described above (i.e. general chemistry, flooding of terrestrial soils, accumulation of mercury etc.), likely occurred following the original construction of the Nonacho and Twin Gorges facilities over 40 years ago. Water quality has likely returned to pre-project conditions. Alterations in water levels and flows because of the proposed expansion of the Taltson hydroelectric facilities may lead to some changes in water quality, but the changes would be less substantial than would happen with the creation of a new reservoir.

Under both upgrade scenarios, increased power generation would require a greater water volume through the hydropower facility throughout the year. Therefore, flows over the SVS would be reduced and water must be stored during freshet in Nonacho Lake when flows are high. Stored water would be released during low flow winter months in an attempt to maintain constant power generation capacity. This would affect the water levels and flows throughout the basin and may subsequently result in changes to water quality.

This section provides a brief overview of the broad-scale proposed changes to the hydrological regime. These broad-scale changes were used to screen out typical hydro project effects on water quality that are not relevant based on the proposed upgrades. Potential water quality effects specific to the Expansion Project were carried forward to Section 13.4.5, where they are assessed by zone and upgrade scenario.

13.4.4.2 Screening Potential Effects

13.4.4.2.1 General Water Chemistry

The dams at the Twin Gorges Forebay and Nonacho Lake were built in 1965 and 1968, respectively. Thus, any major changes to the water chemistry would have occurred within the past 40 years and returned to baseline levels. The proposed upgrades to the existing hydro facility would result in additional changes to the hydrologic regime of the Taltson Basin described in Section 13.3. These changes may alter the general water chemistry of the basin.

General water chemistry changes are difficult to predict because of the complexity of interrelated physical, biological, and chemical processes occurring in the reservoirs, both in the open water season as well as under ice in the winter (Environment Canada 2004). Thus, potential water chemistry changes are typically presented qualitatively rather than quantitatively. The predictions of change to general chemistry are typically based on the range and variability of the modelled water levels and flows that would be experienced under a new hydrological regime. Higher flows and water levels or increased water level variation is associated with the disturbance of aquatic sediments and redistribution of fine sediments into the water column that contain metals, and may affect turbidity or other parameters.

13.4.4.2.2 Mercury

There would be no new inundation of terrestrial soils in the Nonacho Lake reservoir from the proposed Project upgrades. However, increased variation in water levels may disturb sediments and redistribute existing methylmercury back into the water column. Downstream water bodies, particularly Zone 1, may experience downstream effects if methylmercury concentrations in the aquatic environment increase. Zone 2, which has an overflow at the Tronka Chua Gap, would experience a decrease in total annual water volume and less substantial effects in mercury levels from Nonacho Lake.

Mercury concentrations are not a concern for creeks and rivers because the water tends to be well-oxygenated, limiting bacterial conversion of inorganic mercury to methylmercury. Dissolved mercury, transported in the water column from rivers to settling areas such as lakes, may bind to suspended organic matter and settle out of the water column.

13.4.4.2.3 Temperature and Dissolved Oxygen Stratification

The existing discharges from Nonacho Lake and the Twin Gorges Forebay are epilimnetic and would remain epilimnetic. Changes in water temperature from the proposed upgrades would depend on changes in water level relative to the depth of the water body considered. The proposed changes in the hydrological regime would not remove any water from the Taltson Basin. The total annual flow between Nonacho Lake reservoir and the Twin Gorges Forebay hydropower facility would be the same. Hence, the flow rates and patterns would change based on each considered scenario, but the total water volume considered would not. Storing water for extended periods (e.g., months or years) could cause stratification (layers of water of different temperatures) with similar effects on dissolved oxygen levels, nutrient levels, productivity, and the bio-availability of metals (Canadian Dam Association 2007). Under the proposed upgrades, the storage of water at Nonacho Lake may occur for longer periods (months) compared to the existing operations. Consequently, temperature and dissolved oxygen was measured relative to lake depth to see if stratification of these parameters currently occurred in Taltson Basin lakes.

13.4.4.2.4 Eutrophication

The proposed upgrades would not flood any terrestrial soils in the Taltson Basin lakes. Water levels in the proposed scenarios would not exceed the absolute maximum levels currently experienced in Taltson Basin lakes. The exception to this is in Zone 1, where modelled water levels in years with high annual flows would be slightly higher than the existing absolute water level, in the range of 0.1 m to 0.2 m. This increase is relatively small compared to the changes in water levels associated with new hydroelectric reservoirs (i.e. several metres). Additionally, arctic soils are generally poor in nutrients; this is reflected by the low nutrient content of most northern freshwater water bodies. Eutrophication is not a potential concern because of the lack of any present or future major nutrient inputs into the system.

13.4.4.2.5 Erosion and Deposition

Based on the proposed changes to the hydrological regime, lakes and rivers would experience some changes to water levels and flows. In lakes, changes in water level occur gradually over time and are not a concern for the low-sloped lake banks in the Taltson basin. In lake banks with steep slopes, seasonal changes in water level may slowly erode fine soils and sediments leading to bank instability and potential mudslides or landslides. Water levels higher than existing conditions, or more frequently occurring high levels in lakes, increase erosion potential. In contrast, lower water levels would reduce erosion rates, because there would be no water to act as a transport medium for sediments and soils.

Increased river flows may cause erosion in some areas, depending on the types of soils and sediments in each respective water body. Lower water levels and flow rates may increase the rate of deposition in rivers and streams, while lakes would always be a deposition zone. In zones where the flow is expected to increase or become more variable, there is the potential for increased erosion and downstream sedimentation.

13.4.4.3 SUMMARY

Based on the broad-scale changes to the Taltson Basin hydrological regime, the following potential changes to water quality may occur:

- changes in general water chemistry,
- increased mercury levels,
- changes in temperature and stratification, and
- alteration of erosion and deposition rates.

Each of these potential effects is assessed in Section 13.4.5 by upgrade scenario and zone.

13.4.5 Predicted Alterations to Water Quality

13.4.5.1 INTRODUCTION

The proposed upgrades to the Taltson hydroelectric facilities would increase the degree of water management and monitoring at the Nonacho Lake reservoir to maintain a steady water supply throughout the year to the Twin Gorges dam. Under the two potential scenarios, the upgrades would generate between 36 MW to 56 MW of additional electricity. Water bodies in the Taltson basin would experience different degrees of change in water levels and flows for each scenario. Based on the screening exercise in the previous section, the alteration of water levels and flow rates could change general chemistry, mercury, temperature, erosion, and sedimentation rates.

Factors such as surface-to-volume ratio and reservoir depth, geology and soil geochemistry of the surrounding catchment, reservoir latitude, sedimentation rates and magnitude, magnitude and timing of incoming flows and their residency time, and biological productivity levels in the reservoir may affect the overall water quality (Environment Canada 2004). Rivers would likely experience more changes in water quality compared to lakes. Water level and flow rates are more variable in rivers and streams relative to lakes, potentially affecting erosion, deposition, and temperature regimes.

Generally, because it is an expansion, the proposed upgrades would have a lower magnitude of effect on water quality. In particular, the water levels in lakes under the proposed upgrades would not exceed the historic levels. Thus, no terrestrial soils would experience inundation. The following section presents the predicted changes in water quality in the Taltson Basin.

13.4.5.2 OVERVIEW OF MODELLED FLOW AND WATER LEVELS

The degree to which water quality is affected would depend on the proposed upgrades, which include an upgrade to the Nonacho dam control structure to control downstream flows more efficiently. Two power output scenarios (36 MW and 56 MW) are considered for this assessment, which require controlled water releases at Nonacho Lake to maximize power production at the Twin Gorges hydropower generating facility. The controlled water release from Nonacho Lake under the expansion scenarios would have an effect on the hydrologic regime (timing and magnitude of water levels and flows) of downstream lakes and reaches of the Taltson River.

Water levels and flow rates were modelled using HEC-ResSim software to predicted changes to the Taltson Basin under the 36 MW and 56 MW scenarios as described in Section 13.3. These results were compared to the modelled water levels under the existing hydroelectric facility operations using hydrological inputs for the period of 1978 to 1990 (baseline). Modelled results assumed the proposed upgrades were operational during this time period. Flows were predicted for rivers and lake outflows while water levels were predicted for lakes and at river sections where cross-section data were available. Table 13.4.5 presents a summary of the changes in flows in each scenario relative to the baseline conditions from the HEC-ResSim model (Section 13.3) at a number of key locations of interest. The key sites to consider alterations in flow include Nonacho Dam outflow, the inflow to Zone 1; the Taltson River above and below the Twin Gorges Forebay, both in Zone 3; and the Taltson River downstream of Rat River within Zone 4.

Table 13.4.5 — Summary of Predicted Changes to Water Flows in Taltson Basin

Water Flow		Zone 1 Nonacho Lake Outflow to Taltson Lake			Zone 3 Upstream of the Twin Gorges Forebay		
		Baseline	Change from Baseline		Baseline	Change from Baseline	
			36 MW	56 MW		36 MW	56 MW
Daily Water Flow[1] (m^3/s)	Max	215.9	+39.6	+35.3	511.8	+9.8	-39.8
	Min	21.1	-7.1	-7.1	47.8	+16.9	+16.8
Average Monthly Flow (m^3/s)	Max	116.2	-8.1	+8.9	247.0	-48.0	-14.0
	Min	40.9	-6.6	+14.3	88.3	+36.7	+3.8
Water Flow		Zone 3 Downstream of Hydropower Facility			Zone 4 Taltson River Downstream of Rat River		
		Baseline	Change from Baseline		Baseline	Change from Baseline	
			36 MW	56 MW		36 MW	56 MW
Daily Water Flow[1] (m^3/s)	Max	525.2	+9.5	-53.2	751.6	-31.7	-98.4
	Min	50.3	+15.6	+14.3	72.5	+14.0	+13.8
Average Monthly Flow (m^3/s)	Max	251.9	-48.6	-18.9	360.4	-25.3	-15.1
	Min	90.8	+38.8	+1.3	124	+43.7	+3.4

[1] Daily water flows represent the absolute minimum and maximum flow that would occur over a 13-year simulation period.

Table 13.4.6 presents a summary table of the changes in water level in each scenario relative to baseline conditions from the HEC-ResSim model (Section 13.3). The daily flows and water levels represent the absolute range that would occur during the modelled 13-year simulation period. All flows and water levels would be within the absolute range at all times of the year.

Water quality changes were predicted based on water level changes in Nonacho Lake and Taltson Lake in Zone 1, Tronka Chua Lake in Zone 2, and the Twin Gorges Forebay in Zone 3. Taltson Lake and Tronka Chua Lake were selected because they are the first lakes immediately downstream from Nonacho Lake and are the major settling areas for suspended matter in the water column. Water levels were modelled for Taltson River downstream of the Rat River confluence in Zone 4. The purpose was to determine whether the flow changes would affect the water quality as water leaves the Taltson Basin and flows into the Great Slave Lake.

The following section describes the baseline water levels for lakes and flows for rivers and compares them to the modelled results under each scenario. Water levels and flows are described by their absolute minimum and maximum ranges that were estimated for each scenario based on the 13-year simulation period. This range represents the lowest and highest values during unusually dry or wet periods. The minimum and maximum monthly averages for water levels and flows are also described, which gives the ranges typically experienced throughout the year. The changes in water levels and flows are the primary basis for water quality predictions.

Table 13.4.6 — Summary of Predicted Changes to Water Levels in Taltson Basin

Water Level		Nonacho Lake (Reservoir)			Zone 1 Taltson Lake		
		Baseline	Change from Baseline		Baseline	Change from Baseline	
			36 MW	56 MW		36 MW	56 MW
Daily Water Level[1] (masl)	Max	324.1	-0.1	-0.1	313.9	+0.2	+0.3
	Min	322.7	-0.8	-0.9	311.8	+0.1	+0.3
Average Monthly Water Level[1] (masl)	Max	323.4	-0.2	-0.6	313.0	-0.1	+0.1
	Min	323.0	-0.6	-0.8	312.1	0	+0.2
Annual Variation in Average Monthly Water Level (m)		0.49	0.88	0.63	0.86	0.81	0.78
Water Level		**Zone 2 Tronka Chua Lake**			**Zone 3 Twin Gorges Forebay**		
		Baseline	**Change from Baseline**		**Baseline**	**Change from Baseline**	
			36 MW	**56 MW**		**36 MW**	**56 MW**
Daily Water Level (masl)	Max	324.5	-0.2	-0.3	248.7	-0.2	-0.4
	Min	322.3	-0.5	-0.5	247.7	-0.2	-0.2
Average Monthly Water Level (masl)	Max	323.3	-0.2	-0.9	248.3	-0.6	-0.7
	Min	322.6	-0.4	-0.6	247.9	-0.3	-0.4
Annual Variation in Average Monthly Water Level (m)		0.73	0.93	0.45	0.40	0.16	0.15

[1] Daily water levels represent the absolute minimum and maximum flow that would occur over a 13-year simulation period.

13.4.5.3 Assessment Criteria

Table 13.4.7 presents the assessment criteria used to assess potential changes in water quality in the Taltson Basin. The descriptors consider the geographic extent, magnitude, and duration of changes to water quality.

Table 13.4.7 — Assessment Criteria

Criteria	Description
Major	Major shift away from the baseline conditions, such that water quality parameters are continuously outside of the baseline range. Changes in water quality would be large and long-term in nature. Water quality would often exceed the CCME guidelines.
Medium	A moderate shift away from the baseline conditions such that water quality parameters are periodically outside of the baseline range. Changes in water quality would be moderate and medium-term in nature. Water quality would periodically exceed the CCME guidelines.
Low	Minor shift away from average baseline conditions but still within the baseline range. Changes in water quality would likely be relatively small and of a temporary nature. Water quality would remain well within the CCME guidelines.
Negligible	A non-detectable or very slight change from the baseline conditions.

13.4.5.4 Predicted Water Quality Changes

13.4.5.4.1 Nonacho Lake (Reservoir)

Modelled Baseline Scenario

Water levels were modelled for Nonacho Lake under baseline conditions. The minimum and maximum absolute water level was 322.7 masl to 324.1 masl, respectively, over the 13-year simulation period. The average monthly water levels ranged from 323.0 masl to 323.4 masl, with an annual variation in mean monthly water levels of 0.49 m.

36 MW Scenario

The model predicted that the absolute minimum water level in Nonacho Lake would decrease 0.8 m from the absolute minimum baseline water level. The absolute maximum water level would be nearly the same as baseline maximum (only 0.1 m lower). During high flow years, the annual maximum water level would be similar to the absolute maximum under the baseline scenario. Water levels would not increase above the baseline levels of the 13-year simulation period. During years with low flow, the annual maximum water levels would be lower compared to the baseline scenario.

Monthly average water levels would also decrease from baseline. The average monthly maximum and minimum would decrease by 0.2 m and 0.6 m, respectively. In addition, the annual variation in mean monthly water level would increase from the baseline of 0.49 m to 0.88 m, due to an increase in the difference between the monthly maximum and minimum water level.

These modelled changes in water levels would have a low effect on general water chemistry parameters and mercury concentrations. The absolute maximum water level for this scenario would be similar to baseline conditions (0.1 m lower), and no new soils would be inundated. There would be no introduction of new terrestrial materials into the system. When the absolute minimum levels are experienced, which would be 0.8 m below baseline conditions, lake bed area that was permanently submerged at baseline conditions would be periodically exposed. When the water level increases and decreases every year, it could disturb the fine sediment layer in the newly-exposed areas and redistribute these components (i.e. total metals, total suspended solids) into the water column. The effects from the potential redistribution of sediments are considered low because the changes in lake levels would be gradual over the course of weeks to months rather than hours or days. In addition, these low level changes would be temporary because any disturbed sediments would eventually settle out past the lowest water mark. This settling-out may take several years.

Under the 36 MW scenario, temperature and dissolved oxygen profiles would experience negligible effects from the alteration to the hydrological regime in Nonacho Lake. The absolute maximum water levels in this scenario would be the same as baseline, while the absolute minimum would decrease by 0.8 m. Temperature and dissolved oxygen assessments described in the existing environment noted a minor thermocline at depths of 15 m in Nonacho Lake. The decrease in lake level by 0.8 m is small relative to the total depth of Nonacho Lake (30 m), and the change in surface area to lake volume ratio would have negligible effects on temperature and dissolved oxygen stratification, regardless of the season. Summer water temperatures would experience negligible changes while winter ice formation on the lake surface would insulate the underlying water from temperature decreases.

The flow from the inlet to the outlet of Nonacho Lake is very slow and not predicted to change from baseline; as such, current-driven erosional processes would not change. Thus, the effects from erosion conditions under the 36 MW scenario would be negligible

The predicted higher annual water level variation and lower water mark would have a low effect on deposition rates. The effect described above for general chemistry is not related to erosion. This effect would not include the addition of sediments into the system, only a redistribution of existing sediments.

56 MW Scenario

Under the 56 MW scenario, the absolute maximum water level would be similar to baseline (lower by 0.1 m), while the absolute minimum water level would decrease by 0.9 m. However, water levels close to the absolute maximum would only occur once or twice over the modelled 13-year period because years of high precipitation occur infrequently. Water levels close to the absolute minimum would also occur infrequently, depending on the frequency of dry years, which occurs three times during the 13-year simulation period.

Under the 56 MW scenario, the maximum and minimum for the average monthly water level would decrease from baseline conditions by 0.6 m and 0.8 m respectively. Average monthly water levels decrease because releases from Nonacho Lake would generally be required throughout the year to satisfy demand at the Twin Gorges hydropower facility and less of the freshet runoff would be stored during the year. The annual variation in mean monthly water level would increase from 0.49 m at baseline to 0.63 m under the 56 MW upgrade scenario. Overall, the water levels in Nonacho Lake would be substantially lower at all times compared to the baseline.

Changes to water levels in this scenario would have negligible effects on general water chemistry. The high water demand for this scenario would draw down the absolute minimum water level lower in Nonacho Lake by 0.9 m (based on the monthly averages) and water levels would be consistently lower throughout the year compared to baseline. Potential changes in mercury would be low because Nonacho Lake was previously flooded during the original impoundment in 1965. Mercury release from surrounding soils and the anaerobic generation of methylmercury in sediments during post-impoundment years would have settled to sediment layers. Sediment disturbance may remobilize sediment-bound mercury into the water column. Although the degree of disturbance is negligible for general water chemistry, the comparatively higher mercury levels in hydroelectric reservoirs would have a low effect on water quality.

Temperature and dissolved oxygen profiles would experience negligible changes compared to baseline conditions. The minimum for the average monthly water level decreases by 0.8 m and is minor relative to the depth of Nonacho Lake (30 m). Changes in stratification would also be negligible because the Nonacho control structure would be open for most of the year. Water would not be stored for long enough periods to allow temperature or oxygen stratification to occur.

The water level changes would also have negligible effects on erosion in Nonacho Lake. The lake bank generally has a low slope gradient, which is less erodible than steep banks. Erosion on steep banks would decrease shoreline stability over time. Water levels would also change gradually over a period of weeks to months and Nonacho Lake would not experience any strong currents that would erode sediments or shorelines. The absolute maximum water level would be lower than baseline levels and no additional shorelines would be affected. However, the lower water levels would expose previously-submerged lake surface areas. Increased annual variation in mean monthly water level may redistribute sediments in newly-exposed areas but would have a low increase on sedimentation rates below the current minimum water mark. These sedimentation patterns would be similar to those described under the 36 MW scenario.

Table 13.4.8 presents a summary table of the potential effects for Nonacho Lake.

Table 13.4.8 — Potential Water Quality Changes in Nonacho Lake

Parameter	NONACHO LAKE	
	36 MW	56 MW
General Chemistry	Low	Negligible
Total Mercury	Low	Low
Temperature	Negligible	Negligible
Dissolved Oxygen	Negligible	Negligible
Erosion	Negligible	Negligible
Sedimentation	Low	Low

13.4.5.4.2 Zone 1 – Subzone: Nonacho Lake Outflow to Taltson Lake

Modelled Baseline Scenario

The Nonacho Lake outflow to Taltson Lake is dependent on the water volume passing through the Nonacho dam. Under baseline conditions, additional outflow from Nonacho Lake to the Taltson River occurred as leakage through the dam. Daily flow rates experienced an absolute range from 21.1 m^3/s to 215.9 m^3/s over the 13 simulated years. The range of average monthly flows was 40.9 m^3/s to 116.2 m^3/s. The minimum release permitted through the Nonacho dam is 14.0 m^3/s, but flows would not reach the minimum permitted flow under baseline conditions.

36 MW Scenario

The outflow from Nonacho Lake would be managed to maintain consistent power generation at the hydropower facility. The pattern of annual flows under this scenario would be more consistent from one year to the next (i.e. minimum and maximum flows would be consistently experienced in May and January, respectively, and also be at a similar magnitude every year). Under baseline conditions, minimum and maximum flows were experienced during April and July but the magnitudes of flow varied by a greater degree from one year to the next. The maximum daily flow rate would increase by 39.6 m^3/s and the minimum daily flow would decrease by 7.1 m^3/s.

The maximum and minimum mean monthly flows would decrease by 8.1 m^3/s and 6.6 m^3/s relative to baseline. These flow rates were considered similar to baseline conditions but the time of year during which the maximum and minimum flows would be experienced would shift. Under baseline conditions, low flows occurred from January to May, while higher flows occurred from June to September. April to June would experience low flow because of water storage at Nonacho Lake during high snowmelt. This water would be released during the winter, leading to higher flows from December to March.

General water chemistry and mercury in this subzone would experience low-level effects. The outflow region at the Nonacho dam is composed of bedrock (based on photographic evidence), which would not potentially provide increasing general water quality parameters. The low-level effects would result from the effects experienced in Nonacho Lake, which flow into this subzone. Direct input of substances from this subzone into the water column would be negligible because there is insufficient sediment or erodible shorelines that would affect water quality in this area.

Temperature and dissolved oxygen profiles in this subzone would experience negligible changes. Temperature and dissolved oxygen would be dependent on the conditions in Nonacho Lake, which would also experience negligible effect because the changes in water level were small relative to the lake volume. Although the monthly flow pattern would shift compared to baseline (i.e. lowest flows throughout the summer), this subzone spans 10 km before entering Taltson Lake. The water released from Nonacho Lake would pass through this subzone in a short period of time (hours), despite the fact that it is a slow-flowing river. Thus, the time frame for any potential effect on temperature and dissolved oxygen would be limited.

Erosion rates would experience negligible changes from baseline conditions. Aerial photographs show this subzone as a wide, shallow-banked section with slow-flowing waters. These photos also show the river banks to be naturally resistant to erosion because of the small boulders and cobblestones there that provide bank armouring. Sedimentation would be negligible in this subzone. A decrease in the mean monthly flow rate from 6.6 m^3/s to 8.1 m^3/s would be negligible compared to the maximum monthly flow rate of 118.1 m^3/s. Sedimentation rates, if any, would be similar to baseline conditions, but would be higher in the spring instead of the winter.

56 MW Scenario

Under the baseline and 36 MW scenario, most of the outflow from Nonacho Lake occurs in this subzone. Under the 56 MW scenario, even more water from Nonacho Lake would be diverted into this subzone, resulting in less flow into Zone 2. The absolute maximum flow rate would increase by 35.3 m^3/s. The minimum flow would only decrease by 7.1 m^3/s. The maximum and minimum for the average monthly flow in this subzone would increase by 8.9 m^3/s and 14.3 m^3/s, respectively, because a greater proportion of the outflow from Nonacho Lake would be directed into Zone 1 under the 56 MW scenario compared to baseline.

General chemistry and mercury concentrations in this subzone would experience negligible change. This subzone is composed of cobblestone and bedrock (based on aerial photographic evidence). Flows would have no direct effect on general chemistry in this area, and based on the predicted changes in Nonacho Lake under this scenario, there would be a negligible influx of materials. Mercury would have a low effect in this subzone from upstream influxes from Nonacho Lake. However, it would be dissolved or bound to particulate matter in the water column and continue to be transported to the following downstream lake. Any particulate-bound mercury would not settle in this subzone at a rate higher than baseline conditions because the mean monthly flow rates would be higher.

Temperature and dissolved oxygen profiles would experience negligible effects as temperature and dissolved oxygen in Nonacho Lake is not expected to change. Flows in this subzone would be within baseline ranges and the time required to pass through this subzone (hours) would be insufficient for any significant changes to temperature.

Erosion and sedimentation changes would also be negligible in this subzone. The seasonal patterns of flow would be similar to baseline conditions. The flow rates would be higher but within the range of flows experienced at baseline. In addition, the boulder and cobblestone riparian substrate would provide armouring to any potential changes in erosion rates.

13.4.5.4.3 Zone 1 – Subzone: Taltson Lake

Modelled Baseline Scenario

Taltson Lake is 10 km downstream from the Nonacho dam outflow and lake levels would depend on the proposed water release regimes at the Nonacho dam. Under baseline conditions, the absolute range of daily water levels in Taltson Lake would be 311.8 masl (minimum) to 313.9 masl (maximum). The average monthly water level would range from 312.1 masl to 313.0 masl. The annual variation in mean monthly water levels is 0.86 m.

36 MW Scenario

The absolute minimum and maximum for daily water level would increase by 0.1 m and 0.2 m respectively. These water levels would be similar to baseline conditions. However, there would be seasonal changes in water levels associated with the proposed hydrological changes. At baseline, low water levels occur from December to May and higher levels occur between July and September. Under the 36 MW scenario, higher levels would occur from January to March. This would correspond with periods of increased water release from the Nonacho dam during the winter, while lower water levels would occur from May to July when water from snowmelt is stored at Nonacho Lake.

The annual mean monthly water levels would be similar to baseline. The range of mean monthly water levels would only decrease by 0.1 m. This would result in a small decrease in the annual variation in mean monthly water level from 0.86 m at baseline to 0.81 m under the 36 MW upgrade scenario.

General chemistry and mercury concentrations in Taltson Lake would experience low effects. The change in water levels would be very close to the range observed under baseline conditions and would have a minimal direct effect on general water quality. The low level changes in general chemistry predicted in Nonacho Lake would not have settled or deposited in the Taltson River upstream because mean monthly flow rates were higher than baseline. Any changes in general chemistry would flow into Taltson Lake resulting in low level changes.

Water temperature and dissolved oxygen profiles would experience negligible effects because of the absence of any changes between Nonacho Lake and Taltson Lake. Taltson Lake is approximately 12 m deep, and the modelled ranges in water levels were very similar to the range for baseline conditions.

Erosion would experience negligible effects from the proposed water level changes, which are similar to baseline conditions. Aerial photos of Taltson Lake show it to have low-sloped banks, which have a low susceptibility to erosion. Transported materials from Nonacho Lake would settle in Taltson Lake and would result in low changes to sedimentation rates.

56 MW Scenario

The range of flows would be similar to baseline. The absolute maximum and minimum for daily water levels would both increase by 0.3 m. The maximum and minimum average monthly water levels would increase by 0.1 m and 0.2 m, respectively. In addition, there would be a lower variation in water levels. The annual variation in monthly mean water levels would decrease from the baseline of 0.86 m to 0.78 m.

General chemistry in Taltson Lake would experience negligible effects under this scenario. The change in water levels would be very close to the range observed under baseline conditions. In addition, negligible changes predicted in Nonacho Lake would have negligible effects on general chemistry in Taltson Lake. For mercury, low level effects would be experienced because of an influx of mercury from Nonacho Lake. Re-mobilized mercury would not have settled out in the Taltson River between Nonacho Lake and Taltson Lake because the flows would be higher than baseline. Thus, Taltson Lake would be the first large water body encountered after Nonacho Lake.

Temperature and dissolved oxygen changes in Taltson Lake would be negligible. The mean monthly water level increases in the range of 0.1 m to 0.2 m would have a minimal effect on the temperature of the water given the surface area and volume of the lake. In addition, temperature changes were not predicted from Nonacho Lake or the Nonacho Lake outflow to Taltson Lake.

The proposed water level changes would cause low erosion effects. Aerial photos of Taltson Lake show it to have low-sloped banks. The modelled water levels would increase compared to baseline levels. The maximum daily water level increases by 0.3 m and the average monthly water level increases from 0.1 m to 0.2 m. An increase in the maximum daily water level of 0.3 m may affect lake shores that have not been submerged previously. The low-sloped banks would affect larger bank areas compared to steep-sloped banks.

Taltson Lake would experience low changes in sedimentation from materials transported from Nonacho Lake. Any sediment transported from Nonacho Lake is expected to settle in Taltson Lake.

Zone 1 is over 150 km in length and the water in the river and downstream lakes is very slow-moving. Sediment deposition is only expected to occur in Taltson Lake and would have negligible effects on downstream lakes within Zone 1. All other potential effects to water quality in Zone 1 downstream of Taltson Lake would be negligible.

Table 13.4.9 presents a summary table of the potential effects for Zone 1.

Table 13.4.9 — Potential Water Quality Changes in Zone 1

Parameter	ZONE 1			
	Nonacho Lake Outflow		Taltson Lake	
	36 MW	56 MW	36 MW	56 MW
General Chemistry	Low	Negligible	Low	Negligible
Total Mercury	Low	Low	Low	Low
Temperature	Negligible	Negligible	Negligible	Negligible
Dissolved Oxygen	Negligible	Negligible	Negligible	Negligible
Erosion	Negligible	Negligible	Negligible	Low
Sedimentation	Negligible	Negligible	Low	Low

13.4.5.4.4 Zone 2

Modelled Baseline Conditions

When water levels in Nonacho Lake rise above the elevation at the Tronka Chua Gap, water spills over into Zone 2. Under baseline conditions, water levels in Tronka Chua Lake range from 322.3 masl to 324.5 masl. The maximum and minimum for the average monthly water level is 323.3 masl and 322.6 masl. The annual variation in mean monthly water level is 0.73 m.

36 MW Scenario

Tronka Chua Lake would have the same seasonal pattern of water levels as baseline (i.e. low levels in the spring, high levels in the fall), but the total annual water volume entering this zone would decrease. The absolute minimum and maximum water levels would decrease by 0.5 m and 0.2 m compared to baseline conditions. Because the expansion scenarios require a greater water volume through the Nonacho control structure, less water would spill over the Tronka Chua Gap, leading to reduced water levels in Tronka Chua Lake.

The maximum and minimum average monthly water levels would also decrease by 0.2 m and 0.4 m, respectively. However, outflow from Nonacho Lake at Tronka Chua Gap would occur almost every year (except years with very low flows) because of stored water in freshet; this would result in spillage into Tronka Chua Lake in the fall. Water levels near the absolute minimum and maximum would be reached almost every year except during low-flow years. This would increase the annual variation in mean monthly water level from 0.73 m at baseline to 0.93 m.

Changes in general chemistry and mercury concentrations would be low in Tronka Chua Lake. General chemistry parameters would improve from baseline conditions because of reduced flows into this zone resulting in lower lake levels. Aerial photographs of the Tronka Chua Gap show it to be a shallow overspill region. Sparse, submerged vegetation such as grasses are visible, indicating that the region is not flooded annually under baseline conditions. Lower flows through this area would reduce sediment disturbance.

Tronka Chua Lake temperature would experience low effects. No Project-related activities that would increase water temperature from Nonacho Lake to Tronka Chua Lake. Lower flows would reduce the total volume of water entering Zone 2, but a lower monthly mean water level of 0.2 m to 0.4 m would not affect the overall lake temperature.

Changes in erosion and sedimentation rates would be negligible in Tronka Chua Lake. Flow through the Tronka Chua Gap is already low under baseline conditions and further decreases would not affect conditions in Tronka Chua Lake. The higher annual variation in mean monthly water levels is the result of lower water levels experienced every year. The decrease in mean monthly water levels is 0.4 m from the baseline minimum water mark. Lower water levels and the resulting increase in water level variation would not change erosion rates.

56 MW Scenario

The water levels within Nonacho Lake would be consistently below baseline levels. The flow over the Tronka Chua Gap into Tronka Chua Lake would be substantially lower at all times of the year compared to baseline. Water levels in Tronka Chua Lake would be low from February to June (during Nonacho Lake water release) and highest from July to December (during water storage in Nonacho Lake). The absolute maximum and minimum for the daily water level would decrease by 0.3 m and 0.5 m, respectively. The maximum and minimum for the average monthly water levels would decrease by 0.6 m and 0.9 m relative to the lake depth of 6.0 m. The annual variation in mean monthly water level would decrease from 0.73 m at baseline to 0.45 m.

Under this scenario, the reduced flow in Zone 2 and decreased water levels in Tronka Chua Lake would have negligible effects on general chemistry and mercury.

During periods of low flow, little or no water would flow through the Tronka Chua Gap. This would cause a decrease in lake level and flows relative to the baseline and may increase water temperatures and reduce dissolved oxygen concentrations. These effects would be long term because the lower levels would occur every year.

Erosion and sedimentation rates would experience negligible effects because of lower water levels, flows, and water level variability. Under baseline conditions, low levels of suspended solids flowing from Nonacho Lake would settle in Tronka Chua Lake. The reduction in flows into this zone would decrease the inflow of suspended materials and sedimentation would not change substantially.

Table 13.4.10 presents a summary table of the potential effects for Zone 2.

Table 13.4.10 — Potential Water Quality Changes in Zone 2

Parameter	ZONE 2 Tronka Chua Lake	
	36 MW	56 MW
General Chemistry	Low	Negligible
Total Mercury	Low	Negligible
Temperature	Low	Low
Dissolved Oxygen	Low	Low
Erosion	Negligible	Negligible
Sedimentation	Negligible	Negligible

13.4.5.4.5 Zone 3 – Subzone: Upstream of the Twin Gorges Forebay

Modelled Baseline Scenario

Water from Zones 1 and 2 eventually enters the Twin Gorges Forebay. This Taltson River subzone is downstream of the confluence of the two zones before it enters the Twin Gorges Forebay. Under baseline conditions, the absolute minimum and maximum for the daily flows are 47.8 m^3/s and 511.8 m^3/s, respectively. The minimum and maximum for the average monthly flow is 88.3 m^3/s and 247.0 m^3/s, respectively.

36 MW Scenario

The absolute minimum and maximum daily flow would increase by 16.9 m^3/s and 9.8 m^3/s compared to baseline. The minimum flow for the average monthly flow would increase by 36.7 m^3/s, and the maximum average monthly flow would decrease by 48.0 m^3/s.

General water quality would experience negligible effects from the proposed change in hydrological regime. Although the flow rates would experience some change, they are relatively small compared to the total flow through this subzone. For example, the absolute minimum flow would increase from 47.8 m^3/s to 64.7 m^3/s, while the maximum would increase from 511.8 m^3/s to 521.6 m^3/s.

The monthly flow patterns would be the same as baseline conditions (i.e. lower flows from January to April and peak flows from June to September). Monthly flow distribution is similar to baseline conditions because the proposed upgrades would not change the total water volume in the Taltson basin. In this subzone, there would be minimal change to the flow regime. Hence, changes in all of the assessed parameters (e.g., general water chemistry, temperature, erosion and sedimentation) would all experience negligible effects.

56 MW Scenario

Monthly flow patterns would be similar to the baseline and 36 MW scenario. The maximum daily flow would decrease to 39.8 m^3/s while the absolute minimum daily flow would increase to 16.8 m^3/s. The minimum average monthly flow increases by 3.8 m^3/s, while the maximum average monthly flow decreases by 14.0 m^3/s. The amount of change compared to the total water flow under baseline conditions is small.

Potential changes in all water quality parameters would be negligible in this subzone. The monthly flow patterns would be similar to baseline and the 36 MW scenario conditions and would have negligible direct effects on water quality. Potential effects from upstream would also be negligible because of the slow-flowing waters in Zones 1 and 2, which would have settled most suspended solids out of the water column during the 150 km span from Nonacho Lake to this subzone.

13.4.5.4.6 Zone 3 – Subzone: Twin Gorges Forebay

Modelled Baseline Scenario

Under baseline conditions, absolute water levels ranged from 247.7 masl to 248.7 masl with continuous flow over the SVS. The minimum and maximum for the average monthly water level was 247.9 masl to 248.3 masl, respectively. The annual variation in mean monthly water level was 0.40 m.

36 MW Scenario

The absolute minimum and maximum water level would both decrease by 0.2 m. The minimum and maximum average monthly water level would also decrease by 0.3 m to 0.6 m, respectively. However, to maintain the 36 MW power output, the flow through the power facility is consistent throughout most of the year and the annual variation in mean monthly water level would decrease to 0.16 m from 0.40 m under baseline conditions. The Forebay would experience consistently lower water levels, but within the levels experienced under baseline conditions. The absolute minimum water level of 247.5 masl would be reached every year, and during years with low precipitation, the level would be at the minimum for the entire year.

General water quality parameters would experience negligible effects from the changes in water levels. The absolute minimum water level in the Forebay would decrease by only 0.2 m compared to baseline conditions. A decrease in the maximum water level by 0.2 m would not affect general water quality or mercury, and the annual variation in mean monthly water levels is also lower. Thus, rates of sediment disturbance would be lower than baseline.

Within Zone 3, upstream of the Forebay, no Project-related facilities exist that would affect temperature and dissolved oxygen profiles. The water upstream of the Forebay was not expected to experience any water quality changes and the lower water levels and water level variation in the Forebay would not affect erosion or sedimentation processes.

56 MW Scenario

The increased water demand at the Twin Gorges dam would further reduce water levels throughout the year. The absolute minimum and maximum daily water levels would decrease by 0.2 m and 0.4 m. The minimum and maximum for the average monthly water level would decrease by 0.4 m and 0.7 m. Water levels would be near the absolute minimum of 247.5 masl for most of the year. The annual variation in mean monthly water level would also decrease from 0.40 m under baseline to 0.15 m.

At the Forebay, the water level conditions would be similar to the 36 MW scenario. General chemistry and mercury concentrations would experience negligible effects from the lower water levels and annual variation in mean monthly water level. For this scenario, the proposed 56 MW output cannot be maintained at all times throughout the 13-year simulation period. When flows are low, water would immediately flow through the hydropower facility, maintaining the minimum water level.

Temperature and dissolved oxygen profiles would experience negligible changes from the small decrease (0.4 m to 0.7 m) in average monthly water levels relative to the depth of the Forebay (17 m). The existing environment for these parameters shows that no temperature or dissolved oxygen stratification occurs.

Lower water levels and water level variation would also have negligible effects to erosion processes while many suspended materials in the water column would have settled out in upstream regions in Zones 1 and 2.

13.4.5.4.7 Zone 3 – Subzone: Downstream of Hydropower Facility

Modelled Baseline Scenario

Under baseline conditions, the absolute range in daily flow downstream of Twin Gorges would be 50.3 m^3/s to 525.2 m^3/s. Large seasonal fluctuations are experienced and the mean monthly flow range is from 90.8 m^3/s to 251.9 m^3/s. The low flows would occur between March and April and the high flows from June to September.

36 MW Scenario

All of the water from Nonacho Lake flows through this subzone downstream of the hydropower facility. The flow patterns would be similar to baseline because the proposed upgrades would not change the total annual water volume in the Taltson Basin. The absolute minimum and maximum daily flow would increase by 15.6 m^3/s and 9.5 m^3/s, respectively. This increase is relatively small compared to the absolute maximum daily baseline flow of 525.2 m^3/s. The minimum average monthly flow would increase by 38.8 m^3/s, and the maximum average monthly flow would decrease by 48.6 m^3/s.

These changes in flow would be small compared to the total flow in this subzone. The monthly flow patterns would be similar to baseline conditions (i.e. low flow from March to May and high flow from June to August). Changes to flow would have negligible general water chemistry or mercury concentration effects. Upstream effects from the Forebay would be negligible.

Water temperature and dissolved oxygen profiles would have negligible changes because flow rates would be high and water mixing and turbulence would maintain the current temperature and oxygen levels in this subzone.

Erosion effects would be negligible because the flow rates would be similar to the ranges experienced at baseline conditions. Sedimentation processes would also be negligible because of the high flow rates and minimal change in flow patterns from baseline conditions.

56 MW Scenario

Monthly flow patterns would be similar to baseline. The absolute minimum daily flow would increase by 14.3 m^3/s while the absolute maximum daily flow would decrease by 53.2 m^3/s. The average monthly flow would experience little change from the baseline. The maximum average monthly flow would decrease by 18.9 m^3/s and the minimum would increase by only 1.3 m^3/s.

General water quality and mercury concentrations would experience negligible effects in this subzone under this scenario. The flow regime is similar to baseline patterns and ranges. Based on the predictions that upstream subzones in the Forebay would experience no changes, the conditions under this scenario would be similar to baseline.

Temperature and dissolved oxygen profiles would experience negligible effects. Turbulence from water passing through the hydropower facility would cause water mixing so water temperatures and dissolved oxygen would be homogenous with depth. The water volume through this subzone would not change from baseline, supporting the predictions of negligible effects.

Erosion and sedimentation would experience negligible effects as well, since there would be no significant changes in the flow patterns.

Table 13.4.11 presents a summary table of the potential effects for Zone 3.

Table 13.4.11 — Potential Water Quality Changes in Zone 3

Parameter	ZONE 3					
	Upstream of Forebay		Twin Gorges Forebay		Downstream of Hydropower Facility	
	36 MW	56 MW	36 MW	56 MW	36 MW	56 MW
General Chemistry	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Total Mercury	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Temperature	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Dissolved Oxygen	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Erosion	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Sedimentation	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

13.4.5.4.8 Zone 4 - Modelled Baseline Scenario

Zone 4 is the most downstream zone in the Taltson Basin and receives all the water from upstream zones from Nonacho Lake, and Zones 1, 2, 3 and 5. At baseline conditions, the absolute minimum and maximum flow in Taltson River downstream of Rat River ranged from 72.5 m^3/s to 751.6 m^3/s. The minimum and maximum for the average monthly flow would be 124.0 m^3/s and 360.4 m^3/s, respectively. The total annual flow passing through this subzone would remain the same because the proposed upgrades would not add or remove water from the system.

36 MW Scenario

The absolute daily minimum flow would increase by 14.0 m^3/s and the maximum would decrease by 31.7 m^3/s. Because all the water originating from Nonacho Lake eventually enters this zone, flow patterns would be very similar to the baseline. The minimum average monthly flow would also increase by 43.7 m^3/s and the maximum would decrease by 25.3 m^3/s. The proposed changes in flow magnitude would be minor relative to the total flow through this zone. In addition, there would be no seasonal changes of low or peak flow months compared to baseline conditions.

The zone also receives water from the confluence with the Tethul and Rutledge rivers, which would not be affected by the proposed Project. General water quality and mercury would not change because the water level conditions in this scenario would be similar to the baseline and no downstream effects were predicted upstream in Zone 3.

Temperature and dissolved oxygen profile changes would be negligible because this zone is almost 50 km downstream of the Forebay with no proposed activities between these areas. No upstream changes to these parameters would affect Zone 4.

Flows would be lower on average and would have negligible effects on erosion rates. Sedimentation rates would also be negligible because the flow rates and patterns would be within baseline ranges.

56 MW Scenario

Flow patterns would experience minimal changes relative to the baseline. The absolute minimum daily flow would increase by 13.8 m^3/s and the maximum would decrease by 98.4 m^3/s. The decrease in the absolute maximum is small relative to the baseline maximum flow of 751.6 m^3/s. The minimum and maximum average monthly flows would increase by 3.4 m^3/s and decrease by 15.1 m^3/s, respectively. The resulting average monthly flows would be similar to baseline conditions.

The total water volume through this zone would not change compared to baseline conditions, and the flow patterns would be similar as well. Therefore, general water quality parameters and total mercury concentrations would experience negligible changes. There would be no activities from the proposed upgrades that would affect this zone.

Temperature and dissolved oxygen profiles would experience negligible effects. Zone 4 is approximately 50 km from the Forebay and no anthropogenic activities after the hydropower facility would exist. There were also no predicted effects to these parameters in Zone 3, and the hydrological regime in Zone 4 is similar to baseline conditions. The minimal changes in flow regime and upstream effects would also cause negligible effects to baseline erosion and depositional rates.

Table 13.4.12 presents a summary table of the potential effects for Zone 4.

Table 13.4.12 — Potential Water Quality Changes in Zone 4

Parameter	ZONE 4 Taltson River Downstream of Rat River	
	36 MW	56 MW
General Chemistry	Negligible	Negligible
Total Mercury	Negligible	Negligible
Temperature	Negligible	Negligible
Dissolved Oxygen	Negligible	Negligible
Erosion	Negligible	Negligible
Sedimentation	Negligible	Negligible

13.4.6 Ramping

Outages at the Twin Gorges power facility will be scheduled on an annual basis to conduct routine maintenance. Scheduled shutdowns would occur once a year for each turbine for regular maintenance. Each turbine would be inoperative for approximately one week. Maintenance of the turbines would be completed sequentially rather than simultaneously, such that as one turbine is brought back on-line another turbine will be taken off-line. Thus, a scheduled partial shutdown of the existing 18 MW and two proposed 18 MW turbines for a 36 MW expansion, or two 28 MW turbines for a 56 MW expansion would last approximately three consecutive weeks. The preferred timing of the annual outages will be to occur just prior to the onset of freshet, which generally occurs in April or May.

Scheduled outages will occur annually in April/May. However ramping events from the scheduled outages will only occur when turbines are operating at full generation flow (180.6 m^3/s and 240 m^3/s for the 36 MW and 56 MW expansions, respectively. Based on the Flow Model results, this was estimated to occur six times in April or May during the 13-year model simulation period for the 36 MW expansion scenario and once out of 13 years for the 56 MW expansion scenario.

During a ramping event, the level would rise in the Forebay, increasing discharge over the SVS to Trudel Creek and simultaneously decreasing flow in the Taltson River below Twin Gorges. The South Gorge Spillway would be operated and 30 m^3/s would pass to the Taltson River below Twin Gorges, reducing the initial drop of flow in the Taltson River and the increase to Trudel Creek. Flow would remain depressed in the Taltson River below Twin Gorges until the additional spill at the SVS routes through Trudel Creek and returns to the Taltson River, which would require approximately 10 to 16 hours, and return to pre-outage flow.

Upon the re-start of the final turbine, the South Gorges Spillway would be closed and flow over the SVS would decrease. Flow and levels in the Taltson River below Twin Gorges would temporarily increase above pre-outage levels until flow through Trudel

Creek has completely responded to the decrease in flow at the SVS, which would require approximately 10 hours.

Flow in Taltson River below Twin Gorges would change by 44 m^3/s (for the existing turbine) and 23 m^3/s (new 18 MW turbines) from estimated pre-outage conditions for the 36 MW expansion and by up to 53 m^3/s (for an expansion turbine) for the 56 MW scenario; for roughly 10 to 16 hours. Based on average April and May background flow in Trudel Creek during periods of full generation flow at the power plants, the resulting changes in water level would be up to 0.34 m (decrease during initial shutdown and increase upon restart) for the 36 MW expansion and up to 0.32 m (decrease during initial shutdown and increase upon restart) for the 56 MW expansion. Water levels on the Forebay will increase for the duration of the ramping event. Water levels will increase roughly 0.1 m and 0.2 m for the 36 MW and 56 MW options.

13.4.6.1 PREDICTED WATER QUALITY CHANGE

13.4.6.1.1 Twin Gorges Forebay

In the Twin Gorges Forebay, water level changes from a scheduled shutdown would have negligible effects on all water quality parameters. The water level would increase by 0.1 m to 0.2 m when comparing pre-outage and scheduled outage maximum water levels for a duration of three weeks.

13.4.6.1.2 Downstream of Hydropower Facility

In the Taltson River downstream of Elsie Falls, water velocity, flows and water levels would all decrease during a scheduled shutdown for up to 16 hours. The reduction of water would have negligible effects on all water quality parameters because a large proportion of the total flow would still be flowing through the two operational turbines.

When the hydropower facility returns to full operational capacity, increased flows downstream of Elsie Falls would have negligible effects on most water quality parameters. Flows would increase rapidly by 50 m^3/s for roughly a ten-hour period, while only increasing water levels by up to 0.3 m compared to pre-outage conditions. This water level would be below the normal operating conditions at various times of the year.

13.4.7 Uncertainty

A number of assumptions were made when predicting how predicted changes in water levels and flows would affect water quality. These assumptions create a degree of uncertainty associated with the predicted effects, which are discussed in the following sections.

13.4.7.1 WATER LEVELS AND WATER FLOWS

The predicted effects to general chemistry, mercury, water temperature, erosion, and sedimentation were based on modelled water levels and flows. The uncertainties associated with the model are described in Section 13.3. Although there are some uncertainties associated with the range of accuracy of the model, the overall trends in water levels and flows resulting from the proposed upgrades are considered accurate.

13.4.7.2 DOWNSTREAM EFFECTS

In the proposed Project scenarios the operating facilities at Nonacho Lake and the Twin Gorges would be managed to accommodate the increased power output. The changes to the hydrological regime would cause low effects to the water quality downstream of these water bodies. There is some uncertainty in the spatial extent of these low effects. Baseline water quality in Nonacho Lake and the Twin Gorges Forebay were similar for general water quality, mercury, nutrient load and turbidity. These results suggest that the water quality within the basin is ubiquitous. Thus, the downstream extent of the low-level effects from Nonacho Lake and the Forebay cannot be determined using baseline trends in water quality. However, because the effects are predicted to be low, any downstream effects would also be low and/or negligible.

In addition, any potential changes from the 36 MW or 56 MW scenarios in Nonacho Lake would more likely occur in Taltson Lake (Zone 1) and Tronka Chua Lake (Zone 2) than in lakes farther downstream. The changes in water levels and flows would be similar for all lakes within their respective zones. Any water quality changes in Taltson Lake and Tronka Chua Lake would represent “worst-case” effects, while lakes farther downstream (King, Lady Grey, Benna Thy, Thekulthili, and Yatsore Lake) would show an attenuated effect. The distance between Nonacho Lake and Zone 3 is approximately 150 km, and water flowing through Zones 1 and 2 requires up to a month to flow this distance. Suspended materials from Nonacho Lake would settle out of the water column in their respective zones before reaching the Forebay.

13.4.8 Summary

Table 13.4.13 presents a summary of the potential for water quality changes in the Taltson River watershed. Nonacho Lake was predicted to be the main zone that would experience Project-related effects, regardless of the power output scenario. The changes in water levels in Nonacho Lake would disturb lake sediments, potentially affecting general chemistry, mercury, and sedimentation rates in the lake. Downstream transport of these substances would be experienced in the first lakes immediately downstream to the upgraded facilities (Taltson Lake and Tronka Chua Lake). Suspended substances flowing into these lakes would settle out of the water column, depositing in the lake bed. In particular, changes to suspended materials in Nonacho Lake would settle in Taltson Lake (Zone 1) and Tronka Chua Lake (Zone 2), while lakes farther downstream in Zones 1 and 2 would experience lower effects. Zones 1 and 2 are approximately 150 km in length, and suspended substances would have settled out of the water column upon flowing that distance while passing through several lakes.

The temperature and dissolved oxygen profiles would not change in most water bodies. Only Tronka Chua Lake would experience changes to water levels and volumes that would be large enough to affect temperature and dissolved oxygen. Nonacho and Taltson lakes and the Forebay would be too deep for the water level changes to have any effect.

Erosion processes would undergo negligible effects in all assessed zones because the lakes and rivers of the Taltson River watershed are generally low-gradient, low-velocity and deep-water lakes and river sections. Taltson River in Zone 1 river banks contain bank-armouring from small boulders and cobblestone and provide minimal erodible materials. Zone 2 would receive lower flows; thus, lake and river levels would not reach existing levels, reducing erosion potential.

Sedimentation processes are dependent on flow and water velocity, as well as the nature of the river banks. In Nonacho Lake, increased annual variation in mean monthly water levels may change rates of sedimentation by redistributing existing sediments. In Taltson Lake, which is immediately downstream of Nonacho Lake, low-level sedimentation effects may be experienced from suspended materials transported downstream. The same effects would not be experienced in Tronka Chua Lake because under the proposed scenarios, water is directed away from Zone 2 and lower volumes of water enter Tronka Chua Lake.

13.4.9 Future Monitoring

Although low level effects were predicted for mercury, the existing environment shows mercury concentrations in the water column would be either below or slightly above detection limits. Thus, mercury would not be monitored at this time. Mercury concentrations are usually not a concern for creeks and rivers because the water tends to be well oxygenated, limiting bacterial conversion, and the river surface-area-to-water-volume ratio is considerable smaller compared to lakes.

Table 13.4.13 — Summary of Potential Water Quality Changes to the Taltson Basin

Parameter			ZONE 1				ZONE 2	
	Nonacho Lake		Nonacho Lake Outflow		Taltson Lake		Tronka Chua Lake	
	36 MW	56 MW	36 MW	56 MW	36 MW	56 MW	36 MW	56 MW
General Chemistry	Low	Negligible	Low	Negligible	Low	Negligible	Low	Negligible
Total Mercury	Low	Low	Low	Low	Low	Low	Low	Negligible
Temperature	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Low	Low
Dissolved Oxygen	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Low	Low
Erosion	Negligible	Negligible	Negligible	Negligible	Negligible	Low	Negligible	Negligible
Sedimentation	Low	Low	Negligible	Negligible	Low	Low	Negligible	Negligible
Parameter	ZONE 3						ZONE 4	
	Upstream of Forebay		Twin Gorges Forebay		Downstream of Hydropower Facility		Taltson River Downstream of Rat River	
	36 MW	56 MW	36 MW	56 MW	36 MW	56 MW	36 MW	56 MW
General Chemistry	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Total Mercury	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Temperature	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Dissolved Oxygen	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Erosion	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Sedimentation	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

13. WATER FLUCTUATIONS IN THE TALTSON RIVER WATERSHED

13.5 BIOACCUMULATION OF MERCURY

13.5.1 Introduction

Mercury is a naturally occurring element in the environment and exists at trace levels in the air, soil, water and sediments. The concentrations of mercury in the environment are the result of natural geological processes (i.e. volcanic eruptions) and anthropogenic processes (e.g. coal burning, hydroelectric flooding). Mercury is volatile and can travel over long distances in the atmosphere, particularly to polar regions. A large proportion of mercury in pristine arctic soils is the result of atmospheric deposition of mercury.

Terrestrial flooding in newly-constructed hydroelectric reservoirs is commonly associated with bioaccumulation and biomagnification of methylmercury (the most toxic form of mercury). Flooded soils and the resulting changes in soil chemistry release soil-bound mercury into the aquatic environment. Although the proposed Project expansions would not flood any additional terrestrial soils in the Nonacho Lake reservoir, the expansion would result in changes to the hydrograph. These changes would increase the fluctuation in water levels, which could disturb sediment layers at the lake bottom. This in turn could increase methylmercury in the aquatic environment by re-mobilizing mercury that has settled in benthic sediments. Increasing the availability of methylmercury raises the potential for bioaccumulation and biomagnification in the food chain.

The concentration of methylmercury in aquatic life increases with higher trophic levels. These concentrations increase further if the organism is carnivorous, such as piscivorous fish (i.e. fish that consume other fish), or piscivorous mammals such as minks and otters. Elevated concentrations of methylmercury in piscivorous fish can cause adverse health effects to wildlife and people who consume the fish.

To assess any potential effects to fish quality, a mercury model was used to predict fish tissue concentrations of mercury under the proposed 36 MW and 56 MW scenarios in the Nonacho Lake reservoir and Zone 1 in Taltson Lake. Zone 1 is immediately downstream from the Nonacho control structure and could experience an influx of mercury from Nonacho Lake. This mercury would likely be stored in the sediment layers of Taltson Lake. Zone 2 was not modelled because the water flow into this area from Nonacho Lake would be decreased relative to existing flows. Based on modelled water flows described in Section 13.3, the monthly average water flow over the Tronka Chua Gap into Zone 2 is 14.0 m^3/s. Under the 36 and 56 MW upgrade scenarios, the flows decrease to 11.6 m^3/s and 3.1 m^3/s, respectively. Since mercury from Nonacho Lake would transport downstream in the water, mercury concentrations would not be effected in Zone 2. This section discusses the quality of fish tissue, defined by mercury concentrations, as it relates to fish consumption by wildlife and human consumers, under the proposed 36 MW and 56 MW upgrade scenarios.

This section provides the following:

- summary of background information pertaining to methylmercury cycling in the environment, methylmercury toxicity, and applicable CCME mercury guidelines for water and tissue;
- summary of the baseline concentrations of mercury in fish tissue in the Taltson Basin (excluding Trudel Creek); and
- description of the mercury predictive model used to predict mercury concentrations in fish tissue in the Nonacho Lake reservoir and Taltson Lake from the proposed 36 MW and 56 MW upgrades.

13.5.2 Background

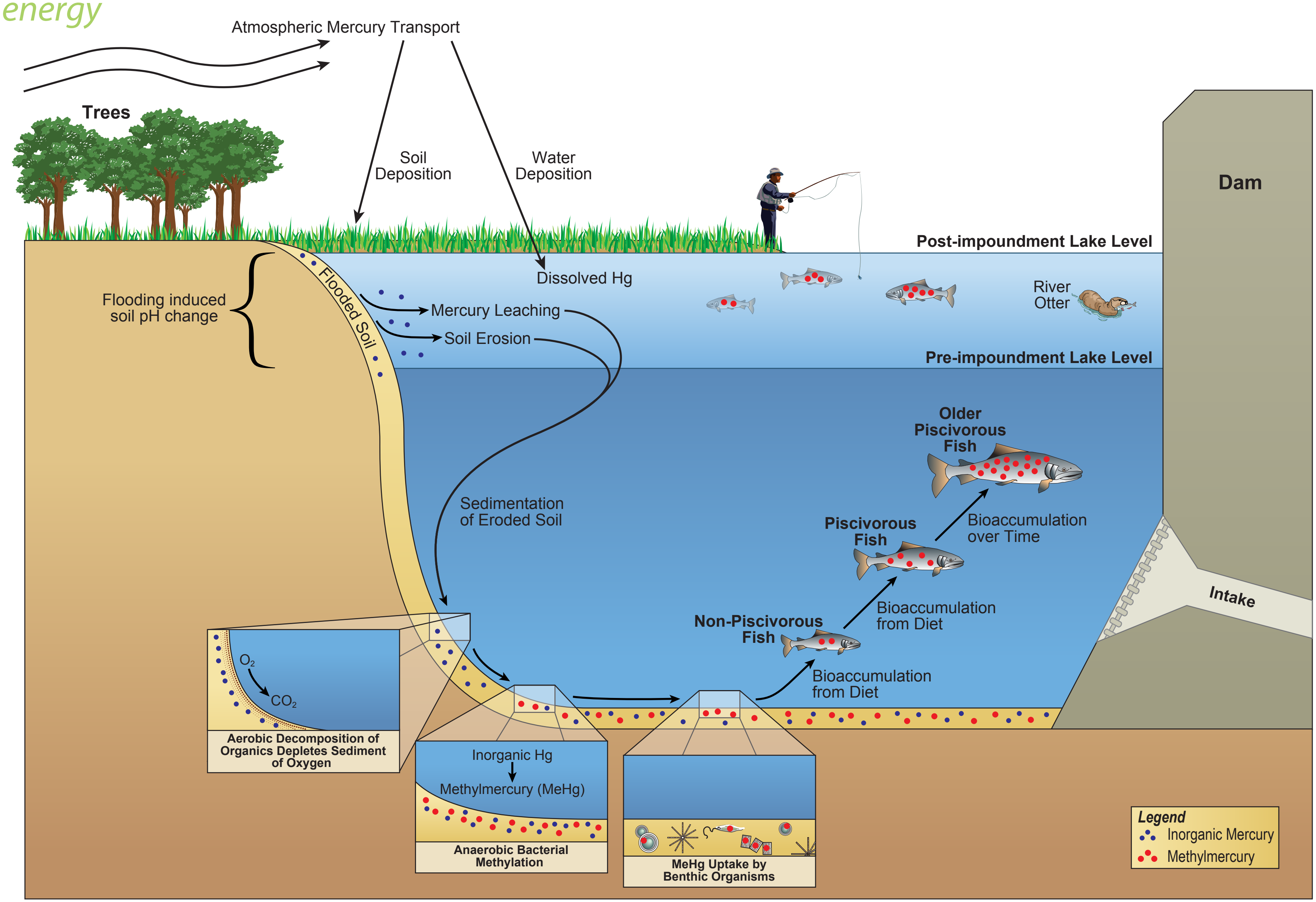
The following sections provide detail on the processes involved in mercury introduction into the environment, its movement through environmental and biological systems, potential toxic effects, and the guideline concentrations of mercury in aquatic systems and biological tissues.

13.5.2.1 Methylmercury Cycling in the Environment

Newly-constructed hydroelectric reservoirs are commonly associated with increased mercury concentrations in the water and sediments. Hydroelectric facilities do not directly generate mercury, but they alter the environment and redistribute existing mercury from terrestrial to aquatic systems. These environmental changes may also chemically modify inorganic mercury into methylmercury in newly-flooded areas. Mercury exists as various chemical compounds or species. Speciation of mercury largely determines its fate in the environment and its toxicity to organisms. Inorganic and metallic mercury species have low water solubilities and tend to associate with organic sediments and organic content in the water. They are poorly absorbed and are typically biologically unavailable to organisms and remain in the environment. Organic mercury species also have low water solubility, and associate with organic content in sediments, but they have a high affinity for biological tissues, particularly fatty tissues.

Figure 13.5.1 presents the conceptual model of methylmercury cycling in newly-flooded reservoirs. In this scenario, post-impoundment flooding induces changes in the soil pH, altering the metal-binding capacity of organic matter in soils. This facilitates the leaching of soil-bound mercury into the aquatic environment, which deposits as sediment. Soil erosion releases detritus into the water column, which also deposit as sediments. The influx of detritus in reservoir sediments promotes aerobic (oxygen consuming) decomposition of organic matter by microbes, which can reduce oxygen concentrations in the sediment layers and create a hypoxic environment. Hypoxic conditions in the sediment promote anaerobic bacterial methylation of inorganic mercury into methylmercury.

Methylmercury associates with sediments and can be ingested by sediment-dwelling organisms. It is absorbed by organisms about six times more efficiently than inorganic mercury, has low excretion rates, and is retained in biological tissues (Environment Canada 2004). Consequently, methylmercury can bioaccumulate in organisms at increasing trophic levels. The highest concentrations of methylmercury are generally present in higher trophic level organisms in the aquatic environment such as piscivorous fish (i.e. fish that consume other fish) or piscivorous aquatic mammals. Due to the low excretion rate of methylmercury, higher tissue concentrations are also found in older organisms within a species. Therefore, it is common to find older, larger piscivorous fish with high mercury concentrations even in undisturbed, pristine water bodies due to the accumulation of trace mercury concentrations over many years.



TALTSON
Hydroelectric Expansion Project

Developer's Assessment Report 2009

Conceptual Model of Methylmercury Cycling in Newly Flooded Reservoirs

(503-005 / a20718w-DAR)

Figure 13.5.1

Increased mercury levels in the water and sediment from newly-flooded soils generally peak between five to ten years after the initial flooding event and gradually decrease as the land undergoes transition from a terrestrial to aquatic environment (Dmytriw et al. 1995). The effect that flooding has on methylmercury decreases with time as the mercury-rich sediment layer is covered with new mercury-poor sediments. According to a study of reservoirs in temperate boreal forests, mercury levels in sediment reach a maximum five years after impoundment and gradually return to pre-impoundment concentrations (Abernathy and Cumbie 1977 and Cox et al. 1979). In northern boreal forests, such as those around Nonacho Lake, this process is slower, requiring 20 to 30 years (Bodaly et al. 1984; Canadian Dam Association 2007). The original hydroelectric project was constructed over 40 years ago, thus, levels in fish within the Taltson Basin are considered reflective of pre-impoundment levels.

Although the proposed Project would not flood any new terrestrial soils around Nonacho Lake, mercury previously released from soils in the original reservoir flooding in 1965 is still present in the deeper sediment layers. Increased variation in water levels associated with the Project Expansion may disturb these sediments and re-mobilize sediment-sequestered mercury into the water column.

13.5.2.2 FACTORS CONTRIBUTING TO ACCUMULATION

Many factors affect the distribution of mercury in surface waters such as basin size, land use/land cover, geology, soil properties, acid/base status and, climatic variables. Other factors such as stream discharge, redox conditions, and general water chemistry indices, which vary in both time (seasonal and short-term) and space can also affect the distribution of mercury in surface waters (Shanley et al. 2005).

The availability of methylmercury to reservoir biota is based on the ratio of flooded surface area to reservoir size (Shanley et al. 2005). Steep-sided reservoirs with organic-poor substrates can be expected to display less efficient methylmercury production, lower ambient methylmercury concentrations, and less bioaccumulation than reservoirs with wide basins and large littoral areas with high organic matter. In addition, the amount and type of wetlands in the littoral areas can affect methylmercury concentrations.

Watershed disturbance is a key factor that can mobilize total mercury and methylmercury in water. Most mercury species have low water solubility and saturates in the water column before reaching detectable levels. An increased level of dissolved organic carbon from watershed disturbance is correlated with increased levels of mercury in the water column due to mercury association with the organic fraction. Watershed disturbances may include high flow events, large fluctuations in water level from seasonal variations, or reservoir manipulation.

Water level fluctuation has been identified as a key variable in explaining elevated mercury concentrations in fish tissue (Verta et al. 1986). Several reservoir systems in the north-east United States illustrate the effects of water level manipulations. Mercury concentrations in loon tissue increased with greater reservoir fluctuations. In reservoirs with large draw-downs (>3 m), mercury concentrations in adult loon blood were significantly higher than in reservoirs with small draw-downs (<1 m) (Evers et al. 2007). Similar patterns in fish mercury concentrations have been documented in smallmouth bass and yellow perch. In Minnesota, dampening water-level fluctuations resulted in significantly improved fish concentrations (Sorensen et al. 2005).

In biological organisms, mercury accumulation is dependent on the trophic level of a species. Vegetation usually has the lowest concentration of mercury in its tissues due to the lack of adipose or fatty tissues. The main route of mercury intake is through the diet. Higher trophic level carnivores and piscivores consume more mercury than herbivorous animals because mercury accumulates in organisms and these higher trophic levels accumulate all the mercury from all prey consumed. However, within a species, considerable variations of mercury concentration are also detectable due to bioaccumulation over time. Older individuals in a species have higher detectable mercury concentrations relative to younger fish. Generally, older fish are correlated with larger body sizes. The relationship between body size and mercury concentration is exponential, hence, a large difference in mercury concentration is often seen between small and large fish. The differences in fish age, size and ecological importance are considered when predicting the effects of fish tissue concentrations on wildlife consumers and human consumers of fish tissue.

13.5.2.3 METHYLMERCURY TOXICITY

Methylmercury toxicity is a concern both for human and ecosystem health. The main exposure route to methylmercury is from the diet. Methylmercury can cross the blood-brain and placental barriers, allowing it to react directly with brain and fetal cells. It causes a wide range of symptoms in organisms, and affects the kidneys and neurological systems in particular. While low levels may not be directly lethal for individual organisms, toxicological effects such as impaired reproduction, growth, development, and learning ability, in addition to behavioural changes, can reduce fitness and survival (Environment Canada 2004).

High levels of mercury in fish have been observed in lakes and reservoirs with low ambient mercury concentrations in the water. This has led to an increased interest in the biomagnification of mercury in aquatic food chains. Because of the effect of bioaccumulation over time, older (and larger) fish tend to have higher tissue concentrations of methylmercury. Concentrations in older fish often exceed tissue residue guidelines, but are typically reflective of the organism size and age rather than mercury contamination in the environment.

13.5.2.4 CCME GUIDELINES

13.5.2.4.1 Water

Typically, methylmercury represents less than 10% of the total mercury in surface waters but can exceed 30% in disturbed systems (CCME 2007). Wetlands tend to have elevated levels of organic material, promoting bacterial methylation of mercury. The Canadian water quality guideline for total inorganic mercury is 0.000026 mg/L. The guideline for methylmercury is 0.000004 mg/L, which is 6.5 times lower than the total mercury guideline. However, the current commercial laboratory detection limit for total mercury is 0.00001 mg/L. Thus, the methylmercury guideline is lower than what can be detected. Due to the range of factors contributing to methylmercury production, there is no established relationship between inorganic and methylmercury concentration ratios in water bodies. Consequently, methylmercury concentrations cannot be extrapolated from inorganic mercury concentrations. For water concentrations, the CCME guideline for total mercury was used for comparison.

Water samples were collected in 2003 and 2004 in water bodies in Zones 1 to 4 and Nonacho Lake. The mercury concentration in all sampled water bodies in the Taltson Basin were below the detection limit of 0.00001 mg/L. No detectable changes to mercury concentrations in the water column were predicted from the proposed 36 MW and 56 MW upgrade scenarios (Section 13.4).

13.5.2.4.2 Tissue

The water guideline for mercury is considered protective of lower trophic level freshwater aquatic life (i.e. plankton and primary producers) against the adverse effects of direct exposure to mercury from water. However, the water guideline may not protect higher trophic level aquatic life because the primary mercury exposure route is through the diet rather than the water (Environment Canada 2003). Subsequently, in order to protect higher trophic levels of aquatic life, Environment Canada has developed a tissue residue guideline.

Environment Canada has developed a tissue residue guideline (TRG) for the protection of consumers of aquatic biota because diet (rather than water) is the most important route of mercury exposure and uptake for organisms higher in the food chain (Environment Canada 2002). These higher level organisms include fish (e.g. walleye and trout), piscivorous birds (e.g. loons and herons), and piscivorous mammals (e.g. mink and otters). The TRG is the concentration of methylmercury on a wet weight basis in aquatic organisms (i.e. fish and other aquatic biota) that is not expected to adversely affect the wildlife that consumes them. To protect all wildlife at a site, TRGs should be applied to the highest known aquatic trophic level.

The generic Environment Canada TRG is 0.033 mg/kg ww (wet weight). The TRG was derived by dividing the Tolerable Daily Intake (TDI) by the food intake rate to body weight ratio (FI:BW). In order for the TRG to be protective of all life stages of birds and mammals that consume aquatic organisms, the tissue residue guideline was derived using the highest mammalian and avian FI:BW ratios known for Canadian wildlife. For birds, the highest FI:BW is 0.94 for the Wilson's storm petrel and the TDI is 0.031 mg/kg. This results in a tissue residue guideline of 0.033 mg/kg diet ww. For mammals, the highest FI:BW is 0.24 for mink and the TDI is 0.022 mg/kg body weight per day. This results in a tissue residue guideline of 0.092 mg/kg diet ww. The Wilson's storm petrel tissue guideline is lower than the mink's; therefore, it was selected as the generic Canadian Tissue Residue Guideline for methylmercury.

For the TRG to be protective of all Canadian birds and mammals that consume aquatic life the lowest FI:BW ratio had to be used, which was based on the Wilson's storm petrel. However, Environment Canada recognizes that in areas where the Wilson's storm petrel is not found, the FI:BW of a resident wildlife species may be applied (Environment Canada 2002). Environment Canada provides a list of calculated reference concentrations (RCs) that can be used in place of the TRG when the Wilson's storm petrel is not present at the site.

The Wilson's storm petrel is a pelagic sea bird that does not occur within the Taltson Basin. Thus, an RC that is protective of species that actually occur in the Taltson Basin would be more applicable. The next lowest RC provided by Environment Canada is 0.051 mg/kg diet ww for the common tern (*Sterna hirundo*). The common tern's breeding ground overlaps with the Taltson Basin (Birds of North America Online 2007). As such, the common tern RC is the most applicable for the Taltson Basin. The RC of 0.051 mg/kg diet ww is selected as the site-specific reference concentration. It is considered to be protective of all birds and mammals that occur in the Taltson Basin.

Notably, the recommended methylmercury RC of 0.051 mg/kg diet ww is lower than most methylmercury concentrations that have been measured in sport fish from Canadian freshwaters (Environment Canada 2002). However, fish typically consumed by wildlife are much smaller, are from lower trophic levels, and have proportionately less mercury than their larger commercial sport fish counterparts. Subsequently, Environment Canada cautions about making inferences regarding risks to wildlife from mercury levels in large (>350 mm fork length) fish. Hence, the RC is applicable to fish below 350 mm fork length for the protection of aquatic wildlife consumers.

The tissue residue guideline set by Health Canada for commercially consumed fish is 0.5 mg/kg ww (Health Canada 2007). The fish sizes usually consumed by humans ranges considerably and includes >350 mm fork length for wildlife consumers. Maximum mercury concentrations in piscivorous fish in boreal reservoirs usually exceed the recommended level of 0.2 mg/kg ww for individuals consuming large quantities of fish (Wheatley 1984), as well as the Health Canada guideline. For example, northern pike of 700 mm fork lengths from 59 undisturbed lakes in northern Quebec had mean mercury concentrations ranging from 0.30 to 1.81 mg/kg ww (Schetagne and Verdon 1999).

Fish tissue exceeding the guideline does not necessarily pose a health risk because risk is also dependent on the quantity of fish consumed. To assess potential human health effects, the recommended maximum weekly intake (RMWI) can be determined. This would show if the consumption rates of these fish poses any health risks. Under these circumstances, Health Canada recommends limited consumption of six predatory fish species, which are tuna, swordfish, shark, escolar, marlin and orange roughy. Adults should limit consumption of these fish species and predatory fish in general to one meal per week, while young children and pregnant women should consume no more than one meal per month due to life-stage sensitivities.

Although inorganic mercury may exist in trace levels in tissues, it was assumed that 100% of detected mercury in tissues was methylmercury. This approach is conservative because it overestimates the amount of methylmercury, providing a worst-case estimate.

13.5.3 Existing Environment

The following section describes the existing mercury concentrations in fish collected from the Taltson Basin. Changes in tissue mercury concentrations have been shown to increase in piscivorous fish and return to baseline levels 20 to 30 years after initial reservoir impoundment. It has been over 40 years since the initial flooding of the Twin Gorges Forebay and exactly 40 years since the flooding of Nonacho Lake, thus any alterations to fish quality would have already occurred and returned to pre-impoundment levels. This is supported by evidence from the water effects monitoring program showing mercury concentrations in water, sediment, aquatic vegetation, and fish in Nonacho Lake to be similar to concentrations found at reference sites (Rescan 2003; 2004).

Fish tissue mercury concentration sampling was conducted at six water bodies within the Taltson Basin. The objective of the sampling was to collect and analyze fish tissue mercury concentrations in fish that may be consumed by humans and/or wildlife.

Mercury concentrations in fish increase with age, size, and trophic level. Humans typically consume larger fish than wildlife, and therefore fish >350 mm in fork length were used for human consumption comparisons (Rescan 2003; 2004).

Fish consumed by wildlife are younger and smaller (i.e. <350 mm) than those consumed by humans, and therefore do not bioaccumulate as much mercury. Fish that were <350 mm in fork length were compared to the site-specific RC of 0.051 mg/kg ww.

13.5.3.1 Ecological Relevance

Lake trout and lake whitefish were collected from Nonacho, Taltson, Gagnon, Rutledge, and Sparks lakes. Lake whitefish was also collected in the Twin Gorges Forebay. Gagnon, Rutledge, and Sparks lakes constitute the reference lakes for the study, because they are connected to the Taltson Basin system but do not experience any Project-related effects.

This section presents the baseline data for lake trout and lake whitefish that were less than 350 mm in fork length. Table 13.5.1 presents a summary of the mercury concentrations in lake trout and lake whitefish, along with a comparison of the data to the RC of 0.051 mg/kg ww.

13.5.3.1.1 Lake Trout

The average mercury concentrations in lake trout under 350 mm were above the site-specific RC in all water bodies, including the reference lakes. In general, the mercury concentrations in fish from each of the lakes were similar. Nonacho Lake had the highest average mercury concentration (0.1411 mg/kg ww), followed by Gagnon, Rutledge, and Sparks lakes (0.1240, 0.1067, and 0.0830 mg/kg ww, respectively). However, the small sample size from each lake inhibits a detailed interpretation of the tissue concentration trends. It is likely that these data represent natural variation among the lakes in the Taltson Basin.

Figure 13.5.2 presents the relationship between fork length and mercury concentration for sampled fish under 350 mm. The average fish fork length between lakes was similar. Among the reference lakes, there was not a strong relationship with fork length and mercury concentration. Because their youth and size preclude high mercury accumulation, a low relationship is expected.

13.5.3.1.2 Lake Whitefish

The average mercury concentrations in lake whitefish tissue from Gagnon and Nonacho lakes and the Twin Gorges Forebay were above the site-specific RC, and fish from Rutledge, Taltson, and Sparks lakes were below the site-specific RC (Table 13.5.1).

Figure 13.5.3 presents the relationship between fork length and mercury concentration for lake whitefish. All lake whitefish from the Twin Gorges Forebay were above the site-specific RC and showed a strong relationship between fork length and mercury concentration. In other lakes, this relationship was not present and similar ranges of mercury concentrations were measured among all fork lengths that were <350 mm. Further, lake whitefish from Twin Gorges Forebay had the lowest average fork length (170 mm), and the lowest average weight (62 grams) among all water bodies. It is unknown why smaller lake whitefish from the Twin Gorges Forebay have greater mercury concentrations than larger lake whitefish from other lakes as there have been no substantial changes to the aquatic system since the original impoundment.

Table 13.5.1 — Summary of Fish Below 350 mm Fork Length

Species	Water body	Number of Samples	FORK LENGTH (mm)			WEIGHT (grams)			MERCURY CONCENTRATION (mg/kg ww)			
			Maximum	Mean	Standard Error	Maximum	Mean	Standard Error	Maximum	Mean	Standard Error	Number of Exceedances[1]
Lake Trout	Gagnon Lake	20	347	272	9	448	228	22	0.2450	0.12399	0.00819	20
	Rutledge Lake	5	344	293	40	734	376	114	0.1820	0.10670	0.02286	4
	Nonacho Lake	7	344	297	15	412	273	40	0.2020	0.14114	0.01093	7
	Taltson Lake	1	243	243	n/a	139	139	n/a	0.1310	0.13100	n/a	1
	Sparks Lake	7	335	284	11	380	262	31	0.1420	0.08299	0.01406	5
Lake Whitefish	Gagnon Lake	19	345	229	14	557	161	33	0.2150	0.06782	0.00935	10
	Rutledge Lake	24	269	216	6	208	110	11	0.0868	0.03854	0.00320	2
	Nonacho Lake	6	330	226	35	386	168	62	0.0926	0.06775	0.00597	6
	Taltson Lake	17	346	254	14	545	233	39	0.0579	0.03744	0.00280	3
	Sparks Lake	8	320	265	10	419	218	32	0.0658	0.03750	0.00517	1
	Twin Gorges Forebay	33	230	170	6	139	62	6	0.1810	0.09916	0.00521	33

[1] Site-specific reference concentration for the protection of aquatic life = 0.051 mg/kg ww

Arctic and subarctic regions are environmental sinks for mercury from atmospheric transport and deposition (Ariya et al. 2004). Although the lake whitefish concentrations from the Twin Gorges Forebay were above the site-specific RC, the range of concentrations that were measured are typical of undisturbed Arctic and subarctic environments and represent baseline tissue concentrations in the Taltson Basin.

Notably, lake whitefish tend to accumulate less mercury in their tissues than lake trout. This was observed in this data set where the average accumulation for all lake trout and lake whitefish <350 mm collected was 0.11783 mg/kg ww and 0.06416 mg/kg ww, respectively.

13.5.3.2 HUMAN RELEVANCE

This section presents baseline data for lake trout and lake whitefish that were greater than 350 mm in fork length, which are more likely to be consumed by humans than smaller fish. Table 13.5.2 presents a summary of the mercury concentrations in lake trout and lake whitefish with a comparison of the Health Canada guideline of 0.5 mg/kg ww.

13.5.3.2.1 Lake Trout

The average mercury concentrations in lake trout that were >350 mm were below the Health Canada guideline in all water bodies. However, on an individual basis there were some exceedances for fish with larger fork lengths. Lake trout from Nonacho and Taltson lakes had higher average mercury concentrations (0.3955 and 0.3250 mg/kg ww, respectively) than Gagnon, Rutledge, and Sparks lakes (0.3137, 0.2443, and 0.1446 mg/kg ww). Only one lake trout was collected from Twin Gorges Forebay.

Figure 13.5.2 presents the mercury concentrations and fork lengths of lake trout >350 mm. More of the lake trout sampled in lakes in the Project area exceeded the Health Canada guideline than in the reference lakes, but they were also generally larger than the fish sampled there. Mercury concentrations above the guideline were noted among fish with fork lengths greater than 530 mm, except in the Twin Gorges Forebay where only one lake trout was collected. In reference lakes, mercury concentrations above the guideline were noted for fish with fork lengths above 730 mm fork length.

The range of mercury concentrations in fish tissue in the Taltson Basin lakes is similar to fish tissue concentrations in other lakes in the Canadian Arctic and subarctic. For example, mercury concentrations in lake trout from Stewart Lake, Northern Quebec, were found to contain an average mercury concentration of 0.59 ± 0.41 mg/kg ww at 394 ± 90 mm fork length (Power et al. 2002). Because mercury concentrations were occasionally above the guideline for lake trout with fork lengths above 530 mm, consumption of fish greater than this size should be limited, particularly for women of child-bearing age, infants, and children.

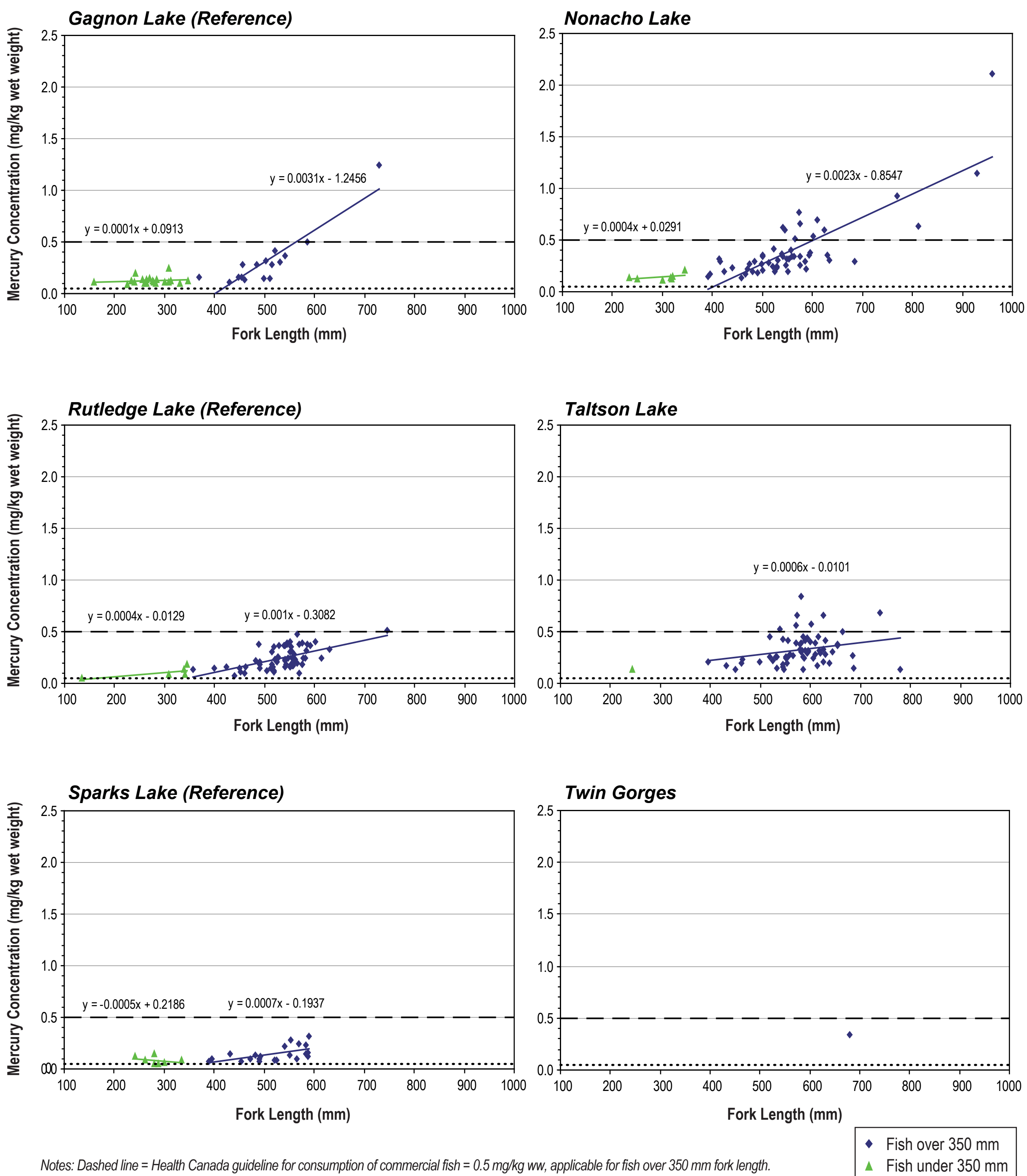
13.5.3.2.2 Lake Whitefish

All tissue samples of lake whitefish were lower than the Health Canada guideline for all water bodies. The highest average mercury concentrations for lake whitefish >350 mm were from Twin Gorges Forebay, Nonacho, and Gagnon lakes (0.1975, 0.1367, and 0.1076 mg/kg ww, respectively). Rutledge, Taltson, and Sparks lakes had the lowest concentrations (0.0812, 0.0791, and 0.0601 mg/kg ww, respectively).

Table 13.5.2 — Summary of Fish Above 350 mm Fork Length

Species	Water body	Number of Samples	FORK LENGTH (mm)			WEIGHT (grams)			MERCURY CONCENTRATION[1] (mg/kg ww)			
			Maximum	Mean	Standard Error	Maximum	Mean	Standard Error	Maximum	Mean	Standard Error	Number of Exceedances
Lake trout	Gagnon Lake	16	728	502	20	3,892	1,493	203	1.2500	0.31369	0.06853	2
	Rutledge Lake	65	745	535	7	4,035	1,650	62	0.5110	0.24430	0.01267	1
	Nonacho Lake	54	960	556	15	10,000	2,023	229	2.1100	0.39550	0.04235	12
	Taltson Lake	66	780	581	8	5,435	2,236	92	0.8400	0.32503	0.01808	7
	Sparks Lake	21	589	517	14	2,663	1,613	124	0.3220	0.14463	0.01592	0
	Twin Gorges Forebay	1	680	680	n/a	4,400	4,400	n/a	0.3430	0.34300	n/a	0
Lake whitefish	Gagnon Lake	15	566	463	23	2,511	1,387	188	0.2060	0.10765	0.01405	0
	Rutledge Lake	47	615	511	5	3,422	1,772	61	0.3560	0.08117	0.00861	0
	Nonacho Lake	56	585	512	6	2,977	1,831	60	0.4270	0.13671	0.00916	0
	Taltson Lake	53	598	510	8	3,100	1,924	91	0.2070	0.07913	0.00415	0
	Sparks Lake	26	571	506	10	2,387	1,753	95	0.1960	0.06013	0.00698	0
	Twin Gorges Forebay	2	600	575	25	3,518	3,020	498	0.2050	0.19750	0.00750	0

[1] Health Canada guideline for human consumption of commercial fish = 0.5 mg/kg ww



Notes: Dashed line = Health Canada guideline for consumption of commercial fish = 0.5 mg/kg ww, applicable for fish over 350 mm fork length.
Dotted line = Site-specific reference concentration for the protection of aquatic life = 0.051 mg/kg ww, applicable for fish under 350 mm fork length.

TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Mercury Concentration and Fork Length in Lake Trout (503-005 / a20726f)	Figure 13.5.2

Figure 13.5.3 presents the relationships between fork length and mercury concentration in lake whitefish. The average fork lengths of lake whitefish >350 mm were comparable between Project lakes and reference lakes, except for Twin Gorges Forebay. Only two lake whitefish were collected from the Twin Gorges Forebay and both were fairly large. This may not be representative of the true average mercury concentration in lake whitefish because of the small sample size.

13.5.4 Mercury Modelling in Fish Tissue

13.5.4.1 Introduction

This section describes the use of a mercury model to predict fish tissue concentrations resulting from the proposed Project upgrades.

For inorganic and biologically unavailable mercury to become organic and bioavailable, mercury methylation in aquatic sediments must occur. The availability of methylmercury to biota is based on the ratio of flooded surface area to lake size (Shanley et al. 2005). The proposed Project upgrades are not predicted to result in any additional flooded soils. However, water level variation in lakes and reservoirs has been identified as a variable in explaining elevated mercury concentrations in fish tissue (Sorenson et al. 2005). This study measured the mercury concentrations in young-of-the-year yellow perch from 14 lakes. Six of these lakes were influenced by two hydroelectric dams constructed in 1914 and 1909 and eight lakes were not influenced by hydroelectric dams. The data showed that mercury concentrations in yellow perch collected from both types of lakes correlated to water level fluctuations. A 12-year data set of perch tissue collected from one of the lakes, under the influence of the hydroelectric project, showed that summers with higher water levels correlated to years with higher mercury concentrations. This indicates that summer high-water levels are important, even though the higher levels may not be considered flooding. It may be that as the water levels rise, areas of increasing organic content are inundated, thus promoting increasing microbial activity responsible for methylmercury production (Sorenson et al. 2005).

In the proposed Expansion Project, annual water levels in Nonacho Lake would be more frequently closer to the existing minimum and maximum levels, and would disturb a larger surface area of the lake bottom compared to the existing water level regime due to the increased water level variation. The increases in water level variations (i.e. higher draw-downs and maximum water levels) would expose and disturb aquatic sediments that are environmental sinks for methylmercury. Methylmercury that has settled to lower sediment layers over time is sequestered away from the food chain. Sediment disturbance redistributes sediment-bound methylmercury back into the water column, making it available to small organisms; the mercury concentration can then rise through the food chain. Increases in water level variation caused by the Project compared to the current variation would disturb a greater surface area of the lake bottom. The disturbance in lake-bottom surface area relative to the total volume of the basin was considered the primary factor that could contribute to increases in mercury concentrations in fish tissue.

Methylmercury levels in fish tissue were predicted using a two-variable linear model developed by Johnston et al. (1991). The two variables were the per cent benthic disturbance (i.e. the additional lake benthic surface area exposed between the maximum and minimum water levels) and the lake benthic surface area to lake water volume ratio at the highest water level.

13.5.4.2 METHODS

The mercury model assumed that the redistribution of mercury from sediment disturbance would affect fish quality to the same degree as newly-flooded soils. Thus, the model is considered highly conservative as newly-flooded soils cause new mercury introduction into the aquatic system and greater mercury disturbance and accumulation compared to water level fluctuation changes.

Changes in mercury concentrations were modelled for lake trout and lake whitefish. Lake trout and lake whitefish were selected for use in the model because they are piscivorous, they are well-distributed in the study area, and were the species of focus in the environmental baseline studies.

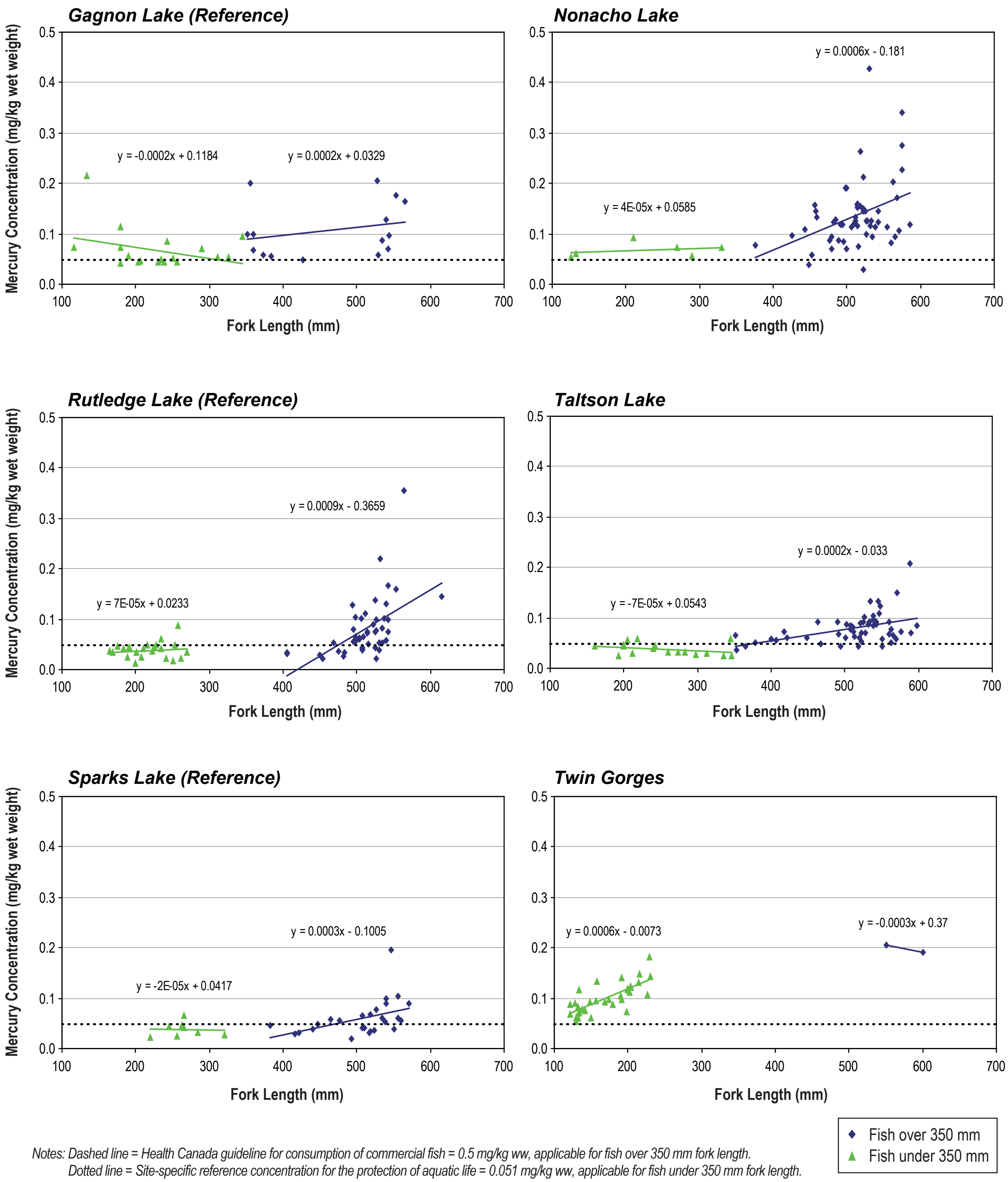
The modelling objective was to predict potential changes in the quality of fish that both wildlife and humans consume. The baseline study focused on the quality of fish that people consume; thus, the data set for baseline fish tissue is typically for fish larger than 200 mm, which is not necessarily representative of the size of fish consumed by wildlife. Mercury concentrations in lake trout and lake whitefish were predicted based on modelled water-level variations for the proposed 36 MW and 56 MW power output scenarios. The predicted concentrations were compared to the Health Canada guideline for human consumption of commercial fish and the site-specific RC for the protection of wildlife consumers.

Section 13.4 presented the predicted water-quality changes in the Taltson Basin regarding mercury concentrations (Zones 1 to 4 and Nonacho Lake). These predictions were based on the modelled changes to the hydrograph (Section 13.3). Nonacho Lake and Zone 1 (Taltson Lake) had greater potential for mercury increases. Subsequently, fish in Nonacho and Taltson lakes were selected for potential mercury bioaccumulation modelling. Mercury concentrations were not modelled for other lakes in the Taltson Basin because mercury changes in these lakes are expected to be minimal or undetectable.

13.5.4.3 MODEL INPUTS

The redistribution of sediment-bound methylmercury to biota is related to the ratio of the disturbed lake benthic surface area (i.e. the lake benthos that are submerged and exposed to the air at different times of the year) and the total water volume of the lake. Figure 13.5.4 presents the conceptual mercury model for fish tissue caused by water level-induced disturbance and redistribution of sediment-bound methylmercury.

The mercury model considers environmental factors (i.e. changes in water level variation and water volume in the lake) and biological factors (i.e. site-specific average mercury concentrations in fish) when predicting mercury concentrations in fish resulting from the proposed expansion upgrades. The following section describes the environmental and biological factors in more detail.



Notes: Dashed line = Health Canada guideline for consumption of commercial fish = 0.5 mg/kg ww, applicable for fish over 350 mm fork length.
Dotted line = Site-specific reference concentration for the protection of aquatic life = 0.051 mg/kg ww, applicable for fish under 350 mm fork length.

TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Mercury Concentration and Fork Length in Lake Whitefish** (503-005 / a20727f)	**Figure 13.5.3**

13.5.4.3.1 Environmental Factors

Using HEC-ResSim software described in Section 9.3, the lake characteristics were calculated for the mercury model. Total lake volume was calculated based on the maximum water level for Nonacho and Taltson lakes. The lake benthic area at a particular water level was calculated using the lake surface area (at maximum water level) and a calculated lake slope for Nonacho and Taltson lakes.

The HEC-ResSim software modelled daily water levels between 1978 and 1990 under the baseline conditions and the proposed 36 MW and 56 MW options to determine the average annual water level variation (i.e. the average annual maximum water level subtracted by the annual minimum water level). The average annual water level variation for each expansion option was used to calculate the surface area of the lake bottom that would be exposed when water levels were at a minimum. Under the expansion options, there would be increased water level variations compared to baseline conditions and a larger surface area of the lake bottom would be exposed compared to baseline conditions. The exposed area supporting benthic invertebrates under the 36 MW and 56 MW options was subtracted by the baseline area of exposed benthic invertebrates to determine the additional exposed area. The additional exposed benthos area was the disturbed surface area (DA) in the mercury model (i.e. the area that experiences submergence and exposure in coordination with storage and release of water at the Nonacho control structure). The DA was calculated for the 36 MW and 56 MW scenarios in Nonacho and Taltson lakes.

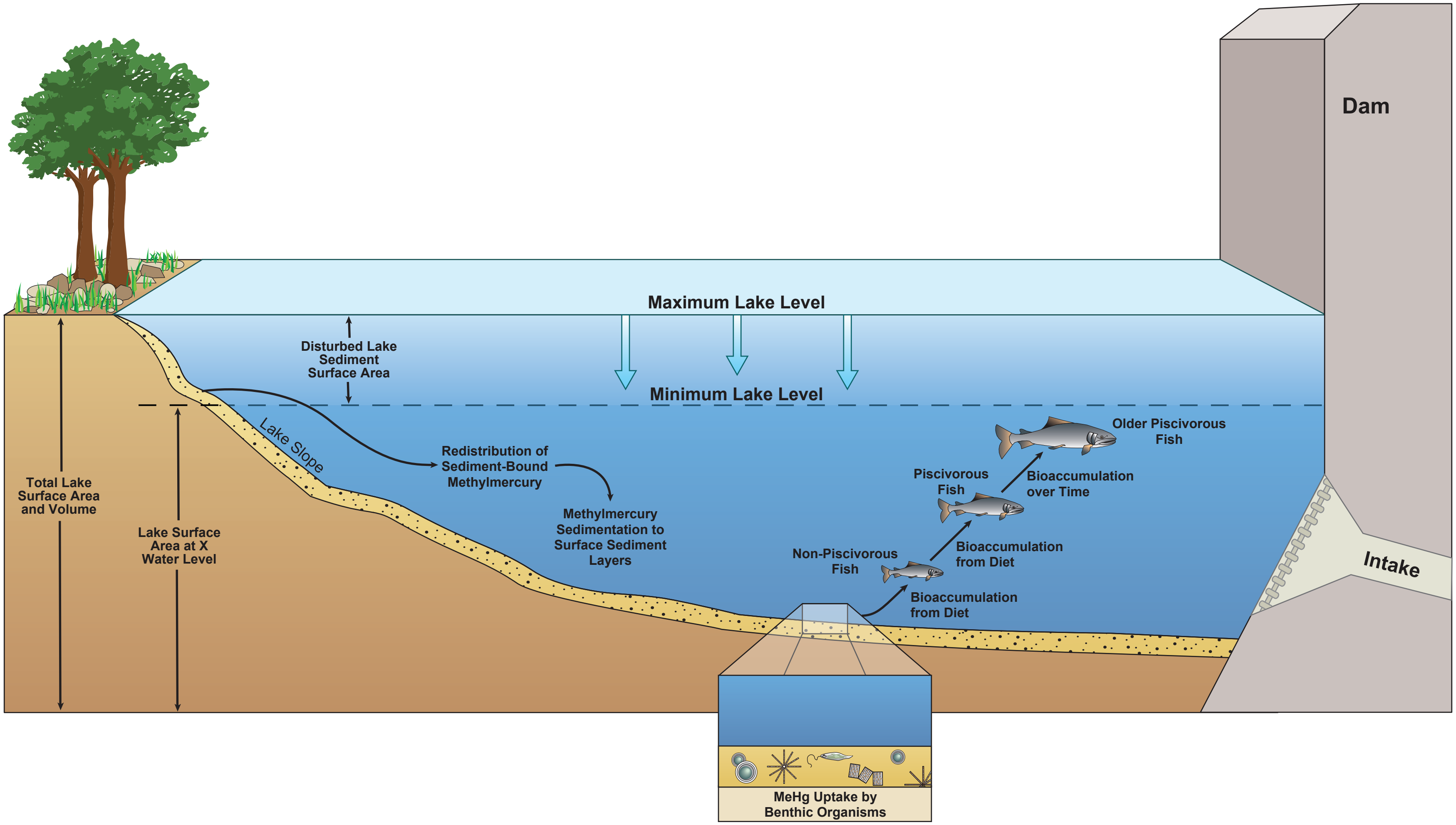
The total area (TA) is the total lake benthic surface area at the average annual maximum water level. The percent disturbed area (PDA) for each lake was calculated as:

$$\mathbf{PDA} = \frac{\mathbf{DA}}{\mathbf{TA}} \times \mathbf{100}$$

The total volume (VOL) is the lake capacity at the maximum water level. The model also considered mercury influx from Nonacho Lake into Taltson Lake. Upstream parameters are noted as upstream disturbed area and upstream total volume. Thus, Nonacho Lake would only experience in-lake effects, while Taltson Lake would experience in-lake effects and upstream effects from Nonacho Lake. The model also considers the dilution effect based on the DA and the volume of water in the lake to give an area-to-volume ratio (AVR). The AVR was calculated for each lake as:

$$\mathbf{AVR} = \frac{\mathbf{DA}}{\mathbf{VOL}}$$

To account for mercury influx from Nonacho Lake into Taltson Lake, the PDA and AVR of Nonacho Lake were redefined as upstream percent disturbed area (UPDA) and upstream area to volume ratio (UAVR).



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Conceptual Model of Water Level-Induced Methylmercury Redistribution (503-005 / a21360f)	Figure 13.5.4

13.5.4.3.2 Biological Factors

In addition to environmental factors, biological factors such as the existing mercury concentrations in lake trout and lake whitefish were used as a baseline. To reduce variations between fish and size, the body burden of mercury per fish, rather than tissue concentration, was used in the mercury model. The body burden is the total amount of mercury in a fish, regardless of age, size, or weight. The average mercury body burden (MERC) is the product of the average fish wet weight and average mercury concentration.

13.5.4.3.3 Calculation

To calculate the MERC for each fish species, a two-variable linear regression model was used. The two-variable linear models for MERC were calculated as:

$$MERC_i = b_0 + b_1X_1 + b_2X_2 + \varepsilon$$

Where: $MERC_i$ = predicted mean mercury burden of species *i*.

- X_1 and X_2 = lake environment factors, PDA/UPDA or AVR/UAVR.
- b_0 = baseline MERC for species *i*.
- b_1 and b_2 = species-specific independent fitted parameters for the mercury model suggested by Johnston et al. (1991) for lake whitefish. The model did not examine independent fitted parameters for lake trout. Consequently, the values for lake whitefish were used for both fish species.

Applying the mercury model to predict concentrations in Taltson Basin fish is considered a conservative approach. Based on the HEC-ResSim modelling, the annual peak water levels may be higher than the baseline for years with high precipitation because this water would be stored in Nonacho Lake. However, the absolute maximum water level (i.e. the highest water level ever reached during the 13-year modelling period) in Nonacho Lake under the proposed 36 MW and 56 MW scenarios would not exceed baseline absolute water levels since a greater water demand is required at the Twin Gorges power facility to maintain the higher power generation. Hence, Nonacho Lake would experience no new inundation of terrestrial soils. Therefore, an influx of mercury from the soil into the aquatic environment is not expected; only existing mercury in disturbed sediments may be redistributed in the water.

A sample calculation of the mercury model is presented below for lake trout in Nonacho Lake under the 36 MW scenario:

Scenario: Lake Whitefish <350 mm for Nonacho Lake at 36 MW

b_0	= 11.3955	Based on mean weight = 168.2 grams
b_1	= 0.85	Johnston et al (1991)
b_2	= 0.60	Johnston et al (1991)
X_1	= 1.9144	PDA
X_2	= 4.32×10^{-3}	AVR
$MERC_i$	= 11.3955 = (0.85 x 1.9144) + (0.60 x [4.32×10^{-3}])	
	= 13.0253	

Predicted mercury concentration	= $MERC_i$ / mean weight
	= 13.0253 / 168.2 g
	= 0.07744 mg/kg ww

13.5.5 Results and Discussion

The mercury model was based on the relationship between fish mercury concentration, the percentage of disturbed lake area (PDA), and the disturbed area-to-lake volume ratio (AVR). Predicted mercury concentrations for lake trout and lake whitefish were calculated based on the proposed 36 MW and 56 MW scenarios in Nonacho and Taltson lakes. The model predicted mercury concentration increases relative to measured baseline concentrations. The modelled mercury concentrations represent the concentration increases for fish <350 mm (for wildlife consumers) and >350 mm (for human consumption). The baseline fish characteristics (i.e. length and weight) were presented in Table 13.5.2.

The following section presents the model input parameters and predicted concentrations for lake trout and lake whitefish under each option.

13.5.5.1 36 MW Option

Table 13.5.3 presents the environmental input parameters of Nonacho and Taltson lakes under the 36 MW options. In Nonacho Lake, the variation in annual water level would increase by 0.50m. Water level change would affect an additional 91% (PDA) lake surface area. The total water volume of Nonacho Lake is 3.8 billion m^3.

Table 13.5.3 — Mercury Model Input Parameters for 36 MW

Parameter	Nonacho Lake[1]	Taltson Lake
Lake Slope	5.85°	3.92°
Increase in Water Level Variation	0.50 m	0.21 m
Disturbed Area (DA)	16.5 km^2	0.7 km^2
Total Area (TA)	863.9 km^2	77.9 km^2
Percent Disturbed Area (PDA)	1.9144%	0.8470%
Upstream Disturbed Area (UDA)	n/a	16.5 km^2
Upstream Total Area (UTA)	n/a	863.9 km^2
Upstream Per cent Disturbed Area (UPDA)	n/a	1.9144%
Lake Volume (VOL)	3,822,858,600 m^3	243,700,500 m^3
Disturbed Area to Volume Ratio (AVR)	4.32×10^{-3}	2.71×10^{-3}
Upstream Volume (UVOL)	n/a	3,822,858,600 m^3
Upstream Disturbed Area to Volume Ratio (UAVR)	n/a	4.32×10^{-3}

[1] = Nonacho Lake does not experience upstream mercury effects

n/a = Not applicable

In Taltson Lake, the variation in annual water level would increase by 0.21 m, for a total additional disturbed area of 0.7 km^2 compared to a total lake area of 77.9 km^2. Water level changes would affect an additional 0.84% (PDA) lake surface area. The total lake volume of Taltson Lake is 243 million m^3.

Table 13.5.4 presents the measured baseline and modelled mercury tissue concentrations of lake trout and lake whitefish collected from Nonacho and Taltson lakes. Tissue concentrations were modelled for the average fish fork length <350 mm and >350 mm.

Table 13.5.4 — 36 MW: Modelled Mercury Concentrations

Fish Species	FISH UNDER 350 mm		FISH OVER 350 mm	
	Average Baseline Mercury Concentration (mg/kg ww)	Predicted 36 MW Average Mercury Concentration (mg/kg ww)	Average Baseline Mercury Concentration (mg/kg ww)	Predicted 36 MW Average Mercury Concentration (mg/kg ww)
Nonacho Lake				
Lake trout	0.14114	0.14712	0.39550	0.39589
Lake whitefish	0.06775	0.07744	0.13671	0.13714
Taltson Lake				
Lake trout	0.13100	0.13103	0.32503	0.32503
Lake whitefish	0.03744	0.03747	0.07913	0.07913

13.5.5.1.1 Fish <350 mm

Fish that were <350 mm in fork length were modelled and compared to the site-specific guideline of 0.051 mg/kg ww. There would be a small increase in the average mercury concentration for both lake trout and lake whitefish. For lake trout and lake whitefish, the modelled increase in mercury concentration was small compared to the total measured concentrations for fish <350 mm at baseline.

In Nonacho and Taltson lakes, all lake trout collected were above the site-specific RC for the protection of aquatic life under baseline conditions. The modelled mercury concentration under the 36 MW scenario would increase from 0.14114 mg/kg ww to 0.14712 mg/kg ww in Nonacho Lake and 0.13100 mg/kg ww to 0.13103 mg/kg ww in Taltson Lake. This increase would be slightly above the laboratory detection limit, and account for <0.01% of the total mercury relative to the baseline concentrations. The ecological effect would be low or undetectable.

For lake whitefish, the modelled mercury concentration would increase from 0.06775 mg/kg ww to 0.07744 mg/kg ww (14.3% increase). The higher per cent increase is due to the smaller average weight of lake whitefish in Nonacho Lake. In Taltson Lake, the mercury concentration would increase from 0.03744 mg/kg ww to 0.03747 mg/kg ww (0.08% increase). Lake whitefish in Nonacho Lake were above the site-specific RC under baseline conditions and the modelled increase would be negligible compared to the total mercury concentration. For lake whitefish in Taltson Lake, the increase in average mercury concentration may be above the detection limit, but would not be distinguishable from the variation of concentrations in the fish. The average predicted concentration would still be below the site-specific RC of 0.051 mg/kg ww and similar to the surrounding reference lakes.

13.5.5.1.2 Fish >350 mm

Fish that were >350 mm in fork length were modelled and compared to the Health Canada guideline of 0.5 mg/kg ww for human consumption (Table 13.5.4). No measurable changes would be detected for lake trout and lake whitefish in Taltson Lake.

Under baseline conditions, lake trout that were >530 mm in Nonacho lakes were occasionally above the Health Canada guideline. The modelled increases in Nonacho Lake fish would be negligible relative to the baseline mercury concentrations. Mercury concentration in lake trout would increase from 0.39550 mg/kg ww to 0.39589 mg/kg ww (<0.10% increase), and from 0.13671 mg/kg ww to 0.13714 mg/kg ww (0.31% increase) in lake whitefish. Baseline mercury concentrations in larger lake trout occasionally exceeded the guideline. Lake trout that are >530 mm would continue to exceed the guideline. Therefore, it is recommended that consumption of lake trout that are >530 mm be limited, particularly for infants, children, and women of child-bearing age.

13.5.5.2 56 MW Option

Table 13.5.5 presents the environmental input parameters of Nonacho and Taltson lakes under the 56 MW option. Under this option, there would be less exposed lake benthos area from changes in water level variation compared to the 36 MW scenario. Modelled increases in fish tissue concentrations would be less than the 36 MW scenario.

Table 13.5.5 — Mercury Model Input Parameters for 56 MW

Parameter	Nonacho Lake[1]	Taltson Lake
Lake Slope	5.85°	3.92°
Increase in Water Level Variation	0.24 m	0.09 m
Disturbed Area (DA)	7.9 km^2	0.3 km^2
Total Area (TA)	847.4 km^2	77.4 km^2
Percent Disturbed Area (PDA)	0.9368 %	0.3632 %
Upstream Disturbed Area (UDA)	n/a	7.9 km^2
Upstream Total Area (UTA)	n/a	847.4 km^2
Upstream % Disturbed Area (UPDA)	n/a	0.9368 %
Lake Volume (VOL)	3,822,858,600 m^3	243,700,500 m^3
Disturbed Area to Volume Ratio (AVR)	2.08×10^{-3}	1.15×10^{-3}
Upstream Volume (UVOL)	n/a	3,822,858,600 m^3
Upstream Disturbed Area to Volume Ratio (UAVR)	n/a	2.08×10^{-3}

[1] = Nonacho Lake does not experience upstream mercury effects

n/a = Not applicable

Under the 56 MW option, in Nonacho Lake, the variation in annual water level would increase by 0.24 m. An additional lake area of 7.9 km^2 would experience water level disturbance relative to the total lake area of 847.4 km^2. Water level changes would affect an additional 0.94% (PDA). The total water volume of Nonacho Lake is 3.8 billion m^3.

In Taltson Lake, the variation in annual water levels would increase by 0.09 m from baseline, for a total additional disturbed area of 0.3 km^2 compared to a total lake area of 77.4 km^2. Water level changes would affect an additional 0.36% (PDA) of lake benthic surface area. The total lake volume of Taltson Lake is 244 million m^3.

13.5.5.2.1 Fish <350 mm

Table 13.5.6 presents the measured baseline and modelled mercury tissue concentrations of lake trout and lake whitefish that were <350 mm. The modelled tissue concentrations were compared to the site-specific RC of 0.051 mg/kg for the protection of aquatic life.

Table 13.5.6 — 56 MW: Modelled Mercury Concentrations

Fish Species	FISH UNDER 350 mm		FISH OVER 350 mm	
	Average Baseline Mercury Concentration (mg/kg ww)	Predicted 56 MW Average Mercury Concentration (mg/kg ww)	Average Baseline Mercury Concentration (mg/kg ww)	Predicted 56 MW Average Mercury Concentration (mg/kg ww)
Nonacho Lake				
Lake trout	0.14114	0.14407	0.39550	0.39589
Lake whitefish	0.06775	0.07249	0.13671	0.13714
Taltson Lake				
Lake trout	0.13100	0.13101	0.32503	0.32503
Lake whitefish	0.03744	0.03746	0.07913	0.07913

Under the 56 MW option, fish from Nonacho Lake and Taltson Lake would experience a small increase in average mercury concentration, which would be several magnitudes smaller than the total mercury concentration that was measured under baseline conditions. Fish that are currently above the site-specific RC would continue to be above the guideline, experiencing small increases relative to the total mercury concentration. Fish that were under the site-specific RC would continue to be below this level.

In Nonacho Lake, lake trout concentrations increased from 0.14114 mg/kg ww to 0.14407 mg/kg ww (2.1% increase), while lake whitefish increased from 0.06775 mg/kg ww to 0.07249 mg/kg ww (7.0% increase).

In Taltson Lake, the modelled mercury concentrations would be within the concentration variation. Lake trout would increase from 0.13100 mg/kg ww to 0.13101 mg/kg ww (<0.01% increase), and lake whitefish would increase from 0.03744 mg/kg ww to 0.03746 mg/kg ww (0.05% increase).

13.5.5.2.2 Fish >350 mm

Fish that were >350 mm in fork length were compared to the Health Canada guideline of 0.5 mg/kg ww for human consumption. Under the 56 MW scenario, there would be less disturbed lake area compared to the 36 MW scenario. The effect on mercury concentrations in Taltson Lake would be undetectable (i.e. < 0.00001 mg/kg ww) for both fish species.

Average concentration in Nonacho Lake would increase by a small amount relative to the total mercury concentration. The modelled average concentration would increase from 0.39550 mg/kg ww to 0.39589 mg/kg ww (0.1% increase), while lake whitefish would increase from 0.13671 mg/kg ww to 0.13714 mg/kg ww (0.3% increase).

Under baseline conditions, lake trout that were >530 mm in Nonacho and Taltson lakes were occasionally above the Health Canada guideline. Lake trout >530 mm would continue to exceed the guideline. It is recommended that consumption of lake trout that are >530 mm be limited, particularly for infants, children, and women of child-bearing age.

13.5.6 Uncertainty

The process of modelling fish tissue concentrations involves multiple steps. Each step has an inherent uncertainty associated with it that affects the final predicted fish concentration. These uncertainties may include data gaps such as insufficient sample sizes, and assumptions made for the mercury model such as environmental characteristics. These uncertainties may result in the under- or over-estimation of mercury concentrations in fish tissue. The following section describes the key uncertainties associated with the mercury model and the associated predictions.

13.5.6.1 Baseline Mercury Body Burden

The baseline mercury body burden is an unweighted average, defined as b_0 in the mercury model. It reflects all fish weights and mercury concentrations that were collected from each lake. Ideally, equal numbers of fish from a representative range of fish sizes would be used to calculate the mean concentrations. Thus, if there were equal numbers of fish from a representative range of fish sizes there would be less uncertainty in the calculated means.

The range of fish fork length sizes collected from Taltson Lake was better distributed than in Nonacho Lake for lake whitefish. However, there were relatively few lake trout that were <350 mm, while the majority were >350 mm. In Taltson Lake, only one lake trout <350 was collected among a total of 67. Taltson Lake may naturally contain larger-sized lake trout, which is typical of biological sampling because populations are not always homogenous or distributed evenly.

The uncertainties with the baseline mercury body burden would affect the initial baseline MERC (b_0), but not enough to significantly change in the modelled MERC, because it was calculated from independent environmental parameters of the water bodies (i.e. PDA, AVR).

13.5.6.2 Water Levels and Surface Area

The predicted changes to methylmercury concentrations in fish tissue were based on modelled water levels and flows. The uncertainties associated with the model are described in Section 13.3. The uncertainties associated with the HEC-RAS hydrological model may affect the predicted mercury concentrations. The mercury model measured percent disturbed area (PDA) of each lake, which was calculated from the average annual water level variation. This parameter was calculated from the annual maximum and minimum water levels during the 13-year simulation period. Uncertainties in the annual maximum and minimum water levels would affect the amount of lake benthos surface area that would experience disturbance from exposure and submergence.

13.5.6.3 Mercury Model

It is noted that other mercury models exist to predict fish tissue concentrations. For example, the Mercury Cycling Model (MCM) was developed as part of the Mercury and Temperate Lakes Program sponsored by the Wisconsin Department of Natural Resources (Hudson et al. 1994) and has been employed in various methylmercury models in the Great Lakes. However, this model is much more complicated and requires a lot more data than what was available for this assessment. For example, the MCM examines the partitioning of different mercury species (e.g. elemental, divalent and methylmercury), water and mercury inflows, wet and dry mercury deposition from the atmosphere and precipitation, physical parameters (e.g. water pH, dissolved oxygen, sediment particle size), and biological factors (e.g. phytoplankton biomass), in addition to other parameters. The MCM was applied to the Great Lakes, which is a major water body for commercial and industrial use, where a much larger quantity of environmental research data has been conducted (Leonard et al. 1995).

The mercury model used in the Taltson Basin assessment was developed as a practical model (Johnston et al. 1991). The mercury model does not include the range of factors that the MCM considers such as food chain effects, water and sediment mercury chemistry, and atmospheric mercury influx to the system. However, such considerations are important for environments such as the Great Lakes, where substantial industrialization of the area increases anthropogenic mercury inputs. The mercury model used in the Taltson Basin assessment is considered accurate for hydroelectric projects with minimal or no substantial industrialization or direct anthropogenic mercury introduction because the environment is less dynamic and variable.

The mercury model also provided species-specific independent variables (i.e. b_1 and b_2) for fish species. Of the species modelled by Johnston et al. (1991), only lake whitefish was present in the Taltson Basin. Independent variables were not available for lake trout. Consequently, the values for lake whitefish were applied for both fish species. The applicability of this value for lake trout is not known. Although independent variables are provided for other species such as northern pike and walleye, these species are primarily piscivorous and they naturally have a greater potential to bioaccumulate mercury (i.e. the independent variables were 10 to 30 times greater than for lake whitefish). The diets of lake trout and lake whitefish are similar (i.e. small invertebrates at juvenile life stages, small fish at adult stages) and the independent variable for lake whitefish is considered the most appropriate value for lake trout.

13.5.7 Summary

Overall, the baseline mercury concentrations in fish from Nonacho and Taltson lakes are similar to the reference lakes. The reference lakes have not experienced any effects from the current hydroelectric project and would not experience any effects from the proposed expansion. Currently all fish in each of the lakes are considered baseline conditions of natural pristine subarctic lakes. Fish in other remote northern water bodies in Canada have similar ranges of mercury concentrations for lake trout and lake whitefish (Stephens 1995).

Typically, new reservoirs increase water levels by several metres and flood a large terrestrial surface area compared to the proposed Expansion Project. Under the two expansion scenarios, the absolute maximum water level would not exceed the levels experienced under baseline conditions. Variation in annual water level would increase; however, there would be no flooding of new soils, only the potential for redistribution of existing mercury in lake sediments.

The following presents a summary of the model predictions for changes in tissue concentrations in lake trout and lake whitefish in Nonacho and Taltson Lakes under both expansion scenarios.

13.5.7.1 36 MW Summary

The modelled mercury concentrations under the 36 MW scenario would experience a low increase in the average mercury concentration for fish in Nonacho Lake, but undetectable or near undetectable changes in Taltson Lake. The modelled increase for <350 mm fish in Nonacho Lake would represent a small increase relative to the average baseline concentration.

For fish >350 mm, modelled increase in average mercury concentration would not be detectable for fish in Taltson Lake, with a small increase in Nonacho Lake (0.31% maximum). Lake trout that are >530 mm would continue to exceed the Health Canada guideline, which is commonly seen in larger fish due to bioaccumulation over time. Mercury concentrations in these lake trout would be similar to the surrounding reference lakes at equivalent fork length sizes. Consumption of lake trout >530 mm should be minimized by all people. Lake whitefish would be below the guideline for all fish sizes.

13.5.7.2 56 MW Summary

Under the 56 MW scenario, there would be less effect to mercury concentrations in fish compared to the 36 MW scenario. The modelled increase would be detectable in lake whitefish from Taltson Lake <350 mm because these fish experience in-lake and upstream lake effects. The mercury concentration would increase from 0.03744 to 0.03746 mg/kg ww. This concentration would be below the site-specific reference concentration (RC). In Nonacho Lake, lake whitefish <350 mm would experience the highest per cent increase (7%). The net increase is relatively small.

The concentration in lake whitefish in Nonacho Lake and lake trout in both lakes that were <350 mm had average mercury concentrations exceeding the site-specific RC at baseline levels. Under the expansion scenario, no detectable increases would occur and there would be no measurable ecological effect.

For fish sizes that were >350 mm, the modelled mercury concentration increases above baseline for lake trout and lake whitefish in Taltson Lake were lower than the detection limit. Small increases up to 0.3% were modelled in Nonacho Lake.

For larger fish, baseline maximum concentrations exceeded the human health guideline for lake trout >530 mm, they would be representative of baseline conditions, and similar to reference lakes for equivalent-sized fish. Consumption of lake trout >530 mm should be minimized by all people. Lake whitefish would be below the guideline for all fish sizes.

13.5.8 Future Monitoring

The 36 MW and 56 MW scenarios would not flood any new terrestrial surfaces, and only increase the disturbance of a small area of mercury-bound sediments at the lake bottom. This would only redistribute existing mercury in the aquatic system, rather than introducing new mercury from the surrounding soils. Any potential increase in mercury concentrations in fish tissue from the expansion scenarios would not be observed in fish tissue until at least five to ten years following the upgrades. However, based on the predicted increases in mercury concentrations for average-sized fish <350 mm, effects from the Expansion Project would be negligible or within the natural variation of mercury concentrations. As such, no monitoring of fish mercury levels is recommended at this time.

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

13. WATER FLUCTUATIONS IN THE TALTSON RIVER WATERSHED

13.6 ALTERATION OF ICE STRUCTURE

13.6.1 Introduction

The potential for alteration to river and lake ice formation, structure, and strength caused by the proposed upgrades to the Twin Gorges facility, and the proposed changes to the structure and operation of Nonacho Lake dam has been identified as an issue of concern. In the NWT, ice crossings of lakes and rivers can be important transportation corridors for wildlife and humans. Changes to ice structure that might affect the viability of these crossings would be considered an adverse effect on the area.

This section provides a qualitative discussion of potential changes to ice structure within the Taltson River Basin. To make quantitative estimates of changes to ice structure at critical sites (i.e. important winter crossing points) more extensive, site-specific work would be required. This work would include field visits and measurements at key crossing sites. If necessary, numerical models could be initiated to simulate winter ice effects at specific reaches both with and without the operational changes associated with plant expansion.

13.6.1.1 Ice Freeze-up Process

In a typical northern river, an ice cover would begin to form with the onset of cool winter temperatures. The nature of the cover would vary with location and water velocity, but generally can be described as either a smooth “lake ice” or a rougher more dynamic “river ice.” In general, ice cover on lakes forms earlier and breaks up later than river ice. The thickness of river ice is more variable than lake ice because of the dynamic nature of river ice formation and transportation. Because of the differences in ice formation processes, ice cover on lakes is often relatively unaffected by changes in water level, while river ice can be broken up by changes in water level and flow conditions Ashton (1986). For the Taltson River, the winter period extends from October through April of the following year, and the primary ice formation period is considered to last from October through to mid- or late December.

13.6.1.1.1 Lake Ice Formation

Lake ice usually forms in areas of very low velocity such as lakes or deep, slow-moving river sections. It forms when cold air temperatures cool the water surface to freezing at the beginning of the winter. As the air temperatures drop, the water temperature at the surface of the lake gradually decreases. When the water at the lake surface reaches 4 °C (when water is at its most dense) the lake turns over. This process is repeated until the entire lake reaches 4 °C. Once this uniform temperature has been reached, the surface water temperature cools until a stable, lighter layer of water is formed at the surface. This surface water cools further until a layer of ice forms on its surface. Ice crystals grow downward into the water column and the heat of crystallization is conducted upwards through the existing column. This ice cover is referred to as thermal ice.

Thermal ice cover on a lake generally forms as a continuous sheet over the complete surface of the lake. The formation of the initial thin layer of thermal ice is often associated with a calm, cold night. This type of ice cover forms very quickly, often within the span of a single night, and grows steadily in thickness with time. The thickness of lake ice is primarily governed by air temperature and the depth of snow cover on the ice. The presence of snow would insulate the ice cover, and result in a thinner thermal growth. If the snow cover becomes excessively deep, it can weigh the ice cover down causing it to sink below the water surface. This can cause cracks to form in the ice, allowing water to flood over the ice surface creating “slush” on the lake. Lake ice formation can be further complicated if the presence of wind causes the initial ice surface to break apart and drift within the lake.

The lake outlets and inlets also cause increased complexity. Open water zones or “leads” can form at the outlets and inlets of lakes because of increased flow velocities. The lake inlets can also show evidence of accumulation and juxtaposition ice as drifting ice is carried from upstream river reaches into the lake and is incorporated into the lake ice cover.

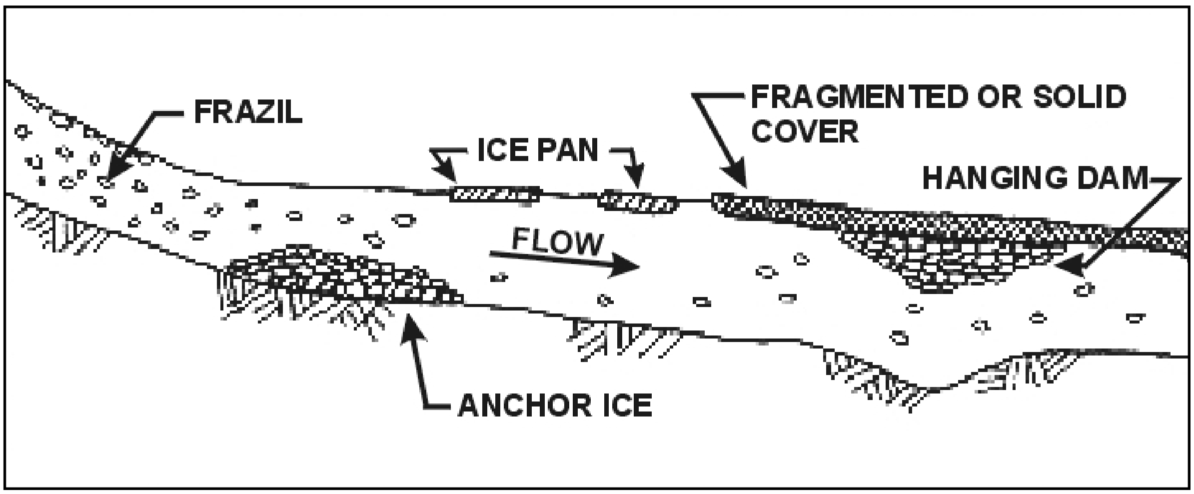
13.6.1.1.2 River Ice Formation

In more swiftly moving sections of a river, the nature of the ice cover would be significantly different. In these areas, the cover would evolve based on four basic processes, as depicted in Figure 13.6.1 below:

- ice generation,
- border ice formation,
- ice front progression and formation of hanging ice dams, and
- anchor ice formation.

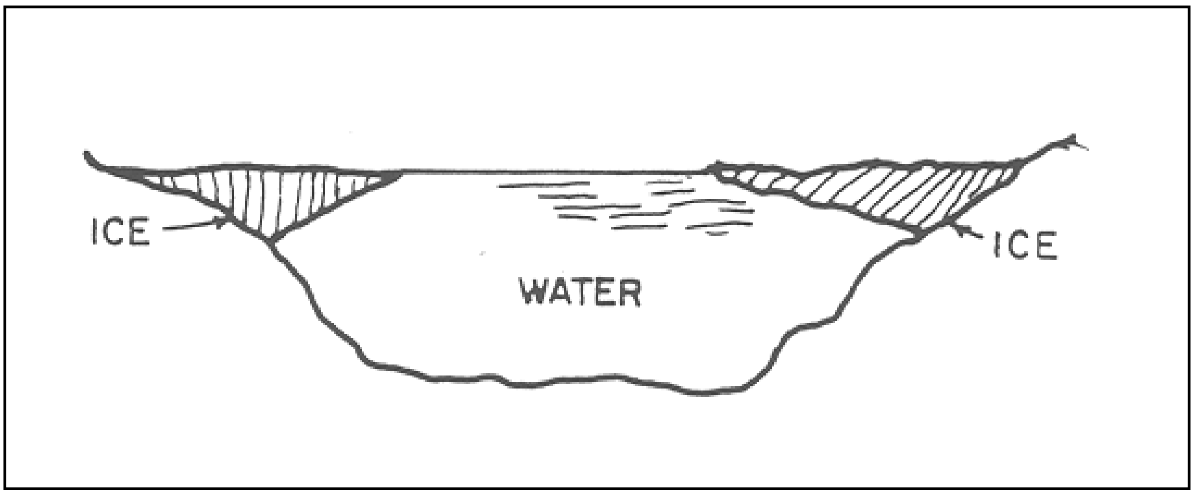
Thermal ice is first to form in slow-moving, non-turbulent areas (lakes, bays, and backwaters). In rivers, thermal ice first forms along the banks where the velocity is low. This border ice progresses slowly out from each bank towards the centre of the river. Lateral growth rates are sometimes augmented as drifting ice pans attach to the shorefast ice. Throughout the winter, border ice would continue to grow by these processes, gradually reducing the area of open water. In particularly low velocity locations, the border ice forming along each shore may eventually grow together, creating an ice bridge and hence an ice front against which drifting ice floes can begin to accumulate. The extent of border ice formation is governed by the flow velocity, river geometry, and winter temperatures. Figure 13.6.2 illustrates a typical border ice growth formation.

As air temperatures decrease, ice particles start to form in the remaining open water areas, where the streams are flowing too fast to allow a thermal ice cover to form. This mobile ice develops first as frazil ice nuclei that build up to form discrete particles within the water column. These small particles, known as frazil ice, resemble fine snow crystals and are highly attracted to solid objects and each other. They gather together (or agglomerate), and eventually rise to the surface to form slush ice and ice pans. These pans drift along the water surface, and in turn join together forming larger ice sheets. In turbulent areas in or downstream of rapids, the particles may be carried downward because of turbulent mixing and adhere to the river bed. This type of ice is called anchor ice.



Source: Adapted from Davar, 1996

TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Typical River Ice Processes (503-005 / a21583w)	Figure 13.6.1



Source: Adapted from Davar, 1996

TALTSON **Hydroelectric Expansion Project**	**Developer's Assessment Report** **2009**	**Typical Border Ice Growth** (503-005 / a21584w)	**Figure** **13.6.2**

Matousek (1984) gives general criteria for what conditions the various types of ice can form. The type of ice generated is dependent on flow velocity, the heat exchange (amount of cold at the ice/water interface) and the bed roughness and wind.

In reaches where the water surface is turbulent caused by either the bed being rough, high velocity, or high winds, smaller ice pans form. The slush ice and ice pans continue downstream until they reach an obstruction. As these ice pans move with the flow, they contact and stick to each other, forming larger and larger ice sheets. These pans and sheets can sometimes adhere to the growing border ice. At locations where border ice growth has significantly narrowed the open water portion of the channel, these sheets and pans can sometimes jam, forming an ice bridge. When the ice pans and sheets encounter such an ice bridge, one of two things would occur:

- If flow velocities at the ice front are low enough, and the cover strength is sufficient, the ice cover would begin to advance upstream through the accumulation of these sheets and pans — a process known as juxtaposition. The zone at the upstream edge of the cover is referred to as the ice front, or leading edge. The ability of the leading edge to advance upstream depends on the river velocity and the supply of ice being generated in the upstream reach. Multiple ice bridges, along with their corresponding accumulation covers, can form at a number of places on a river at the same time. Over time, the accumulation cover can advance far enough upstream to cover all open water areas. However, in many streams open water areas would remain at the fastest-flowing reaches such as rapids.
- However, if the advancing cover reaches a section of high velocity, the cover “stalls,” and the ice pans begin to be drawn down under the cover. These ice pans would travel under the cover until they reach a location with a low enough velocity to allow the ice to “deposit” under the surface ice. This can lead to the formation of a “hanging ice dam,” which is essentially an upside-down ice dune. The accumulation of this ice can result in a substantial rise in water level as the ice cover grows and thickens progressively over the winter. This process is called staging.

In rapids sections, the water is warmed by the conversion of potential energy (drop in level) to heat. At a set of rapids, there is generally an open-water lead that usually starts just upstream of the head of the rapids as the flow velocity increases, and then continues down through to the foot of the drop. Heat gained as a result of the head drop is dissipated through heat loss at the water/air interface. The rate of heat removal depends on the severity of the air temperatures (temperature difference between the water and ambient air). Depending on the height of the rapids, the flow, and the coldness and duration of the winter season, rapids may remain ice-free or may drown out and be closed over by staging from downstream.

During freeze-up, river discharges are generally dropping. Under open water conditions, this is normally accompanied by a reduction in water levels. However, as the border ice grows out from the banks, the wetted perimeter for the river is effectively increased. This increases the friction and head loss. Finally, when the accumulation cover becomes complete, with its rough lower surface, the head loss reaches a maximum. As the rivers finally close, water levels rise smoothly over their full width, gradually lifting the ice covers over the various reaches between control sections. As the ice lifts, local flooding occurs along the edges as water seeps through the hinge cracks that develop along the banks.

13.6.2 Available Data for Taltson River

Three primary sets of data are available for use in characterizing the ice regime along the Taltson River. These include:

- meteorological data,
- flow data, and
- ice observation reports.

Each is briefly described below.

13.6.2.1 Meteorological Data

There are over 18 different climate stations (operating and non-operating) near the Taltson basin. Three of these stations provide a long-term record base (over 40 years of data) — namely stations in Fort Smith, Yellowknife, and Fort Resolution. Of these three, the station at Fort Smith is likely the most representative station, and has been used to represent the meteorological regime of the basin. Climate normals from the Fort Smith station are presented in Section 9.4.3.

13.6.2.2 Flow Data

There are several WSC gauges that have operated in the basin, either currently or in the past (see Section 9.3). Of these, four are currently active: Taltson River above Porter Lake, Nonacho Lake near Łutsel K'e, Tazin River near the Mouth, and Taltson River below the hydro dam. Additionally, flows and water levels have been simulated throughout the Taltson Basin between Nonacho Lake and Great Slave Lake using the Taltson Basin Flow Model (see Section 9.3.3)

13.6.2.3 Ice Observation Reports

Field visits were taken on three separate occasions to help characterize the existing ice regime along the Taltson River. The field visits were staggered in time over the winter to ensure observations were available at the beginning, middle, and end of the season. The first trip was undertaken on November 25, 2003, the second on December 7, 2006, and the third on April 7, 2007. Data collected during these trips include information on the overall extent and nature of the ice cover along the river, spot ice thickness measurements, and periodic measurement of water temperatures in open water areas.

The 2003 Water Effects Monitoring Program included a detailed survey of the freeze-up processes of the Taltson River (Rescan 2003). Data collected during the field trip at freeze-up included visual observations, as well as measurements of ice thickness and water temperature taken at locations along the Taltson River. Figures 13.6.3 to 13.6.5 show the locations of ice surveys conducted during 2003.

Water temperature measurements and visual observations were carried out on the Taltson River from November 25 to 27, 2003. The survey was timed to occur when between 200 to 300 freezing degree days (°D < 0 °C) had been reached and the air temperature was -10 °C or less.

The number of freezing degree days recorded at Fort Smith up to the beginning of the ice survey in 2003 compared to the average record (1980 to 2003) indicate that 2003 was a warmer than average freeze-up. The average number of freezing degree days by November 25 for the period was 318 °D, and the value in 2003 was 280 °D.

The warmer than average freeze-up temperatures likely resulted in a delay in ice cover formation and thinner than average ice thicknesses.

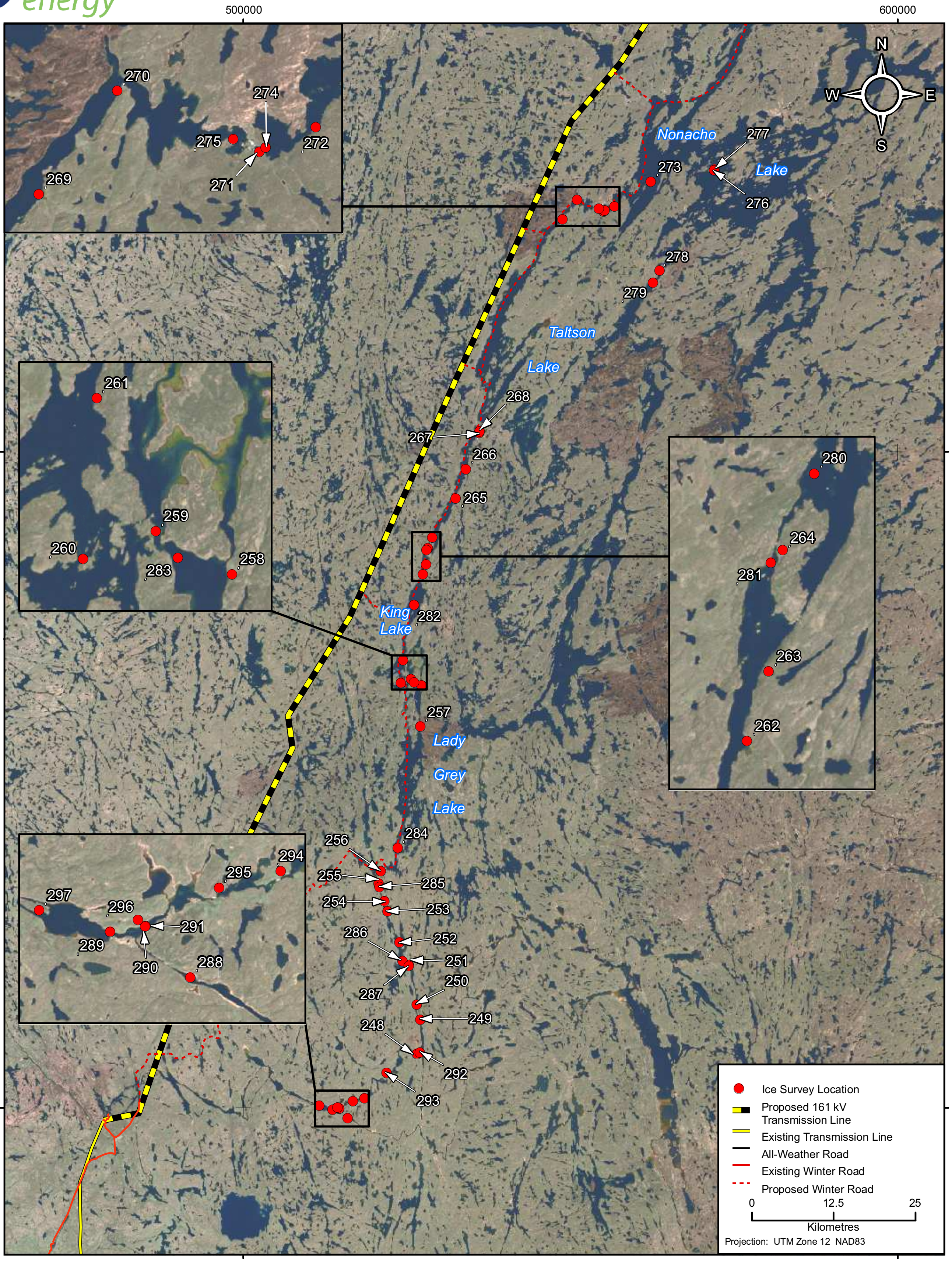
Ice thicknesses were measured by drilling a hole in the ice and obtaining a thickness with a rigid rod equipped with a graduated scale with a hook at the base. The hook is inserted under the bottom of the ice and the thickness is measured from the scale.

Water temperature profiles were obtained using a calibrated electronic thermistor (precision ± 0.01 °C) and an ohmmeter attached to 30 m of cable. Once the hole in the ice was cut and the ice thickness measured, the thermistor was lowered to the riverbed and the depth was recorded. The ohmmeter reading was allowed to stabilize and it was read in 1 m increments from the river bed to the water surface.

From December 7 to 8, 2006, ice thickness measurements and visual observations were again taken on the Taltson River (Whitlock 2006). The objective of the field visit was to gather additional winter baseline data later in the freeze-up process.

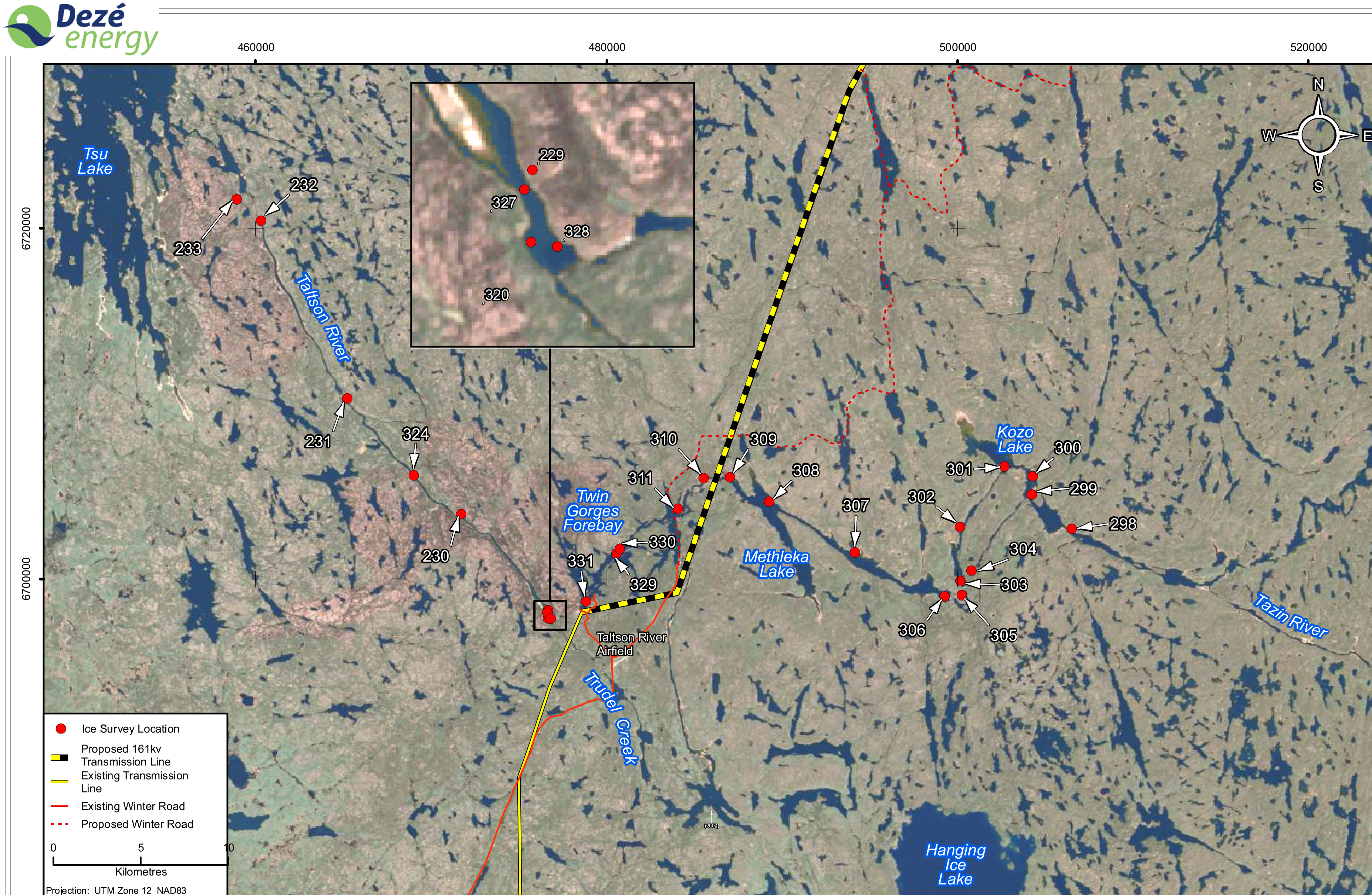
At the time of the survey, the river reach had been exposed to approximately 600 freezing degree days (°D < 0 °C). For reference, the average number of freezing degree days recorded at Fort Smith up to December 7 is approximately 450 to 500. Therefore, this was a colder than normal winter. Also for reference, by winter's end, the river is typically exposed to between 2,500 and 3,000 freezing degree days.

Flows recorded at the WSC gauge below Elsie Falls indicate river flows at the time of the survey were in the order of 255 m^3/s. The long-term average flow for this site is 253 m^3/s for this time of year. Therefore winter conditions for the period up to December 7, 2006, were colder than normal, with above average river flows.



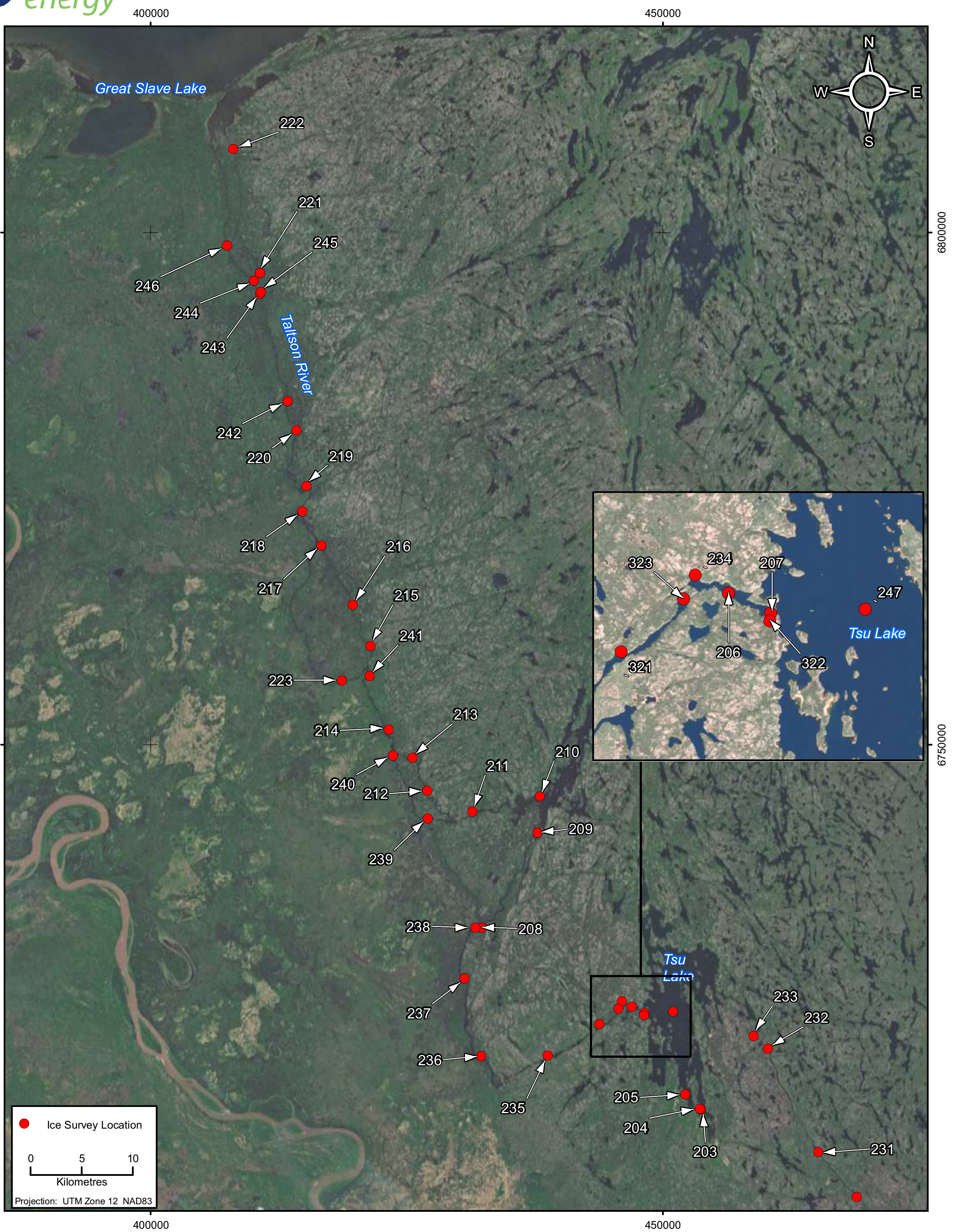
TALTSON **Hydroelectric Expansion Project**	**Developer's Assessment Report 2009**	**Taltson River Ice Survey Locations Zone 1: Nonacho Lake to Tazin River**	**Figure 13.6.3**

gis no. TAL-01-005aDAR



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson River Ice Survey Locations Zone 3: Tazin River to Tsu Lake Outfall	Figure 13.6.4

gis no. TAL-01-005bDAR



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Taltson River Ice Survey Locations Zone 4: Tsu Lake Outfall to Great Slave Lake**	**Figure 13.6.5**

gis no. TAL-01-005cDAR

Ice thicknesses were measured by drilling a hole in the ice and obtaining a thickness with a rigid rod equipped with a graduated scale with a hook at the base. A total of 17 ice thickness and snow depth measurements were taken at various waypoints along the reach. Ice thicknesses ranged from as little as 12.5 cm at some locations to as much as 51 cm at others.

From April 19 to 20, 2007, ice thickness measurements and visual observations were taken on the Taltson River (Whitlock 2007). The objective of the trip was to gather additional baseline data on the ice regime at a point that was late in the winter.

At the time of the survey, the river reach had been exposed to approximately 2,500 freezing degree days (°D < 0 °C). For reference, the average number of freezing degree days recorded at Fort Smith up to the end of April is approximately 2,750. Therefore this was a slightly warmer than normal winter.

Flows recorded at the WSC gauge below Elsie Falls indicate river flows at the time of the survey were in the order of 130 m^3/s. The long-term average flow for this site is 121 m^3/s for this time of year. Therefore, winter conditions for the period up to April 19, 2007 were warmer than normal, with above/below average river flows.

Ice thicknesses were once again measured by drilling a hole in the ice and obtaining a thickness. A total of 17 ice thickness and snow depth measurements were taken at various waypoints along the reach. Ice thicknesses ranged from as little as 44 cm at some locations, to as much as 102 cm at others. The variation in ice thickness was a function of the velocity of flow at each cross-section and the depth of snow insulating the ice cover.

13.6.3 Potential Change to Ice Structure in the Taltson River

As outlined in Sections 13.3 and 14.3, following the upgrade to the Project, there would be a change in winter hydrology of the Taltson River Basin compared to baseline conditions. The amount of change in the flow regime would vary depending on the expansion scenario as presented below:

13.6.3.1 36 MW Expansion Scenario

For a 36 MW expansion, total average flows from Nonacho Lake into the Taltson River during the freeze-up and early winter period (October to November) would be similar to the baseline condition.

Flows through the Tronka Chua Gap would be similar to baseline conditions for most of the winter.

Nonacho Lake levels would remain close to baseline conditions from October through to December. After this, the lake level would begin to drop from the baseline level. By April, the average expected lake level would be approximately 0.6 m lower than baseline.

Beginning in December, and persisting into April, flows from Nonacho Lake are predicted to be higher than baseline, as stored water is discharged from the reservoir to support power generation during the winter months. Increases of up to 40% above baseline are expected during the latter part of the winter.

Average monthly flows released immediately downstream of the powerhouse would increase by approximately 100 m^3/s (200%) when the new powerhouse is commissioned. Below Elsie Falls, flow in the Taltson River would not be affected to the same degree, as flows released at the SVS would decrease by close to the same amount as water is re-routed through the new powerhouse facility.

For almost all reaches, average monthly flows are expected to either remain relatively constant over the winter period, or fall gradually. The only exception to this is the reach of river between the Nonacho Lake outflow and Lady Grey Lake. This reach would see increasing flows over the initial formation period (until January), and steadily decreasing flows thereafter.

13.6.3.2 56 MW Expansion Scenario

Total average flows from Nonacho Lake into the Taltson River during the freeze-up and early winter period (October to December) could be up to 10% to 20% greater than current baseline conditions. However, flows through the Tronka Chua Gap would be lower than the baseline conditions by an equivalent amount. Therefore, flows in the Taltson River below Lady Grey Lake would be very near to baseline conditions, i.e. little change would be expected during the freeze-up process.

During mid-winter and into ice break-up, flows from Nonacho Lake are predicted to be higher than baseline, as stored water is discharged from the reservoir to support power generation during the winter months. Increases of up to 30% above baseline are expected during the latter part of the winter in the lower reaches of the river.

Flows released into the river immediately downstream of the powerhouse would increase by approximately 125 m^3/s (250%) when the new powerhouse is commissioned. Flows at the SVS would decrease by close to the same amount as water is re-routed through the new powerhouse units.

For all reaches, monthly flows are expected to either remain relatively constant over the winter period, or fall gradually. The seasonal recession pattern expected for this scenario is very similar to that of the baseline condition.

Notably, for both expansion scenarios, these patterns could vary from year to year depending on hydrological conditions. If stream flows are low in October, then extra water might be discharged from Nonacho Lake to maintain power production. In contrast, if background stream flows are high enough to allow peak power production, then Nonacho Lake discharges would be decreased. The changes in flow patterns are typical for a river system after hydropower project development. An additional complication when considering the effect of reservoir discharges on ice formation is that water coming from the reservoir is expected to be warmer than river water.

Model results indicated that during the freeze-up period (October through to December) stream flows immediately downstream of Nonacho Lake may be slightly reduced from baseline conditions for the 36 MW development scenario. Lower stream flows during freeze-up are likely to result in more rapid ice formation and a more stable cover. Flow velocities within the channel would be reduced, and this would allow rapid progression of border and skim ice within the slower river and lake reaches. However, if during freeze-up flows from Nonacho Lake are increased over baseline, as is predicted for the 56 MW development scenario, this would result in slower ice-cover formation and it is likely that the reach immediately downstream from the plant and reservoir would remain open longer. This would lead to increased ice generation, and this in turn would generally lead to the development of a rougher and thicker ice cover immediately downstream of any open water areas. In addition, when water surfaces remain open later into the winter and are subjected to progressively lower air temperatures, this produces periods of local ice crystal fogs in the river valleys. Ice crystal fogs form when the water vapour at the open water surface freezes creating a frozen fog.

Following the upgrade to the power plant, mid-winter flows within the Taltson River system are expected to be higher than baseline, but flows throughout the winter would tend to be more constant to maintain power production. The model results indicate average monthly flow rates for both scenarios would tend to slowly fall over the mid- to late winter period. This would tend toward maintaining a more constant ice cover throughout the winter period.

Overall, the changes in flow patterns within the system are expected to have a limited effect on ice formation on larger lakes and very deep or slow river sections, where flow velocities would be low under baseline and post-development conditions. The main effects are expected to be seen on river sections and in Nonacho Lake, where there would be the largest change in water levels during the winter months as water is progressively discharged to supply the power generation plant. The increase in drawdown of the reservoir over the winter months may cause the ice cover to further settle along the shoreline as the ice drops with the lowered water table. This has the potential to create a rougher ice surface at the lake edges and could cause access difficulties for the local population. The falling water levels in the reservoir also have the potential to create a hanging ice surface with air under the thermal ice cover. The bearing strength of the ice would be reduced in this situation. Notably, under baseline conditions the Nonacho Lake level normally falls by almost 0.3 m over a winter season. The 36 MW expansion scenario would increase this drop to approximately 0.9 m, while the 56 MW expansion scenario would increase it to approximately 0.6 m.

Changes in flows from Nonacho Lake might result in a rougher, heavier ice cover along some river sections. It is unlikely that the rougher ice would introduce any problems to human uses (i.e. ice bridges, recreation) as there is no known human winter use of Taltson River downstream of Nonacho Lake. However, people who normally would cross the river on the natural ice cover in the reach just downstream from Twin Gorges may find their way cut by the open water reach, or by the variable thickness and location of the upstream edge of the ice cover.

This section provides an overview of potential changes to ice cover in the Taltson River system following Project development. However, changes in ice conditions at any one crossing site would depend on a number of local factors, including local flow hydraulics and the morphology of the crossing point (river depth, presence of pinch points, rock outcrops, etc.). Site-specific field observations would be required at key crossing points to provide quantitative estimates of changes to ice structure.

13.6.4 Winter Use of the Taltson River Basin

The Taltson River Basin is in a remote area that currently does not have year-round road access. When the facility at Twin Gorges was first constructed (1964 to 1966) a winter access road was developed from Fort Smith to Twin Gorges. This road has not been in use for Twin Gorges operations for many years, although the route is still visible. Most access to the area is done through the use of small planes, snowmobiles, and occasionally cross-country skis and snowshoes. Winter activities in the area include camping, hunting, trapping, and ice-fishing. River and lake ice crossings are important for local communities who use the area for winter hunting, trapping, and fishing.

The Canadian and Northwest Territories governments publish safety guides (Treasury Board of Canada 1993) that provide a number of recommendations for ice thicknesses required to support moving and stationary loads, and outline methods for the preparation and maintenance of ice crossings.

The bearing capacity of ice depends on both the thickness and how it was formed. Thermal ice (clear blue) is considered the strongest ice and is the standard of quality for determining bearing strength. Snow ice (opaque) is considered half as strong as blue ice. An effective thickness of ice should be determined for any ice crossing. The effective thickness is the summation of the actual thickness of blue ice and half the thickness of snow ice (i.e. if blue ice is 10 cm thick, and snow ice is 12 cm thick, the effective thickness is 16 cm). From the Canadian government's safety guide, ice that has an effective thickness of less than 15 cm should not be used for any crossings. After that, a general rule of thumb of 2.5 cm of clear blue ice per 1,000 lbs (450 kg) can be used to determine the bearing strength of the ice.

The guidelines also recommend that ice crossings not be undertaken at locations with known currents and/or springs as these would have an effect on the thickness and strength of the ice. The safety guidelines are a good starting point to discuss ice crossings in the area.

13.6.4.1 Identification of Key Winter Crossings

Currently, there is little information available as to the locations of key winter ice crossings for people and wildlife within the Taltson River Basin. The area is along the caribou migration route between calving habitat and over-wintering habitat. When the locations of crossings have been determined, site-specific field investigations can be undertaken if necessary to gather data to allow more quantitative discussions of the magnitude of possible changes to ice structure at these locations. The results can be used to assess the likely changes on human and wildlife use.

13.6.5 Nonacho Lake

Nonacho Lake is a large expanse of water (approximately 850 km^2). It acts as the storage reservoir for the Twin Gorges hydropower facility. Currently, flows are discharged from the reservoir through the uncontrolled spillway at Tronka Chua Gap, and to the Taltson River over the semi-controlled spillway at Nonacho Lake Dam, as leakage through the dam and through underflow gates in the dam. The proposed upgrades include modifying the existing Nonacho Lake Dam by sealing the dam, constructing new underflow gates and raising the uncontrolled spillway. No proposed upgrades are being considered at Tronka Chua Gap. See Chapter 6 for a detailed Project Description.

13.6.5.1 EXISTING CONDITIONS

During each ice freeze-up survey, Nonacho Lake was completely covered by a layer of thermal ice. An open water lead had formed immediately upstream of the spillway, and skim ice was being formed at the upstream edge of the open water. Ice thicknesses on the lake generally grow to close to 1 m by winter's end. The average monthly lake level typically falls over the winter period by approximately 0.3 m.

13.6.5.2 PREDICTED CONDITIONS

For both proposed development scenarios, average monthly water levels on Nonacho Lake are expected to be at or below the baseline condition. However, the expected range in level for each month is considerably larger. During the freeze-up period (September to December) the water level is expected to be lower than baseline for both development alternatives, but it is predicted to remain fairly stable during this period under the new regime (+/– 0.2 m). As a result, ice freeze-up conditions should remain consistent with baseline conditions. Thermal ice growth would continue to form to approximately the same thickness.

The water level is predicted to decrease through the winter in the reservoir under the proposed upgrade scenarios (see Section 13.3). Under baseline conditions, the Nonacho Lake level normally falls by almost 0.3 m over a winter season. The 36 MW expansion scenario would increase this drop to approximately 0.9 m, while the 56 MW expansion scenario would only marginally increase it to approximately 0.6 m. This has the potential to create an air pocket beneath the ice and decrease the bearing strength of the ice cover, as the ice cover may settle along the shoreline. This would create an uneven ice surface at the shoreline, potentially affecting access onto the lake surface.

The bearing strength of the lake ice cover could be affected to a larger degree at locations within Nonacho Lake where there are constriction points between deeper portions of the lake. At these locations, any currents that exist under baseline conditions would increase under the expansion scenarios as average water levels would decrease, resulting in smaller cross-sectional flow areas at these locations and therefore increased velocities. Increased velocities at such locations could have an effect on the ice thickness, and therefore on the local bearing strength of the ice cover. Although it is not anticipated that this would result in any substantial effects to bearing strength, such locations could be identified and considered for ongoing monitoring.

The increase in discharge from the reservoir through the winter may have an effect on the open water lead that forms immediately upstream of the dam spillway. Higher flow velocities can be expected to marginally increase the area of the open water lead.

There is no information available as to the breakup conditions on Nonacho Lake. It is expected that the ice on the lake simply deteriorates and melts in situ in the spring.

13.6.6 Zone 1

The discharge from the Nonacho Lake dam (including underflow gates, leakage through the dam and flow over the spillway) provides the flow into the Taltson River for Zone 1. The zone extends to the confluence of the Taltson and Tazin rivers. The reach between Nonacho Lake and the confluence with the Tazin River is a complex series of low-gradient, slow-moving river reaches divided by a series of large lakes, rapids, and waterfalls. The major lakes along this reach include: Taltson, King, Lady Grey, and Benna Thy lakes.

13.6.6.1 Existing Conditions

The following is a brief summary of the visual observations from the ice freeze-up surveys. Downstream of the Nonacho Lake dam, the Taltson River was observed to be ice-free for a few hundred metres because of the combined effect of high velocities and warmer water released from the reservoir. This open water area was also evident during the December and April surveys. Downstream of Nonacho Lake the Taltson River was covered by a thermal ice layer punctuated by the occasional open water lead where the river narrows or shallows and velocities increased.

The downstream lakes were covered by a thermal ice cover. Ice thickness measurements taken on these lakes indicate significant ice growth by winter's end. Thicknesses recorded during the April, 2007, survey indicated ice growth of 80 m to 90 cm in almost all areas. This implies that velocities within these areas are very slow. The inlet rapids and outlet rapids of the lakes were free of ice. Ice bridges formed upstream of some of the faster moving sections of the river (i.e. where the channel narrows, or the river braids and velocities increase). Accumulation ice formed upstream from these bridges. Frazil ice was observed accumulating in some of the open water leads.

13.6.6.2 Predicted Conditions

For the 36 MW development scenario, the proposed changes to the management of flows from Nonacho Lake include releasing near to baseline flows in October and November, but then increasing the discharges from December through April. This means that during ice freeze-up, the flows would be lower than baseline, and the ice would potentially be quicker to form and the open water leads would be smaller.

In the reach between Nonacho Lake and the confluence with Tazin River, flows are likely to increase during mid-winter, with the potential to cause the existing ice cover to lift. Model results show that stage increases, on average, would be limited to 0.2 m to 0.3 m. This may lead to some minor flooding of the shore zone ice, and lead to the formation of a slushy layer on top of the shorefast ice. At the rapids sections and in the open water leads, increasing the flow would also lead to some staging of the water level. However, overall the changes in this reach of river would be minor.

For the 56 MW development scenario, flows in this reach of the river during the ice formation period would be higher than for the baseline condition. This may slow the ice-cover formation somewhat in this reach. It is expected that an ice cover would continue to form relatively quickly on the many lakes and slow-velocity reaches in this zone despite the increased flow. However, the open water leads that currently exist at the narrower channel sections and rapids would likely be a bit larger in extent. The increased open water area may lead to the development of a rougher and thicker ice cover immediately downstream of any of these open water areas.

On average, monthly flows would gradually fall over the winter period, as they do now, and therefore the ice cover would settle along the banks. The level, on average, is expected to drop by up to 0.8 m, as it does under baseline conditions.

13.6.7 Zone 2

Flow enters this zone from Nonacho Lake through an uncontrolled spillway called Tronka Chua Gap. Flow through Tronka Chua Gap enters a series of very large lakes separated by hydraulic pinch points and rapids or waterfalls. Flow through this section rejoins the main stem of the Taltson River at Lady Grey Lake.

13.6.7.1 Existing Conditions

Very little information is available on the existing ice formation conditions in this zone. The only location surveyed during 2003 was at Tronka Chua Gap. The rapids at Tronka Chua Gap were ice-free during the freeze-up survey in 2003. No observations were taken in this area during the 2006 and 2007 surveys.

13.6.7.2 Predicted Conditions

Under the 36 MW development scenario, flows through Tronka Chua Gap are expected to be quite similar to baseline conditions during the formation months of October through to December. Therefore, the ice cover in this reach would develop much as it does today. Beginning in February, flows through the gap would drop considerably from the baseline condition. The cover would remain intact under these lower flows, but minimum water levels may be 0.4 m to 0.6 m lower than present day levels. The hydrology of the area is dominated by large lakes. The changes in flow conditions are not expected to have a large effect on thermal lake ice formation through this zone.

Under the 56 MW development scenario, flows through the Tronka Chua Gap would be considerably less than the baseline condition. Lower stream flows during freeze-up are likely to result in more rapid ice formation and a more stable cover. Flow velocities within the channel would be reduced, and this would allow rapid progression of border and skim ice within the slower river and lake reaches.

Very little data have been collected for this zone, although expected effects on the ice regime in this reach should be minor. More studies are needed to fully characterize ice freeze-up and mid-winter conditions along this section. Ice survey locations should be added to this reach for any upcoming ice survey work.

13.6.8 Zone 3

The Taltson River from the confluence of Tazin River to the outlet of Tsu Lake consists of a collection of lakes and low gradient river sections, with the majority of elevation change occurring over a series of localized rapids and waterfalls. The largest lakes in this reach are Tsu Lake and the Twin Gorges Forebay. Smaller lakes include Methleka and Kozo lakes upstream of the Forebay. There are four major rapids sections in this zone: Nende Rapids immediately upstream of the inlet to Tsu Lake, Natla Rapids upstream of Nende Rapids, Three Bears Rapids downstream of

Methleka Lake, and Napie Falls downstream of Kozo Lake and upstream of Methleka Lake.

13.6.8.1 EXISTING CONDITIONS

The results from the various freeze-up ice surveys indicated that, in general, the lakes and low-gradient low-velocity river sections in this reach were covered with a solid thermal ice cover. However, the major rapids and waterfalls were open and remained open throughout the winter. Upstream of these rapids, ice can generally be considered either smooth juxtaposition or thicker and rougher accumulation ice, with the occasional open water lead. Small hanging dams may form downstream of these rapids, depending on the length of the open water lead upstream of each rapids.

Between the confluence with the Tazin River and Kozo Lake, the river gradient is small, and a thermal cover forms over most of this reach. Open water may persist throughout the winter at narrow points along the river, but covers appear to be quick to form upstream of these localized higher-velocity zones. Ice thickness measurements taken immediately downstream of the confluence of the Taltson and Tazin rivers indicate the cover to be up to 0.79 m thick by winter's end.

The Taltson River exits Kozo Lake through two separate channels that eventually join again just downstream of Napie Falls. The eastern channel likely carries a smaller discharge, and forms a solid ice cover each year. The western channel is generally open for a short distance downstream of Kozo Lake (steeper gradient), but an ice cover forms over the lower portion of the reach. Napie Falls, with an estimated head drop of 8 m, remains open, but the river velocities are low enough upstream of the falls to allow the formation of an ice bridge. This promotes the advancement of a cover upstream of the falls.

The reach from Methleka Lake to a point downstream of Napie Falls is primarily ice-covered, except for one or two small open-water leads evident at localized rapids sections. Downstream of Methleka Lake, a solid cover forms up to point just upstream of Three Bears Rapids. The river at and just downstream of Three Bears Rapids (which has an approximate drop of 7 m), remains open throughout the winter period. This may lead to the development of a small hanging dam downstream of Three Bears Rapids.

An ice cover forms quickly on the Twin Gorges Forebay each winter, and thermal ice thicknesses of up to 0.8 m were recorded in this area. Downstream of the generating station, the channel remains open up to its confluence with Trudel Creek owing to the slight warming of the water as it passes through the Project, and the steeper gradient in this reach.

From the confluence down to Natla Rapids, the reach is ice-covered with the occasional open-water lead evident. The velocities in the channel upstream of Natla Rapids are low enough that the cover is able to bridge across relatively early in the winter season, and a juxtaposed cover advances upstream from this bridging point. In the upper section of this reach, the cover appears to consolidate and thicken somewhat. A cover thickness of 0.73 m was measured at a point approximately 6 km upstream of Natla Rapids during the 2007 survey.

At Natla Rapids, the river falls approximately 4 m and the river remains open in this reach throughout the winter. The river gradient is very gradual between the head of Nende Rapids and the foot of Natla Rapids and the ice cover in this reach is generally complete with very few open water leads. However, just downstream of Natla Rapids, it appears that a small hanging dam typically forms. This leads to a thicker accumulation, identified by the distinct shear lines at the border ice boundaries and the parabolic shove lines at the ice surface. Water typically seeps through the hinge cracks at the river's edge in this area as the cover stages over the winter.

At Nende Rapids, the river falls approximately 14 m and the river also remains open in this reach throughout the winter. However, a thermal cover forms almost immediately downstream of Nende Rapids and except for one or two open-water leads, the river remains ice covered through to Tsu Lake. Tsu Lake is covered with a thick, thermal ice cover.

13.6.8.2 PREDICTED CONDITIONS

For the 36 MW development option, on average, the change in operations of Nonacho Lake and the increased power production capacity at Twin Gorges should not change flow conditions appreciably during the ice formation period in this zone (see Sections 13.3 and 14.3 for details). However, the flows are expected to increase above baseline conditions from January to April.

For the 56 MW development scenario, monthly flows through this reach are expected to be quite similar to the baseline condition throughout the winter period.

For both development scenarios, flows in the short reach from the existing powerhouse to the channel's downstream confluence with the Taltson River would be up to or considerably higher than occurs under baseline conditions, while Trudel Creek flows would be reduced by a comparable amount.

Considering this, the following effects on winter ice conditions are considered possible in this reach as a result of the proposed Project Expansion.

Since post-Project average monthly flows are not expected to vary from baseline conditions during the formation period, for the most part, ice formation processes in this reach of the river should continue to evolve each winter as they currently do.

For the 36 MW development scenario, winter flows in the latter part of the winter are expected to be 40% to 50% higher than baseline flows. In addition, model simulations indicate that in some years, flows in the mid-winter period may actually be higher than flows experienced during the ice formation period. In these instances, water levels in the reach may rise by a few tenths of a metre later in the winter, and occasionally this could lead to some minor hinging and flooding of shorezone areas of ice. Higher flows in the latter part of the winter may also lead to some additional adjustment and thickening of the juxtaposed cover that forms between Natla Rapids and the powerhouse tailrace channel. Open water leads would not be expected to change significantly, although they may increase in size marginally. For the 56 MW scenario, such mid-winter increases in flow are rare.

For either development scenario, it is unlikely that thermal ice formation in the lakes would be effected by the change in operations in the Taltson River Basin. The water elevation in the lakes remains relatively stable during the period of freeze-up.

For both development scenarios, flows in the tailrace channel downstream of the powerhouse would increase significantly. This reach already remains open and would continue to do so under a post-Project scenario. However, since more water would be released through the powerhouse than through the SVS, these releases would be slightly warmer when they reach the Taltson confluence. Flows released through the SVS have a much longer travel path and a greater opportunity to cool. This would mean that the open-water lead evident at the confluence now along the north bank might be larger under a post-expansion scenario.

On an annual basis, the turbines at Twin Gorges are scheduled to be shut down for routine maintenance and inspection. The timing of the outage would be set to coincide with the start of the spring freshet. As each turbine is turned off, water levels in the Forebay would rise. Once levels reach the elevation of the SVS, flows into Trudel Creek would increase by roughly 50 m^3/s. This would likely increase the rate of spring break-up of the ice cover along Trudel Creek. In response, Trudel Creek water levels would rise by approximately 0.8 m, and this may lead to break-up and mobilization of portions of the ice cover. Any mobilized ice fragments would then likely re-jam either at one of the downstream lakes, or, should the lake cover also be compromised, in the Taltson River, likely between Natla Rapids and the tailrace channel. This could also occur under the baseline condition, but with a reduced effect.

13.6.9 Zone 4

Zone 4 consists of river sections from the outlet of Tsu Lake to the inlet of Great Slave Lake. The reach is characterized by a series of low-gradient river sections that are hydraulically controlled by the occasional set of rapids. The largest lake in this reach is Deskenatlata Lake, which is fed by both the Taltson and Rutledge Rivers.

13.6.9.1 Existing Conditions

The river reach downstream of Tsu Lake typically remains open over a distance of approximately 30 km. Warmer water discharged from the lake combined with the energy produced as the water drops over a series of large rapids raised the water temperature by a few hundredths of a degree. As the water is cooled back down to 0 °C by the cold air temperatures, ice generation eventually commences again. The gradient in the river in this reach is high enough that it is not possible for thermal or skim ice to form across the full width of the river. Rather, the ice cover here consists of border ice that has grown out from the banks, and thin juxtaposed ice sheets. Ice bridges are sometimes formed by the thin ice sheets themselves when they become lodged between the border ice edges at their narrowest points.

A thermal ice cover develops on Deskenatlata Lake, and the cover in the eastern channel upstream of the lake also consists of a smooth thermal ice.

Downstream of Deskenatlata Lake, in the slow, low-gradient sections of the Taltson River main channel, an almost continuous ice cover forms. This cover is punctuated by occasional, small open-water leads. In small side channels within the system, freeze-up occurs quickly with little border ice growth. The channels were closed quickly by the juxtaposition of skim or pan ice generated on the slow moving current.

There are also a number of high-gradient sections of the river, which remain open over the winter period. These sections are at the Iche, Rat River, and Fishing Hole rapids. In these areas, water velocities are high, and the reach remains open for a distance upstream and downstream of each set of rapids. Ice generated in these open water areas would accumulate at the leading edge of the downstream cover, leading to some shoving and consolidation of the cover.

13.6.9.2 Predicted Conditions

The proposed upgrades to Twin Gorges hydropower facility and the change in operations at Nonacho Lake is not expected to significantly change flow conditions downstream of Tsu Lake during the ice formation period (October to December). Neither expansion option would increase flows during this critical period; further, the 36 MW option would see flows drop slightly during the formation period. However, the flows are expected to increase above baseline conditions from January to April for both options.

Since post-Project average monthly flows are not expected to vary from baseline conditions during the formation period, for the most part ice formation processes in this reach of the river should continue to evolve each winter as they currently do.

For the 36 MW development scenario, winter flows in the latter part of the winter are expected to be 30% higher than baseline flows. In addition, model simulations indicate that in some years, flows in the mid-winter period may actually ramp up, or be higher than flows experienced during the ice-formation period. In these instances, water levels in the reach may rise by a few tenths of a metre later in the winter, and occasionally this could lead to some minor hinging and flooding of shorezone areas of ice. Open water leads would not be expected to change significantly, although they may increase in size marginally. For the 56 MW scenario, such mid-winter increases in flow are rare.

For either development scenario, it is unlikely that thermal ice formation on Deskenatlata Lake would be affected by the change in operations in the Taltson River Basin. The water elevation in the lakes remains relatively stable during the freeze-up period.

13.6.10 Monitoring

Additional years of observing ice conditions under varying formation conditions (i.e. flows and air temperature) could provide an improved understanding of the variation in ice conditions from year to year. Additional ice monitoring could be paired with identification of winter crossings used by humans or wildlife so that the monitoring program could be focused on key sites of concern.

A monitoring program would be developed in detail with regulatory agencies that focuses on the key areas of concern and areas that are predicted to experience the greatest change from current conditions. Following review of the DAR, the areas of greatest concern would be identified via discussions with the Board, federal and territorial agencies, Aboriginal groups and the public.

13.6.11 Summary

Ice conditions on the Taltson River have been reviewed and assessed qualitatively on the basis of three available ice surveys. Predictions have also been made on how the development of either a 36 MW or 56 MW Expansion Project would affect the existing ice regime in this reach.

For the 36 MW development scenario, the proposed changes to the management of flows from Nonacho Lake include releasing near to baseline flows from October through December, suggesting that ice freeze-up would be similar to the baseline condition. Discharges from the reservoir are predicted to increase above baseline conditions from January through April. At rapids sections and in the open water leads, increasing the flow may cause staging or backwatering effects and increase the potential for localized flooding along the shoreline.

For the 56 MW development scenario, releases from Nonacho Lake into the Taltson River would be higher than baseline from October through December, but flows through the Tronka Chua Gap would be lower than baseline. For regions downstream of the Taltson/Tazin confluence, ice formation flows are expected to be similar to the baseline condition. An increase in the formation flow may slow the ice cover formation somewhat in the reach between the Taltson/Tazin confluence and the Nonacho reservoir. It is expected that an ice cover would continue to form relatively quickly on the many lakes and slow-velocity reaches in this zone in spite of the increased flow. However, the open-water leads that currently exist at the narrower channel sections and rapids would likely be a bit larger in extent. The increased open water area may lead to the development of a rougher and thicker ice cover immediately downstream of any of these open-water areas.

The changes to operations at Nonacho Lake are not expected to have an effect on the large lakes downstream of the reservoir. The increased lake depth during the freeze-up period is not expected to change the mechanism of thermal ice generation. The ice thickness should remain consistent with baseline conditions. However, on Nonacho Lake, the lake level is expected to decrease throughout the winter months, which is likely to break up the ice cover close to the shoreline. This is similar to what occurs under baseline conditions.

It is possible that during scheduled outage events at the Twin Gorges facility, the Trudel Creek ice cover may partially break up and re-jam within the channel or in the Taltson River downstream of Elsie Falls. This could lead to localized flooding at and immediately upstream of any ice-jam. Although there is potential for this to occur under baseline conditions, the probability of this occurring would increase under the proposed Expansion Project.

This qualitative assessment of potential changes in ice structure is based on three ice field studies within the Taltson River watershed and on predictive hydrologic modeling. The effect of changes in flow conditions on ice structure at critical locations would depend on the local river hydraulics and stream morphology at the individual sites. Site-specific field work and possibly modeling would be required to give a quantitative assessment of change.

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF PLATES

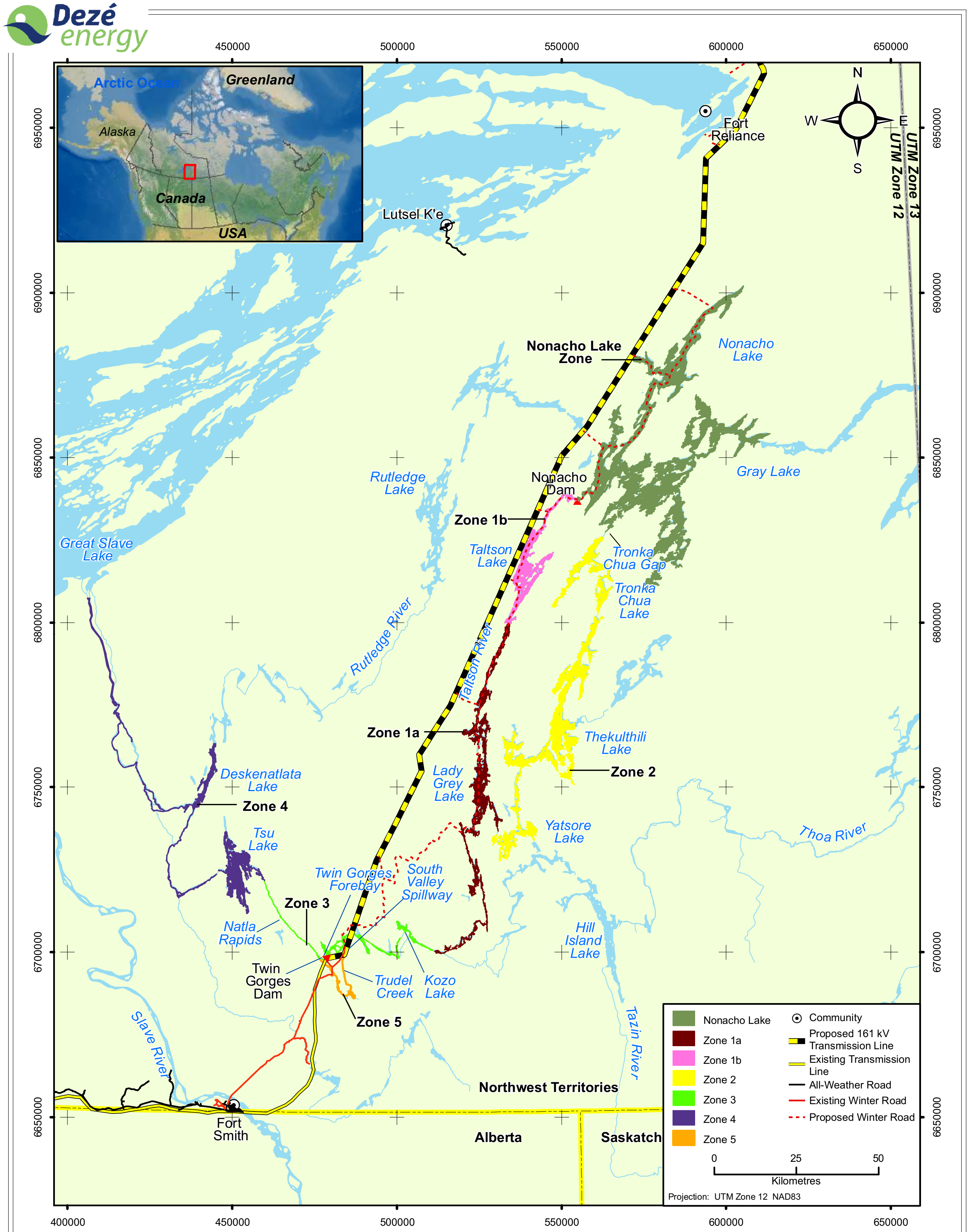
APPENDICES

13. WATER FLUCTUATIONS IN THE TALTSON RIVER WATERSHED

13.7 WETLANDS

13.7.1 Existing Environment

Wetlands are transition ecosystems that connect aquatic and terrestrial environments (Mitsch and Gosselink 2000). The federal wetland definition describes wetlands as "land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment" (NWWG 1988). As a result of their environmental characteristics, wetlands perform a variety of functions that contribute to the maintenance of biodiversity and "healthy ecosystems." For instance, wetlands provide habitat for fish and wildlife but also regulate hydrology, water quality, and climate of a given area. The Canadian Environmental Assessment Agency (CEAA 2005) defines wetlands as Valued Ecosystem/environmental Components (VECs) when they may be affected by development projects. Wetlands in Zone 1 and the Nonacho Lake Zone (Figure 13.7.1) were surveyed to determine the potential effects to wetland quality and quantity from the Taltson Hydroelectric Expansion Project (The Project).



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Wetland Study Zones	Figure 13.7.1

gis no. TAL-22-009cDAR

13.7.1.1 SURVEY SUMMARY

There were three components to the wetland baseline study: (1) mapping wetlands, (2) identifying wetland properties and wetland classification, and (3) modelling ecological assembly. Wetlands were mapped in Zone 1 and the Nonacho Lake Zone using a number of different data sources. Wetlands in the southern portion of Zone 1 (Zone 1a) were mapped using satellite imagery available on Google Earth version 4.0.2091 (2006). Wetlands in the remainder of Zone 1 (Zone 1b) and the Nonacho Lake Zone were mapped using non-ortho corrected georeferenced aerial photographs taken in June 2008. Because the photographs are not ortho corrected, there exists an unknown amount of error caused by variations in yaw angle and flight elevation (Appendix 13.7a). As such, direct comparisons of wetland size cannot be made. Complete photo capture and mapping methods are presented in Appendix 13.7a. Wetland areas were not mapped in Zones 2, 3, and 4; however, a brief aerial reconnaissance was conducted for Zone 2.

Wetlands in Zone 1 and the Nonacho Lake Zone were surveyed in August 2008. At each site, vegetation, soil, and hydrodynamic characteristics were recorded and used to categorize them into wetland classes following the Canadian System of Wetland Classification (Warner and Rubec, 1997). Elevations of the shrub/sedge wetland boundary were recorded using a differential GPS. These data were used to generate a predictive model of ecosystem assembly which predicts the potential effects of the Project on wetland ecosystems. The following sections summarize the baseline condition (size, distribution, functions and values) of wetlands found in each zone.

13.7.1.1.1 Zone 1

A total of 14 wetland ecosystems were surveyed in Zone 1. The dominant ecosystem class was the riparian marsh, which consisted of four distinct communities. One fen ecosystem was surveyed in the north end of Zone 1a. Two mapping sources were used to map wetlands and calculate their extent in Zone 1 (Table 13.7.1). The photos used to map wetlands in Zone 1b did not cover the entire zone and they were not ortho corrected. Hence, wetland areas should be considered approximate values for Zone 1b.

Table 13.7.1 — Wetland Area from Zone 1a and Zone 1b

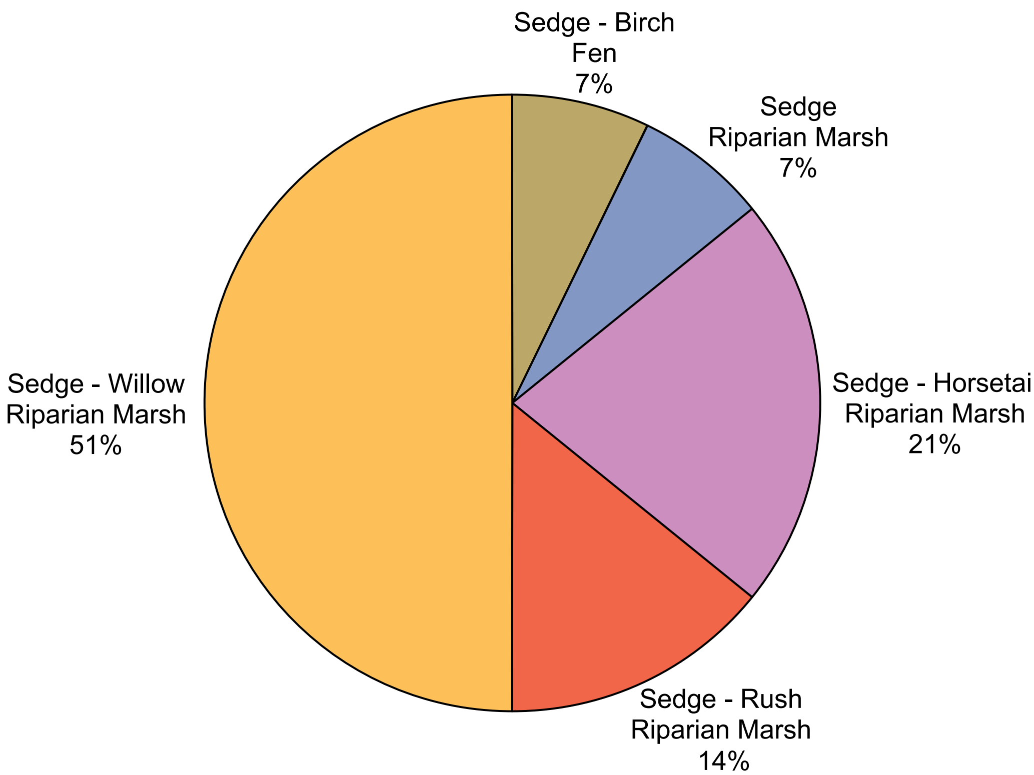
Zone	Data Source	Approximate Area (ha)
Zone 1a	Google Earth	1233
Zone 1b	Un-Ortho Corrected Aerial Photos (2008)	344

The most common wetland community in Zone 1 was the Sedge-Willow riparian marsh, which was observed at seven sites (50% of survey sites) (Figure 13.7.2). This marsh community was observed in all zones of the study area. Most riparian wetlands had a willow component as a band between the sedge community and the upland community. Sedge-Willow marshes had this band and a number of small willow communities scattered throughout the sedge-dominated portions of the wetland (Plate 13.7.1). These communities had shallow organic soil with varying ranges of decomposition. The mineral soils were poorly- to moderately well-drained loams.

Vegetation consisted of *Carex utriculata*, *Carex aquatilis*, and/or *Carex lasiocarpa* with a variety of *Salix* species.

Two other riparian marsh communities (Sedge-Horsetail and Sedge-Rush) combined accounted for 35% of the wetlands surveyed in this zone (Figure 13.7.2). The Sedge-Horsetail communities (Plate 13.7.2) typically had less than 40 cm fibric organic soil. The mineral soils were poorly- to well-drained sands, silts, or loams with coarse fragment content usually below 20%, although it exceeded 70% at sandy sites. Vegetation was typically dominated by *Carex utriculata* and/or *Carex aquatilis* and *Equisetum hyemale*. The Sedge-Rush community (Plate 13.7.3) was observed as a floating vegetation mat and riparian community on the river bank. These sites had deep, well-decomposed organic soil. The mineral soils, where present, were sands, sand loams, or silt loams and were poorly- to imperfectly drained. Vegetation was composed of sedges and/or rush/bulrushes such as *Carex lasiocarpa*, *Carex utriculata*, *Carex aquatilis*, *Scripus acutus*, *Juncus arcticus*, and *Scripus* sp.

The remaining wetland communities in Zone 1 included a Sedge-dominated riparian marsh and a Sedge-Birch fen. The sedge riparian marsh (Plate 13.7.4) had a deep mesic organic soil (> 40 cm) with a veneer of silt approximately 60 cm below the soil surface. Vegetation was dominated by *Carex utriculata* and *C. lasiocarpa*. The Sedge-Birch fen community was only observed at one site in the study area. This wetland was a floating vegetation mat and had organic soil deeper than 40 cm. The underlying mineral soil was a very poorly-drained clay loam with <20% coarse fragments. Vegetation at this site consisted of primarily *Carex aquatilis* and *Betula nana*, with a number of willow species (Plate 13.7.5).



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Wetland Vegetation Community Associations Observed in Zone 1 (Taltson River)** (503-005 / a22006m)	**Figure 13.7.2**

Plate 13.7.1 — Sedge-Willow Community at Site TW26 in Zone 1

Plate 13.7.2 — Sedge-Horsetail Community at Site TW21 in Zone 1

Plate 13.7.3 — Sedge-Rush Community at TW19 in Zone 1

Plate 13.7.4 — Sedge Riparian Marsh Community at TW27 in Zone 1

Plate 13.7.5 — Sedge-Birch Fen Community at TW25 in Zone

13.7.1.1.2 The Nonacho Lake Zone

A total of 15 wetlands were surveyed in the Nonacho Lake Zone. In this zone, wetlands occur in roughly equal proportions of bogs, fens, and riparian marsh communities. Wetlands were mapped using non-ortho corrected aerial photographs collected in June 2008. The photograph area covers approximately 10% of the study area (Appendix 13.7a). An accurate area of wetland extent is not known for this zone because the photographs do not cover the entire zone and they were not ortho corrected. Approximate wetland areas of the photographed portion of Nonacho Lake are presented in Table 13.7.2.

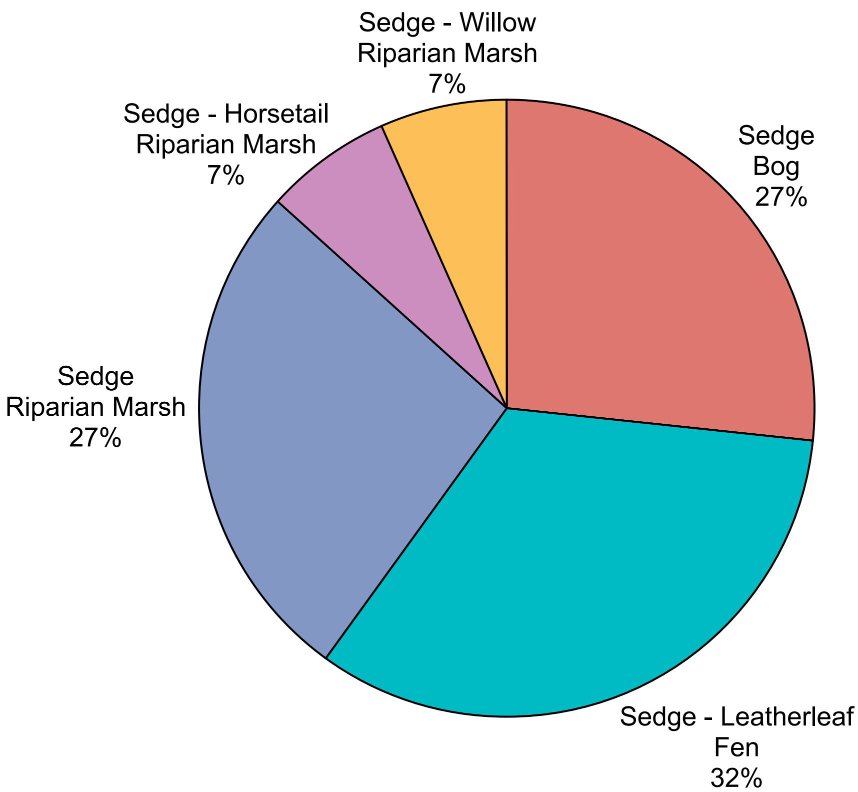
Table 13.7.2 — Wetland Area from the Nonacho Lake Zone

Zone	Data Source	Approximate Area (ha)
Nonacho Lake	Un-Ortho Corrected Air Photos (2008)	651

The most common wetland community in this zone was the Sedge-Leatherleaf fen (Plate 13.7.6), which accounted for 33% of wetlands surveyed (Figure 13.7.3). This fen community was observed in the Nonacho Lake Zone as either a floating vegetation mat or on the shore of Nonacho Lake. It is similar to a sedge bog community but had high percent cover of *Chamaedaphne calyculata* (approximately 60%). The communities surveyed had a number of standing dead trees. The organic soil was deep, fibric, peat. The underlying mineral soil was a poorly drained silty or sandy soil. Vegetation was dominated by *Chamaedaphne calyculata*, *Carex aquatilis*, and *Carex utriculata*.

Plate 13.7.6 — Sedge-Leatherleaf Fen Community at TW36 in the Nonacho Lake Zone

The next most abundant communities in the Nonacho Lake Zone were the Sedge riparian marsh (27%) and the Sedge bog (27%) (Figure 13.7.3). The Sedge riparian marshes are similar to those in Zone 1 as described in the previous section. The Sedge bog communities (Plate 13.7.7) were only observed in the Nonacho Lake Zone as floating vegetation mats. The organic soils tended to be very fibric. Permafrost was often observed within approximately 40 cm of the soil surface. These sites also typically had a number of standing dead trees, likely remnants of low upland forest that occupied this site prior to the dam construction and the subsequent water level rise (Plate 13.7.7). Vegetation was dominated by *Carex aquatilis* and *Sphagnum* spp. There was also a low percentage of bog shrubs such as *Vaccinium oxycoccos*, *Kalmia microphylla*, and *Chamaedaphne calyculata*.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wetland Vegetation Community Associations Observed in Nonacho Lake (503-005 / a22007m)	Figure 13.7.3

Plate 13.7.7 — Sedge Bog Community at TW33 in the Nonacho Lake Zone

The remaining 13% of surveyed wetland communities in the Nonacho Lake Zone were Sedge-Horsetail and Sedge-Willow riparian marshes (Figure 13.7.3). These communities were only observed at one location each and are identical to the communities described in Section 13.7.1.1. The riparian marsh class of ecosystems appears to be more common in the southern study area whereas fens and bogs are present in the north. This difference in community distribution is a reflection of climatic conditions, which control species composition, water availability, solar radiation, and decomposition rate.

13.7.1.1.3 Zones 2, 3, and 4

No wetlands were mapped or surveyed in Zones 2, 3 and 4. However, a number of wetlands were photographed in Zone 2 during the August 2008 wetland survey (Plates 13.7.8 - 13.7.10).

Plate 13.7.8 — Unconfirmed Wetland Communities in Zone 2

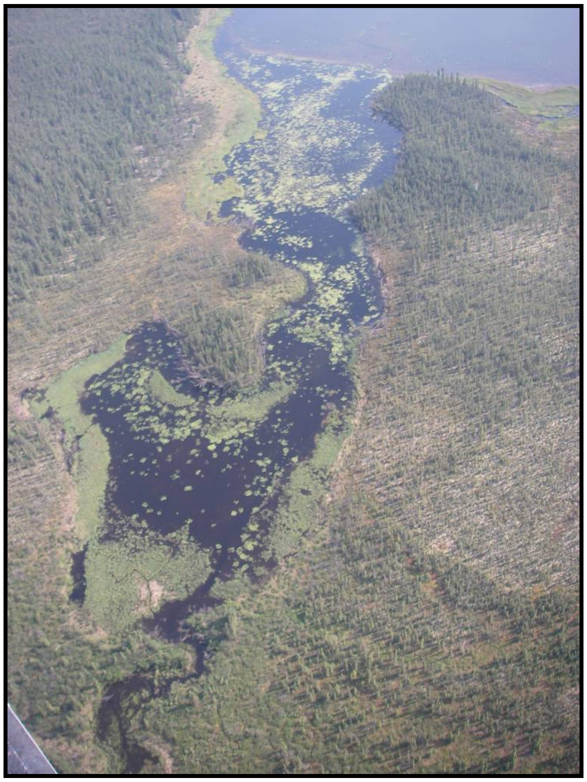


Plate 13.7.9 — Unconfirmed Wetland Communities in Zone 2

Plate 13.7.10 — Unconfirmed Wetland Communities in Zone 2

13.7.1.2 ECOLOGICAL ASSEMBLY

Ecological assembly is defined as the structure and composition of an ecosystem. Ecological assembly is an integral component of classification and mapping of ecosystems. Structure relates to the vertical and horizontal ground cover by all species within a community, whereas composition is the abundance and distribution of individual species within a community. Ecological assembly is used to separate ecosystem classes such as fens from bogs. It is also helpful in determining the function of wetland habitat and ecology. For example, songbirds that require shrub communities would not live in an area where the structure and composition of an ecosystem does not contain shrubs.

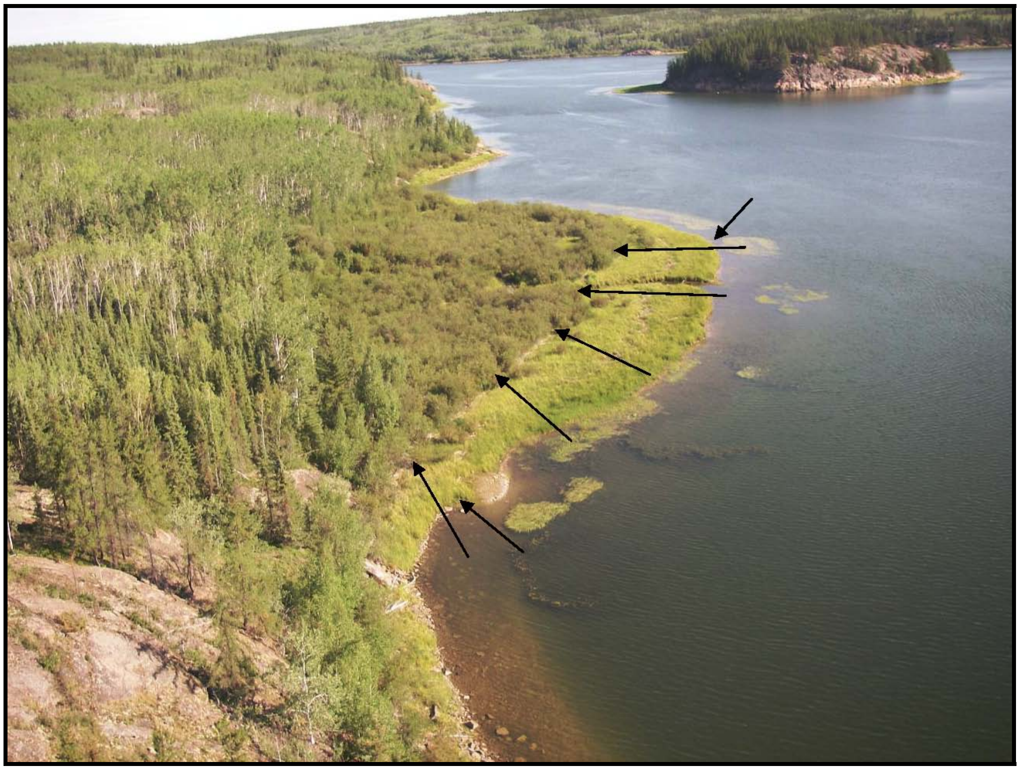
The relative proportion of woody shrubs versus sedges and other herbaceous plants in riparian wetlands is controlled by the flood regime. The flood regime is defined as the frequency and duration that water inundates various levels of wetlands throughout the year. The number of days that water inundates a wetland can be modelled from the water level of the river and the height of the flood-controlled community boundary (such as the willow–sedge boundary) within riparian wetland ecosystems. The effect of water inundation on a wetland is controlled primarily by flooding during the growing season. The growing season is established by the mean daily temperatures. Each of these factors (water levels, community boundary, and growing season as a function of temperature) can be modelled or measured in the field. Water levels were modelled throughout the study area and data was available for specific hydrology model locations (Rescan 2008b). Temperature was recorded by Environment Canada and compiled from data available for Fort Smith, NWT. The elevation of the community boundary was measured in the field using a differential GPS.

The principle behind the model is that flood levels control the presence and absence of shrub-dominated wetlands, particularly along riparian corridors. These ecosystems are shrub wetlands with drier areas described as shrub-carr. Shrub-carr communities do not fit the classic definition of a wetland but are often associated with wetland ecosystems. The sedge wetlands connected to the shrub wetlands area described as emergent wetland communities; emergent communities can also include species such as *Equisetum* sp. The submergent community is defined as the communities dominated by submergent vegetation in the Taltson River and Nonacho Lake supporting submergent vegetation.

For this assessment, the fraction of the growing season that was flooded was calculated at the ecosystem boundary elevation; i.e., the boundary between sedge and willow communities. Ecosystem boundary elevations were defined by the flood level. Water elevations above the ecosystem boundary were considered flood events, and growing season was established from temperature data. The ecosystem boundary was defined as the edge between *Carex* spp. and *Salix* spp. there was >70% cover by *Salix* spp. These data were combined to build a flood regime data set which was used to predict community structure and composition based on the frequency and duration of flood events during the growing season.

Elevation above sea level was collected at three to five sites along the sedge-shrub ecosystem boundaries at twenty of the field survey plots in Zone 1 and the Nonacho Lake Zone (Plate 13.7.11). This elevation was established as the flood zero (Fl0) position. Two other flood levels were established by adding or subtracting 0.5 m from the Fl0 position to create Fl+5 and Fl-5 positions, respectively. Elevations were corrected by subtracting the difference between the hydrology station benchmark elevations and GPS elevations collected at these benchmarks on the same day of the survey.

Plate 13.7.11 — Ecological Assembly Survey Locations



Arrows indicate the location of ecological assembly GPS survey positions.

Water level data from four hydrology reference locations (T30, T39, T49, and Nonacho Lake) (Section 13.3) were used to build the flood-regime database for the Taltson River and Nonacho Lake. The distance between most of the ecology assembly survey locations and hydrology reference locations was >5 km. Hence, ecological assembly was modelled at the sites closest to the hydrology reference location.

The relative percent difference between the modelled elevation and averaged corrected GPS positions was calculated for each model zone. This was done to identify significant errors between the measured elevation data and the data used in the model. The relative percent difference of the model height from the actual corrected height was less than 1% in all cases, except for T30 (Zone 1a) which had a relative percent difference (RPD) of 4.3% (Appendix 13.7a). The T30 hydrology results are the least representative of the hydrology data (Section 13.3).

Another necessary component of the ecological assembly model was the establishment of the growing season. Growing season for the Project was calculated as the number of days between when the temperature exceeded 11ºC for five of seven days and when temperature was below 11°C for five of seven days. Based on the temperature records, the growing season in the region is 98 days (from May 28 to September 2). This growing season length is consistent with field observations and literature (Territorial Farmers Association 2000).

The percentage of the growing season that the Fl-5, Fl0 and Fl+5 elevations were flooded was calculated by counting the number of days in each growing season where water levels exceeded one of the flood levels and dividing the total by the number of days in the growing season (98). The last day of the first flood (ld) and the time of the second flood (tsec) were also recorded as these variables have been identified as being significantly correlated to ecological assembly (Toner and Keddy 1997). However, flooding often started before the growing season and at some locations continued past it; therefore, the ld and tsec data are not presented in this assessment. The Fl+5 flood statistics are also not presented because this elevation was never flooded during the growing season (Appendix 13.7A).

13.7.1.2.1 Summary of Modelled Hydrology Changes

The hydrology information presented in this assessment is based on average monthly water level fluctuations. The range provided is not the minimum and maximum range of the data set but the minimum and maximum monthly average water level fluctuations.

The hydrology model predicts that in the northern part of Zone 1 (Taltson Lake), water levels would increase between approximately 5 cm to 59 cm over baseline conditions from November to May for the 36 MW scenario. Water levels from June to October would be between approximately 8 cm and 59 cm below baseline conditions; the largest difference (-59 cm) is expected to happen in July for the 36 MW scenario. In Taltson Lake (Zone 1) under the 56 MW scenario, water flows are only expected to be <10 cm below baseline in June and July. Water levels are expected to be between 12 cm and 31 cm above baseline for all other months under the 56 MW scenario. This pattern is similar to what is expected in King Lake, Lady Grey Lake, and Benna Thy Lake (Section 13.3).

In Tronka Chua Lake (Zone 2) the hydrology model predicts that water levels would be continually below baseline for both expansion scenarios. Under the 36 MW scenario water levels are expected to be between 1 cm and 53 cm below baseline conditions; for the 56 MW scenario water levels would be between 63 cm and 95 cm below baseline. The hydrograph of Tronka Chua Lake follows a more natural pattern under the 56 MW scenario than the 36 MW scenario. In the southern part of Zone 2 at Thekulthili Lake water levels would also continually be below baseline. Under the 36 MW scenario water levels would drop 1 cm to 18 cm below baseline, while under the 56 MW scenario water levels would be 26 cm to 36 cm below baseline (Section 13.3).

In Zone 3, between the Twin Gorges Forebay and the Tazin River, water levels are expected to be similar for the expansion scenarios, although the magnitude of water level reductions is different. Water levels are expected to range from 13 cm to 65 cm above baseline from December to May and 2 cm to 75 cm below baseline from June to November. In the Twin Gorges Forebay, annual water levels are expected to be 28 cm to 58 cm below baseline for the 36 MW option and 38 cm to 63 cm below baseline for the 56 MW option. Farther downstream in Zone 3, water levels would follow a similar pattern to Zone 1 water levels in that, under the 36 MW option, water would be 1 cm to 44 cm above baseline for November to May and between 8 cm and 33 cm below baseline for the June to December period. Under the 56 MW option water levels are expected to be between 1 cm and 11 cm above baseline from

September to June and between 2 cm and 10 cm below baseline for July and August (Section 13.3).

In Zone 4 the pattern of water level fluctuations is expected to be similar to Zone 1 downstream of Twin Gorges. The largest water level fluctuations are for the 36 MW option (59 cm above baseline to 54 cm below baseline). The range for the 56 MW option is approximately 20 cm above to 16 cm below baseline. The timing of water level fluctuations is an important process as it maintains flood regime and ultimately community structure. Under the 36 MW option water levels would be on average 33 cm below baseline. For the 56 MW option water levels would be on average 8 cm below baseline for the same period (Section 13.3.)

The hydrology model predicts that in the Nonacho Lake Zone water levels are generally expected to be below baseline conditions. Water levels would be between 59 and 76 cm lower for the 56 MW option and 6 cm and 59 cm lower for the 36 MW option. Average water levels drops during the growing season are expected to be 63 and 28 cm for the 56 and 36 MW scenarios respectively (Section 13.3.)

These water level fluctuations would result in noticeable changes to the flood regime of the flood positions Fl-5 and Fl0. Wetland model data is not available for Zones 2, 3, and 4; however, if changes to water levels change the flood regime of the riparian communities, changes to ecological assembly would occur. Table 13.7.3 presents model statistics for the baseline conditions and the difference between upgrade scenarios and baseline conditions for the 36 MW and 56 MW scenarios at the Fl-5 and Fl0 flood positions.

Table 13.7.3 — Percentage of Growing Season Flooded at Fl-5 and Fl0 Positions for the Baseline Period

Zone	Hydrology Reference	Survey Plots	Flood Level	Growing Season Flooded % (Baseline)
Zone 1	T30	19, 20, 21, 22, 23	Fl-5	60
Zone 1	T39	24, 25, 26	Fl-5	85
Zone 1	T49	27, 28, 30, 31, 32	Fl-5	88
Nonacho Lake Zone	Nonacho Lake	35, 37, 38, 42, 43, 44, 45	Fl-5	100
Zone 1	T30	19, 20, 21, 22, 23	Fl0	22
Zone 1	T39	24, 25, 26	Fl0	39
Zone 1	T49	27, 28, 30, 31, 32	Fl0	42
Nonacho Lake Zone	Nonacho Lake	35, 37, 38, 42, 43, 44, 45	Fl0	36

13.7.2 Valued Components

Wetlands are a Valued Component (VCs) because of their importance as wildlife habitat, regulators of hydrology, biodiversity, and productivity levels. For this assessment, the VC of wetlands was separated into two sub-VCs relating to wetland extent and wetland function.

13.7.2.1 WETLAND EXTENT

Wetland extent is defined as the size of individual wetlands, total wetland area, and the distribution of specific ecosystems within the study area. Wetland extent was chosen as a VC because loss of wetland area is one of the largest threats to wetlands in the Northwest Territories, Canada, and worldwide. Wetland extent is measured through a footprint analysis. Given the size of the basin, it was not feasible to measure wetlands in every zone. Subsequently, the focus of the baseline study and footprint analysis was on Zone 1 and Nonacho Lake, because it was thought that these zones had the greatest potential for effects. Thus, wetland extent was not quantified in Zones 2, 3, and 4. Wetland extent in Zone 1 was mapped using two different geographic data sources and as such this zone was separated into two subzones. In the southern portion of Zone 1 (Zone 1a) wetlands comprise approximately 1233 ha. In the northern portion of Zone 1 (Zone 1b) wetlands make up approximately 344 ha. Wetlands in the Nonacho Lake Zone account for approximately 651 ha.

13.7.2.2 WETLAND FUNCTION

Wetland function was selected as a VC because it is a standard measure of wetland quality. Wetland function is defined as a process or series of processes that wetlands carry out, such as regulating hydrology. Environment Canada (2003) identifies four primary functions in their Wetland Environmental Assessment Guideline document; however, only three functions were considered in this assessment. The three functions included in this assessment and their definitions are provided below.

- Hydrological Function – contribution of the wetland to the quantity of surface and groundwater.
- Habitat Function – terrestrial and aquatic habitat provided.
- Ecological Function – role of the wetland in the surrounding ecosystem.

The biochemical function of wetlands, such as their ability to sequester metals and break down environmental pollutants, is not included in this assessment. Effects of the Project on the biochemistry in the aquatic environment are addressed in Sections 13.4 and 13.9.

13.7.2.2.1 Hydrological Function

The wetlands in the study area are closely connected with the surface water flow of the Taltson River system. Riparian wetlands are not net contributors of water; rather, they temporarily store water and release them over a long period. Riparian marshes are well known for their flood control and sediment trap functions. It is estimated that 0.4 ha of wetlands can store 6000 m^3 of flood water (RAMSAR 2008). Because wetlands are closely linked to the surface water system, alterations in wetland hydrology is a primary pathway for environmental effects to wetland function. Marsh wetlands are particularly susceptible to hydrological changes (MacKenzie and Moran 2004).

13.7.2.2.2 Habitat Function

The habitat function is the terrestrial and aquatic habitat provided by wetlands. This was identified through wildlife observations during the ecosystem survey. A number of amphibians and mammals were observed in the study area. Moose frequent the many riparian marshes and shallow open water wetlands in the summer to cool off and escape from insect pests (Flook 1959; Renecker and Hudson 1986). A number of moose beds were observed in riparian marsh communities throughout the study area. In the winter, willows found along the Sedge-Willow community boundary in riparian wetlands provide valuable forage for moose.

13.7.2.2.3 Ecological Function

Riparian wetlands in the study area are strongly connected with the upland environment and often form complexes of multiple wetland associations. Riparian marsh associations abruptly transition into tall shrub swamps and shrub-carr associations before continuing upslope and eventually drying out and becoming upland forest. The structural variety of wetland communities provides habitat for a number of wildlife species, benefiting the function and biological integrity of surrounding ecosystems (Galatowitsch and Van Der Valk 1998).

13.7.3 Assessment Endpoints

The assessment endpoints represent the key features of the VC that should be protected and are used to illustrate how the pathways affect wetlands. The assessment endpoints for the wetland VC are presented in Table 13.7.4.

Table 13.7.4 — Wetland Valued Components and Assessment Endpoints

Key Line of Inquiry	Valued Component	Assessment Endpoint
Water Fluctuation in the Taltson River Watershed (Excluding Trudel Creek)	Wetlands	Preservation of wetland extent within the Taltson River watershed
Water Fluctuation in the Taltson River Watershed (Excluding Trudel Creek)	Wetlands	Maintenance of wetland function within the Taltson River watershed

13.7.4 Assessment Boundaries

The assessment boundary can be separated into two categories (1) spatial and (2) temporal. The following section describes the spatial and temporal boundaries as they relate to wetlands.

13.7.4.1 Spatial Boundary

The spatial boundaries for the assessment are small, medium, regional, and beyond regional. The small-scale area is a single zone of the Taltson River watershed (Figure 13.3.2). The medium-scale is multiple zones. The regional boundary is defined as the Taltson River watershed. The beyond regional assessment boundary is defined as the Great Slave watershed.

The five small-scale study zones for this DAR included:

- Nonacho Lake.
- Zone 1 (Taltson Lake and River from Nonacho Dam to confluence with Tazin River).
- Zone 2 (Tronka Chua Lake, Thekulthili Lake, to confluence with Lady Grey Lake).
- Zone 3 (Taltson River from Tazin River confluence, through Twin Gorges Forebay and dam, to Tsu Lake).
- Zone 4 (Tsu Lake and Taltson River downstream to Great Slave Lake).

13.7.4.2 TEMPORAL BOUNDARY

Two components were considered when selecting the temporal assessment boundaries for the effects assessment:

1. Duration of Project Activities. Project activities are highly correlated with the various phases of the Project: construction, operations and decommissioning and closure. Construction is not covered in the Taltson KLOI but is addressed in Section 15.2 (SON Canal Construction). Currently, the Project is expected to operate for 20 years to service the existing and proposed diamond mines. However, the infrastructure would have a lifespan of at least 40 years, and it is the intent of the Dezé Energy Corporation (Dezé) to solicit new customers to extend the Project beyond 20 years. Subsequently, the expected length of time that Project-related stressors would influence VCs during the operation phase is assumed to be 40 years. Although Dezé intends to operate the Project longer than 40 years if customers can be found, increasing the duration of the operation phase of the Project would increase the uncertainty in the effects predictions. For example, it is currently not known how much of the transmission line would be in operation after 40 years. Therefore, 40 years was defined as the longest reasonable duration of the operation phase for predicting and assessing effects from the Project. The details on decommissioning are not comprehensive enough to complete an effects assessment at this time; however, it is Dezé's plan to complete the necessary studies seven to ten years prior to closure. Closure and restoration details are provided in Section 6.8 (Project Closure and Restoration).

2. Ecology of the Valued Components. The wetlands VCs include many different plant species with different life cycles. Depending on the disturbance, these different species may respond differently to similar disturbances. Thus, the duration of an effect could vary when considering individual species. The temporal boundaries were therefore defined based on the duration of an effect to the wetland as a whole. For example, if an effect caused a shift in the community boundary between willow and sedge, the duration of the effect was determined by the time required for that boundary to re-establish with both willow and sedge, as opposed to succession of a single species and thus an unstable wetland. The specific definitions used for the temporal assessment boundaries are presented in the Effects Classification section below (Section 13.7.9 Residual Effects Analysis).

13.7.5 Project Components

Given that this KLOI relates to potential effects of the Project on wetlands because of water level fluctuations in the Taltson River watershed (excluding Trudel Creek) only activities affecting water levels are considered in this assessment. Other Project components that may affect wetlands (i.e., power line poles or winter roads) are assessed on other sections of this document.

Therefore, the assessment would focus on two Project phases; (1) construction (Section 15.2) and (2) operation. The details on decommissioning are not sufficiently detailed to complete an effects assessment at this time; however, it is the plan of the Dezé to complete the necessary studies seven to ten years prior to closure.

The operation of the Project refers to activities carried out after construction and in the normal operation of the Project under either the 36 MW or the 56 MW expansion scenarios and scheduled ramping of water levels due to the maintenance of turbines and power generating facility at Twin Gorges. As discussed in Section 13.7.4.2, the anticipated lifetime of the Project is 40 years. The construction of the Project includes a six-month drawdown of water in Nonacho Lake during the winter of 2010-11. The increased water levels in the Taltson River associated with the drawdown in Nonacho Lake are not expected to adversely affect wetlands given that the drawdown is scheduled to occur outside the growing season and is expected to be a short, onetime event.

13.7.6 Pathway Analysis

The measurement endpoint of this assessment and the divisions of magnitude are based on flood regime rather than wetland area, because the dominant wetland found was marsh communities and they are primarily maintained by hydrology. Changing flood regimes would elicit changes in wetland extent and ultimately wetland function.

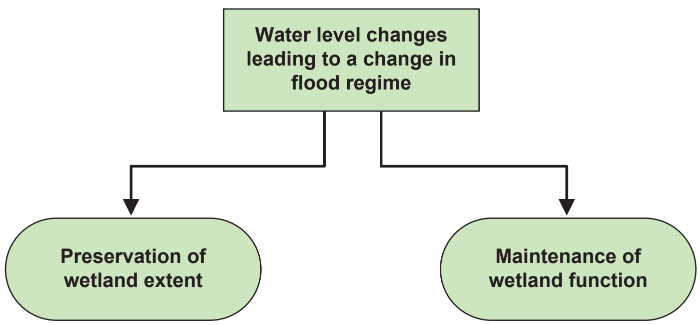
13.7.6.1 Identification of Pathways

Pathways were identified that link potential effects to wetland extent and wetland function and ultimately the assessment endpoints for both expansion scenarios (Table 13.7.5 and Figure 13.7.4).

Table 13.7.5 — Wetland Assessment Pathways

Project Phase	Valued Component	Assessment Endpoint	Pathway
Operation	Wetlands	Preservation of Wetland Extent	Water level changes leading to a change in flood regime which alters wetland extent in Nonacho Lake, Zone 1, Zone 2, Zone 3 and Zone 4. Rapid water level changes leading to a change in flood regime which alters wetland extent due to scheduled ramping in Zone 3.
		Maintenance of Wetland Function	Water level changes leading to a change in flood regime which alters wetland function (hydrological, habitat and ecological) in Nonacho Lake, Zone 1, Zone 2, Zone 3 and Zone 4. Rapid water level changes would change the flood regime which would alter wetland function (hydrological, habitat and ecological) due to scheduled ramping in Zone 3.

Two pathways exist that could affect the wetland assessment endpoints in each zone under operations. Changing water levels would affect the current flood regime, which is the primary force in maintaining riparian wetland communities (Odland and Moral 2002; Toner and Keddy 1997; and Nilsson and Svedmark 2002). The direction of change (increase or decrease in flows) is not as important as the magnitude and duration. Water levels substantially above or below current ecosystem community boundaries would result is species composition shift following natural succession. Water level changes in each zone are expected from baseline conditions.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wetlands - Pathways and Assessment Endpoints for Potential Effects in the Taltson Basin (503-005 / a22353f-C13)	Figure 13.7.4

13.7.7 Mitigation

Canadian federal policy regarding wetland conservation identifies three hierarchical mitigation alternatives (Lynch-Stewart et al.1996) when considering potentially-affected wetland habitats:

- **Avoid:** relocate Project activities to prevent loss of wetland habitat.
- **Minimize:** plan Project activities to have little direct or indirect effects to wetland ecosystems.
- **Compensate:** create wetland habitat with similar values to replace wetland habitat irrevocably altered during Project activities.

Effects of the Project would be minimized through two primary mitigation measures: (1) mitigation practice and (2) mitigation design. Mitigation practice includes activities and strategies that would reduce or avoid a negative effect. Mitigation design refers to a Project component incorporated into the Project to reduce or avoid a negative effect. Design mitigation for Project activities within the Taltson River watershed are presented in Section 13.1 (Introduction). Mitigative measures of the Expansion Project as they relate to wetlands include maintaining water levels within the current Water Licence levels, continued release through the Tronka Chua Gap, construction of a bypass spillway at the Twin Gorges power facilities, staggered start-up following plant outage to reduce flow ramping events, and multiple power units to minimize changes in water levels through operations.

13.7.8 Pathway Validation

Pathways are considered "Valid" when there is an effect on a VC because of a Project component after a mitigation measure (practice or design). Pathways where mitigation is not expected to avoid or reduce a negative effect were identified as Valid, and were carried through to the effect analysis and classification. Pathways where mitigation reduces a negative effect were considered Minor or Valid depending on the significance of the pathway and the degree to which mitigation would likely lessen the negative effect; only Valid pathways were carried through to the effect analysis.

Marsh wetland communities would undergo structural change if their hydrological regime is not maintained; this includes both water level increases and reductions. Specific, directional water level changes, as well as magnitude, and duration were addressed through using the ecological assembly model. Pathways were considered Valid if the flood regime responsible for maintaining a specific community was altered.

If the average difference between baseline and expansion scenario ecological assembly values (Fl0 and Fl-5) was >20% in each zone, the pathway was identified as Valid. Pathways were identified as minor if the average difference between baseline and expansion scenario ecological assembly values (Fl0 and Fl-5) was between 10% and 20%. Pathways were identified as Invalid if the average difference between baseline and expansion scenario ecological assembly values (Fl0 and Fl-5) was <10%. Table 13.7.6 presents the ecological assembly flood statistics comparing baseline conditions to the 36 MW and 56 MW expansion scenario flood statistics at the Fl-5 and Fl0 elevations.

Table 13.7.6 — Percentage of Growing Season Flooded in Zone 1 and Nonacho Lake at Fl-5 and Fl0 Positions for the Baseline and 36 MW and 56 MW Expansion Scenarios

Zone	Hydrology Reference	Survey Plots	Flood Level	Growing Season Flooded % (Baseline)	Growing Season Flooded % (36 MW)	Growing Season Flooded % (56 MW)
Zone 1	T30	19, 20, 21, 22, 23	Fl-5	60	0	44
Zone 1	T39	24, 25, 26	Fl-5	85	43	83
Zone 1	T49	27, 28, 30, 31, 32	Fl-5	88	44	88
Nonacho Lake	Nonacho Lake	35, 37, 38, 42, 43, 44, 45	Fl-5	100	79	0
Zone 1	T30	19, 20, 21, 22, 23	Fl0	22	0	14
Zone 1	T39	24, 25, 26	Fl0	39	0	19
Zone 1	T49	27, 28, 30, 31, 32	Fl0	42	0	42
Nonacho Lake	Nonacho Lake	35, 37, 38, 42, 43, 44, 45	Fl0	36	0	0

Rapid changes in water level associated with scheduled outages are expected in Zone 3 (Forebay and downstream of Twin Gorges). Scheduled ramping would occur as a result of water rerouting during a contiguous three-week maintenance event on the power-generating facility. Scheduled ramping would occur before the growing season. The water level fluctuations associated with scheduled ramping would be low-magnitude changes occurring when water is rerouted from Twin Gorges through Trudel Creek (Section 13.3.4). There is expected to be a lag of approximately 10 to 16 hours before rerouted water from Trudel Creek re-enters the Taltson River. During this period there would be a reduction in water levels in Zone 3 between Elsie Falls and Tsu Lake; after 10 to 16 hours water levels would return to background. This fluctuation in water levels in Zone 3 would be followed by an increase over background when the maintenance of a given turbine(s) is complete. The increased water levels over background would last for 10 hours until the last of the rerouted water drains from Trudel Creek. Flow in the Taltson River below Twin Gorges would change by 44 m^3/s (for the existing turbine) and 23 m^3/s (new 18 MW turbines) from estimated pre-outage conditions for the 36 MW expansion and by up to 53 m^3/s (for an expansion turbine) for the 56 MW scenario for roughly 10 to 16 hours. Based on average April and May background flow in Trudel Creek during periods of full generation flow at the power plants, the resulting changes in water level would be up to 0.34 m (decrease during initial shutdown and increase upon restart) for the 36 MW expansion and up to 0.32 m (decrease during initial shutdown and increase upon restart) for the 56 MW expansion. Water levels on the Forebay would increase for the duration of the ramping event. Water levels would increase roughly 0.1 m and 0.2 m for the 36 MW and 56 MW options.

For both the 36 MW and 56 MW expansions, the timing, duration, and magnitude of these events would not alter wetland extent and function in the zone.

Ecological assembly model data was not collected in Zones 2, 3, and 4; therefore, pathways were validated based on average annual water fluctuations in these zones >20 cm between baseline and expansion scenario. Pathway validations for the 36 MW and 56 MW options are presented in Table 13.7.7 and Table 13.7.8, respectively.

Table 13.7.7 — Pathway Validation for 36 MW Option

Project Phase	Pathway	Pathway Validation
Operation	Water level changes leading to a change in flood regime which alters wetland extent in Nonacho Lake, Zone 1, Zone 2, Zone 3 and Zone 4.	Valid. Changing water levels would change the flood regime which would alter wetland extent.
	Rapid water level changes leading to a change in flood regime which alters wetland extent due to scheduled ramping in Zone 3.	Minor. Ramping is scheduled in early spring, before the growing season. Timing and duration not likely to alter wetland extent.
	Water level changes leading to a change in flood regime which alters wetland function (hydrological, habitat and ecological) in Nonacho Lake, Zone 1, Zone 2, Zone 3 and Zone 4.	Valid. Changing water levels would change the flood regime which would alter wetland function.
	Rapid water level changes would change the flood regime which would alter wetland function (hydrological, habitat and ecological) due to scheduled ramping in Zone 3.	Minor. Ramping is scheduled in early spring, before the growing season. Timing and duration not likely to alter wetland function.

Table 13.7.8 — Pathway Validation for 56 MW Option

Project Phase	Pathway	Pathway Validation
Operation	Water level changes leading to a change in flood regime which alters wetland extent in Zone 1 and Zone 4.	Minor. Changing water levels would not substantially change the flood regime; there would be little effect on wetland extent.
	Water level changes leading to a change in flood regime which alters wetland extent in Nonacho Lake, Zone 2, and Zone 3.	Valid. Changing water levels would change the flood regime which would alter wetland extent.
	Rapid water level changes leading to a change in flood regime which alters wetland extent due to scheduled ramping in Zone 3.	Minor. Ramping is scheduled in early spring, before the growing season. Timing and duration not likely to alter wetland extent.
	Water level changes leading to a change in flood regime which alters wetland function (hydrological, habitat and ecological) in Zone 1 and Zone 4.	Minor. Changing water levels would not substantially change the flood regime; there would be little effect on wetland function.
	Water level changes leading to a change in flood regime which alters wetland function (hydrological, habitat and ecological) in Nonacho Lake, Zone 2, and Zone 3.	Valid. Changing water levels would change the flood regime which would alter wetland function.

Project Phase	Pathway	Pathway Validation
	Rapid water level changes would change the flood regime which would alter wetland function (hydrological, habitat and ecological) due to scheduled ramping in Zone 3.	Minor. Ramping is scheduled in early spring, before the growing season. Timing and duration not likely to alter wetland function.

13.7.9 Effect Classification

Effects to wetland extent and function were defined for available information. Effects assessment descriptors are defined in Section 13.2 and Chapter 10. Definitions of the effect assessment descriptors that varied from those presented in Section 13.2 are defined below.

The magnitude of effect on wetland assessment endpoints was heavily weighted by community shifts, as measured by a difference from the baseline ecological assembly statistics. Magnitude divisions for community shifts are presented in Table 13.7.9.

The duration of effects was defined by considering the duration of Project activities, which are correlated with Project phases, and the duration of effects on measurement endpoints (e.g., habitat) which shadow effects on the assessment endpoints. Short-term was defined as less than three years, which corresponds to the predicted length of time required for some species to adjust to disturbance (e.g., submergent vegetation). Medium-term was defined as less than 10 years, which corresponds to the predicted length of time required for emergent vegetation to re-establish following disturbance. Long-term was defined as less than 40 years, which corresponds to the duration of the operations phase of the Project.

The geographic extent was based on the extent of the effect: a single zone, multiple zones, or the entire Taltson River watershed (regional scale). The reversibility was assessed based on whether the effect is reversible if the stressor remains or if removed. That is, the pathway could remain (e.g., decreased water levels) but the effect could be reversed over time (new willow-sedge community boundary). Alternatively, an effect reoccurs or remains until the stressor is removed (e.g., ramping events cease at the end of operations). The overall residual effect considers the qualitative ratings of effects on the assessment endpoint for each pathway.

Table 13.7.9 — Ecological Assembly Statistics and Community Shift Magnitude

Difference from Baseline at Fl0[1]	Assessment Magnitude	Difference from Baseline at Fl-5[1]
0-5	Normal	0-5
6-10	Negligible	6-15
11-15	Low	16-25
16-20	Moderate	26-35
>20	High	>35

[1] Represent discrete value changes from the percent of growing season flooded ecological assembly model statistics.

13.7.9.1 36 MW Expansion Scenario

13.7.9.1.1 Zone 1 Extent and Function

Wetlands in Zone 1 would be affected because water levels are not expected to continue flooding at the Sedge-Willow ecosystem boundary. Currently, approximately 1,233 ha of wetlands, susceptible to alteration, are in the southern part of the zone (Zone 1a) and 344 ha of wetlands in the north part of the zone (Zone 1b). The majority of these wetland communities are riparian marshes with a willow boundary. That boundary is expected to move down in elevation until it reaches a point that is flooded for <40% of the growing season. The ecological assembly model for the north part of Zone 1 predicts a boundary shift of approximately 0.5 m vertically or 10 m slope distance – assuming a 5% slope. The current emergent community is expected to be replaced by a willow community based on the flood statistics (Appendix 13.7a). However, a number of unknown variables may influence the movement of any community into the currently submerged areas, such as:

- the sediment and soil composition in the submergent zone,
- the topography of the submergent zone, and
- the seed bank of dominant wetland species.

Table 13.7.10 presents the effect classification for wetland extent in Zone 1.

The effect of the proposed upgrade is difficult to quantify for wetland function. Wetlands currently function by buffering downstream environments from flooding during high water and maintaining water flow during low-water periods. This function is preformed by both sedge and willow communities. The contributions of each community to the overall hydrological function were not studied in detail; however it is likely that changes in wetland extent would affect the hydrological function of wetlands. One of the primary contributors to wetland hydrological function is wetland soil, which forms, in part, because of the vegetation present. The surface soil layer of the riparian marsh communities surveyed was organic, which acts as a sponge, soaking up water as water level rises and releasing it slowly as water levels subside. A changed flood regime would result in organic soils isolated from the river and therefore a reduced flood control capacity. Although, the hydrology function of riparian wetlands would be altered, it is not the dominant hydrological contribution to the Taltson River.

The effects on the habitat and ecological function, too, are not easily quantified. Moose beds were observed in sedge communities but they also depend on willow for food, especially in winter months (Renecker L.A. and R.J. Hudson 1986). The change in community structure and wetland extent would alter the habitats and ecological functions. Table 13.7.10 presents the effect classification for wetland function in Zone 1.

Table 13.7.10 — Wetland Effects Classification under 36 MW Scenario for Zones 1 to 4 and Nonacho Lake

Pathway	Project Phase	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Overall Residual Effect
Water level changes leading to a change in flood regime which alters wetland extent in Nonacho Lake, Zone 1, Zone 2, Zone 3 and Zone 4.	Operation	Adverse	High	Entire Taltson River Watershed	Medium-term	Reversible	Continuous	Likely	Moderate
Water level changes leading to a change in flood regime which alters wetland function (hydrological, habitat and ecological) in Nonacho Lake, Zone 1, Zone 2, Zone 3 and Zone 4.	Operation	Adverse	Moderate	Entire Taltson River Watershed	Medium-term	Reversible	Continuous	Likely	Moderate

13.7.9.1.2 Zones 2, 3 and 4 Extent and Function

No wetlands were studied or mapped in Zones 2, 3, and 4. However, wetlands were observed in these zones and they would be affected by the magnitude, timing, and duration of water level changes. Effects on wetlands in these zones were predicted using modelled hydrology data. The ecological assembly model predicts that there would be changes to the flood regimes in Zone 1 and the Nonacho Lake Zone, and that these changes would cause an alteration of wetland extent and wetland function. If wetlands are present in Zones 2, 3, and 4 it is probable that effects would be observed in these areas as well. Pathways for alteration to wetland extent and function were carried through the assessment process as a precautionary measure, but actual effects cannot be quantified in these zones.

Water levels in Tronka Chua Lake (Zone 2) are expected to drop an average of 26 cm over the year but would be down approximately 50 cm during the growing season. This would change the hydrology of riparian marshes and would lead to an alteration of extent and function in this part of the zone. However, at Thekulthili Lake (Zone 2) the magnitude of reduced water levels is not as great; there would be a yearly reduction of 9 cm and a growing season drop of 16 cm. This change in water levels would not be expected to substantially alter wetland extent and function. Based on water level changes alone, effects were predicted to wetlands in Zone 2. Table 13.7.10 presents the effect classification for wetland extent and function in Zone 2.

Water levels in the Taltson River downstream of the Tazin River are expected to be higher than baseline from December to May and lower than baseline from June to November with an average growing season drop of 55 cm. This pattern of reduced water levels is also expected in the Taltson River downstream of Twin Gorges; however, the growing season water level drop would only be approximately 24 cm. This would change the hydrology of riparian marshes and would lead to an alteration of extent and function in this part of the zone. In the Taltson River at Twin Gorges, growing season water levels are only expected to drop by approximately 55 cm. This would have a moderate effect on riparian marshes, depending on ecosystem structure and the slope of the riparian area.

Water levels in Tsu Lake (Zone 4) are expected to drop an average of 33 cm in the growing season. This would elicit a low to moderate reduction in riparian marsh extent and function. Farther downstream in Zone 4 water levels are expected to be closer to baseline because of the lake systems buffering alterations to water level fluctuations. It is expected that effects to wetlands downstream of Tsu Lake in Zone 4 would not substantially be affected by the Project. Table 13.7.10 presents the effect classification for wetland extent and function in Zone 4.

13.7.9.1.3 The Nonacho Lake Zone Extent and Function

The ecological assembly model predicts that there would be a slightly greater than moderate effect to wetland extent at the (Fl-5) submergent community currently present in Nonacho Lake (Table 13.7.9). The existing submergent community is expected to be flooded approximately 21% less during the growing season because of an average drop in growing season water levels of 0.28 m. This indicates that some submergent areas may become emergent areas (sedge-dominated). Assuming that the sedge ecosystem can adjust to changing water levels, the submergent community would be expected to occupy areas 0.6 m vertically below the current Sedge-Willow boundary, for a total 0.1 m vertical shift.

The Sedge-Willow ecosystem boundary is expected to shift toward the new water level, although the distance is unknown. Assuming a constant slope of 5%, it is probable the boundary would change its position by approximately 0.3 m vertically or approximately 6 m (slope distance). This indicates a loss of sedge-dominated riparian wetlands in the Nonacho Lake Zone. Table 13.7.10 presents the effect classification for wetland extent in the Nonacho Lake Zone.

A reduction in sedge community in the marshes of the Nonacho Lake Zone would result in an alteration of habitat and ecological function. A number of moose beds were observed in marsh communities through the study area; indicating moose presence. A reduction in the extent of these marshes would inevitably reduce the availability of these habitats. The change in marsh extent would also change the diversity of wetland ecosystems in the area. This would have an effect on the ecological integrity and biodiversity in the region.

As mentioned above, both willow and sedge communities have a hydrologic function. The composition of wetland ecosystems is expected to change but this is not expected to alter the hydrological function in the lake because both sedge and willow communities have a hydrologic function. Nonacho Lake is now, and would be even more so, a reservoir; flows would be actively managed. Wetland hydrological function, outside holding water for wetland vegetation, is not an important wetland function in this Zone. Table 13.7.10 presents the effect classification for wetland function in the Nonacho Lake Zone.

13.7.9.1.4 Overall Residual Effect

The change in the hydrologic regime would cause a change in community structure as determined by the ecological assembly model and/or inferred solely via changes in water levels. Changes in the community structure would result from a change in the flood-controlled community boundary. For wetlands in the Taltson River watershed, this is predicted to allow willow and sedge to shift downslope as the habitat dries. Submergent vegetation is also predicted to shift down with the water level. Little net change in wetland extent is predicted, assuming both willow and sedge succession is successful over time (Table 13.7.10). The overall residual effect is moderate given the length of time assumed for the wetland to stabilize.

As the community structure changes in response to changes in the flood regime, so too would wetland function. In terms of Taltson wetland hydrologic function, the current wetlands are not considered key factors in the rate of release of freshet volume over time (given the large storage capacity of Taltson lakes), nor are they considered instrumental in maintaining minimum flows through the winter (given that the Taltson River is relatively self-regulated by significant but few hydraulic controls from Nonacho to Twin Gorges). Thus, the overall hydrologic function of Taltson wetlands on the Taltson River hydrograph is minimal. Taltson wetlands are, however, assumed to play a significant role in terms of wildlife habitat. Under the 36 MW option, the overall wetland extent is not expected to change measurably in the medium term. In the short term, there would be succession in species location and abundance but there won't be periods of large reductions in overall habitat. Thus, the overall residual effect on wetland function has been conservatively rated as moderate.

13.7.9.2 56 MW Expansion Scenario

13.7.9.2.1 Zone 1 Extent and Function

The areas of wetlands in Zone 1 and the Nonacho Lake Zone that are susceptible to alteration are the same as the areas presented in Section 13.7.8.1. However, the magnitude potential effects are different because the different water requirements under the 56 MW scenario would maintain the baseline flood regime, ultimately preserving wetland extent and function.

The effect of the Project on wetlands in Zone 1 is expected to be minimal. Ecological assembly model results show minimal average differences in flooding (<20%) at both the Fl0 and Fl-5 flood positions. The expected change is a 6% decrease in flooded time during the growing season – approximately 5 days. This is not expected to alter community structure in the riparian area of Zone 1. This pathway is not presented in the effects classification table (Table 13.7.11) because this was identified to be a minor pathway. With little effect on wetlands expected, it is unlikely that wetland function would be significantly affected.

13.7.9.2.2 Zones 2, 3 and 4 Extent and Function

Effects on wetlands in these zones were predicted using modelled hydrology data. The ecological assembly model predicts that there would be changes to flood regime in the Nonacho Lake Zone and that these changes would cause an alteration of wetland extent and wetland function. If wetlands are present in Zones 2, 3, and 4 it is probable that effects would be observed in these areas as well. Pathways for alteration to wetland extent and function were carried through the assessment process as a precautionary measure but actual effects cannot be quantified in these zones.

Water levels in Tronka Chua Lake (Zone 2) are expected to drop an average of 76 cm over the year but would be down approximately 90 cm during the growing season. This would substantially change the hydrology of riparian marshes and would lead to an alteration of extent and function in this part of the zone. At Thekulthili Lake (Zone 2) the magnitude of reduced water levels is not as great; there would be an average yearly and growing season reduction of 31 cm. This change in water levels would not be expected to alter wetland extent and function as much as around Tronka Chua Lake. Based on water level changes alone, effects on wetlands were predicted. Table 13.7.11 presents the effect classification for wetland extent and function in Zone 2.

Water levels in the Taltson River downstream of the Tazin River are expected to be higher than baseline from September to May and lower than baseline from June to August with an average growing season drop of 15 cm. This magnitude of reduced water levels is also expected in the Taltson River downstream of Twin Gorges. This would not substantially change the hydrology of riparian marshes and would not alter extent and function in this part of the zone.

Water levels in Tsu Lake (Zone 4) are expected to drop an average of 8 cm in the growing season. This would not reduce riparian marsh extent and function. Farther downstream in Zone 4, water levels are expected to be closer to baseline because of the lake systems buffering alterations to water level fluctuations. It is expected that effects to wetlands downstream of Tsu Lake in Zone 4 would not substantially be affected by the Project. Table 13.7.11 presents the effect classification for wetland extent and function in Zone 4.

Table 13.7.11 — Wetland Effects Classification under 56 MW Scenario for Zones 1-4 and Nonacho Lake

Pathway	Project Phase	Direction	Magnitude	Geographic Extent	Duration[1]	Reversibility	Frequency	Likelihood	Overall Residual Effect
Water level changes leading to a change in flood regime which alters wetland extent in Nonacho Lake, Zone 2 and Zone 3	Operation	Adverse	Moderate	Multiple Zones	Medium-term	Reversible	Continuous	Likely	Moderate
Water level changes leading to a change in flood regime which alters wetland function (hydrological, habitat and ecological) in Nonacho Lake, Zone 2, and Zone 3	Operation	Adverse	Moderate	Multiple Zones	Medium-term	Reversible	Continuous	Likely	Moderate

[1]Duration - Short-term (<3 years); Medium-term (3-10 years); Long-term (10-40 years); Indefinite

13.7.9.2.3 The Nonacho Lake Zone Extent and Function

The effect of the Project on wetlands in the Nonacho Lake Zone was predicted based on changes to the ecological assembly model. Flooding would no longer happen at the Fl-5 and Fl0 positions; this would affect all of the wetlands in this zone. This includes the 651 ha of mapped wetlands and an unknown amount of wetlands not surveyed. The effect on wetland extent would also affect wetland function. As the wetlands are dried out, soil decomposition would increase, turning these areas into productive upland forests, and changing water storage ability and habitat type.

It is likely that wetlands in the Nonacho Lake Zone would re-stabilize because large water level fluctuations are not expected. Changes to the Nonacho Lake level are expected to be between 59 cm and 76 cm below baseline, with an average drop during growing season of 63 cm. Although the lake level is expected to be lower than baseline the magnitude of water fluctuations month to month are relatively constant. This would allow vegetation to establish quickly. It is expected that the sediment quantity and composition are likely sufficient to facilitate colonization of the previously submergent community. The effect classification for wetland extent in the Nonacho Lake Zone is presented in Table 13.7.11.

Wetland functions in the Nonacho Lake Zone are primarily ecological and habitat-related. Hydrological functions of wetlands associated with lakes are less important than in riparian systems. The reduction in wetland extent in this zone would also reduce the habitat and ecological functions of wetlands. However, there is the likelihood that wetlands here would be able to colonize the previous submergent community; this would allow for the maintenance of ecological and habitat functions, once communities are re-stabilized, roughly 3 to 10 years after water drawdown. Table 13.7.11 presents the effect classification for wetland function in this zone.

13.7.9.2.4 Overall Residual Effects

The overall effects and rationale for them under the 56 MW expansion are similar to those of the 36 MW expansion. Following a medium-scale time horizon, there would be little change in the overall extent of wetlands. Wetlands would experience change during this time frame. However, while the wetland undergoes a shift in location and structure in response to the changes in flood regime, it is not predicted that there would be a lengthy period during which overall vegetation available as habitat for wildlife would be markedly reduced.

13.7.9.3 Cumulative Effects

No mining or forestry projects situated within the Taltson Watershed have overlap with the study area. Additional hydroelectric projects have not been registered in the area. As there are no reasonably foreseeable projects identified in the study area, no other projects would provide cumulative effects to the Expansion Project since there is no spatial overlap. Should any project or projects move towards development in the regional assessment area there may be cumulative effects to the proposed Expansion Project.

Existing developments include a hydroelectric facility in the Tazin River system. The regulated flows of the Tazin River into Taltson River have been considered in the current Taltson hydrologic model used for all assessments in this document. There are no additional potential cumulative effects from the Tazin River facility.

Initial development of the Twin Gorges facility and the Nonacho Lake control structure resulted in flooding upstream of the Twin Gorges facility and in Nonacho Lake. This is assumed to have had a major effect on wetland communities within these areas. This assumption is based on known hydrologic changes and observations made during a 2008 survey. There were a number of sites in the Nonacho Lake Zone that appeared to be wetlands created due to the original dam construction and subsequent water level increases. A number of sites was observed with standing dead trees (Plate 13.7.12) and the original forest floor was observed 40 cm to 60 cm below the current wetland soil surface (Plate 13.7.13). This indicates that the potential for wetland creation exists when altering the hydrology of the lake. However, it is difficult to quantify the amount of wetlands that may have been created by the Expansion Project.

There are no data on wetland communities occupying the region during pristine environment conditions. However, such a major change would have inundated emergent vegetation and farther covered submergent vegetation, changing ecosystem structure, distribution and function. Existing wetland communities are most likely stabilized from this initial anthropogenic stress which occurred 43 years ago. Riparian wetland communities have developed within Nonacho Lake based on the new hydrologic regime, but are potentially quite different from pre-development wetland habitat as water levels changed.

The proposed expansion options present incremental adverse effects including medium-term reduced wetland extent and altered wetland function, at least until mature wetland communities would be assumed to develop (3 to 10 years following expansion). The adverse incremental effects arise from changing water levels and their affect on wetland extent and function. Potential residual effects from initial hydroelectric project development include changes in wetland structure, loss of wetland habitat, and alterations to wetland function. There exists a high degree of uncertainty as to how the wetland communities have changed in terms of extent, structure, and function, from pristine times to post-initial-development (e.g., 1969) to baseline (current), and exactly how future periods would compare. In any case, the proposed development presents change to the Taltson River and Nonacho Lake wetlands that have likely stabilized since the initial development and would be expected to restabilize in approximately 10 years following the proposed expansion of Twin Gorges and the Nonacho Lake control structure (based on rates of vegetative succession in emergent communities). Thus, the incremental changes are considered changes from a stabilized environment and therefore not cumulative in nature relative to pristine, given that no information exists to quantify and qualify wetlands pre-development.

Plate 13.7.12 — Standing Dead Trees in Nonacho Lake Zone Bog

Plate 13.7.13 — Original Forest Floor in the Soil Profile of a Nonacho Lake Bog

13.7.10 Uncertainty

There are a number of factors that contribute to levels of uncertainty in this assessment:

- wetlands in Zones 2, 3, and 4 were not surveyed or mapped,
- mapping data sources at the baseline and regional scales and their level of accuracy,
- inputs and interpretations of the ecological assembly model,
- factors contributing to wetland vegetation succession,
- information on the "pristine conditions" of wetlands, and
- significance determination at the regional scale from local data..

13.7.10.1.1 Wetlands in Zones 2, 3, and 4

During the scoping and planning of the wetland baseline study, Zones 2, 3, and 4 were not included in the study. Preliminary hydrological model data indicated that potential effects to wetlands in these zones would be minimal and would therefore not require study. However, at that time only the 36 MW expansion scenario was considered. Generally, the 56 MW scenario has water levels close to baseline for Zone 4 and the lower portion of Zone 3. However, more substantial water level differences are expected for Zone 2 under the 56 MW scenario. Zones 2, 3, and 4 were not included in the baseline study and are therefore under-represented in this effects assessment.

13.7.10.1.2 Mapping Data

The lack of continuous satellite image or ortho-corrected aerial photographs also increased the uncertainty in the assessment. As a result, a landsat image from Google Earth and oblique aerial photographs collected in 2008 were used to map wetlands extent in the northern portion of Zone 1 and the Nonacho Lake Zone. The resulting data sets were not comparable between locations because (1) the oblique photos were not ortho-corrected and therefore have distortion associated with fluctuating height above ground and yaw angle of the helicopter during photo-capture, and (2) the accuracy of the Google Earth digitizing tool is not known. Although, the potential error between wetlands digitized from the photos and the Google Earth image may be small they should not be combined because the error is unknown. Another confounding factor to the level of certainty regarding wetland extent is the percent area covered by each image source. The Google Earth image covered 100% of the area it was available for in Zone 1. The aerial photographs collected in 2008 covered 35% of the northern portion of Zone 1 and 10% of the Nonacho Lake Zone. It is likely that wetlands in the northern portion of Zone 1 and the Nonacho Lake Zone are present. However, estimations of their abundance, extent, and distribution cannot be made.

13.7.10.1.3 Ecological Assembly Model

The model of ecological assembly is a powerful tool to track the potential changes to ecosystem structure from dynamic water levels. However, the accuracy of the model is dependant on the accuracy of the data used to build the model. Water levels used for the ecological assembly model were themselves modelled for the baseline, 36 MW, and 56 MW expansion scenarios. These modelled water levels have their own levels of uncertainty because of the methods used to calculate them (Rescan 2008a). The flood levels that were established for the ecological assembly model were collected using a GPS with a vertical accuracy of <1 m. Although submetre accuracy is acceptable, it is not as precise as necessary to narrow the vertical difference between the flood positions (Fl-5 and Fl+5). Toner and Keddy (1997) used flood positions of ± 0.05 m, which improves the accuracy of the model. The relatively large (1 m) vertical difference between the flood positions in this study removes some of the resolution of the model. This is reflected in that of the three variables calculated, only one was applicable at all model locations. The last day of the first flood and the time to the second flood were not always available because of the large vertical difference in flood positions.

Another factor leading to uncertainty was the difference between ecological assembly survey locations and the hydrology reference locations. The reference locations used by Toner and Keddy (1997) were generally less than 5 km from the wetlands surveyed. Although the average distance between hydrology reference locations and wetland survey locations in this study was within the 5 km distance employed by Toner and Keddy (1997), to remain consistent with the ecological model for the remainder of the baseline study area (Section 9.6), wetlands closest to hydrology reference locations were modelled. The model results were used to infer changes to community structure over the portion of the baseline study area upstream of the hydrology reference location, until the next hydrology reference location. Although this is not ideal, it does provide useful information relating the potential for community change with respect to different water levels, and is consistent between all areas modelled for ecological assembly.

13.7.10.1.4 Succession

The rate of succession and colonization is difficult to determine because they are dependant on the magnitude, duration, and timing of flood regime changes, as well as the species involved. Succession and colonization rates would likely be different for different wetland areas, given varying site conditions and species.

13.7.10.1.5 Pristine Conditions

Pristine condition relates to status of the area prior to the original Taltson hydroelectric project. Information describing the pristine conditions of wetlands was needed to complete the cumulative effects assessment. However, there exists very little pristine condition information and specifically on the condition of wetlands. Cumulative effects were assessed assuming that wetland structure and composition was similar to baseline.

13.7.11 Monitoring

Any monitoring should be done ensuring consistent and transferable data so that comparisons can be made to wetlands before, during, and after the Expansion Project. A monitoring program should be tied into monitoring of wildlife within the Taltson River watershed.

TABLE OF CONTENTS PAGE

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF PLATES

13. WATER FLUCTUATIONS IN THE TALTSON WATERSHED

13.8 AQUATIC RESOURCES

Aquatic resources include all the primary and secondary producers within streams, rivers, lakes and wetlands of the Taltson River watershed, but exclude fish, as they were assessed separately (Section 13.9 – Taltson Fisheries). Primary producers are the photosynthetic organisms in ecosystems and include periphytic algae (attached to submerged substrates or the bottom of a water body), phytoplankton (free-floating algae), and aquatic plants (emergent and submergent). Secondary producers are organisms feeding on autotrophs, detritus, and each other. They are represented by zooplankton, which are free-swimming invertebrates in the water column, and benthic invertebrates (benthos), which are found within sediment habitat. Together, these primary and secondary producers comprise the bulk of aquatic ecosystem biomass and diversity. They provide the energy base for aquatic food webs, including fish and wildlife. Primary and secondary producer communities are widely used in aquatic monitoring programs to detect changes related to development. Due to their relatively limited mobility, aquatic resources provide excellent tools to assess physical or chemical changes in both water and sediment. Algae are especially good indicators of changes in nutrient levels, which can potentially occur with reservoir projects. Zooplankton are sensitive to changes in water quality, they are the main food source to lake fish, and are the main consumers of phytoplankton. Benthos are good indicators of water and sediment quality, and are important food sources in shallow areas with macrophyte cover. As a result, aquatic resources are identified as a Valued Component (VC).

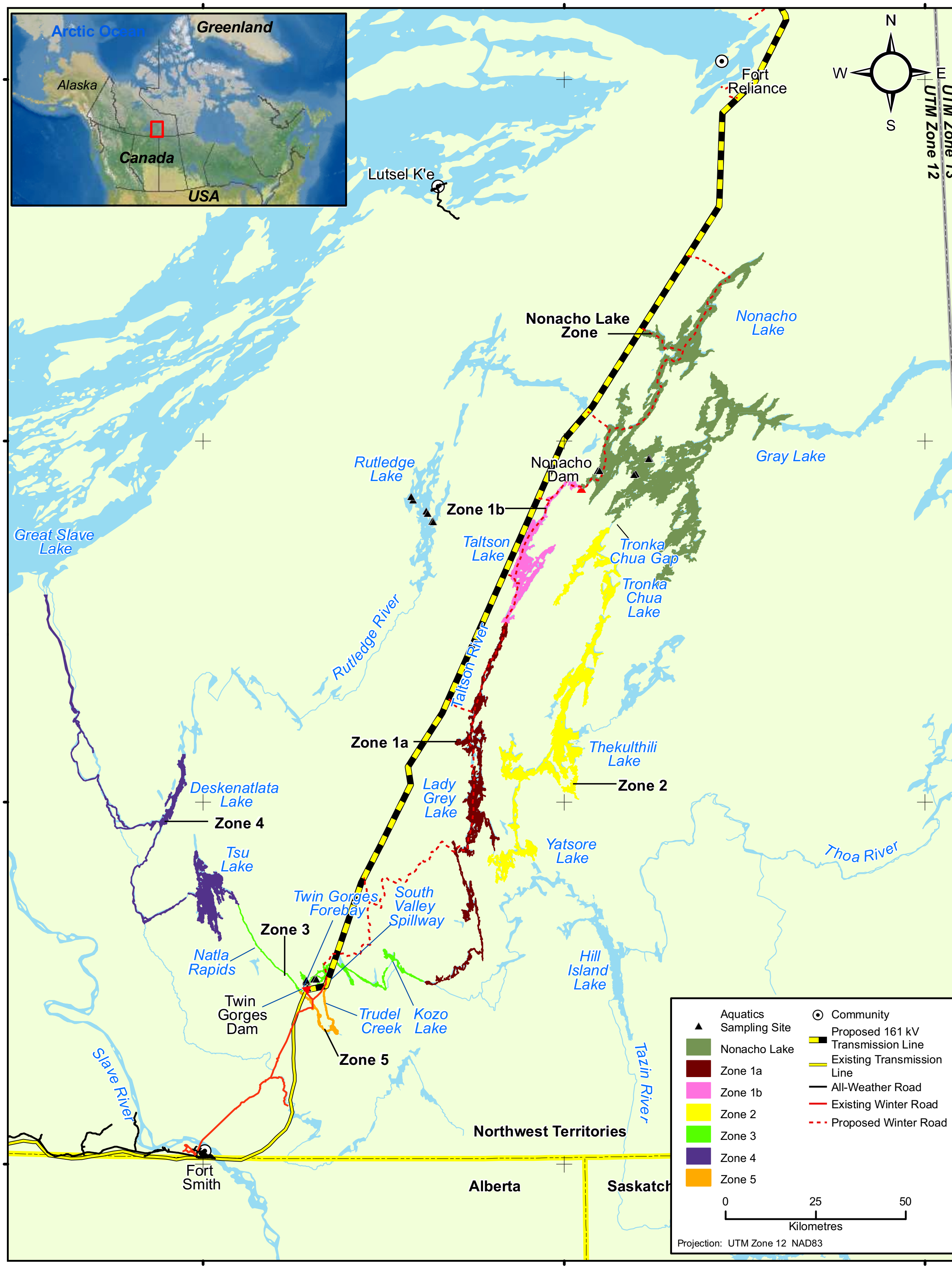
13.8.1 Existing Environment

13.8.1.1 NONACHO AND REFERENCE LAKES, AND TWIN GORGES FOREBAY

Baseline data on aquatic resources includes studies conducted in 2003 (Rescan, 2004) and 2004 (Rescan 2005). These covered Nonacho Lake and Rutledge Lake, and Twin Gorges Forebay of Zone 3 (Figure 13.8.1; Plate 13.8.1 and Plate 13.8.2). No data exists for the remaining lakes and the majority of reaches of the Taltson River within the Project area, including the areas immediately downstream of the Nonacho dam and the power generating station.

Each of these three sites was surveyed with three pairs of shallow and deep stations. Studies included limnology, water and sediment quality, macrophyte mercury concentrations, and surveys of primary and secondary producer communities.

Limnological studies (Section 13.3 – Water Quality) indicated that both Nonacho and Rutledge lakes were clear, soft-water lakes with low dissolved solids and thermal stratification at 8 m to 12 m depth.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Aquatics Study Area, 2003 to 2004	Figure 13.8.1

gis no. TAL-22-009bDAR

Plate 13.8.1 — Nonacho Lake

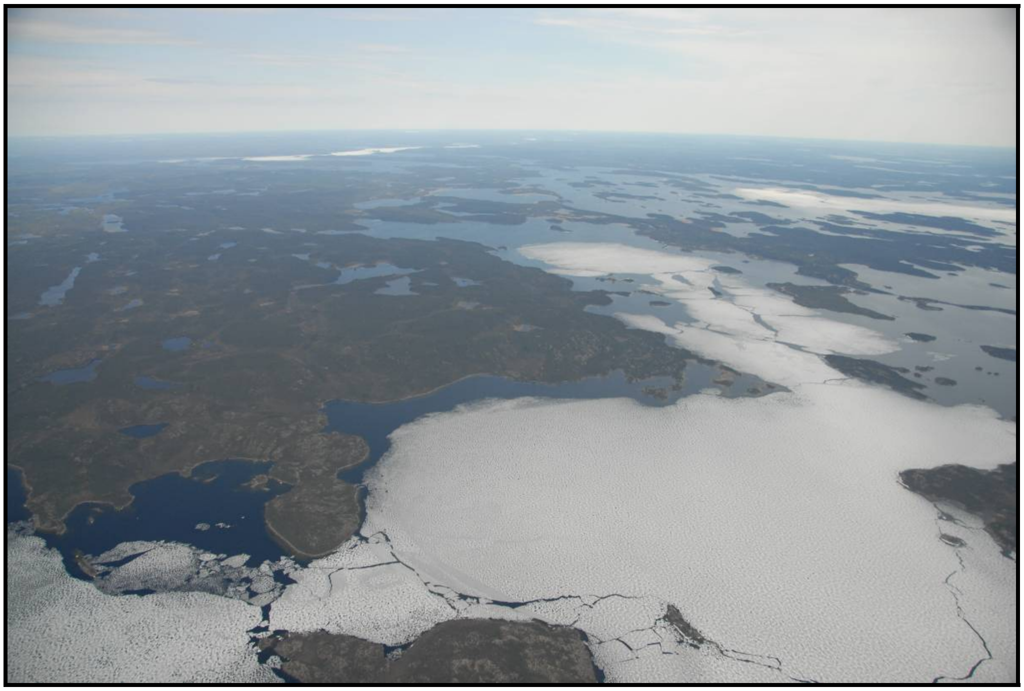


Plate 13.8.2 — Twin Gorges Forebay

Aquatic plants (*Potamogeton* sp.) were sampled in shallow littoral zones of the Twin Gorges Forebay, Nonacho Lake and Rutledge Lake to assess mercury concentrations and subsequent potential risk to higher trophic levels (moose, muskrat, etc.). Methylmercury, the most toxic form of mercury, can bioaccumulate, and is associated with flooding terrestrial habitat resulting in methylation and release of sediment-bound mercury into water and sediment media. Reservoir creation has the potential to raise methylmercury concentrations in the aquatic environment. However, all plant samples were well below the Canadian water and sediment guidelines for protection of aquatic life (Section 13.5 – Bioaccumulation of Mercury). Concentrations ranged from detection limit (0.005 mg/kg ww) to 0.019 mg/kg ww. Mercury values were lowest in Twin Gorges Forebay and similar in Rutledge and Nonacho lakes.

In 2003, phytoplankton communities were surveyed in the two lakes. Biomass was low in both lakes at all stations (0.7 µg/L to 1.2 µg/L as chlorophyll *a*); this is reflective of typical oligotrophic conditions of the north. Algal density ranged from 288 to 1,030 organisms/m^3, and was slightly higher in Nonacho Lake compared to Rutledge Lake. Algal density was higher in Nonacho Lake due to the presence of numerous crytophyte algae. However, density was comparable to that seen in other lakes of the north (Envirocon et al. 1975). Similar species were present in Nonacho Lake in 2003 as those observed in 1975. Cyanophytes dominated both lakes, which was not observed in 1972 (Falk 1979). Genus richness was similarly high at both lakes, ranging from 15 to 21 genera per station. The Simpson's Diversity Index ranged from 0.65 to 0.85, indicating a healthy and diverse community at both lakes.

Zooplankton communities were surveyed at the two lakes in 2003, and were typical of northern lakes. Density ranged from 13,540 to 70,909 organisms/m^3 and was generally higher at Rutledge Lake due to the high numbers of cladocerans (*Daphnia* sp.) present. Communities showed significant variation among stations within each lake. Nonacho Lake was represented mainly by rotifers, cyclopoid and calanoid copepods. Rutledge Lake had primarily cladocerans, cyclopoid copepods and rotifers. Historical data from Falk (1979) indicates a shift in assemblage, possibly related to decreasing turbidity from 1972 to 2003, although sampling methodology (i.e. mesh size of nets) may have played a role.

In 2003, lake benthos density ranges were similar among stations of the two lakes, although more variability was seen in Nonacho Lake (Table 13.8.1). Density was slightly lower in Twin Gorges Forebay. Nonacho Lake also showed consistently higher density in shallow stations compared to deep stations. However, no depth effect was seen at Rutledge Lake, indicating differences in habitat quality among lakes of the area. Genus richness was similar among the three sites but was more variable among shallow sites of Nonacho Lake compared to Rutledge Lake.

Table 13.8.1 — Baseline Benthic Invertebrate Community Data for Nonacho and Rutledge Lakes: August 2003 and 2004

Location	Density (organisms/m^2)	Genus Richness (# of taxa)	Simpson's Diversity Index
Nonacho Lake (2003)	2,430 to 10,904	1 to 9	0.17 to 0.81
Nonacho Lake (2004)	445 to 3,704	2 to 8	0.22 to 0.65
Rutledge Lake (2003)	4,741 to 6,311	3 to 7	0.48 to 0.81
Rutledge Lake (2004)	637 to 2,474	4 to 9	0.54 to 0.73
Twin Gorges Forebay (2004 only)	267 to 1,126	3 to 12	0.45 to 0.63

Both Nonacho and Rutledge lakes showed similar benthic community structure, dominated by amphipods, molluscs (snails and clams) and dipterans. Historical data from Nonacho Lake is in agreement with these findings (Falk 1979). Similar community structure was observed at Twin Gorges Forebay, but with greater dominance by dipterans and much fewer amphipods. Megalopterans were unique to the Twin Gorges Forebay. Minor proportions of other taxa were also noted at the three sites, including turbellarian, nematode and oligochaete worms, ostracods, cladocerans, trichoptera, hemiptera, copepods and arachnids. Nematodes, oligochaetes and ostracods were present as subdominant (5% to 15%) groups at some Nonacho Lake stations, while copepods, cladocera and oligochaetes were subdominant in some Rutledge stations. Simpson's Diversity Index values were similarly high for shallow stations of both lakes (0.77 to 0.81) but Nonacho deep stations showed lower diversity than those of Rutledge Lake. The dipteran diversity and richness were consistent with other lakes of northern Canada (Rescan 2001).

13.8.1.2 Zones 1, 2, 3, 4

No aquatics surveys were conducted within the other zones within the Project area (i.e. Zones 1, 2, 3 [except at Twin Gorges Forebay], and 4).

Modelled hydrology data is available for all areas of the Project in Zones 1, 2, 3 and 4. Based on the model, it is anticipated that aquatic communities in these zones would experience the same types of potential effects as those predicted for Twin Gorge Forebay and/or Nonacho Lake, if at all.

13.8.2 Valued Components

Aquatic resources were identified together as one valued component (VC) related to the effects assessment in this chapter of the Taltson Developer's Assessment Report (DAR). Aquatic resources were also identified in the Terms of Reference (TOR) for the Project. The inclusion of aquatic resources is supported by their importance in a variety of ecological functions in aquatic systems. These functions include aquatic biodiversity, aiding in nutrient and organic material cycling, photosynthetic energy production and transfer through the food web. In addition, they are easily and commonly measured (practical measurement endpoints), and are effectively used in biomonitoring programs for a variety of anthropogenic stressors (temperature, flows, habitat quality and contaminants). They form the bulk of the biomass in aquatic systems, and provide the food base for a number of aquatic (i.e. amphibians, reptiles, birds and fish) and terrestrial (i.e. birds, mammals and reptiles) organisms. As such, their importance is underlined by cultural and aesthetic values placed on a variety of fish, duck, raptor, and bear species that rely on this abundant food source.

13.8.2.1 ASSESSMENT ENDPOINTS

The assessment endpoint represents key features of the VC that should be protected and are used to illustrate how the Project pathways affect each VC. The evaluation of aquatic resources considered a single comprehensive assessment endpoint: preservation of sustainable aquatic communities (Table 13.8.2). Within the umbrella of this assessment endpoint lie several overlapping attributes or subcomponents including:

- biodiversity of primary and secondary producer communities,
- community structure and taxonomic dominance of primary and secondary producers, and
- levels of biological productivity within lakes and rivers of the Project area.

Assessment of effects was conducted on all subcomponents of the assessment endpoint concurrently by using measurement endpoints (e.g. changes in aquatic habitat). For example, a potential pathway resulting in loss of aquatic habitat relates to a loss of productivity, due to the fact that aquatic biota cover most areas of their habitat (to varying degrees). The presence and condition of aquatic habitat in rivers and lakes in the Project area directly relates to the aquatic species found there. Using available aquatic habitat information from the lakes and creek area of the Taltson River watershed, a quantitative assessment of habitat effects was conducted. Baseline information of aquatic habitat was coupled with results from predictive flow modelling under the 36 and 56 MW expansion options to predict changes in aquatic habitat.

Table 13.8.2 — Aquatic Resources Assessment Endpoints

Key Line of Inquiry	Valued Component	Assessment Endpoint
Water fluctuations in the Taltson River Watershed (Excluding Trudel Creek)	Aquatic Resources	Preservation of sustainable aquatic resources within the Taltson River Watershed

Biodiversity in ecosystems is considered a valuable trait of healthy ecosystems, and can aid in resisting ecosystem perturbation through redundancies in ecological niches and capacities for adaption to new conditions or environments (Rosenfeld 2002). Baseline information for benthic communities in shallow and deep areas of Nonacho Lake and Twin Gorges Forebay was collected. The data showed higher density in shallow zones but was similar in structure within the two water bodies. Remaining study zones were assumed to be similar to these sites, since there is no other information available. The lack of detailed bathymetry restricts the assessment of changes to habitat which could alter diversity. The assessment of preservation of aquatic ecosystem biodiversity is reserved to a general level because it is very difficult to predict specific changes on a species level.

Community structure and the presence of dominant taxonomic groups is useful in monitoring changes to ecosystems and can be used to detect change prior to more serious effects ocurring, as more sensitive taxa are the first to show signs of stress. As described above, for the diversity component of the overall assessment endpoint, the paucity of aquatic community baseline data or detailed bathymetry in each zone limits quantitative analysis of potential changes from the Project. Potential effects are described based on limited hydrologic modelling without bathymetric support.

By their nature, pathways that may affect biodiversity (related to number and proportions of species) also have the potential to affect the community structure (related to identity of species present) associated with that biodiversity value, and vice versa. Therefore, these two assessment endpoints were combined, where possible, under a combined assessment endpoint when discussing the potential effects pathways to aquatic resources.

The fourth attribute of the overall assessment endpoint relates to ***productivity*** of the plant and animal life that is sustained within the lakes and rivers of the Taltson watershed. Productivity is measured over a growing season and is defined as the dry organic matter or its energy equivalent, produced per unit area per unit time into biomass. No baseline information is available to quantify productivity for the Project areas, therefore only a general discussion of potential effects to aquatic productivity is available at this time. Productivity is related to density of organisms, available habitat area, nutrient loadings and environmental quality.

13.8.2.1.1 Measurement Endpoints

A measurement endpoint is a quantifiable attribute of a biological system that relates directly to an assessment endpoint. For aquatic resources, the assessment endpoint was sustainability of aquatic resources. The sustainability of aquatic resources can be evaluated through an assessment of aquatic resource productivity, biodiversity and community structure. These three components of aquatic resources are directly affected by changes in aquatic habitat (i.e. measurement endpoint of aquatic resources).

Aquatic habitat within the Taltson River watershed was broken down into littoral, profundal and pelagic. Pelagic habitat is aquatic habitat within the water column that is dominated by phytoplankton and zooplankton. Littoral and profundal habitat are benthic habitat (both shallow and deep water, respectively). Generally, littoral habitat is the most productive and diverse habitat within rivers and lakes. Littoral habitat is the "shallow" zones of rivers and lakes. The habitat is home to emergent and submergent vegetation, which adds a degree of complexity to the benthic habitat and thus benthic diversity and productivity. Field assessments of littoral zones within the Taltson River watershed found littoral depth to extend about one metre below spring/early summer water levels (CGL 2008). The field study relied on the visual presence of aquatic plants to define the lower extent of the littoral zone. Habitat deeper than 1 m was defined as profundal habitat. Profundal habitat was considered less productive and less biologically diverse.

Project-induced hydrological changes that cause changes in river and lake water levels have the potential to affect aquatic habitat, both littoral and profundal. An increase in water level would increase wetted area. The newly inundated wetted area may or may not meet the requirements of littoral habitat in terms of habitat characteristics and submergent/emergent plants. Thus the newly-inundated habitat would require time to become "suitable littoral habitat". For this assessment, ***suitable littoral habitat*** is shallow water habitat (approximately 1 m below spring/early summer water levels) that has the appropriate habitat characteristics to support, and is currently supporting, a productive community of macrophytes, algae and invertebrates. Conversely, if water levels decrease, suitable littoral habitat would be dewatered and thus there would be a net loss of habitat. The newly formed littoral zone would take time to become "suitable" (i.e. presence of submergent/emergent vegetation). However, over time littoral habitat should obtain pre-disturbance productivity, biodiversity and community structure and thus little net loss of littoral habitat would occur. There would be, however, a net loss of profundal habitat.

Considering strictly increases and decreases in water levels, profundal habitat does not have a "suitability" requirement as per littoral habitat. If water levels increase, profundal habitat would extend to higher elevations as the photic zone shifted to higher elevations (i.e., the transition between profundal and littoral habitat as defined herein). If water levels decrease, there would be a permanent loss of profundal habitat.

Changes in suitable littoral habitat and profundal habitat are used throughout this assessment to quantify and subsequently qualify effects on the sustainability of aquatic resources within Trudel Creek.

13.8.3 Assessment Boundaries

The assessment boundaries can be separated into two categories, spatial and temporal. The following section describes the spatial and temporal boundaries as they relate to aquatic resources.

13.8.3.1 Spatial Boundary

The spatial boundary for the assessment included a small-scale (assessment zones composed of reaches of the Taltson River), medium-scale (multiple zones), and a regional scale (Taltson River watershed) (Figure 13.8.1). The beyond-regional scale was considered the Great Slave Lake drainage and other watersheds feeding this lake. The five small-scale study zones for this DAR included:

- Nonacho Lake.
- Zone 1 (Taltson Lake and River from Nonacho Dam to confluence with Tazin River).
- Zone 2 (Tronka Chua Lake, Thekulthili Lake, to confluence with Lady Grey Lake).
- Zone 3 (Taltson River from Tazin River confluence, through Twin Gorges Forebay and dam, to Tsu Lake).
- Zone 4 (Tsu Lake and Taltson River downstream to Great Slave Lake).

The reference system for Nonacho Lake included Rutledge Lake directly west of Taltson Lake. Rutledge Lake flows directly into Rutledge River and into lower Taltson River well below the Twin Gorges Dam. This lake would serve as a reference in future Water Effects Monitoring Programs.

The spatial extent of this assessment encompasses a large area, which extends from Nonacho Lake approximately 300 km downstream to the Twin Gorges Dam, and another 150 km down-river beyond the existing power generation station to Great Slave Lake. However, aquatics data were only collected within Nonacho Lake, Rutledge Lake and Twin Gorges Forebay. Therefore, the spatial grain of this assessment is coarse. Zones 1, 2, and 4 do not have baseline information on aquatic resources.

13.8.3.2 TEMPORAL BOUNDARY

Two components were considered when selecting the temporal assessment boundaries for the effects assessment:

1) Duration of Project Activities. Project activities are highly correlated with the various phases of the Project: construction, operations and decommissioning and closure. Construction is not covered in the Taltson KLOI but is addressed in Section 15.2 – SON Canal Construction. Currently, the Project is expected to operate for 20 years to service the existing and proposed diamond mines. However, the infrastructure would have a lifespan of at least 40 years, and it is the intent of Dezé Energy Corporation (Dezé) to solicit new customers to extend the Project beyond 20 years. Subsequently, the expected length of time that Project-related stressors would influence VCs during the operation phase is assumed to be 40 years. Although Dezé intends to operate the Project longer than 40 years if customers can be found, increasing the duration of the operation phase of the Project would increase the uncertainty in the effects predictions. For example, it is currently not known how much of the transmission line would be in operation after 40 years. Therefore, 40 years was defined as the longest reasonable duration of the operation phase for predicting and assessing effects from the Project. The details on decommissioning are not comprehensive enough to complete an effects assessment at this time; however, it is Dezé's plan to complete the necessary studies seven to ten years prior to closure. Closure and restoration details are provided in Section 6.8 – Project Closure.

2) Ecology of the Valued Components. The aquatic resources VCs have many different life cycles and thus the duration of an effect could affect a portion of an individual's life cycle, the entire life cycle, or multiple generations. Given the relatively short life cycles of aquatic resources, the ecological component of temporal boundaries focused on the time required for habitat that would be affected by the Project to return to baseline conditions. The rationale was that once the habitat recovered, the aquatic resources would follow shortly, given their short life cycles and ubiquitous nature. The definitions used for the temporal assessment boundaries are presented in the Effects Classification Section below (Section 13.8.8 – Residual Effects Analysis).

13.8.4 Project Components

This Key Line of Inquiry (KLOI) Water Level Fluctuations in the Taltson River Watershed (excluding Trudel Creek) relates to hydrological changes in the aquatic environment. Potential Project effects to aquatic resources were assessed using spatial (zones vs. whole-watershed) and temporal (operation) boundaries to isolate potential effects due to hydrological changes. Project components linked to hydrologic changes that could affect aquatic resources in Taltson River include the power generating facilities (flow release at the Nonacho control structure and/or flow through the generating facilities).

13.8.5 Pathway Analysis

13.8.5.1 IDENTIFICATION OF PATHWAYS

Pathways were identified that link potential effects to the aquatic resources VC. The hydrologic zones were grouped together at this early stage of the pathway identification, since they share common basic pathways (Table 13.8.3). Both expansion scenarios were included together in the identification of pathways. Although the specific characteristics and extent of potential effects from each pathway could differ between the two expansion options, the basic nature of the pathways is the same.

Following identification of potential pathways, pathway validation was conducted for each expansion option. Pathways were considered based on the hydrologic model output, which was presented in Section 13.3 – Alterations of Water Quantity.

There are five identified pathways associated with the assessment endpoints for aquatic resources (Figure 13.8.2). These include:

1. Increased flows (increased water levels, velocity, wetted surface areas, volume).
2. Decreased flows (decreased water levels, velocity, wetted surface areas, volume).
3. Increased flow range (more variation through the year).
4. Decreased flow range (less variation through the year).
5. Altered hydrograph (timing and change in peak flow/minimum flow).

Table 13.8.3 — Potential Pathways to the Valued Component Aquatic Resources

Valued Component	Assessment Endpoint	Pathway and Associated Effect
Aquatic Resources	Preservation of sustainable aquatic resources within the Taltson River Watershed	*Increased flows* - loss of suitable littoral habitat and reduced productivity; decreased habitat quality (from increased methylmercury increases, increased nutrient loading, increased TSS); increased productivity (from altered ice processes); altered physical habitat (due to increased velocity); potentially increased profundal habitat and pelagic habitat for plankton.
		Decreased flows – loss of suitable littoral habitat and reduced productivity; loss of profundal habitat; loss of pelagic habitat for plankton; decreased habitat quality and productivity (from altered ice processes); altered physical habitat (due to slower water velocities).
		Increased flow range – increased winter drying of habitat; increased disturbance of wetted areas; decreased habitat quality (from release of methylmercury, increased TSS and nutrients loadings from riparian habitat); unstable littoral habitat.
		Decreased flow range – decreased habitat quality (from decreased inputs of nutrients from riparian habitat); decreased habitat complexity; potentially more stable littoral habitat.
		Altered hydrograph parameters – altered habitat quality and complexity (through altered timing and duration of freshet period, extended periods of minimum flows, rapid decreases and increases in flow, i.e. ramping).

13.8.5.1.1 Increased Flows

Increased flow rates relates to a number of hydrologic changes to an aquatic system. Water velocity, water levels, wetted area, surface area and volume all increase with increased flows. Following these hydrologic changes, effects to aquatic resources could then follow.

Water velocity plays a strong role in determining the aquatic community that colonizes and occupies an aquatic environment, in terms of affecting hunting/feeding behaviour, availability of substrates for building shelters, and movement. Certain biotic groups are more accustomed to fast-flowing river conditions, while others require slow-moving or static conditions of a lake. A major increase in the velocity of a system could drive lentic benthic invertebrates to drift downstream to more suitable habitat. It could also affect availability of fine organics to benthos, increase erosion rates (increased TSS loadings) and affect the aquatic plant and algal communities that would then be forced to endure stronger currents. In the fall, it could delay the onset of ice formation, ice thickness, and cause earlier ice break-up. Some areas near pinch points could be affected more strongly (less ice) than other sections such as lake areas. This would translate into a lengthened open water season, potentially positively affecting life cycles and increasing productivity.

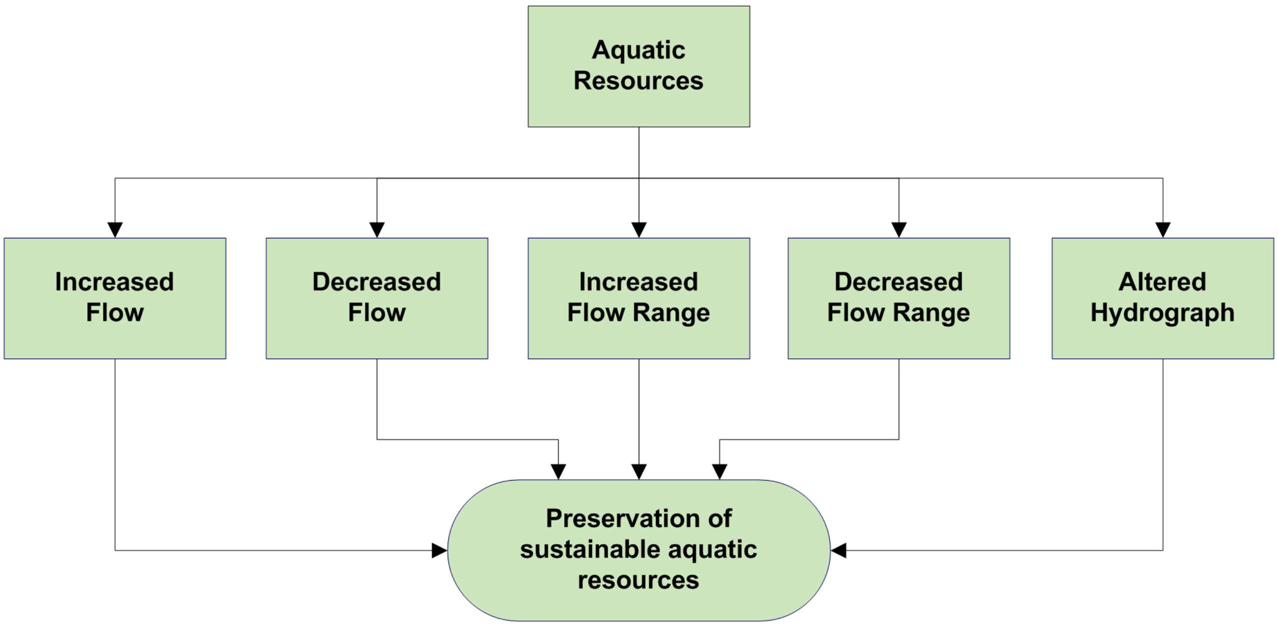
Increased water levels could result in a variety of physical and chemical changes to the aquatic environment. First, it would transform existing littoral zones into deeper aquatic habitat, changing its character and affecting its suitability to resident species. On a positive note, it could potentially create new profundal habitat as littoral habitat shifts inland. Habitat loss would occur in a period of hours to days, whereas creation of new habitat can take months to years, and is dependent on availability of seed banks from various species, organic materials available and substrate composition (Wallace 1990). The extent of habitat loss and potential gain would largely depend on the slope of shoreline ground (shallower slope would mean that more terrestrial area is inundated; cliff zones would preclude inundation of terrestrial zones). The current hydrologic model does consider shoreline slopes for rivers at discrete points, but it assumes box geometry of lakes (Section 13.3 – Alterations of Water Quantity).

Increased water levels could also result in increased nutrients and organics. Nutrients (nitrogen- and phosphorus-based) and organics from riparian areas from leaf litter, decomposing plant and animal matter could be washed into nearby river or lake habitat during periods of raised water levels. This would affect productivity levels, dissolved oxygen, and physical parameters. Algal blooms could result in changes in water clarity and quality, which could in turn reduce productivity.

Increased water levels could result in flooding of shoreline terrestrial areas could result in increased methylmercury production in an aquatic system (Rodgers et al. 1995). This would depend on whether the terrestrial areas had been flooded previously in the 1960s during the initial development of the dams (which is generally the case). If an area had been previously flooded, it would not be likely to produce more methylmercury, since the available mercury in the soil would have previously been leached out. This compound is highly toxic to aquatic life, and if it did increase in concentration, could result in mortality and habitat degradation for aquatic resources. Mercury has been identified as its own pathway and was assessed in Section 13.5 – Bioaccumulation of Mercury). Other metals potentially toxic to aquatic organisms (e.g. cadmium, copper and zinc) could be mobilized into the water column as a result of increased water levels (Finlayson et al. 2000); this was assessed in Section 13.4 – Alterations of Water Quality.

Surface areas and wetted areas would also increase with increased flows, related to increased water levels discussed above. As flows and levels increase, the extent of a river or lake would expand over terrestrial habitat. Depending on the nature of the hydrograph, this could create new aquatic habitat, or simply provide ephemeral side channels which may be prone to drying over the year (leading to potential loss of trapped biota in those areas).

Volume of a river or lake would increase with increased flows, related to increases in water levels discussed above. Pelagic organisms (phytoplankton, zooplankton) would then have a greater extent of habitat under these conditions. The productivity within the lake could increase, depending on availability of N and P nutrients and water temperatures.



TALTSON
HYDROELECTRIC EXPANSION PROJECT

Developer's Assessment Report 2009

Aquatic Resources - Pathways and Assessment Endpoints for Potential Effects in Taltson River

Figure 13.8.2

13.8.5.1.2 Decreased Flows

Decreased flow rates relates to a number of hydrologic changes to an aquatic system. Water velocity, water levels, wetted surface areas, and volumes of creeks and lakes would all decrease with decreased flows. These in turn could then cause a variety of effects to aquatic resources, depending on the type and severity of change.

Decreased flows could result in reduced water velocity in rivers and at the inlet/outlet of lakes. These reduced velocities would represent a major change to the physical environment of aquatic resources. Species accustomed to faster-flowing waters would likely leave these areas, to be gradually replaced by slow-water species. This could affect not only algae and aquatic plants but also benthic invertebrates. Water quality could also change, with reduced erosion (lower TSS loadings), and increased settling of fines in bottom substrate (more organics). These water quality changes could be beneficial to remaining biota in terms of clarifying water quality and increasing organics for food and shelter. However, under greatly reduced velocities, anoxia can become an issue leading to unsuitability of habitat and reduced productivity. This is more of a potential concern in winter during ice cover than during the open-water season. In the fall, reduced water velocity could also cause earlier onset of ice formation, greater ice thickness (a threat to shallow areas which could experience higher risk of freezing to bottom) and in the spring cause later ice break-up. This would translate into a shortened open-water season and potentially greater risk of mortality from ice damage, adversely affecting life cycles and productivity. Potential changes in ice conditions and formation were presented in Section 13.6 – Alteration of Ice Structure.

Decreased water levels could dry out existing aquatic habitat, resulting in mortality of macrophytes, algae and invertebrates. Areas at risk include shallow beach or littoral zones, which may become dewatered each year. This would result in loss of productivity where aquatic biota would be killed through exposure to air and dried habitat. A shift in community structure and loss of some diversity would also be possible, depending on the areas exposed (Aroviita and Hämäläinen 2008). Littoral areas are generally the more productive and taxonomically-diverse areas of lakes and rivers (Rennie and Jackson 2005), and to a lesser degree in rivers. It is also possible that some profundal (deep water) areas may become shallow littoral areas, which could subsequently change the character and suitability of aquatic habitat (Figure 13.8.3). This would be dependent on available seed banks, substrates and organic content of previously deep zones that could potentially be colonized by new aquatic flora and fauna. It was assumed that for any affected littoral habitat that was lost due to lowered water levels, new littoral habitat would develop of equivalent extent and quality. There would then be a net loss of some profundal habitat and short-term loss of littoral habitat. Emergent and submergent vegetation communities are reported to take approximately three years, and one to two years for basic colonization, respectively (Odland and Moral 2002; Cott et al. 2008).

Decreased flows would affect water levels, and therefore would result in decreased wetted areas. As flows and levels decrease, the extent of a river or lake would recede away from the existing water line, drying out littoral habitat, leading to mortality of organisms (plants, algae, some benthos) unable to move to deeper water areas, and reducing productivity. In the case where littoral zones are completely removed, this could reduce taxonomic richness and alter community structure.

The volume of a river or lake would also decrease with decreased flows, related to decreases in water levels discussed above. Pelagic organisms (phytoplankton, zooplankton) would then have a reduced extent of habitat under these conditions. This could then result in a reduction in productivity within the lake. However, productivity of arctic and subarctic lakes are often limited by availability of N and P nutrients and water temperatures as opposed to habitat extent.

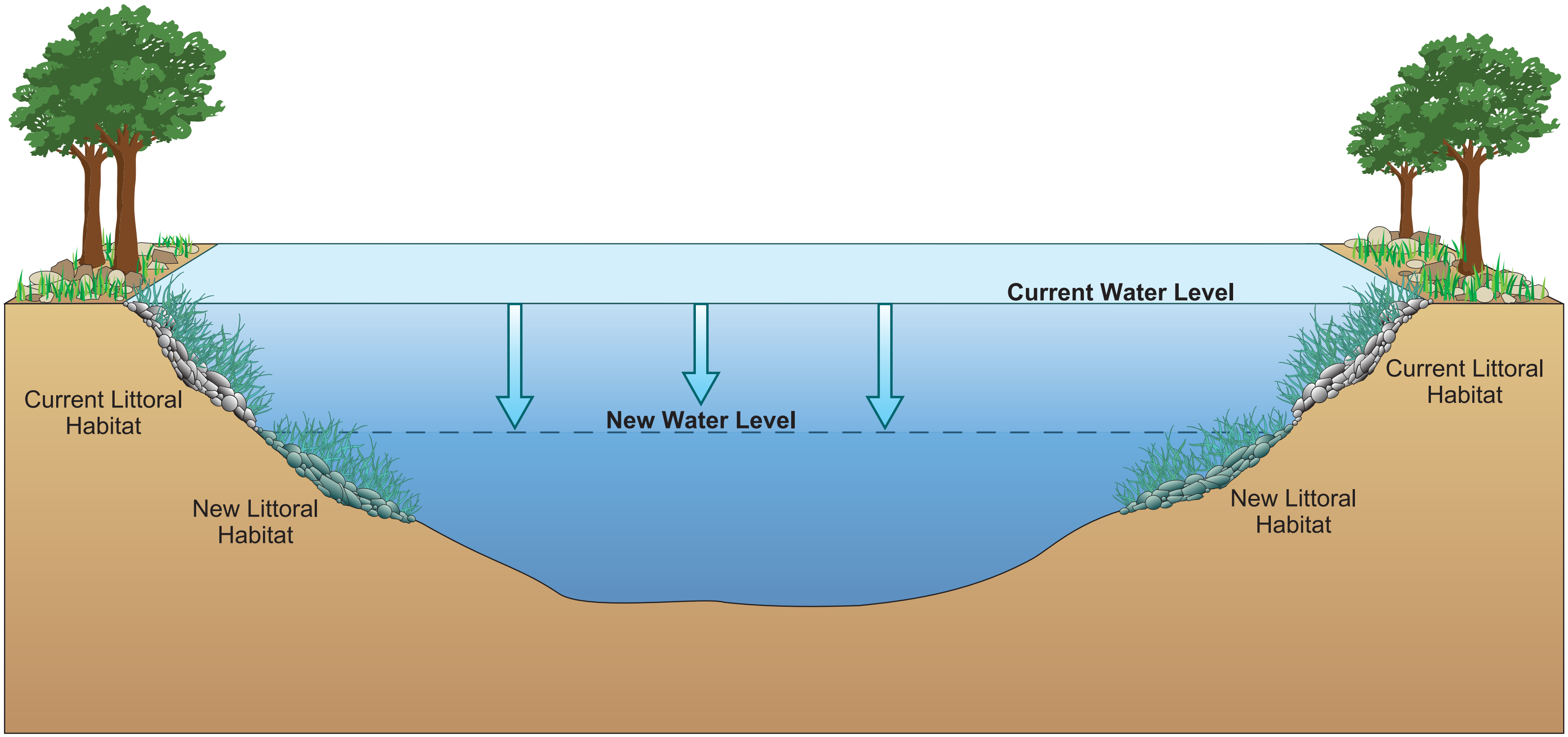
13.8.5.1.3 Increased Flow Range

Increased flow ranges would result in lower annual minima and higher annual maxima for water levels, surface areas and volumes of creek and lake habitat. This represents a general increase in the level of disturbance of aquatic habitat. Potential adverse effects include drying of littoral habitat, increased erosion and TSS loading to waterways from repeated drying and wetting of habitat (particularly in the case where aquatic plants die off, since they act to stabilize creek bed substrates), and increased methylmercury or nutrient loadings from riparian sources. For mercury and nutrients, this pathway relates to frequency of fluctuation in flows/levels. It represents a repeated effect related to increased disturbance of sediment layers that could release these chemicals, unlike continuously-increased water levels which could affect nutrient loadings in a different manner. Methylmercury risk is assessed separately for water quality as its own component in Sections 13.4 and 13.5.

Effects from wetting and drying of littoral habitat, which would cause stress or mortality to organisms, depends on the frequency, timing and degree that water levels fluctuate (Leira and Cantonati 2008). For example, monthly fluctuations up to 1 m were optimal for maintaining diverse littoral zone communities; however, narrow ranges (i.e. <1 m) allow few competitively-dominant species, and greater fluctuations (i.e. >1 m) allow only tolerant species to survive (NIWA 2003). Submergent vegetation could become exposed, and any algae or invertebrates living on this vegetation would also be affected. This could affect diversity and productivity. Habitat loss in the littoral zone can be replaced by habitat with a comparable degree of complexity in the profundal zone. However, given greater and more long-term fluctuations, only tolerant species are likely to survive. Littoral zone habitat suitability would be the most effected by water level fluctuations. Thus, benthic invertebrate richness and taxonomic abundance can be reduced in littoral zone habitats as a result of habitat loss (e.g. Baumgärtner et al. 2008; Brauns et al. 2008; White et al. 2008).

13.8.5.1.4 Decreased Flow Range

Decreased flow ranges would result in more constant water levels, surface areas, and volumes of creeks and lakes throughout the year. Water levels would not drop as low or rise as high throughout the year. This represents a change to the normal hydrologic regime. Potential adverse effects include a reduction in nutrient and organics loadings from riparian zones, and a reduction in habitat complexity related to littoral zones that undergo wetting/drying cycles. This latter effect could reduce biodiversity in the local area. Potential positive effects could include a more stable aquatic environment since shoreline vegetation and biota would not experience as much drying/wetting cycles, and erosion rates would also be expected to decrease which would reduce TSS loadings.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Decreasing Water Levels in River Causing a Shift in Littoral Zone Habitat (503-005 / a21036f)	Figure 13.8.3

13.8.5.1.5 Altered Hydrograph

Changes to the existing hydrograph within rivers and lakes could have adverse effects on resident biota. Water management may result in altered timing and duration of freshet, longer annual minimum flow periods, and periods of sudden changes in flows (ramping from scheduled plant shutdowns for maintenance).

Changes to the timing of freshet could affect productivity if it occurred a significant amount of time before or after normal freshet timing, since life cycles of aquatic organisms (life stage development, reproduction) are adapted to their physical environment and timed based on seasonality and climate of a particular region. It is likely that biological communities would require a number of years to adjust and synchronize to the new freshet period, and it is possible that some species would be more flexible in their life history than others. This could then result in a change in productivity (until communities adjust) and community structure (more permanent). Moderate changes in the duration of freshet would not affect aquatic resources so long as nutrient and organic loadings remained fairly similar (see decreased flows and flow ranges). Large-scale changes in the duration of freshet could reduce productivity, depending on flows and flow changes that relate to nutrient and organics supply to aquatic biota as energy and shelter substrates.

Extended periods of minimum flow could adversely affect aquatic resources depending on the timing of these low flows relative to the normal hydrograph. If minimum flows extended throughout the critical summer period for feeding, growth, and reproduction, adverse effects to aquatic resources would be expected. Late summer and early fall are especially important for seeding (aquatic plants) and egg-laying (benthos), although many aquatic species produce multiple generations each summer.

Sudden decreases and increases in flow rates (ramping) during a scheduled and unscheduled shutdown of the turbines could affect aquatic resources in the Taltson River within the Forebay and in the Taltson River downstream of the facility. Ramping would present a new hydrologic event that does not occur normally in nature. The sudden drop in flows over a period of hours could leave aquatic life stranded in side channels and pools, since they may not be able to move to deeper water areas fast enough. In this case, this would then lead to mortality and loss of productivity. Some species of plants and benthos are more suited to short-term periods of drying compared to other species, therefore biodiversity could be affected. The accompanying sudden increase in flows could result in adverse effects related to increased erosion, scouring and TSS loading, and physical effects of washing away biota downstream should they not find shelter in time. This could also reduce productivity and biodiversity of aquatic communities.

13.8.6 Mitigation

Following the identification of potential pathways that could lead to effects on aquatic resources, mitigation was identified and suggested for implementation.

Hydrologic modelling coupled with regulation of flows at Twin Gorges and Nonacho spillways would be based on permit limits. This would act to reduce potential effects to the aquatic system.

Potential scheduled ramping effects have been mitigated by planning the required annual servicing of the three turbines so that only one turbine would be shut down at any time. This would prevent one large pulse from travelling down Trudel Creek and subsequently causing effects to aquatic resources farther downstream in Taltson River. Also, the timing of scheduled servicing is just prior to freshet, the period when water levels are most variable through the year.

Another mitigation design includes a bypass spillway at Twin Gorges dam that would operate under any outage scenario to ensure that minimal flows in the tailrace (30 m^3/s) and lower Taltson River always meet permit requirements. This would also serve to reduce the temporary water drawdown below Twin Gorges at the start of an outage.

Also, no new flooding would occur under either expansion option during normal operating conditions. Water management would be designed to maintain ranges in maximum water levels based on the modelled 13-year baseline period, thus would act to minimize any potential of the formation of methylmercury.

13.8.7 Pathway Validation

Pathways were identified as Valid if mitigation was not expected to fully avoid or eliminate a negative effect. Valid pathways were carried through to the effect classification stage. In general, summer (June to late August) was the period where changes to the aquatic system were deemed most important, since this is the period of open water when photosynthesis occurs and organisms are most active in terms of feeding, reproducing, and moving in their habitat. Altered water levels and flows during winter months would occur under ice, while biological activity is minimal or dormant. Any change that would occur in winter that could affect aquatic biota was also included in the assessment.

Pathway validation was conducted for the two expansion scenarios together, discussing each zone within the Taltson River Watershed separately. To assess potential effects to aquatic resources, the Taltson hydrological model results from Section 13.3 were used. This included time series and monthly summary figures for each of the study zones in the Taltson River study area. The average monthly values were compared for each option to the baseline average.

Predictions in water levels from the Taltson flow model (36 MW and 56 MW options) were reviewed and presented to determine whether a pathway was Valid, not Valid or Minor. The Taltson Flow model computed average monthly flows and water levels for each month over a 13-year period of record. The average monthly values represent the intra-annual variation. Intra-annual variation was reviewed for the entire year, for the summer period (June to August) and the winter period (November to April).

The daily flow and water level values that were used to generate the average monthly values were also utilized for the assessment. The daily values over the entire period of record represent the inter-annual variation. The daily values were grouped by years to roughly separate low, average, and high flow baseline years so that comparisons to the flow regime under the 36 MW and 56 MW expansions could be made.

Pathway validation for the 36 MW and 56 MW options is presented in Table 13.8.4.

Table 13.8.4 — Pathway Validation for Aquatic Resources: 36 MW and 56 MW Options

Pathway	Pathway Validation
Increased flows – increased water levels/ surface areas/ volumes, increased velocity; flooding shallow littoral zone below euphotic depth; increased methylmercury, nutrients and organics; increased TSS; delayed ice formation and early ice break-up - in Nonacho Lake and Zones 1 to 4.	36 MW & 56 MW: Invalid for all zones. Average monthly water levels would not increase in summer months in any zone. Modest increases in winter levels would not relate to effects due to ice cover and limited biological activity. No new flooding therefore no risk of methylmercury increases.
Decreased flows - decreased water levels/ surface areas/ volumes, decreased velocity; drying shallow littoral zone; decreased TSS; earlier fall ice formation and later spring ice break-up - in Nonacho Lake and Zones 1 to 4.	36 MW: Valid for all zones. Water level decreases during summer months would occur to varied extent. 56 MW: Valid for Zones 2, 3 and Nonacho. Water flow and level decreases would occur to varied extent in summer (and winter for Nonacho Lake and Twin Gorges Forebay).
Increased flow ranges – increased variation in water levels and frequency of fluctuation, causing more wetting and drying areas or more winter drying of habitat; loss of productivity; increased nutrients and TSS from littoral/riparian areas; potential redistribution of methylmercury through sediment disturbance- in Nonacho Lake and Zones 1 to 4.	36 MW: Valid for Nonacho and Zone 2. An increase of inter-annual and summer intra-annual fluctuations in water levels would occur in these zones. 56 MW: Valid for Nonacho. Inter-annual and summer intra-annual fluctuations in water levels would increase.
Decreased flow ranges – decreased variation in water levels causing decrease in nutrient and organic inputs from riparian areas; decreased habitat complexity; reductions in productivity and diversity; decreased TSS loadings and more stable water levels - in Nonacho Lake and Zones 1 to 4.	36 MW: Valid for Zones 1, 3 and 4. A decrease of inter-annual and summer intra-annual fluctuations in water levels would occur in these zones. 56 MW: Valid for Zones 1, 2, and 3. Inter-annual and summer intra-annual fluctuations in water levels would decrease.
Altered hydrograph – altered freshet timing; reduced freshet duration; extended period of minimum flows; rapid decreases and increases in flows (ramping) over short periods- all potentially causing mortality, drying of habitat, reduced productivity in Zones 3 and 4.	36 MW: Valid for Zones 1, 2, 3 and 4. A decrease of inter-annual and summer intra-annual fluctuations in water levels would occur in these zones. 56 MW: Valid for Zones 2 and 3. Inter-annual and summer intra-annual fluctuations in water levels would decrease.

13.8.7.1 INCREASED FLOWS

For the 36 MW option, summer flows and water levels in Nonacho Lake would be slightly higher in years of average flows but would not exceed normal maxima based on the modelled 13-year baseline period. Therefore, no new terrestrial areas would be inundated and no risk of methylmercury increases is predicted. Average monthly levels would not exceed baseline for any month. No increased water levels were projected for Nonacho Lake under the 56 MW option. Therefore, increased water level is not a Valid pathway for Nonacho Lake for either expansion option.

Zone 1 includes Taltson Lake, King Lake, Benna Thy Lake (Zone 1b), Taltson River (down to Tazin confluence) and Lady Grey Lake (Zone 1a) (Plate 13.8.3). Taltson Lake is predicted to have increased water levels from November to May (5 cm to 59 cm and 20 cm to 30 cm for 36 MW and 56 MW, respectively), compared to baseline levels. Similar patterns of smaller increases are predicted for the lakes farther downstream of Taltson Lake in Zone 1. Elevated winter levels are not linked to effects to aquatic resources since biological activity is minimal in fall and winter. Plants and invertebrates are dormant or relatively inactive. This would simply indicate that water and ice levels are higher during winter. Summer water levels are predicted to decrease (36 MW) or remain roughly same (–9 cm to 12 cm change for the 56 MW option) compared to baseline. Predicted levels generally fall well within 13-year baseline levels, with slightly higher levels for low-water years. No new flooding of terrestrial habitat would occur. The lack of predicted water level increases in summer months also implies no changes in nitrification, mercury loading and particulate sedimentation. This indicates that the summer growing season would not have noticeable increases in flows or water levels under either option, and increased flows are not a Valid pathway for Zone 1.

Zone 2 receives water from Nonacho Lake through the Tronka Chua Gap, and extends down into Tronka Chua Lake, Thekulthili Lake and Yatsore Lake before rejoining Zone 1 at Lady Grey Lake (Plate 13.8.4). Water levels in Zone 2 were modelled at two points (Tronka Chua and Thekulthili Lakes). Based on both the 36 MW and 56 MW options, future summer levels would not increase based on average monthly levels. Water levels would be slightly higher in average-to-wet runoff years (36 MW option only), but would be well within normal ranges modelled for the 13-year baseline period for both options. No new terrestrial flooding would occur, therefore methylmercury loading is not predicted. Therefore, increased water level is not a Valid pathway for Zone 2 under both options.

Zone 3 encompasses the Taltson River from the mouth of the Tazin River confluence through Kozo Lake and the Twin Gorges Forebay downstream to the inlet of Tsu Lake (Plate 13.8.5 and Plate 13.8.6). For the Taltson River above and below the Forebay zone, water levels would increase from December to May (15 cm to 65 cm and 2 cm to 24 cm for 36 MW and 56 MW options, respectively), and show decreases the rest of the year (both options). These modestly elevated winter water levels do not pose a threat to the aquatic resources. No new terrestrial flooding would occur, therefore methylmercury loading is not predicted. Levels in the Forebay would not increase, but would decrease in all months. Since there would be no water level increases during the summer in any sections of Zone 3, this is not a Valid pathway for this zone under either option.

Tsu Lake and the Taltson River below this lake are included in Zone 4. This zone would have increased water levels predicted for the December to May period (8 cm to 55 cm and 0 cm to 10 cm for 36 MW and 56 MW options, respectively), but would not have increases during the biologically-active summer period. Mercury production requires reducing conditions in the open water period, and because no new terrestrial flooding would occur, therefore there is no projected risk of mercury to aquatic resources (see also Sections 13.3 and 13.5). Since there would be no water level increases during the summer in any sections of Zone 4, this is not a Valid pathway for this zone for either option.

Plate 13.8.3 — Taltson Lake

Plate 13.8.4 — Tronka Chua Gap

Plate 13.8.5 — Twin Gorges Forebay and the South Valley Spillway

Plate 13.8.6 — Twin Gorges Forebay and the Lower Taltson River

13.8.7.2 DECREASED FLOWS

Flow from Nonacho Lake is predicted to decrease. Nonacho Lake water levels are also expected to decrease for all months of the year (6 cm to 59 cm and 59 cm to 76 cm for the 36 MW and 56 MW options, respectively). During the summer, levels would decrease by 15 cm to 44 cm and 59 cm to 70 cm for the 36 MW and 56 MW options, respectively. Lowered flows would result in decreased water levels, wetted areas, and volumes. Decreased water levels and wetted areas correspond to loss of habitat for littoral benthos, periphytic algae and rooted plants along the perimeter of the lake. Decreased water volumes relates to loss of living space for phytoplankton and zooplankton. These changes could together subsequently result in loss of productivity. Low-water years would show greater drops (70 cm to 80 cm) in water levels. Therefore, decreased water levels (in both summer and winter) are considered a Valid pathway of effects to aquatic resources in Nonacho Lake for both expansion options.

Zone 1, including Taltson Lake, would have decreased levels in summer from June to August (36 cm to 59 cm and 0 cm to 6 cm for the 36 MW and 56 MW options, respectively). Similar but more moderate changes would be expected for King Lake, Benna Thy Lake and Lady Grey Lake, as water level decreases in these lakes were predicted to decrease to a lesser degree than in Taltson Lake. For all of Zone 1, winter water levels would be slightly higher than baseline. Therefore, decreased water levels (in summer only) are considered a Valid pathway of effects to aquatic resources in Zone 1 for the 36 MW option only.

Water flows and resulting water levels in Zone 2 would decrease in the summer months (by 38 cm to 53 cm and 81 cm to 95 cm for the 36 MW and 56 MW options, respectively) in Tronka Chua Lake. During winter, levels would also decrease under both options (1 cm to 34 cm and 62 cm to 81 cm for the 36 MW and 56 MW options, respectively). Summer and winter levels would also decrease to a lesser degree in Thekulthili Lake and other areas farther downstream in this zone. Additionally, during low flow years, no flow would pass through the Tronka Chua Gap; this was predicted for 4 of 13 modelled years for the 36 MW option (and 9 of 13 years for the 56 MW option). Winter levels would also slightly decrease with the 36 MW option. Therefore, decreased water levels in summer and winter are considered a Valid pathway of effects to aquatic resources in Zone 2, for both options.

Summer flows and water levels in Zone 3 were predicted to decrease in the Taltson River downstream of Tazin River confluence (by 28 cm to 74 cm and 7 cm to 29 cm for the 36 MW and 56 MW options, respectively). This summer pattern would also occur within the Twin Gorges Forebay (by 50 cm to 58 cm and 45 cm to 63 cm for the 36 MW and 56 MW options, respectively). Levels would show lesser decreases in the Taltson River below Twin Gorges (by 8 cm to 33 cm and 0 cm to 10 cm for the 36 MW and 56 MW options, respectively). Although water levels would slightly increase or would not change in the winter in these sections of the Taltson River, levels would decrease in winter in the Forebay (by 32 cm to 63 cm and 37 cm to 50 cm for the 36 MW and 56 MW options, respectively). Therefore, decreased summer (all sections) and winter (Forebay) water levels are considered a Valid pathway of effects to aquatic resources in Zone 3 for both options.

In Zone 4, summer water levels in Tsu Lake were predicted to decrease (by 0 cm to 52 cm and 0 cm to 18 cm for the 36 MW and 56 MW options, respectively). A similar pattern of summer decrease was predicted for the Taltson River in Zone 4. Winter levels were projected to increase or only negligibly decrease in these areas. Therefore, decreased summer water levels are considered a Valid pathway of effects to aquatic resources in Zone 4 for the 36 MW option only.

13.8.7.3 INCREASED FLOW RANGES

Summer fluctuations in water levels is a potential pathway of effects to aquatic resources, as this is the period that aquatic life is most active and includes the reproductive cycle. In Nonacho Lake, the inter-annual variation, as measured by the range of minimum and maximum water levels from the 13-year daily baseline time series, would roughly double for both options related to decreased minima (see Section 13.3 – Alterations of Water Quantity). This indicates that the system would experience greater hydrologic changes over the years, and could experience more TSS and mercury loadings in Nonacho Lake reservoir due to repeated disturbance of sediment (Rodgers et al. 1995; Finlayson et al. 2000; see Section 13.5 – Bioaccumulation of Mercury). However, increased mercury levels in the water and sediment from newly-flooded soils generally peak between five and ten years after the initial flooding event and gradually decrease as the land undergoes transition from a terrestrial to aquatic environment (Dmytriw et al. 1995).

The effect that flooding has on methylmercury decreases with time as the mercury-rich sediment layer is covered with new mercury-poor sediments. In northern boreal forests such as those around Nonacho Lake, this process is slower, requiring 20 to 30 years (Bodaly et al. 1984 and Canadian Dam Association 2007). The original hydroelectric Project was constructed over 40 years ago, thus, levels within the Taltson Basin are considered reflective of pre-impoundment levels. Furthermore, the proposed expansion options would only result in fluctuations of under 1 m, compared to changes in water levels of tens of metres for new reservoirs. Nonetheless, to further assess mercury risk, modelling of mercury was conducted (Section 13.5 – Bioaccumulation of Mercury) and showed negligible to low potential for effects to higher trophic levels (fish). This model considered the bioaccumulative potential for mercury. Therefore, the likelihood of increased mercury concentrations in lower trophic levels is negligible, and mercury does not pose a risk to aquatic resources. Similarly, nutrients and TSS would not be loaded into Nonacho Lake due to the lack of or minimal increases in lake levels that could lead to transfer from terrestrial to aquatic habitat (Section 13.4 – Alteration of Water Quality).

Flow modelling predictions indicate that inter-annual variation in flow ranges of Nonacho Lake would increase and thus is a Valid pathway of effects to habitat and productivity for both the 36 MW and 56 MW options.

For summer months, intra-annual variation would increase by 23 cm and 10 cm under the 36 MW and 56 MW options, respectively. Yearly intra-annual variation would increase by 38 cm and 15 cm for 36 MW and 56 MW options, respectively. Therefore intra-annual is a Valid pathway in Nonacho Lake for both options.

In Taltson Lake of Zone 1, the inter-annual variation over the 13-year baseline period would decrease slightly in low flow years and increase slightly in average years, thereby not changing significantly on average for the 36 MW option. Under the 56 MW option, inter-annual variation would decrease slightly for average years. The frequency of low and high flow years remains constant for both options. Intra-annual variation would decrease marginally over the year (both options) but would increase slightly in summer months only, by 12 cm and 18 cm for the 36 MW and 56 MW options, respectively. Since inter-annual variation would not increase, but intra-annual summer fluctuations would show slight increases, increased flow range is considered a "Minor" pathway of effects (<20 cm change) for Zone 1 for both options. Regarding potential mercury issues, no new flooding of terrestrial areas would occur in Zone 1. Water levels would increase by 20 cm to 30 cm in winter months when the lake is frozen, and would decrease below baseline values in summer months. Besides flooding-induced mercury loading, disturbance of sediment layers by fluctuating water levels can also lead to increased mercury concentrations in lakes. However, as described for Nonacho Lake, modelling of fish in Taltson Lake indicated little to no increase in tissue concentrations of mercury (Section 13.5). Because primary and secondary producers are below fish in the aquatic food web, the former groups have even lower risk of any mercury body burden increases. Therefore, there would be no risk of methylmercury formation, or surface transport of nutrients and TSS from riparian to aquatic resources. Based on predicted future water levels and degree of fluctuation, flood-related effects are not a Valid pathway for Zone 1.

Inter-annual variation in water levels in Tronka Chua Lake (Zone 2) would increase during average flow years (36 MW expansion) and decrease for the 56 MW option. At Thekulthili Lake, intra-annual water level variation in Zone 2 would also increase slightly at Tronka Chua Gap by 20 cm (27%) for the 36 MW option, and decrease by 28 cm (by 38%) for the 56 MW option over the year. Summer intra-annual variation would increase by 15 cm (by 31%) for the 36 MW option, and decrease by 10 cm

(21%) for the 56 MW option. However, as average water levels would decrease throughout the year including the critical open-water season in Zone 2, no additional mercury, nutrient or sediment loading is projected. Since mercury production requires reducing conditions in the open water period, there is no projected risk of mercury to aquatic resources (see also Sections 13.3 and 13.5). Intra-annual variation would decrease over the year and over summer months for the 56 MW option. Therefore, increased flow ranges related to inter-annual variation is considered a Valid pathway in Zone 2 for the 36 MW option only.

In Zone 3, inter-annual variation in water levels for the Taltson River below Tazin River would remain the same or decrease slightly for the 36 and 56 MW options. No years of extended minimum flows are predicted. Intra-annual water level variation would decrease by 113 cm and 22 cm for the 36 MW and 56 MW options, respectively. Summer variation would decrease by 22 cm and 10 cm for the 36 MW and 56 MW options. In the Taltson River below the Twin Gorges facility, the flow ranges follow a pattern similar to those described for Taltson River below the Tazin River confluence. Therefore, increased flow range is not a Valid pathway for the Taltson River in Zone 3 under either option.

In the Twin Gorges Forebay in Zone 3, inter-annual variation in summer water levels would decrease on average for both options. Because water levels would be consistently below current water levels and mercury has equilibrated over the past 40 years as discussed above (and no mercury risk exists in Nonacho and Taltson lakes based on modelling), mercury is not predicted to pose a risk to aquatic resources in Twin Gorges Forebay. Intra-annual variation would decrease under both options over the year by 23 cm (by 57%) and 25 cm (by 62%) for the 36 MW and 56 MW options, respectively. Summer intra-annual variation was negligible during the baseline period and would remain the same for both options. Therefore, increased flow range is not a Valid pathway for the Twin Gorges Forebay in Zone 3 under either option.

In Tsu Lake of Zone 4, inter-annual variation in average flow years would decrease under the 36 MW option, but remain unchanged for the 56 MW option. Intra-annual variation would decrease by 101 cm and 18 cm under the 36 MW and 56 MW options. Summer variation would decrease by 52 cm and 18 cm for the 36 MW and 56 MW options, respectively. Therefore, increased flow range is not a Valid pathway for Zone 4 for either option.

13.8.7.4 DECREASED FLOW RANGES

Decreased range of flows could result in decreased nutrient and organic loadings to waterways from riparian sources, which could reduce productivity and habitat quality. Decreased flow ranges could also result in less habitat heterogeneity, which could reduce biodiversity of aquatic plant and invertebrate communities. However, a reduction in the frequency and range of flows and water levels could act to reduce erosion and TSS loadings. In more turbid systems, this could improve water clarity, which could increase photosynthetic activity. However, water clarity is already very good in the Taltson system, therefore reductions in TSS would likely not affect primary production, which is likely nutrient-limited.

Nonacho Lake would increased flow ranges based on both inter-annual and intra-annual variation in water levels. Therefore decreased flow ranges would not occur in Nonacho Lake and this is an inValid pathway for both options.

In Taltson Lake of Zone 1, the inter-annual variation over the 13-year baseline period would decrease slightly in low-flow years and increase slightly in average years, thereby not changing significantly on average for the 36 MW option. Under the 56 MW option, inter-annual variation would decrease slightly in all years. The frequency of low and high flow years remains constant for both options. Intra-annual variation would decrease marginally over the year (6 cm to 9 cm for both options). During summer, variation would increase for both options. Therefore, decreased flow range is a Valid pathway for the 56 MW option in Zone 1, since inter-annual variation would decrease.

Inter-annual variation in water levels in Tronka Chua Lake (Zone 2) would increase during average flow years for 36 MW option, and decrease for the 56 MW option during both low and average flow years. A similar pattern would occur in Thekulthili Lake. Intra-annual water level variation in Zone 2 would also increase at Tronka Chua Gap by 20 cm (27%) and 28 cm (by 38%) for the 36 MW and 56 MW options. Summer intra-annual variation would increase by 15 cm (by 31%) for the 36 MW option, and decrease by 10 cm (21%) for the 56 MW option. Therefore, decreased flow ranges related to both inter-annual and intra-annual variation are considered a Valid pathway in Zone 2 for the 56 MW option only.

In Zone 3, inter-annual variation in water levels for the Taltson River below Tazin River would remain the same or decrease slightly (in average flow years) for the 36 MW option, but would remain the same as baseline for the 56 MW option. Intra-annual water level variation would decrease 113 cm (by 53%) and 22 cm (by 10%) for the 36 MW and 56 MW options, respectively. Summer variation would decrease by 22 cm (by 65%) and 10 cm (by 29%) for the 36 MW and 56 MW options. In the Taltson River below the Twin Gorges facility, the flow ranges follow a pattern similar to those described for Taltson River below the Tazin River confluence. Therefore, decreased flow range is a Valid pathway for the Taltson River in Zone 3 only for the 36 MW option, based on both inter- and intra-annual variation.

In the Twin Gorges Forebay in Zone 3, inter-annual variation in summer water levels would decrease on average for both options, particularly during low flow years. Intra-annual water level variation would decrease by 23 cm (by 57%) and 25 cm (by 62%) for the 36 MW and 56 MW options, respectively. In summer, the intra-annual variation was negligible during the baseline period and would remain the same for both options. Therefore, decreased flow range is a Valid pathway for the Twin Gorges Forebay in Zone 3 under both options.

In Tsu Lake of Zone 4, inter-annual variation in average flow years would decrease under the 36 MW option, but remain unchanged for the 56 MW option. Intra-annual variation would decrease by 101 cm (by 52%) and 18 cm (by 9%) under the 36 MW and 56 MW options. Summer variation would decrease by 52 cm (by 75%) and 18 cm (by 26%) for the 36 MW and 56 MW options. Changes under the 56 MW option are considered Minor. Therefore, decreased flow range (inter-annual and intra-annual) is a Valid pathway for Zone 4 only for the 36 MW option.

13.8.7.5 ALTERED HYDROGRAPH

Alterations of the hydrograph could result in changes affecting aquatic resources in terms of water levels and velocities through various times of the year. The summer period is the most important time for aquatic plants and invertebrates as they lie dormant or inactive for much of the fall and winter periods. Potential relevant changes to the hydrograph include altered timing of freshet, extended periods of minimum flows over one or more years, and rapid changes in flows and levels (ramping) related to scheduled shutdown of turbines. These could all result in drying of habitat, reductions in productivity due to mortality (drying out or being washed away during ramping), increased benthic drift, reduced nutrient and organic supply during the critical growing and reproductive summer season, and altered physical habitat (i.e. velocity changes during ramping which could affect physical nature of environment, and also ice timing and thickness which could then affect productivity and survival of biota).

Nonacho Lake outflow would have no years with continuous minimum flows, and thus no change from baseline for either option in this respect. The predicted hydrographs have the same general shape (based on monthly averages over a 13-year period of record) as the baseline. The timing of freshet is not expected to change, and no ramping effects would occur in this zone. Therefore, altered hydrograph effects is not a Valid pathway for either option in Nonacho Lake.

In Taltson Lake of Zone 1, changes to the hydrograph would include one year of continuous minimum flows, for both options. Effects would be similar but likely lower in magnitude of change for other lakes in Zone 1 downstream of Taltson Lake. The hydrographs are predicted to change from baseline in terms of higher winter flows and reduced summer flows. This effect is higher for the 36 MW option than for the 56 MW option. The timing of freshet is not expected to change for the 56 MW option, but would be delayed by one month on average (based on monthly mean levels and flows) under the 36 MW option due to storage of waters upstream in Nonacho Lake. No ramping effects would occur in this zone for either option. Therefore, altered hydrograph effects are a Valid pathway in Zone 1 only for the 36 MW option.

In Zone 2, including Tronka Chua Lake and Benna Thy Lake, several changes to the existing hydrographs would be expected for both options. These include an increase in the number of years with continuous minimum flows, for both options. Minimum flow years would occur a total of 4 of 13 years and 9 of 13 years for 36 MW and 56 MW options, respectively, compared to only 1 of 13 years for baseline. Also, flow rates at Tronka Chua Gap would decrease to zero in low water years and be markedly lower in other years. The predicted hydrographs change from baseline in terms of reduced flows throughout the year for both options but particularly for the 56 MW option. However, the timing of freshet would not change greatly under either option since flows from Nonacho Lake into Zone 2 are not regulated but are free to spill through Tronka Chua Gap. No ramping effects would occur in this zone for either option. Therefore, altered hydrograph effects are a Valid pathway for both options in Zone 2.

In the section of Zone 3 including the Taltson River from the Tazin River mouth to just before the Twin Gorges Forebay, changes to the existing hydrograph would be expected for the 36 MW option only; the 56 MW option would be fairly similar to baseline conditions. Changes under the 36 MW option would include higher winter flows and lower summer flows compared to baseline. However, freshet timing would remain the same for both options, and there would be no years with continuous minimum flows, similar to baseline conditions. No ramping effects would occur in this section of Zone 3 for either option. Therefore, altered hydrograph effects are not a Valid pathway in this section of Zone 3 for either option.

In the section of Zone 3 below Twin Gorges Forebay, some changes to the existing hydrograph would be expected. Changes under the 36 MW option would include higher winter flows and lower summer flows compared to baseline. However, freshet timing would remain the same for both options, and there would be no years with continuous minimum flows, similar to baseline conditions. Changes under the 36 and 56 MW option would occur during ramping. However, the effects would be more pronounced under the 56 MW option.

Flow in the Taltson River below Twin Gorges would change by 44 m^3/s (for the existing turbine) and 23 m^3/s (new 18 MW turbines) from estimated pre-outage conditions for the 36 MW expansion and by up to 53 m^3/s (for an expansion turbine) for the 56 MW scenario; duration of the change would be roughly 10 to 16 hours. Based on average April and May background flow in Trudel Creek during periods of full generation flow at the power plants, the resulting changes in water level would be up to 0.34 m (decrease during initial shutdown and increase upon restart) for the 36 MW expansion and up to 0.32 m (decrease during initial shutdown and increase upon restart) for the 56 MW expansion. Water levels on the Forebay would increase for the duration of the ramping event. Water levels would increase roughly 0.1 and 0.2 m for the 36 MW and 56 MW options. Because these flow changes would occur over a much shorter time scale than normal, this could cause some effects to aquatic biota and their habitat. Therefore, altered hydrograph effects are considered a Valid pathway in Zone 3 below Twin Gorges for both options.

In Zone 4 at Tsu Lake, some changes to the existing hydrograph would be expected for the 36 MW option only; the 56 MW option would be fairly similar to baseline conditions. Changes under the 36 MW option would include higher winter flows and lower summer flows compared to baseline, as seen in other zones. Freshet timing would shift one month later for the 36 MW option only. There would be no years with continuous minimum flows, similar to baseline conditions. No effects of ramping would be observed, based on dampening of flow changes in Tsu Lake (due to a much larger surface area) and farther downriver. Therefore, altered hydrograph effects are considered a Valid pathway in Zone 4 only for the 36 MW option.

13.8.8 Residual Effect Analysis

The residual effect analysis and classification was conducted for each of the Valid pathways for each of the two expansion options. The effects of the Project were quantified where possible and discussed separately for the five zones of the Taltson River. The effect classification was completed per effect on aquatic resources of the Taltson River as a whole and not individual zones. The magnitude, geographic extent, duration, frequency, reversibility, likelihood, and overall residual effect rating were determined for each effect based on methods outlined in Section 13.2 and Chapter 10. Magnitude of the effects on the assessment endpoint (productivity, biodiversity and community structure) was weighted heavily on the change in water levels and thus changes in habitat quantity and quality. The magnitude of change in water levels was assigned a qualitative rating, which contributed heavily to the magnitude of effect rating on the assessment endpoint.

Categories of magnitude for change in water level relative to baseline are provided below:

- 0 to 19 cm decrease or increase = Negligible.
- 20 to 49 cm decrease or increase = Low.
- 50 to 99 cm decrease or increase = Moderate.
- Over 100 cm decrease or increase = High.

These categories were based on typical depths of littoral zones and associated vegetation, since a change in water level corresponds to a potential effect to aquatic habitat. Reported changes in summer water levels includes June to late August. The summer growing season was considered the critical time period for the assessment of changes to aquatic habitat. As these changes in water levels relate to changes in littoral zone, there remains a high level of uncertainty associated with these categories, dependent on slope of lakeshore or river bed, types of vegetation present (horsetail vs. taller bulrush species), and physical substrates present (i.e. silt and sand vs. bedrock, relating to TSS issues from fluctuating water levels).

Effects of changes in water levels on the littoral zone have been used to predict effects within the associated benthic community. NIWA (2003) suggests that a water level drop of 20 cm to 50 cm in a New Zealand lake had a minor effect on the reduction in littoral habitat. The small reduction in littoral habitat would likely effect benthic communities but the effects would be restricted to a small area of the littoral zone and therefore the overall effect to aquatic communities would be minimal. Aroviita and Hämäläinen (2008) found that for 11 lakes with drawdown ranges between 119 cm and 675 cm annually, macroinvertebrate richness decreased and taxonomic composition varied when compared to an unregulated lake (natural drawdown of 55 cm annually). The authors also found a negative relationship of the intensity of regulation (drawdown) and species richness.

The duration of effects were based on both the duration of Project activities, which are correlated with Project phases, and the duration of effects on measurement endpoints (e.g. habitat) which shadow effects on the assessment endpoints. Short-term was defined as less than 3 years, which corresponds to the predicted length of time required for submergent vegetation to re-establish following disturbance. Medium-term was defined as less than 10 years, which corresponds to the predicted length of time required for emergent vegetation to re-establish following disturbance. Long-term was defined as between 10 and 40 years, which corresponds to the end of the operations phase of the Project.

The geographic extent was based on the extent of the effect: a single zone, multiple zones, or the entire Taltson River watershed. The reversibility was assessed based on whether the effect is reversible if the stressor remains and if removed. That is, the pathway could remain (e.g. decreased water levels) but the effect could be reversed over time (new suitable littoral habitat and thus baseline productivity levels). Alternatively, an effect could reoccur until the stressor is removed (e.g. ramping events cease at the end of operations). The overall residual effect considers the qualitative ratings of effects on the assessment endpoint for each pathway. The classification of residual effects is presented in Table 13.8.5 and Table 13.8.6 for the 36 and 56 MW options, respectively.

13.8.8.1 36 MW OPTION

In this section, the potential residual effects to aquatic resources during the operations phase are discussed for each of the five study zones based on the 36 MW upgrade. A summary of the residual effects classification is presented in Table 13.8.5.

Effects are discussed below by zone. However, residual effects classification was completed based on the entire extent of the effect on aquatic resources. Where effects extended beyond a single zone, the magnitude of effect presented in the Table 13.8.5 is the highest magnitude for all zones affected.

Table 13.8.5 — Residual Effect Classification of Valid Pathways for Aquatic Resources: 36 MW Option

Pathway	Effect	Direction	Geographic Extent	Magnitude	Duration	Frequency	Likelihood	Reversibility	Overall Residual Effect
Decreased Flow/Water Level - leading to loss of suitable littoral habitat and permanent loss of profundal habitat	Decreased productivity Biodiversity Community structure	Adverse	Taltson Watershed (Nonacho Lake, Zone 1, 2, 3, 4)	Moderate (short-term littoral effect) Low (long-term profundal effect)		Continuous	Likely	Reversible	Low
Increased Flow Range - leading to reduced habitat quality and loss of habitat due to lower water levels	Decreased productivity Biodiversity Community structure	Adverse	Multiple Zones (Nonacho and Zone 2)	Low	Long-term	Periodic	Likely	Reversible	Low
Decreased Flow Range - leading to decreased nutrient and organic loading, and habitat complexity	Decreased productivity Biodiversity Community structure	Adverse	Multiple Zones (Zone 3 and 4)	Low	Long-term	Continuous	Likely	Reversible	Low
Altered Hydrograph (altered freshet timing) - leading changes in availability of nutrients and organics	Decreased productivity	Adverse	Multiple Zones (Zone 1, 2 and 4)	Low	Long-term	Periodic	Likely	Reversible	Low

Pathway	Effect	Direction	Geographic Extent	Magnitude	Duration	Frequency	Likelihood	Reversibility	Overall Residual Effect
Altered Hydrograph (extended minimum flow) - leading to decreased habitat complexity, and nutrient and organic levels	Decreased productivity Biodiversity Community structure	Adverse	Multiple Zones (Zone 2 and 3)	Moderate	Long-term	Periodic	Likely	Reversible	Moderate
Altered Hydrograph (flow ramping) - leading to reduced habitat quality	Decreased productivity Biodiversity Community structure	Adverse	Zone 3 only	Low	Short-term	Periodic	Likely	Reversible	Low

Table 13.8.6 — Residual Effect Classification Valid Pathways for Aquatic Resources: 56 MW Option

Pathway	Effect	Direction	Geographic Extent	Magnitude	Duration	Frequency	Likelihood	Reversibility	Overall Residual Effect
Decreased Flow/Water Level - leading to loss of suitable littoral habitat and permanent loss of profundal habitat	Decreased productivity Biodiversity Community structure	Adverse	Multiple Zones (Nonacho Lake, Zone , 2, 3)	Moderate (short-term littoral effect) Low (long-term profundal effect)		Continuous	Likely	Reversible	Low
Increased Flow Range - leading to reduced habitat quality and loss of habitat due to lower water levels	Decreased productivity Biodiversity Community structure	Adverse	Single Zone (Nonacho Lake)	Low	Long-term	Periodic	Likely	Reversible	Low
Decreased Flow Range - leading to decreased nutrient and organic loading, and habitat complexity	Decreased productivity Biodiversity Community structure	Adverse	Multiple Zones (Zone 1, 2 and 3)	Low	Long-term	Continuous	Likely	Reversible	Low

Pathway	Effect	Direction	Geographic Extent	Magnitude	Duration	Frequency	Likelihood	Reversibility	Overall Residual Effect
Altered Hydrograph (extended minimum flow) - leading to decreased habitat complexity, and nutrient and organic levels	Decreased productivity Biodiversity Community structure	Adverse	Multiple Zones (Zone 2 and 3)	Moderate	Long-term	Periodic	Likely	Reversible	Moderate
Altered Hydrograph (flow ramping) - leading to reduced habitat quality	Decreased productivity Biodiversity Community structure	Adverse	Zone 3 only	Low	Short-term	Periodic	Likely	Reversible	Low

13.8.8.1.1 Nonacho Lake

Nonacho Lake was predicted to have low magnitude decreases in water levels throughout the year. In summer, these decreases could result in minor loss of habitat along the perimeter of the lake, affecting littoral vegetation (emergent and submergent) and associated littoral benthos. This would subsequently result in loss of productivity as aquatic biota would be exposed to air and their habitat would dry out. This could result in short-term loss of a proportion of littoral habitat followed by development of new littoral habitat at the new waterline. Field surveys in 2008 by fisheries biologists indicated that emergent vegetation grows to 1 m depth, and submergent vegetation was generally observed from about 25 cm to 105 cm depth (CGL 2008). Therefore, the projected decreases in water levels would affect the upper 15% to 44% of littoral habitat in summer, but leave deeper emergent plants intact. Effects to submergent littoral communities would only be observed in the upper sections, based on field observations of established vegetation. It was also noted (CGL 2008) that vegetation may grow deeper than that observed because surveys were done earlier in the growing season. Any profundal habitat that changes to littoral habitat would represent a net loss of profundal habitat. This loss is considered negligible based on the total profundal habitat within Nonacho Lake which is 20 m to 30 m deep. There is a fair degree of uncertainty as to the timing and success of redevelopment of littoral habitat in the lake.

During winter and early spring, levels would decrease below baseline levels. This could result in drying and ice scour of eggs and root/seed beds. Overall, local residual effects to sustainability of aquatic resources from decreased water levels are rated as low for Nonacho Lake. Effects would largely relate to altered productivity, diversity, and community structure in plant and benthic communities in littoral habitat. Negligible effects would occur in profundal benthic habitat as only a small proportion of this habitat could be lost.

The effects of decreased water levels on the productivity of the littoral community would vary depending on the quality of littoral habitat being affected. Shorelines with steeper banks would support less aquatic productivity (relative to shallow sloping beach and wetland areas) and thus the effect on productivity would vary for a given water level change.

Increased flow ranges (inter-annual and intra-annual) in summer and over the year at Nonacho Lake would increase to a moderate degree. However, this increase in range would not occur every year. Its occurrence would be correlated with average to below-average flow years. The effect of increased flow range is related to additional disturbance to littoral lake habitat, which could result in reduced habitat quality and reduced productivity. Some reductions in diversity and change to dominant taxa could also occur. The larger difference between summer and winter variation could result in increased ice scour and drying in winter periods. Residual adverse effects to sustainability of aquatic resources are considered to be moderate for Nonacho Lake. These effects relate to decreased littoral habitat productivity and diversity. Effects to community structure within littoral habitat and effects on all assessment endpoints within profundal habitat would be negligible.

13.8.8.1.2 Zone 1

Water flows and levels would show low magnitude decreases in summer in Taltson Lake, King Lake, Benna Thy Lake, and Lady Grey Lake. Lowered summer water levels would cause loss of habitat along the perimeter of the lake. The degree of loss would depend on shoreline slope and habitat type. Decrease in summer water levels would result in loss of productivity as the overall wetted area would decrease and in particular the littoral community would be disturbed. A shift in community structure and loss of some diversity would also be possible, depending on the areas exposed. Field surveys in 2008 indicated that Lady Grey Lake had emergent and submergent vegetation from 0 cm to 150 cm depth (CGL 2008). No data was available for other areas in Zone 1. This suggests that only the top portions (20% to 30%) of littoral vegetation would be disturbed by the decreased water levels during summer. The overall magnitude of the change in water level is low for Zone 1. Effects relate to decreased littoral habitat productivity, diversity, and community structure in the short-term. No effects to profundal habitat are predicted since only a small proportion of deep habitat would be changed to littoral habitat.

The hydrograph was predicted to change, with higher winter flows and lower summer flows in Taltson Lake and farther downstream in Zone 1, resulting in the freshet being delayed by a month (start in late June on average). The change in the freshet timing could mean that plants and invertebrates would not receive the same levels of nutrients and organics normally transported to them at the start of the growing season (June). New seedlings and invertebrate larvae develop at set rates based on their short life cycles, therefore this alteration of their environment would disrupt their development to a certain degree. This could reduce growth and productivity of aquatic resources.

13.8.8.1.3 Zone 2

Water flows and levels in Zone 2 are expected to show low magnitude decreases over summer months. This could cause drying of habitat and loss of productivity and diversity in Tronka Chua Lake and farther downstream in this zone. No field information is available regarding depth distributions for littoral vegetation in Zone 2. Effects relate to decreased littoral habitat, productivity diversity and community structure.

Increased flow ranges are predicted for Zone 2. Inter-annual variation in Zone 2 increases, with very low flow years quite different from flows in average or high flow years, whereby average flow years would have higher summer–winter flow variations. Intra-annual variation is also slightly increased compared to baseline over fall and winter, however within-summer monthly variation would be similar to baseline. Effects relate to decreased littoral habitat productivity, diversity and structure. Profundal habitat would not be noticeably affected due to the relatively small proportion that could be lost.

The hydrograph was predicted to change in Zone 2. There would be an increase in frequency from 1 in 13 to 4 in 13 years where flows would be consistently minimal through the year. During low flow years (4 of 13 baselines), no flow would pass through Tronka Chua Gap. This would cause loss and altered quality of littoral habitat in the Tronka Chua Gap area of Zone 2. Other small local tributaries would still flow into Zone 2 although the relative amounts are small compared to baseline flow over the gap. This change therefore is not a new effect but a change in frequency of low flow years, which is not expected to affect biodiversity but would likely reduce overall productivity. The magnitude of change is rated moderate, and duration would be long-term (life of Project).

13.8.8.1.4 Zone 3

Water flows and water levels would show a moderate magnitude decrease in the summer in the Taltson River downstream of the Tazin River confluence, and to a lesser extent below the Twin Gorges spillway. In the Twin Gorges Forebay, summer levels would show a low-moderate magnitude decrease. Lower summer levels would affect littoral productivity (plants, algae, benthos) and may affect community structure, due to exposure and alteration of littoral habitat. No field information is available regarding depth distributions for littoral vegetation in Zone 3. Profundal habitat would remain abundant, as the proportion that would transform from profundal to littoral is quite small overall.

Decreased water level ranges (113 cm or 53% annually, and 22 cm or 65% over summer) are predicted for the Taltson River in Zone 3. This is related to increased winter levels and decreased summer levels compared to baseline. These reductions could result in reduced nutrient and organics transport from riparian zones into the river during high flows. This would reduce productivity.

In Zone 3 above Twin Gorges Forebay, no important changes to the hydrograph were predicted. In the Forebay, the hydrograph would change such that 3 of 13 years would become extended low-flow years. This did not occur during baseline years. This change would not likely affect biodiversity but would likely reduce overall productivity in the three low-flow years and is considered a continuous effect. The magnitude of change in flow range is rated moderate, and duration would be long-term (life of Project).

In the Taltson River below the Forebay, scheduled shutdowns would result in negligible to low increases in water levels; between 0.1 m and 0.2 m over a three-week period. The overall loss of productivity would be minimal given the low magnitude change in water level and given that water levels during this time of year are traditionally variable. On the Taltson River downstream of Elsie falls there would be a quick decrease in water levels (roughly 0.3 m) that would last for up to 16 hours. Many species of aquatic plants and invertebrates can withstand periods of drying over periods of hours to several days. As turbines are restarted, the resultant increased flows (roughly up to 0.3 m) could also cause mortality by washing away organisms and temporarily increasing TSS loadings, slightly reducing local productivity until particulates settled out of the water. The magnitude of the effects are predicted to be low. The effects would be short-term and reversible. However, the effects would reoccur every ramping event. The overall residual effect is low.

13.8.8.1.5 Zone 4

Water flows and levels in Zone 4 would show low magnitude decreases in the summer months. This would result in loss of some existing aquatic habitat along riverbanks, with related reduction in productivity and diversity as the littoral community is disturbed and shifts down in elevation, and profundal habitat is permanently lost. No field information is available regarding depth distributions for littoral vegetation in Zone 4. The permanent loss of profundal habitat would be negligible given the size of system in Zone 4.

Decreased intra-annual flow ranges (101 cm or 52% annually, and 52 cm or 75% over summer), are predicted for Zone 4. This is related to increased winter levels and decreased summer levels compared to baseline. These reductions could result in reduced nutrient and organics transport from riparian zones into the river during high flows. This would reduce productivity.

In Tsu Lake of Zone 4, the hydrograph was predicted to change. Higher winter flows and lower summer flows would occur, resulting in the freshet being delayed by a month (start in late May instead of late April, on average). The change in the freshet timing could mean that plants and invertebrates would not receive the same levels of nutrients and organics normally transported to them at the start of the growing season. New seedlings and invertebrate larvae develop at set rates based on their short life cycles, therefore this alteration of their environment would disrupt their development to a certain degree. This could reduce growth and productivity of aquatic resources.

13.8.8.2 56 MW OPTION

The potential effects to aquatic resources during operations are discussed for each of the five study zones based on the 56 MW expansion (Table 13.8.6). The types of effects are the same as those related to the 36 MW option, although the ratings of potential effects varies for each zone due to the different water management required.

Effects are discussed below by zone. However, residual effects classification was completed based on the entire extent of the effect. Where effects extended beyond a single zone, the magnitude of effect presented in the Table 13.8.6 is the highest magnitude for all zones affected.

13.8.8.2.1 Nonacho Lake

Nonacho Lake was predicted to have moderate magnitude decreased water levels all year long, with low magnitude decreases in the summer period. In summer, these decreases could result in loss of suitable littoral habitat in the short-term. This would subsequently result in loss of productivity as the deeper profundal habitat would likely not be suitable for littoral type communities for a few years. Field surveys in 2008 by fisheries biologists indicated that emergent vegetation grows to 1 m depth, and submergent vegetation was generally observed from about 25 cm to 105 cm depth (CGL 2008). Therefore, the projected decreases in water levels would affect the upper 59% to 70% of littoral habitat in summer, leaving the deeper emergent plants intact. Effects to submergent littoral communities would also show losses of approximately 50%, based on field observations of established vegetation. It was also noted that vegetation may grow deeper than that observed since surveys were done earlier in the growing season. As profundal habitat could subsequently be transformed into littoral habitat, the effects would be observed to be higher in magnitude in the first few years and decrease following recolonization and regrowth. The difference between summer and winter levels would not change.

Based on inter-annual changes in water levels, the range in flow would double, mainly due to lowered minimal levels in the reservoir. This relates to a moderate magnitude change in water level. The larger difference between summer and winter levels could result in increased ice scour and drying in winter periods. This would relate to additional disturbance to littoral lake habitat, which could result in reduced habitat quality and reduced productivity. Some reductions in diversity and change to dominant taxa could also occur. Average intra-annual variation would increase negligibly (under 20 cm) under the 56 MW option.

13.8.8.2.2 Zone 1

Decreased flow ranges based on inter-annual variation would be predicted to a certain degree under the 56 MW option. This would result in low magnitude water level effect in Zone 1 of the Taltson River. These changes mainly relate to higher annual minima due to different water management in the system. Effects related to reduced nutrient and organic loadings from riparian zones would not be expected since maxima (temporary overflows into higher shoreline zones) would not change.

13.8.8.2.3 Zone 2

Decreased flows and water levels of moderate magnitude were predicted in Zone 2 over both summer and winter periods. This could cause drying of habitat and loss of productivity and diversity in Tronka Chua Lake and farther downstream in this zone. Littoral vegetation and benthos would experience the majority of effects, including mortality and reduced community productivity. No field information is available regarding depth distributions for littoral vegetation in Zone 2. Therefore it is assumed that Zone 2 has similar distributions of macrophytes as observed upstream in Nonacho Lake. This means that 80% to 90% of the current littoral zone could be affected until the new littoral habitat becomes suitable. As profundal habitat is transformed to suitable littoral habitat (1 to 3 years), profundal benthic area would decrease, and profundal productivity would be lowered to a small extent. Pelagic biota would not be affected.

Decreased flow ranges based on inter-annual variation would be predicted in Zone 2 under the 56 MW option. This could result in decreased nutrient and organic loadings to the river from adjacent shoreline areas. These changes mainly relate to more consistent and lower flows in this zone due to changes in water management in the Taltson system. It is possible that TSS loadings could be reduced in these more constant flow conditions, although turbidity is not generally a factor in water quality of the Taltson River.

The hydrograph was predicted to change in Zone 2. There would be an increase from 1 in 13 to 9 in 13 years where flows would be consistently minimal through the year. During low flow years (9 of 13 baselines), no flow would pass through Tronka Chua Gap. This would cause loss and altered quality of littoral habitat in the gap area of Zone 2. Other small local tributaries would still flow into Zone 2 although the relative amounts are small compared to baseline flow in the system. This change therefore is not a new effect but a large change in frequency of low flow years.

Littoral zones would be permanently lowered to the levels which occur at minimal flow, and this would represent a loss in productivity in terms of reduced emergent and submergent vegetation (one to three years). As profundal habitat gradually transforms to suitable littoral habitat, levels of biodiversity and productivity could again return to normal.

13.8.8.2.4 Zone 3

Water flows and levels would show a negligible to low magnitude decrease in summer in the Taltson River downstream of Tazin River confluence, and to an even lesser extent below Twin Gorges spillway. However, levels would decrease with low-moderate magnitude in summer in Twin Gorges Forebay. This could lead to decreased littoral productivity and may affect community structure, due to exposure and alteration of littoral habitat and mortality of emergent vegetation and associated benthos (until the littoral zone adjusts to the new water levels). No field information is available regarding depth distributions for littoral vegetation in Zone 3. Based on observations from Nonacho Lake, approximately 20% of littoral vegetation would be lost in the Taltson River above the Tazin River confluence, and approximately 50% would be lost in Twin Gorges Forebay. These would be short-term losses assuming that littoral vegetation would redevelop farther downslope within each area, leading to transformation from profundal to shallow productive zones. Overall, the local residual effects in Zone 3 from decreased water levels are rated low (Taltson River below Tazin River) and moderate (Twin Gorges Forebay).

Decreased flow ranges were predicted in Zone 3 only for the Forebay and not within the Taltson River upstream and downstream of this area. Within the Forebay, inter-annual variation would decrease due to more consistent low flow levels. Intra-annual variation would also show a low magnitude decrease. This could result in reduced habitat heterogeneity and reduced nutrient and organic input from riparian zones, reducing productivity in the Forebay.

No changes to the hydrograph were predicted for the Taltson River above Twin Gorges Forebay. In the Forebay, the hydrograph would change such that 5 of 13 years would become extended low-flow years. This did not occur during baseline years. This change would not likely affect biodiversity but would likely reduce overall productivity in the three low-flow years and is considered a continuous effect. Although minor ramping effects were predicted related to backwatering during scheduled shutdowns, the effect is low.

In the Taltson River below the Forebay, scheduled shutdowns would result in negligible to low increases in water levels, between 0.1 m and 0.2 m over a three-week period. The overall loss of productivity would be minimal given the low magnitude change in water level and given that water levels during this time of year are traditionally variable. On the Taltson River downstream of Elsie falls there would be a quick decrease in water levels (roughly 0.3 m) that would last for up to 16 hours. Many species of aquatic plants and invertebrates can withstand periods of drying over periods of hours to several days. As turbines are restarted, the resultant increased flows (roughly up to 0.3 m) could also cause mortality by washing away organisms and temporarily increasing TSS loadings, slightly reducing local productivity until particulates settled out of the water. The magnitude of the effects are predicted to be low. The effects would be short-term and reversible. However, the effects would reoccur every ramping event. The overall residual effect is low.

13.8.8.2.5 Zone 4

No residual effects are associated with the 56 MW option in Zone 4 because there are no Valid pathways.

13.8.9 Uncertainty

The following factors contributed to the levels of uncertainty in this assessment:

- Assumption that new littoral habitat of equivalent quantity and quality would develop in river and lake habitat at the new levels to replace lost habitat after a few growing seasons. Tied to the development of littoral areas is the assumption that secondary communities would also develop with similar structure and function compared to existing communities. These are reasonable assumptions. It is fairly certain that at least a basic secondary community would develop, and also likely this community could be similar to existing ones, provided sufficient littoral habitat and conditions are provided.
- Lack of knowledge of aquatic primary producer community diversity and productivity except at two locations (Nonacho Lake and Twin Gorges Forebay). It was assumed that all others would be intermediary of these sites). If there are areas of higher productivity, they are not assessed or considered in this DAR.
- Limited knowledge of habitat quality along shores (information only collected at Nonacho and Lady Grey Lakes), in littoral zones. This relates to the extent of submergent and emergent vegetation distributed within littoral/profundal areas of each zone.
- Uncertainty associated with hydrologic model (as presented in Section 9.3 – Taltson Basin Hydrology and Section 13.3 - Alterations of Water Quantity). Use of the hydrology model results was limited as changes in lake levels do not relate to changes in lakebed surface area.

Bathymetric data would be very useful in predicting changes in surface areas of each lake or river throughout the year. However, there would still be uncertainties associated with the bathymetry data as well as the inherent uncertainty present in the hydrologic model. However, it would provide a quantified account of aquatic habitat loss/change based on the two expansion options.

This assessment used all available output points from the hydrologic model. It is not known whether more sites would improve the quality of the hydrologic model. It is more likely that aquatic and bathymetric surveys would be more useful. In any case, the scale of effects to the aquatic biological communities would not change markedly if there were improved certainty. Unless flows were cut in the Taltson River by 90% or more, some form of aquatic resources would continue to inhabit this area.

13.8.10 Cumulative Effects

Cumulative effects are assessed considering overlapping effects from historical, current, and future activities within the study area.

Regarding current and future activities, no mining or forestry projects situated within the Taltson Watershed overlap with the Taltson River KLOI study area. Additional hydroelectric projects have not been registered in the area. As there are no reasonably foreseeable projects identified in the study area, no other projects would provide cumulative effects to the Expansion Project because there is no spatial overlap. Should any projects move towards development in the study area, these could potentially cause cumulative effects to the proposed Expansion Project.

Existing developments include a hydroelectric facility in the Tazin River system. The regulated flows of the Tazin River into Taltson River have been considered in the current Taltson hydrologic model. There are no additional potential cumulative effects from the Tazin River facility.

Initial development of the Twin Gorges Project facilities in the 1960s resulted in greatly altered water levels in Nonacho Lake and Twin Gorges Forebay. Flow rates and levels were also changed in Zones 1, 2, 3 and 4. The increased water management in the Taltson River resulted in increased winter flows and decreased summer flows. Flow began to run through Tronka Chua Gap into Zone 2 where no such flows existed previously, owing to higher water levels in the Nonacho Lake reservoir, which spilled over the gap and into Tronka Chua Lake. This would have affected water levels throughout Zone 2. Flows in Zone 1 (Taltson Lake and downstream) would have been reduced in an equivalent measure based on flows over Tronka Chua Gap. Flows were regulated within Nonacho Lake from 1968 to 1985, and partially regulated after this date.

These various changes likely had some adverse effects on the aquatic biological communities within Taltson River, at least over the initial years immediately following development. Where the water levels rose substantially (e.g. Nonacho Lake), there would have likely been inundation of emergent vegetation and further covering of submergent vegetation, reducing productivity and potentially altering community structure and biodiversity.

Over time, new suitable littoral habitat would have developed at the new water level over a period of 1 to 3 years. Succession of this habitat to a mature aquatic ecosystem and succession of associated wetland communities with stable emergent vegetation may have taken up to 10 years, given that the new water level could have eliminated most emergent vegetation.

There are no data on primary and secondary producer communities from this pre-development period. Existing biological communities are almost definitely stabilized from this initial anthropogenic stress which occurred 43 years earlier. Recolonization and redevelopment of invertebrate and epiphytic algal communities tie strongly to development of both littoral and riparian plant communities. Both of these communities are important to aquatic biota. Littoral habitat development depends on the availability of seed banks, colonizing invertebrates, suitable water quality and sediment conditions, and appropriate habitat (sufficiently shallow to allow photosynthesis by emergent and submergent vegetation).

The proposed expansion options present incremental adverse effects including reduced productivity, altered habitat extent and quality, reduced biodiversity (at least until a mature littoral zone would be assumed to develop in three years following expansion) and altered community structure. These arise from several pathways including water level changes and increased fluctuations in water levels and flows.

Residual cumulative effects from initial hydroelectric Project development includes changes in habitat structure, loss of primary and secondary productivity during inundations from large rise of water levels, potentially reduced biodiversity, and mortality of existing aquatic communities. It is not possible to quantitatively assess losses from initial development due to lack of bathymetric and biological data. There exists a high degree of uncertainty as to how the biological communities have changed in terms of density and diversity of primary and secondary producers, from pristine times to post-initial-development (1969) to current baseline (post 1986) periods, and exactly how future periods would compare with respect to these parameters. In any case, the proposed development presents further change to the aquatic resources of the Taltson River, which have likely stabilized since the initial development and would be expected to restabilize in approximately 10 years following proposed expansion of Twin Gorges (based on rates of vegetative succession in emergent communities). The sustainability of aquatic resources remains preserved because projected residual effects are not of high magnitude. Thus, the incremental changes are considered changes from a stabilized environment and thus not cumulative in nature relative to pristine, given that no information exists to quantify and qualify aquatic resources pre-development.

13.8.11 Monitoring

A monitoring program would be developed in detail with regulatory agencies that focuses on the key areas of concern and areas that are predicted to experience the greatest change from current conditions. Following review of the DAR, the areas of greatest concern would be identified via discussions with the Board, federal and territorial agencies, Aboriginal groups and the public.

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

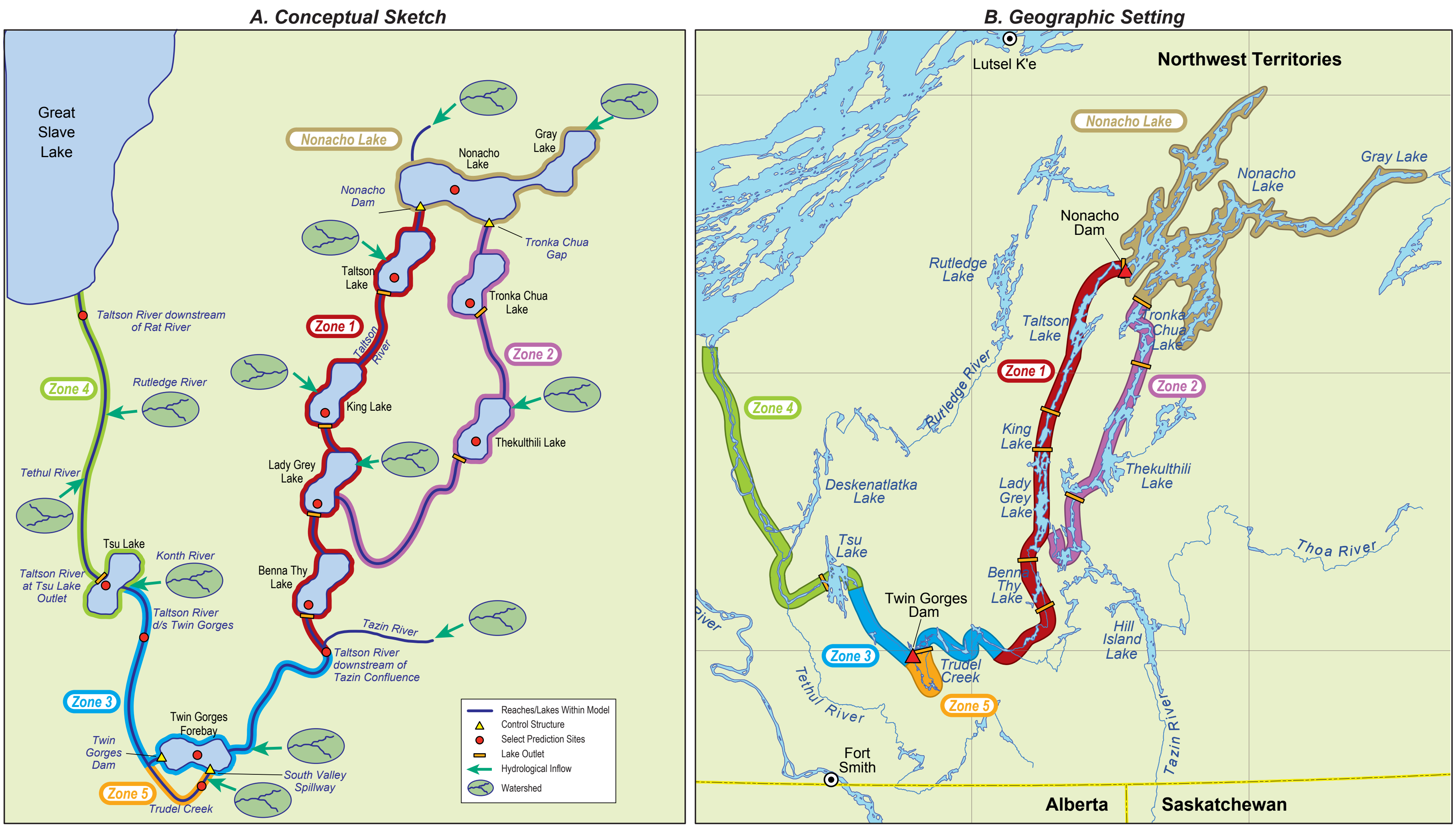
TABLE OF TABLES

APPENDICES

13. WATER FLUCTUATIONS IN TALTSON RIVER

13.9 TALTSON FISHERIES

The section of the Taltson River potentially affected by the Project includes Nonacho Lake and the Taltson River downstream from Nonacho Lake to Great Slave Lake. This area has been divided into zones for the purpose of the Project and specifically for the development of the Taltson basin flow model (Section 13.3 – Alterations of Water Quantity) and shown in Figure 13.9.1. The aquatic environment is presented according to these zones.



TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report** **2009**	**Planar Schematic and Geographic Setting of the Taltson Basin Flow Model**	**Figure 13.9.1**

13.9.1 Fish Species and Habitat Requirements

The fish communities of the Taltson watershed, Great Slave Lake and the tundra Project area (near Ekati Mine) have been surveyed for the Expansion Project and other Projects, and for research and development purposes. The majority of the lakes and rivers in the Project area eventually drain into Great Slave Lake, with the exception of the section of transmission line north of MacKay Lake, which is in the Coppermine River watershed. There are 17 fish species present within the Taltson River. Table 13.9.1 summarizes the key fish species found within Great Slave Lake, the Taltson River, and in the tundra Project area along the transmission line.

Table 13.9.1 — Key Fish Species Known to be Present in the Region

Common Name	Scientific Name	LOCATION			Notes
		Great Slave Lake	Taltson River	Tundra Water Bodies	
Arctic grayling	*Thymallus arcticus*	X	X	X	Mid-sized sport fish, lakes and streams
Arctic lamprey	*Lampetra japonica*	X			Present in Great Slave Lake
Brook stickleback	*Culaea inconstans*	X			In tributaries to Great Slave Lake
Burbot	*Lota lota*	X	X	X	Large predator, lakes and streams
Chum salmon	*Oncorhynchus keta*	X			Spawns in tributaries to Great Slave Lake
Deepwater sculpin	*Myoxocephalus quadricornus*	X			Present only in Great Slave Lake, lake resident only
Emerald shiner	*Notropis atherinoides*	X			In tributaries to Great Slave Lake
Flathead chub	*Platygobio gracilis*	X			Present in Great Slave Lake
Goldeneye	*Hiodon alosoides*	X			Present in Great Slave Lake
Inconnu	*Stenodus leucichthys*	X	X		In tributaries to Great Slave Lake
Lake chub	*Couesius plumbeus*	X	X	X	Small forage fish, lake resident
Lake cisco	*Coregonus aretedii*	X	X	X	Large forage fish
Lake trout	*Salvelinus namaycush*	X	X	X	Large predator, lake resident
Lake whitefish	*Coregonus clupeaformis*	X	X	X	Large forage fish, lake resident
Least cisco	*Coregonus sardinella*	X			Present in Great Slave Lake
Longnose dace	*Rhinichthys cataractae*	X			In tributaries to Great Slave Lake

Common Name	Scientific Name	LOCATION			Notes
		Great Slave Lake	Taltson River	Tundra Water Bodies	
Longnose sucker	*Catostomus catostomus*	X	X	X	Large forage fish, lake and stream resident
Ninespine stickleback	*Pungitis pungitis*	X	X	X	Common, small bodied forage fish
Northern pike	*Esox lucius*	X	X	X	Large predator, lakes, streams and wetlands
Round whitefish	*Prosopium cylindraceum*	X	X	X	Mid-sized forage fish, lake resident
Shortjaw cisco[1]	*Coregonus zenithicus*	X			Present in Great Slave Lake
Slimy sculpin	*Cottus cognatus*	X	X	X	Small, widely distributed lake and stream bottom-dweller
Spoonhead sculpin	*Cottus ricei*	X			Great Slave Lake, stream and lake resident
Spottail shiner	*Notropis hudsonius*	X	X		In tributaries to Great Slave Lake
Trout-perch	*Percopsis omiscomaycus*	X	X		In tributaries to Great Slave Lake
Walleye	*Stizostedion vitreum*	X	X		In tributaries to Great Slave Lake
White sucker	*Catostomus commersoni*	X	X		Large forage fish, lake resident, larger rivers
Yellow perch	*Perca fluvescens*	X	X		In tributaries to Great Slave Lake

Source: Sawatzky et al. 2007

[1] putative

Spawning and rearing habitat requirements for the species found in the Project area are summarized in Table 13.9.2 and Table 13.9.3 presents a summary of their seasonal timing and life cycle. This is followed by a brief life history summary for each species found within the Project area.

Table 13.9.2 — Spawning and Rearing Habitat Preferences for Fish Species in the Taltson Watershed

Common Name	SPAWNING			REARING	
	Habitat	Substrate	Depth	Habitat	Substrate
Arctic grayling	L, R	C, G	0.7 m	L, R, S	G, S
Burbot	L, R, S	G, S	0.3 to 0.5 m	L, R	R, C, G
Inconnu	R	C, G	1.2 to 2.3 m	L	P
Lake chub	R, S	G, C	< 5 m	L, R	R, C
Lake cisco	L, R	G, S	1.0 to 5.0 m	L	R, V
Lake trout	L, R	R, C	0.1 to 55.0	L, R	R, C, P

Common Name	SPAWNING			REARING	
	Habitat	Substrate	Depth	Habitat	Substrate
			m		
Lake whitefish	L, R, S	G, S	< 5.0 m	L	R, C, S
Longnose sucker	L, R, S	G, S	< 1.0 m	L, S	G, S
Ninespine stickleback	L, R	S, V	<1.0 m	L	S, V
Northern pike	L, R	S	< 1.0 m	L, R	C, G, S
Round whitefish	L, R	G	< 1.0 m	L, R	G, S
Slimy sculpin	R, S	R, G, S	< 1.5 m	R	G, S, V
Spottail shiner	L, R	C, G, S	0.1 to 0.5 m	L, R	G, S
Trout perch	L, R	G, S	< 1.0 m	L, S	G, S
Walleye	L, R	R, C, G	< 3.0 m	L, R	B, C
White sucker	L, R, S	G	< 2.0 m	L, R	G, S, V
Yellow perch	L	C, V	< 5.0 m	L	G, S, V

Notes: Habitat: L = lake, R = river, S = stream

Substrate: R = rock, C = cobble, B = boulder; G = gravel, S = sand, V = vegetation, P = pelagic

Table 13.9.3 — Seasonal Timing and Life Cycle Summary of Fish Species Found in the Taltson Watershed

Common Name	Spawning Dates	Egg Incubation	Hatching Dates	Emergence Dates
Arctic grayling	Apr to mid Jun	13 to 18 days	May to Jul	May to Jul
Burbot	Jan to Apr	3 weeks – 3 months	Feb to May	Apr to Jun
Inconnu	Oct	Overwinter	Spring	Jul to Aug
Lake chub	Apr to Aug	3 to 5 weeks	Jun to Sep	
Lake cisco	Sep to Nov	4 to 5 months	Mar to May	
Lake trout	Sep to Oct	4 to 5 months	Mar to Apr	Apr to Jun
Lake whitefish	Sep to Oct	4 to 5 months	Mar. to May	
Longnose sucker	Apr to May	11 to 15 days	May to Jun	Jun to Jul
Ninespine stickleback	May to late Jun			
Northern pike	Apr to May	2 to 3 weeks	May to Jun	Mid May to Mid Jul
Round whitefish	Oct	4 to 5 months	Mar to May	
Slimy sculpin	May	4 weeks	Jun	
Spottail shiner	Jun. to Jul			
Trout-perch	May to Jun	6 to 7 days	May to Jun	
Walleye	May to Jun	5 to 15 days	May to Jul	May to Jul
White sucker	May to Jun	5 to 15 days	May to Jul	May to Jul
Yellow perch	Mid Apr to Aug	8 to 10 days	May to Sep	May to Sep

Note: Empty cell indicates information not available.

Arctic grayling

Arctic grayling live in both rivers and lakes, preferring cold clear water. They spawn from April to mid-June during the same time the ice is breaking up. Spawning can occur in both rivers and lakes over gravel and cobbles at depths to 0.7 m and is generally associated with the inlet or outlet of a stream. Once the eggs are laid, they hatch in 13 to 18 days. The young remain in the gravel for three to four days after hatching and then rear in lotic and littoral areas at depths of 0.2 m to 0.46 m. Arctic grayling mature in three to six years and are generally found over sand and silt substrates where they feed on aquatic invertebrates (Richardson et al. 2001).

Burbot

Burbot live in rivers and lakes as well as streams and pools. They spawn at night, under the ice from November to May, with most between January and April. Burbot prefer shallow waters for broadcast spawning (0.3 m to 0.5 m), but are known to spawn at greater depths. Egg incubation can be as little as three weeks to as long as three months depending on the water temperature. Once hatched, the fry rear in the pelagic zone over sand and rubble substrates. Young of the year become benthic littoral feeders once they reach a size of 20 mm to 40 mm in length. At this time, they become nocturnal feeders. Burbot seek shelter in the shallow water during the day and generally remain inactive. They rear over rock, gravel and sandy shorelines, moving to deeper offshore waters in the summer. Burbot generally mature in three to four years. They are piscivorous and feed on ciscoes, cottids, whitefish, sticklebacks and trout perch *(*Richardson et. al).

Inconnu

Inconnu are known to exhibit both anadromous and adfluvial life history strategies. In the Slave region they are found in large rivers and lakes.

The freshwater or adfluvial populations reside in lakes (Great Slave Lake) and spawn in the adjacent rivers, namely the Slave, Hay and Taltson Rivers. Inconnu generally enter the Slave River in mid- to late-August through early September, preferring water temperatures between 10 °C to 20 °C. Spawning generally occurs in mid-October when water temperatures dip down to 2.4 °C to 4.5 °C.

Once spawning is complete, inconnu move downstream in the rivers back into Great Slave Lake where they overwinter. In spring (June), current year spawners as well as resting inconnu and immature inconnu gather at the mouth of the Slave River. By July, the non-spawning fish have dispersed into the deeper waters of the lake and remain there until the next spring. Spawning inconnu remain and hold at the mouth of the river until 10 °C to 20 °C temperatures arrive in mid-August and September.

Spawning has not been observed in the Slave River; however, inconnu are known to spawn over coarse gravel substrates, in water 1.2 m to 2.3 m deep. Spawning generally occurs every two to four years.

Inconnu may make extensive migrations within Great Slave Lake in the winter months. Further studies need to be conducted to determine key feeding areas and key spawning areas for these fish.

It is thought that the young remain in the tributaries for two years before entering Great Slave Lake. Once in the Lake it is thought that the fish reside in deep off-shore areas. Mature fish live from 7 to 10 years – few longer than 11 years (Richardson et al. 2001).

Lake chub

Lake chub are found in rivers and streams and are found in a wide variety of habitat types, although they prefer lakes when available. Lake chub spawn from April to early August along the lake shores and in tributary streams. Eggs hatch in approximately two weeks. Adults mature in three to four years, generally occupying depths of 12 to 16 feet. Lake chub is generally considered a shallow water species, but has also been found at depth. Insects, algae and zooplankton are the key components of lake chub diet. It should be noted that exposure is a more critical component to the survival of lake chub than vegetation or substrate (Richardson et al. 2001).

Lake cisco

Lake cisco are primarily found in lakes, but is also found in larger rivers in the north. They spawn in September through November in shallow water one to five m deep over sand and gravel. Mud and vegetation is also used as a spawning substrate at times. Young lake cisco is associated with rocky vegetated substrates. Eggs incubate for 10 to 14 weeks and hatch just before ice break up in the spring. The young rearing shallow protected bay habitat until they are about one month old. At that time they assume a pelagic life style and move into deeper waters as the summer progresses. The adults rear in the pelagic area of the lake at depths of 10 m (Richardson et al. 2001).

Lake trout

Lake trout are generally found in lakes, although some populations occur in large clear rivers. They spawn in September through October at shallow in-shore areas. They spawn over rocks and cobbles or rubble areas free of sand, silt or clay. Some wave action is preferred as it keeps the substrate free from silt and clay. Lake trout generally spawn at depths of 0.12 m to 55 m. The eggs settle in the cracks in the rocks, hatching in March and April the next spring. The young remain in the spawning area for several weeks up to several months, moving into deeper water as the summer water temperatures rise. Adults rear in depths grater than 10 m and seek cool waters near 10 °C. Lake trout feed on fish, crustaceans and molluscs.

Lake whitefish

Lake whitefish are most commonly found in lake systems; however, they have been documented in larger rivers and brackish waters. Lake whitefish exhibit both adfluvial and lacustrine life histories. Adfluvial lake whitefish live in lakes and move into the rivers to spawn. River spawners utilize shallow running waters or rapids with cobble and gravel sized substrate materials (Richardson et al. 2001).

Lake whitefish typically spawn in late summer or fall, from September to October. Lacustrine lake whitefish spend most of their life-cycle within lakes and use a variety of types of substrates from large boulders to gravel and occasionally sand for spawning. Juvenile lake whitefish usually remain next to the spawning grounds;

however as surface water temperature increases during summer, juvenile lake whitefish move to deeper waters (3 m to 15 m), where they gradually adopt the bottom feeding habits typical of adults. Juveniles remain in the deeper water habitats until they reach sexual maturity (Richardson et al. 2001).

Longnose sucker

Longnose sucker are found in lakes, rivers and streams. They spawn in the spring shortly after ice melt, in rivers of the shallows of lakes. They prefer to spawn at depths of 10 to 30 cm on an exposed gravel and sand substrate. The eggs incubate for 11 to 15 days. Once the young hatch they remain in the gravel for one to two weeks then rear in shallow vegetation areas with sandy substrates. Adults rear in water from 1 to 24 m deep, generally feeding on aquatic insects (Richardson et al. 2001).

Ninespine stickleback

Ninespine stickleback is found in rivers and lakes, generally in shallow bay areas. They spawn in the spring from May to late June, in shallow water. Nests are built amongst dense vegetation 10 to 15 m off the bottom. The young remain in the spawning area, moving into deeper waters by fall to overwinter. Adult sticklebacks are found in association with dense vegetation and are tolerant of low oxygen levels. They are also found in open-water areas with sandy bottoms and sparse vegetation. Adults generally remain in shallow water, feeding on aquatic insects and zooplankton (Richardson et al. 2001).

Northern pike

Northern pike inhabit densely vegetated or weedy areas of slow meandering rivers and weedy bays of lakes and marshes. Typically, northern pike begin to spawn after ice break-up in May through to June in the shallows of lakes or the backwaters of rivers. Lake and riverine spawners use habitats with very shallow water (<1 m) that are wind-sheltered with a variety of vegetation types. Short emergent vegetation such as grasses, sedges and bull rushes are the best substrates for egg deposition. Bottom substrate at spawning grounds consists primarily of soft fine sediments of silt and mud, although spawning may occur in areas with gravel, cobble or boulder.

Eggs are laid and adhere to the vegetation above the substrate and incubate for 10 to 21 days. After hatching, young northern pike remain attached to the vegetation for 6 to 10 days before they become free-swimming, remaining in spawning areas for several weeks.

Young-of-the-year northern pike are typically found in areas <1 m deep but frequently move to deeper water in the summer or when water temperatures rise.

Adult northern pike remain in areas <5 m deep for most of the year and move into deeper water to overwinter. As adult northern pike are ambush predators, they require moderate densities of vegetation in addition to logs or stumps for cover. An excess of cover tends to inhibit foraging capabilities. Adult northern pike prefer soft substrates, although they may be found in areas with boulders, cobbles and gravel substrates (Richardson et al. 2001).

Round whitefish

Round whitefish are generally found in lakes although some are also found in slow-moving streams and rivers. They spawn in the fall and early winter, typically in October. Preferred spawning habitat includes gravel and rubble substrates in water less than 1 m deep. Eggs incubate for four to five months, hatching between March and May. Young remain in rocky areas with sand and gravel substrates at depths of 1.5 m to 4.5 m. Adults rear in rock areas at depths of 7 to 22 m, feeding primarily on benthic invertebrates (Richardson et al. 2001).

Slimy sculpin

Slimy sculpin are found in rivers and streams and less frequently in lakes. They spawn in May over sand, gravel and rock in shallow water less than 1.5 m deep. Nests are built under rocks and logs for protection. The eggs hatch four weeks later and the young continue to rear in the spawning area. As the sculpin mature, they move into deeper water where adults are found at depths from 0.5 m to 210 m in over a variety of substrates. Slimy sculpin appear to be more productive on soft substrate bottoms. They feed on aquatic insects, crustaceans, small fishes and aquatic vegetation (Richardson et al. 2001).

Spottail shiner

Spottail shiners are found in larger lakes and rivers throughout the north. They are often the most abundant minnow in northern lakes. Spawning takes place in spring and early summer, typically in June and July. Sand, gravel and rubble substrates are preferred at depths of 0 m to 0.5 m. Eggs are often deposited on algae species such as *Cladophora*. Adults prefer shallow warmer waters over sand and gravel substrates and are typically found at depths of less than 13 m. Spottail shiners generally eat insect larvae, plankton and algae masses (Richardson et al. 2001).

Trout perch

Trout perch are found in slow moving rivers and in lakes. They spawn in the spring from May to the first half of June. Trout perch prefer to spawn in shallow streams or along beaches less than 1 m deep over a gravel and sand substrate. The eggs incubate for only six to seven days, then hatch and remain in the spawning area. Juveniles are found in water less than 10 m deep in areas with gravel and sand substrates. Adult trout perch prefer water depths of 7 to 15 m and are also found in areas with sand and mud substrates. Trout perch feed on aquatic insects and crustaceans. They are an important forage fish for other fish species (Richardson et al. 2001).

Walleye

Walleye tolerate a wide variety of environments and may live in larger rivers, lakes and streams. They tend to prefer large shallow turbid lakes and rivers. Spawning in northern regions occurs in June of later. Migration may occur under the ice prior to spring break-up. Spawning begins shortly after ice break up in a lake over a range of 5.6 °C to 11 °C. If temperatures are too cold, spawning may not occur at all in that year.

Walleye typically spawn over gravel, boulder and rubble substrates primarily at depths of less than three metres. Lower egg survival rates occur over soft mud and detritus bottoms. In lakes with soft mud and detritus bottoms, streams and areas of moving water may provide the most suitable spawning habitat.

Fish often move into tributary rivers immediately after the rivers are ice-free and while lakes are still ice-covered. Eggs are laid mostly in late evening. Hatching usually occurs from 12 to 18 days after spawning, but may take longer depending on water temperatures.

In rivers, juveniles occupy shallow edge habitats close to vegetation or other forms of cover in areas with slight currents. In lakes, summer habitat is in-shore in water less than two metres deep.

Newly hatched walleye are pelagic and feed offshore in lakes. They move inshore in summer and are strongly associated with thick weed-beds at depth two to five metres.

Juvenile and adult walleye are photonegative and seek cover from the sun. Walleye are piscivorous and feed on many fish species including burbot, Arctic grayling, trout perch, northern pike, longnose sucker, white sucker, yellow perch as well as aquatic insects (Richardson et al. 2001).

White sucker

White sucker are found in lakes, rivers and streams. They spawn in rivers and lakes in shallow warm water, in May through June. The eggs incubate for 5 to 15 days before hatching. The young remain in the gravel for one to two weeks and then emerge, remaining in the shallow protected water near the shoreline. The young are often associated with vegetated shorelines. Adults rear in water depths of 7 to 13 m and feed on aquatic invertebrates (Richardson et. al. 2001).

Yellow perch

Yellow perch are typically found in lake habitats. They are rarely found in areas with a current. They spawn from mid-April to August in shallow water less than five metres deep. They prefer a substrate of sand cobble and organic rubble. Eggs incubate for 8 to 10 days, and up to 27 days in cooler temperatures. The young remain at the spawning grounds for two to four days and then move into the pelagic Zone. After four to five weeks the young become benthic and feed inshore at depths of 0 m to 5 m. They are generally associated with areas of emergent and submergent vegetation. Adults are found at depths of 1 to 10 m in vegetated areas over gravel, sand and cobble substrates (Richardson et. al. 2001).

13.9.2 Fish Species Distribution and Behaviour

Based on sampling in the Taltson watershed and the tundra near Ekati, it has been determined that most water bodies within the Project area only support a fraction of the species richness present in Great Slave Lake. This variation in species richness is likely associated with a combination of factors, including migratory capabilities of each species, physical barriers to fish movement between water bodies, or unknown limiting factors (i.e. food source, spawning habitat, water temperatures) that directly affect the reproductive success and long-term viability of a population.

Studies of the fish communities in lakes and streams of the Ekati area have been conducted continuously from 1993 to the present and are summarized by the

Environmental Impact Statement for the Ekati Mine (NWT Diamonds Project 1996), which indicates that a total of 10 species of fish have been found in streams and lakes in the tundra near Ekati. These 10 species are also found in the Taltson River. It is expected that fewer species would be found in the smaller tributary streams along the transmission line and winter road due to less variety in habitat characteristics. It is unlikely that the dry swampland and marsh areas contain fish due to lack of connectivity and potential for winter freeze-up.

Studies by Bogdon (1977), Envirocon (1972; 1975), Falk (1979), Envirocon Pacific (1986) and Rescan (2004) indicate that the Taltson River supports 17 species. This is high compared to many watersheds in the Northwest Territories and is mainly due to the Taltson River's connectivity with Great Slave Lake (Rescan 2003).

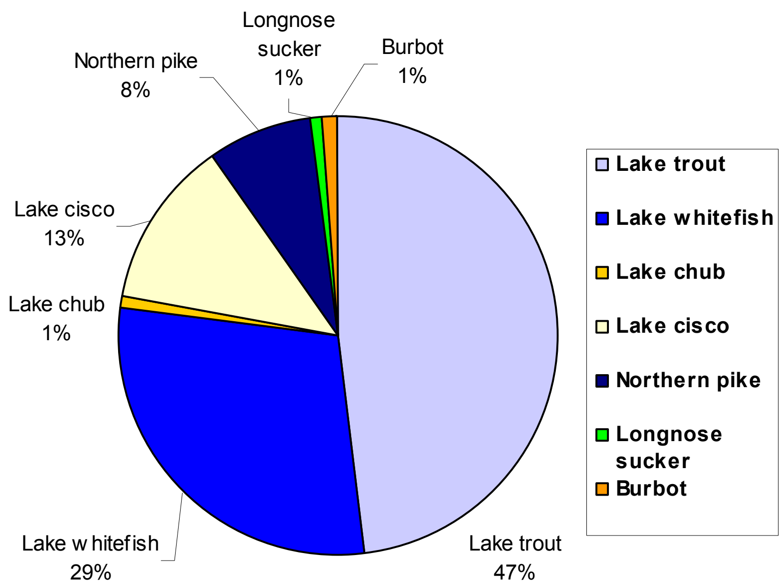
Lake whitefish and lake trout account for the majority of the fish captured during sampling efforts in the Taltson River (Rescan 2004); however, further observation and local knowledge confirm that other species such as northern pike and white sucker are also widely distributed throughout the Taltson River.

13.9.2.1 NONACHO LAKE

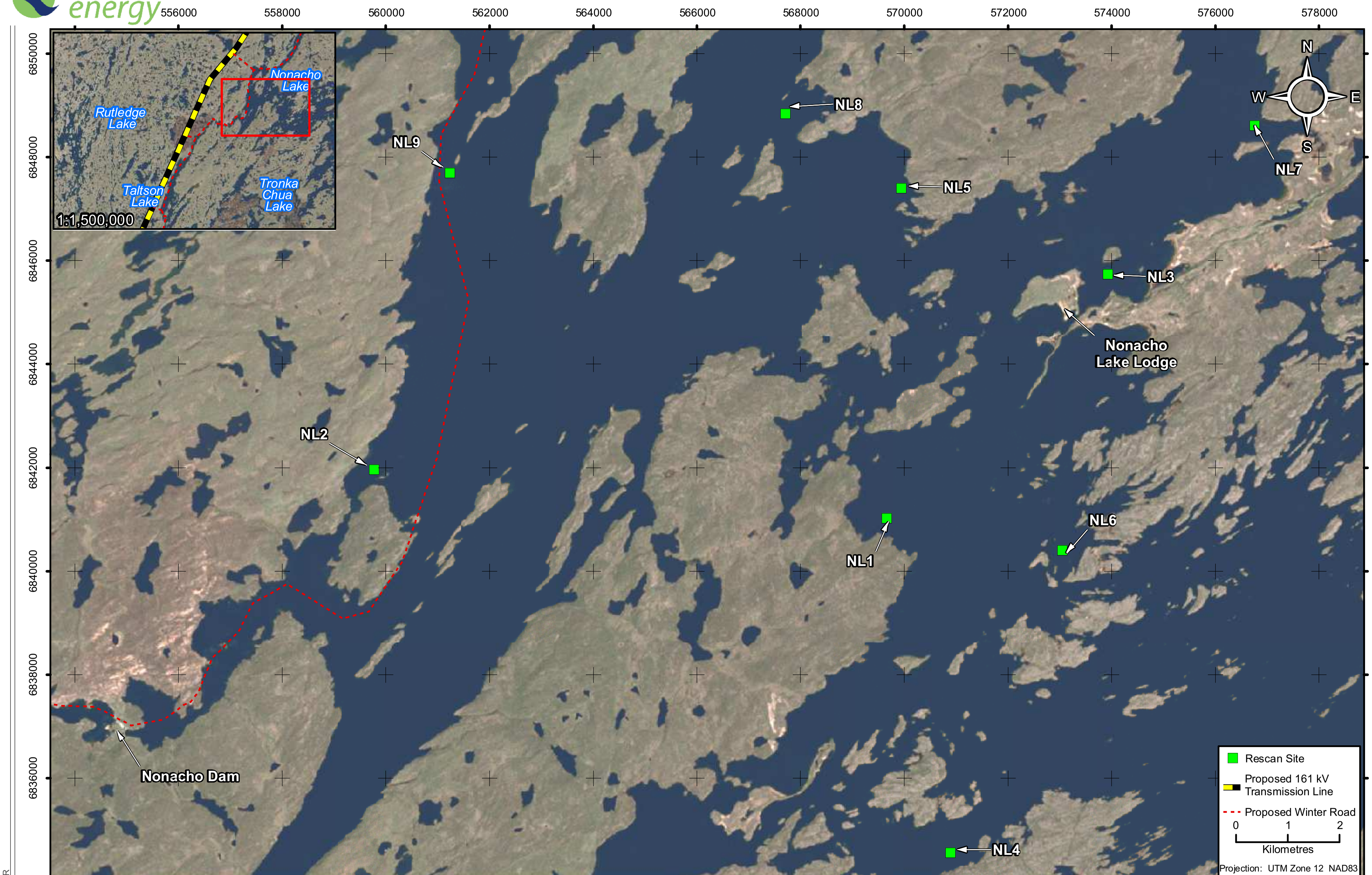
Nonacho Lake provides a large amount of deepwater habitat within the Project area. The Nonacho Lake shoreline provides a combination of steep rocky habitat and shallow bench-type shorelines and flooded bay areas.

Fish sampling in Nonacho Lake was completed in 2003 and 2004 as part of the existing Twin Gorges water licence. Historical sampling was also completed by Envirocon in 1973. A total of seven fish species were captured including lake trout, lake whitefish, lake cisco, northern pike, lake chub, longnose sucker and burbot. The results of all fish sampling were compiled and are illustrated in Figure 13.9.2.

Figure 13.9.2 — Summary of Nonacho Lake Fish Sampling Results



Based on the compiled sample results, lake trout appear to be the most abundant species in Nonacho Lake, followed by lake whitefish. Fish sampling locations are shown in Figure 13.9.3.



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TALSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Fish Sampling in Nonacho Lake	Figure 13.9.3

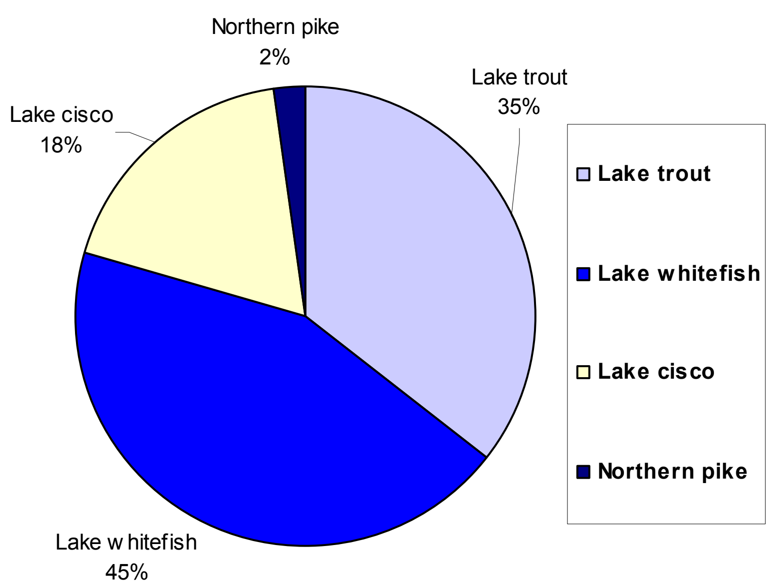
13.9.2.2 ZONE 1 AND 2

Zone 1 provides both riverine habitat with slow to moderate velocities as well as shallow and deeper water lake habitat.

Fish sampling for Zone 1 was completed in Taltson Lake in 2003 and 2004 as part of the existing Twin Gorges water licence and data represents the fish community in the pelagic habitat of Taltson Lake. Historical sampling was also completed by Envirocon in 1973 in Taltson Lake, King Lake, Lady Grey Lake and Benna Thy Lake. A total of four fish species were captured including: lake whitefish, lake trout, lake cisco and northern pike. The results of all fish sampling were compiled and are illustrated in Figure 13.9.4.

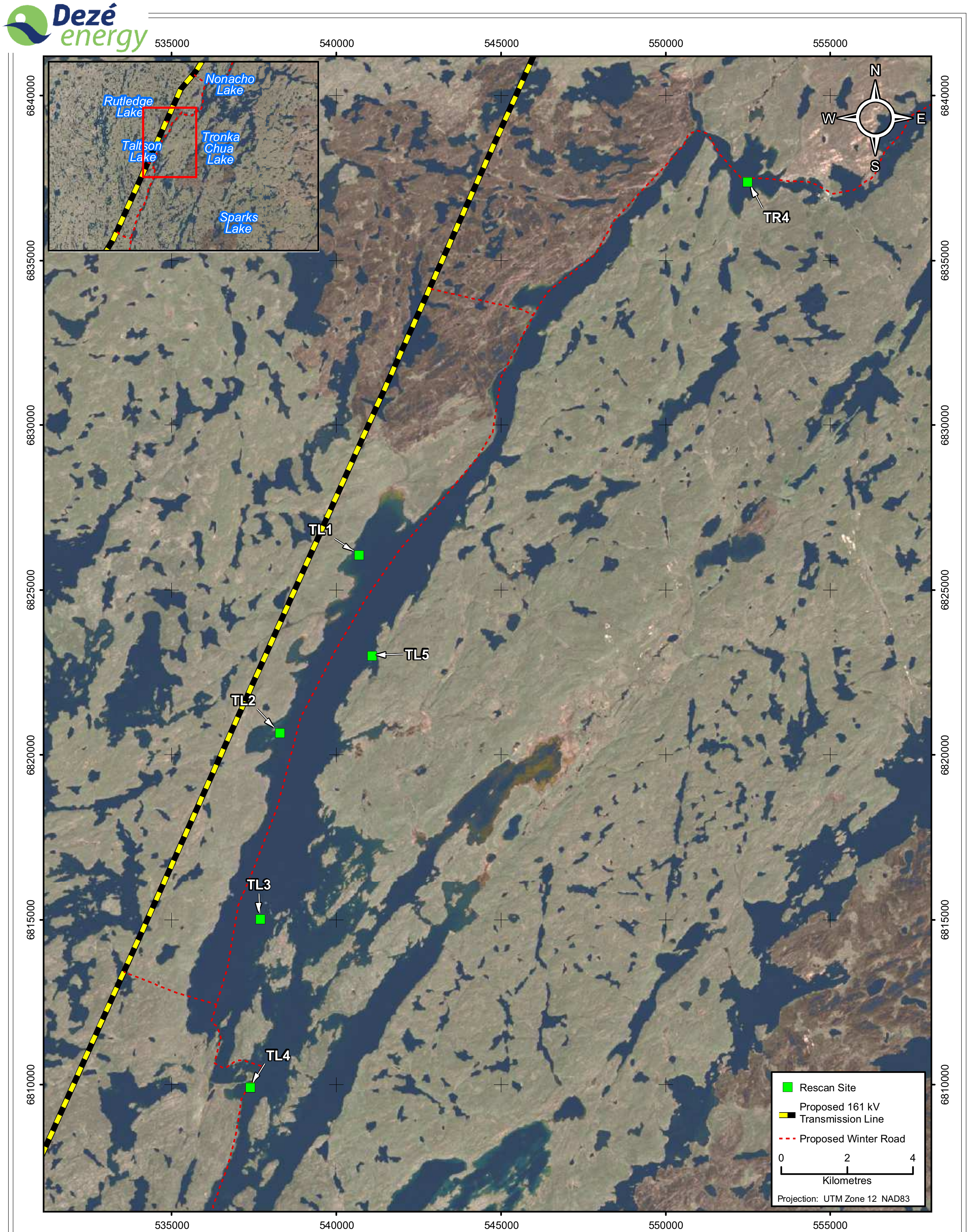
Local knowledge and visual observations during the 2008 aquatic habitat field program indicate that ninespine stickleback, white sucker and sculpin are also distributed throughout the shallow water habitats of Zone 1.

Figure 13.9.4 — Compiled Fish Sampling Results from Zone 1



Based on the sampling results, it appears that lake whitefish is the most abundant species in Zone 1.

Zone 2 provides very similar habitat to Zone 1 and has connectivity to Nonacho Lake and Zone 1; therefore, it is assumed that Zone 2 supports a similar diversity and abundance of species. Fish sampling locations are shown in Figure 13.9.5.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Fish Sampling in the Taltson River	Figure 13.9.5

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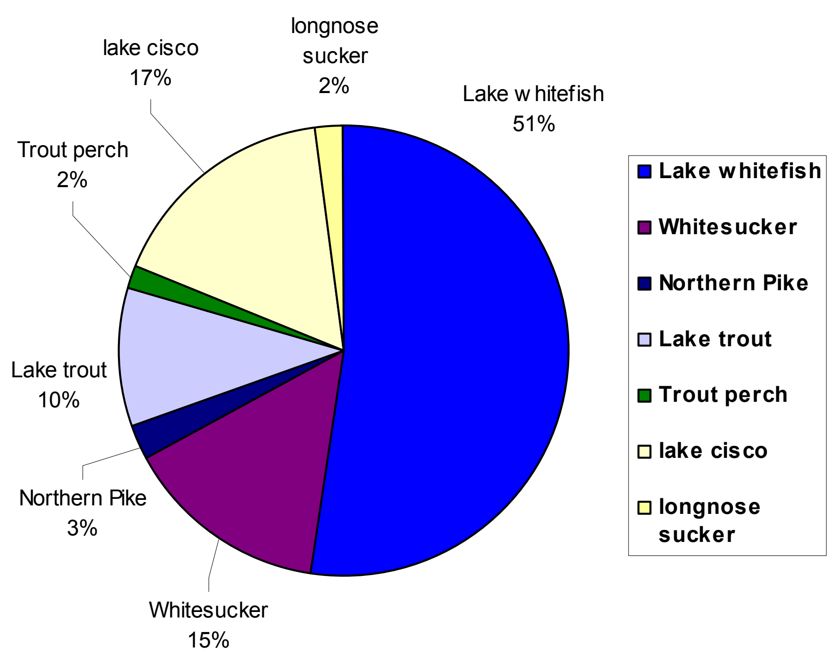
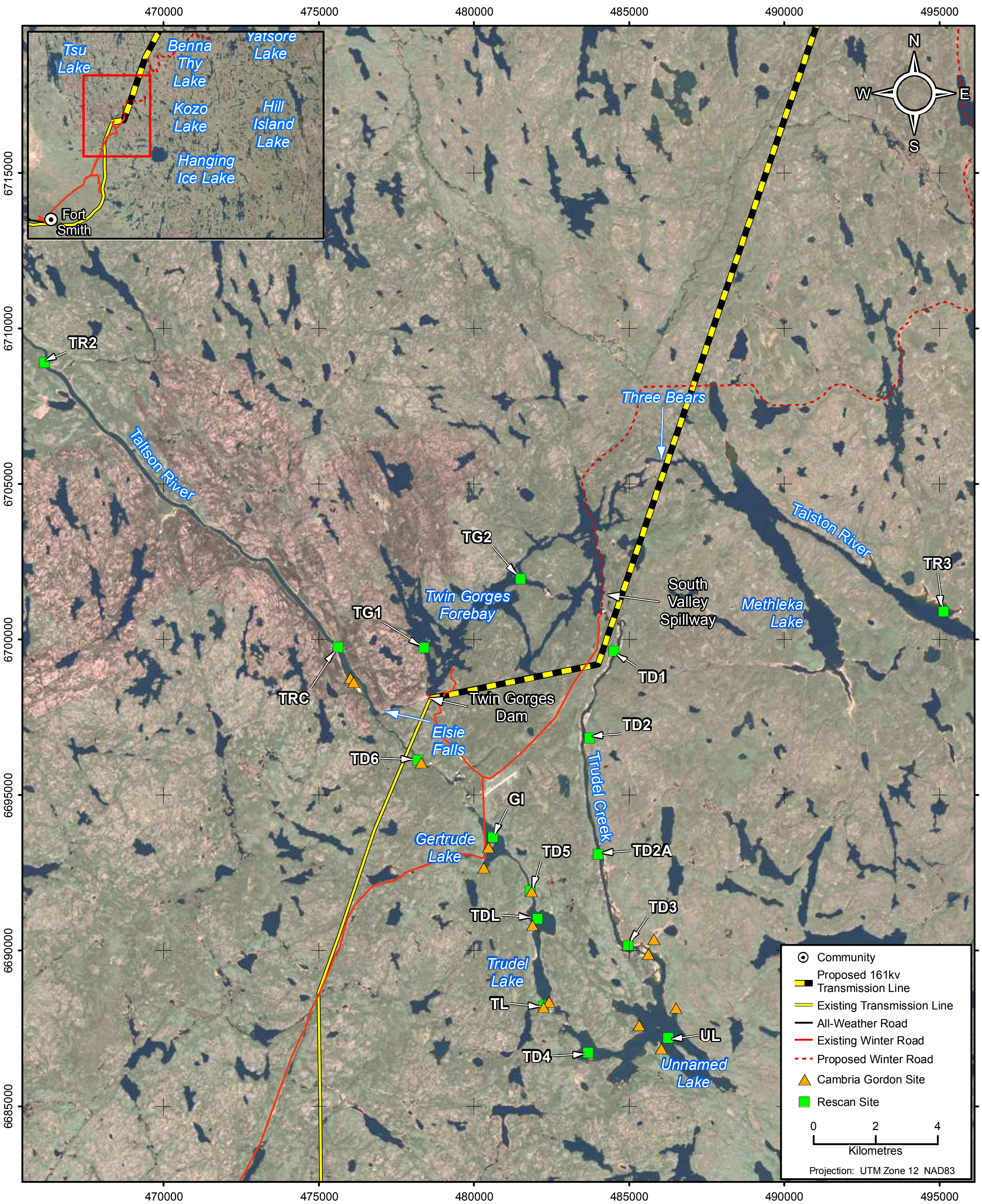
13.9.2.3 ZONE 3

Zone 3 includes areas of the Taltson River above the Twin Gorges Forebay, in the Forebay and below Twin Gorges to the outlet of Tsu Lake. Different fish communities have been found in each of these three areas; therefore, the fish sampling results have been presented accordingly.

Fish sampling above the Twin Gorges Forebay was completed in 2003 and 2004 as part of the existing Twin Gorges water licence. A total of seven fish species was captured including: lake whitefish, lake cisco, white sucker, lake trout, northern pike, longnose sucker and trout perch. Based on the sampling results, lake whitefish appears to be the most abundant species in Zone 3, upstream from the Forebay. The results of these sampling efforts have been compiled and are illustrated in Figure 13.9.6. Fish sampling locations are shown in Figure 13.9.7.

Figure 13.9.6 — Compiled Fish Sampling Results from Zone 3, above Twin Gorges

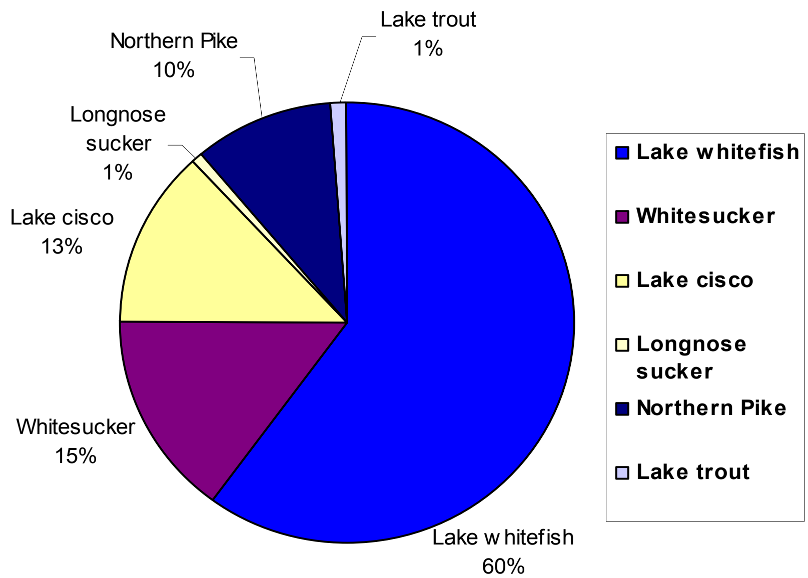




TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Fish Sampling Location in Trudel Creek and the Twin Gorges Forebay	Figure 13.9.7

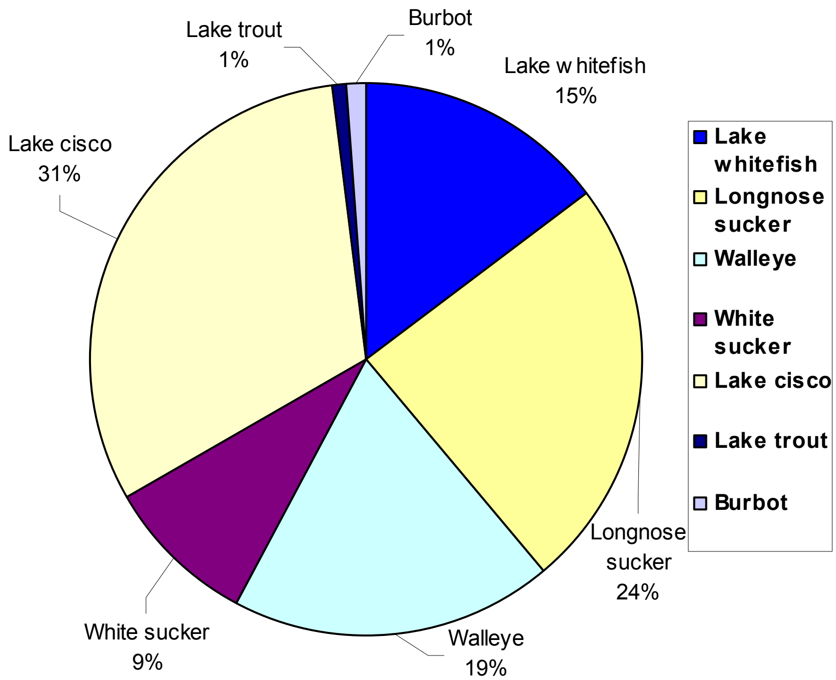
Fish sampling specific to the Twin Gorges Forebay was completed in 2004 by Rescan. This sampling yielded lake whitefish, northern pike, lake cisco, lake trout and longnose sucker and white sucker. From this sampling, lake whitefish appear to be the more abundant species. The results of this sampling are illustrated in 13.9.8.

Figure 13.9.8 — Compiled Fish Sampling Results from the Forebay in Zone 3



In the Taltson River below Twin Gorges, fish sampling was completed in 2003 and 2004 as part of the existing Twin Gorges water licence. Historical sampling was also completed by Envirocon in 1973 in Tsu Lake. A total of seven fish species was captured including: lake cisco, longnose sucker, walleye, lake whitefish, white sucker, lake trout and burbot. The results of these sampling efforts have been compiled and are summarized in Figure 13.9.9. From the sampling, it appears that lake cisco are the most abundant species followed by longnose suckers, walleye and lake whitefish. These results may be skewed as the field data suggests that a large school of lake cisco was captured in one set, likely increasing the percentage of lake cisco above that of the actual abundance in this area. Fish sampling locations are shown in Figure 13.9.7.

Figure 13.9.9 — Compiled Fish Sampling Results from Zone 3, below Twin Gorges



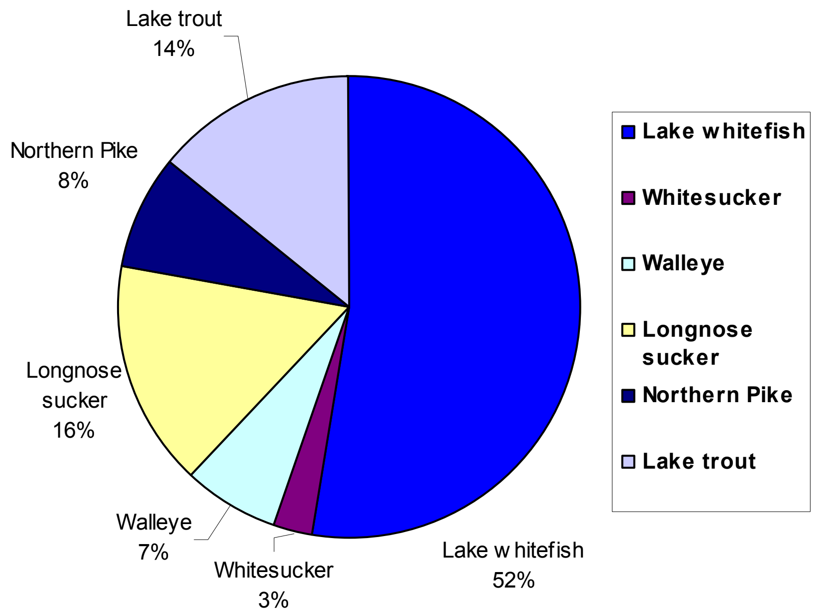
13.9.2.4 ZONE 4

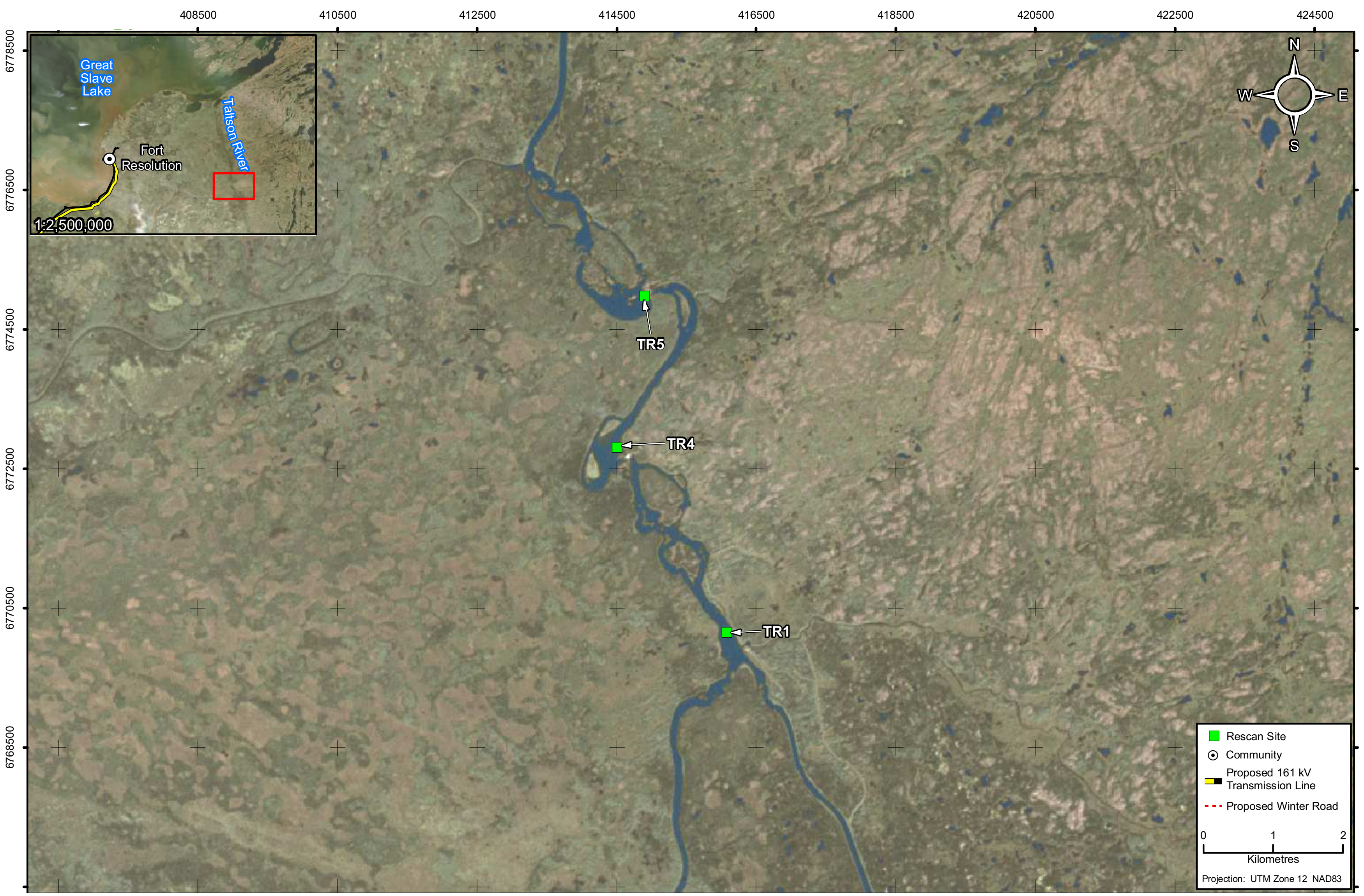
Many species found within the Taltson River section of the Project area are known to be present in Zone 4 below Tsu Lake. Species such as Arctic grayling, spottail shiner and yellow perch are only found in lowest reaches near Great Slave Lake (Rescan 2003).

Due to the Taltson River's connectivity with Great Slave Lake, it is diligent to note that short jaw cisco, a GNWT threatened species, may be present in Great Slave Lake, as it is a deep-water lake species, although at the time of writing there is no confirmation that shortjaw cisco are present in Great Slave Lake. This species is strictly a deep-water lake fish and it is very unlikely that any shortjaw cisco are located in the lower Taltson River or within the Project area, as the Taltson River and bay area are relatively shallow.

Fish sampling in Zone 4 was completed for the Project in 2003 and 2004 as part of the existing Twin Gorges water licence. Historical fish sampling was also completed in the lower Taltson River within a five-mile radius of the mouth in June 1972, by the Fisheries Research Board of Canada (Bogdan 1972). A total of six species has been captured in this zone including: lake whitefish, lake trout, northern pike, longnose sucker, walleye and white sucker. The results of these sampling efforts have been compiled and are summarized in Figure 13.9.10. Fish sampling locations are shown in Figure 13.9.11.

Figure 13.9.10 — Compiled Fish Sampling Results from Zone 4





TALTSON
HYDROELECTRIC EXPANSION PROJECT

Developer's Assessment Report
2009

Fish Sampling Locations in the Lower Taltson River

Figure 13.9.11

13.9.3 Fish Health

Fish captured during the 2003 sampling program were examined externally for deformities, lesions and tumours. There were no tumours observed in any of the fish captured. The incidence of deformities, erosions and lesions was very low, with values of 6% and 2% for Nonacho Lake and the Taltson River respectively. In Taltson Lake the incidence was higher with 17% having observable deformities, erosions and lesions. Rutledge Lake, used as a control lake, had a recorded total of 4%. The cause of the increased levels of deformities, erosions and lesions is unknown, however variations are likely natural. All identified deformities, erosions and lesions, and incidence of each are outlined in Table 13.9.4 (Rescan 2003).

Table 13.9.4 — Number and Percent of Fish in Nonacho, Taltson and Rutledge Lake and Taltson River with Deformities, Erosions and Lesions, 2003

	Nonacho Lake N = 173	Taltson Lake N = 125	Rutledge Lake N = 125	Taltson River N = 83
Deformity				
Pelvic fin	1	0	0	0
Caudal fin	1	1	0	1
Adipose fin	0	2	0	0
Spine	0	1	0	0
Operculum	0	1	0	0
Head	0	1	0	0
Deformity Percentage	*1%*	*5%*	*0%*	*1%*
Erosion				
Caudal fin	1	2	0	0
Adipose fin	0	2	0	0
Dorsal fin	0	1	0	0
Erosion Percentage	*1%*	*4%*	*0%*	*0%*
Lesion				
Stomach	2	0	0	0
Fin	1	3	2	1
Operculum	0	0	1	0
Back	3	4	2	0
Head	0	1	0	0
Other	1	2	0	0
Lesion Percentage	*4%*	*8%*	*4%*	*1%*
Total	10	21	5	2
Total Percentage	*6%*	*17%*	*4%*	*2%*

Source: Rescan 2003

A visual examination of external and internal (where possible) parasites was also conducted on all fish captured. Parasites were observed in lake trout from all water bodies sampled. Lake trout in Rutledge Lake had the highest rate of infection at 85%, followed by Taltson Lake at 71%. In contrast, lake trout in Nonacho Lake and Taltson River had low rates of parasite infection, with 34% and 25% of the fish with observable parasites, respectively. The number of parasites found in the fish species in each lake is outlined in Table 13.9.5 (Rescan 2003).

Table 13.9.5 — Number and Taxonomic Class of Parasites Found Infecting Lake Trout, Lake Whitefish and Walleye in Nonacho, Taltson and Rutledge Lakes and Taltson River, 2003

	Number of Fish Sampled	PARASITE TAXONOMIC CLASS				Fish with Parasites (%)
		Nematodes	Cestodes	Copepods	Trematodes	
Lake trout						
Nonacho Lake	114	21	9	9	0	34
Taltson Lake	41	17	8	4	0	71
Rutledge Lake	55	17	23	7	0	85
Taltson River	4	1	0	0	0	25
Lake whitefish						
Nonacho Lake	54	17	14	19	0	93
Taltson Lake	60	1	8	5	3	28
Rutledge Lake	55	4	14	9	0	49
Taltson River	50	11	1	1	0	26
Walleye						
Taltson River	6	0	1	0	0	17

Source: Rescan 2003

13.9.4 Typical and Sensitive Habitats

The scope of the habitat areas and sensitive habitat for the study area focused primarily on the Taltson basin and Trudel Creek as these aquatic environments would be exposed to considerable Project interactions. The transmission line and winter roads are primarily terrestrial-based activities or occur on frozen surfaces, and the water bodies within these areas of influence would experience minimal or negligible interaction with the Project. No sensitive fish habitat is known to exist within the area of influence by the Project.

13.9.4.1 Taltson Basin

The fish species caught within the Project area have habitat requirements that are typically found throughout the Taltson basin. Three habitat types have been identified as the primary habitats for the species within the Taltson basin. These include shallow rocky or non-vegetated areas, deep lacustrine habitat, and shallow habitat with emergent and submergent vegetation. Of these habitats, vegetated shallow habitat used by northern pike and other species for spawning, rearing and feeding is considered more sensitive than the other habitats due to the need for favourable growth conditions for vegetation. Potential temporal and spatial hydrograph shifts could change the littoral area vegetation growing conditions. Therefore, littoral habitat studies were conducted in June and July 2008 (Cambria Gordon 2008), and are contained in Appendix 13.9A - Littoral Habitat Baseline Report, which includes studies consisting of assessments of two representative lakes in the Taltson Basin (Lady Grey and Nonacho Lake). The assessment identified the elevation ranges of the current emergent and submergent vegetation communities, dominant species, substrate conditions and other forms of cover and observed fish use.

Sampling was completed in the early growing season and from field observations it is anticipated that later in the growing season the range of the submergent vegetation, in particular, extends to lower elevations than recorded. This is due to the ecology of submergent vegetation and its annual growth pattern.

In Lady Grey Lake the emergent vegetation communities (below the water elevation at the time of the survey) appeared to be fairly consistent and primarily comprised;

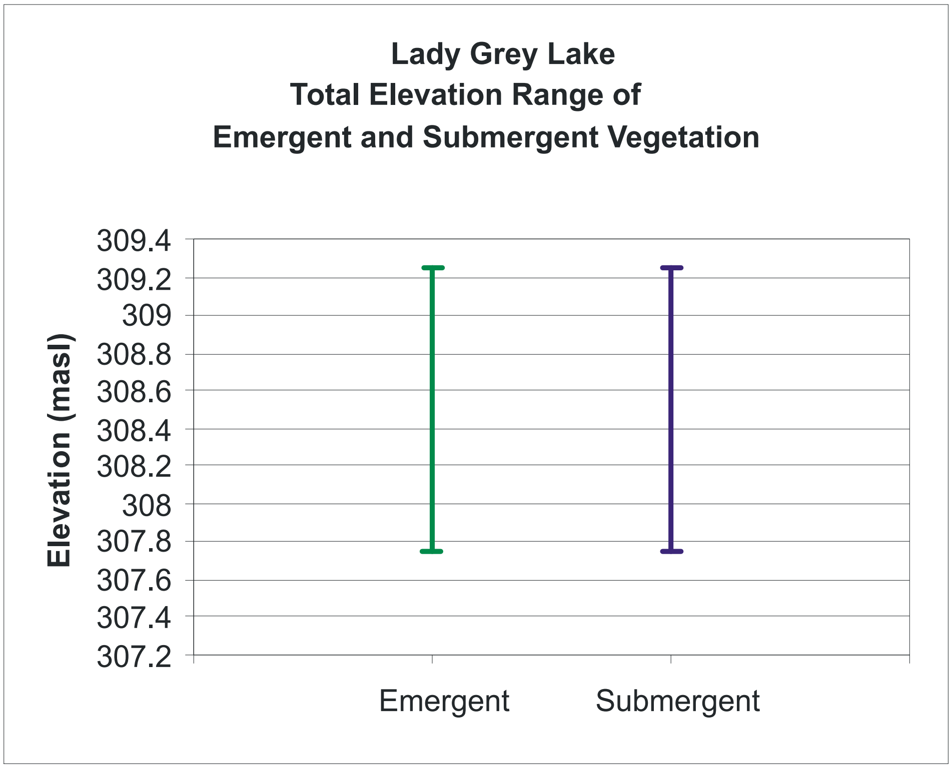
- water sedge (*Carex aquatilis*),
- beaked sedge (*Carex utriculata*),
- swamp horsetail (*Equisetum fluviatile*),
- common great bulrush (*Typha lacustris sp.*),
- creeping spikerush (*Eleocharis paustris*), and
- small yellow pond lily (*Nuphar varigatum*).

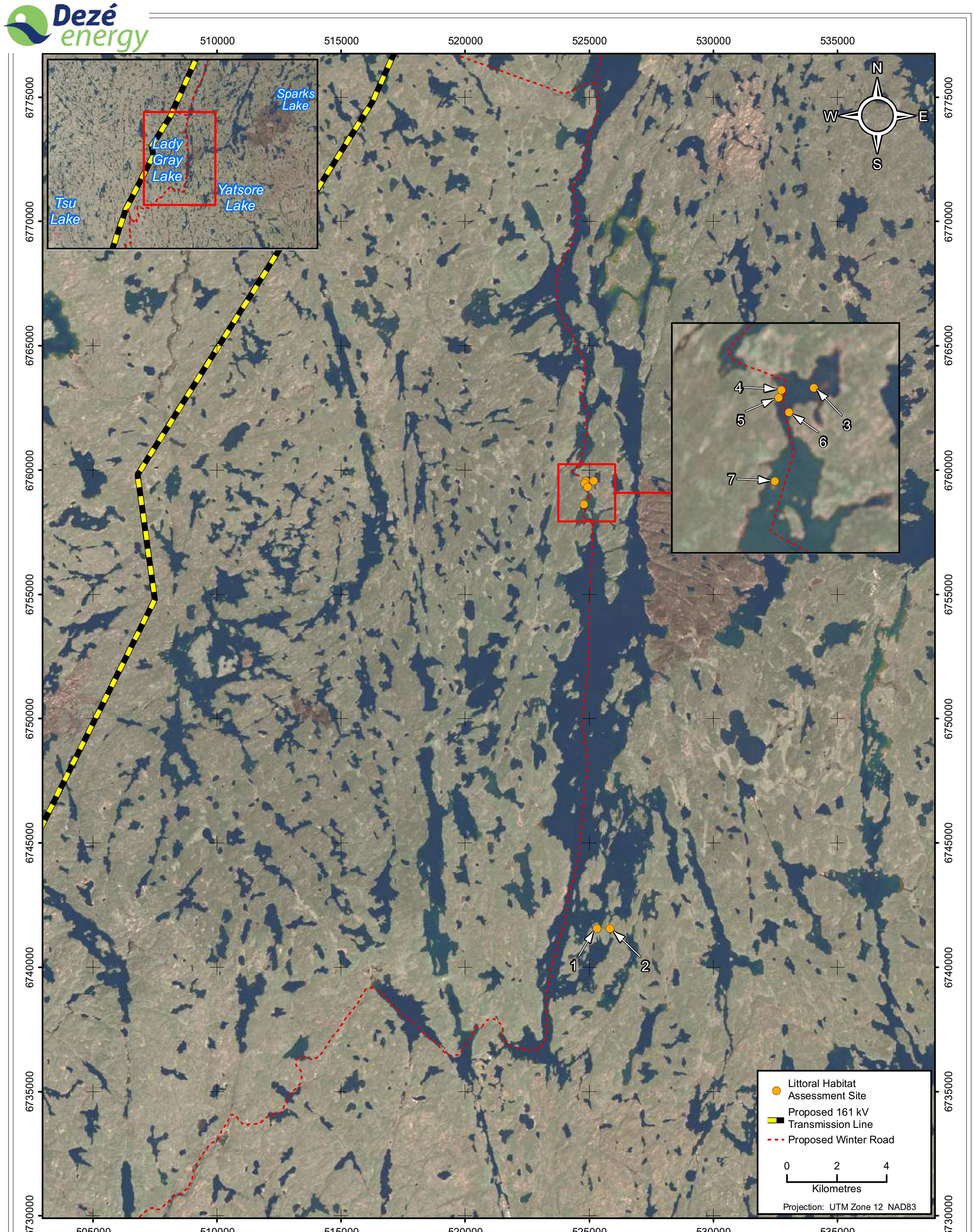
Transect measurements indicate that the emergent plant community assessed in Lady Grey Lake at the time of assessment ranged from 309.3 masl (metres above sea level) to 307.8 masl. Lake water elevations were typical for that time period.

The submergent vegetation community was also fairly consistent throughout Lady Grey Lake and primarily comprised Bladderworts (*Utricularia sp.*) and Pondweed (*Potamogeton sp.*).

Transect measurements indicate that the submerged plant community assessed ranged from 309.3 masl to 307.8 masl, the same elevation range as the emergent vegetation. The total elevation range of emergent and submergent vegetation is illustrated in Figure 13.9.12. Lady Grey Lake vegetation assessment locations are shown in Figure 13.9.13.

Figure 13.9.12 — Total Elevation Range of Emergent and Submergent Vegetation in Lady Grey Lake





TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Lady Gray Lake Littoral Habitat Sites	Figure 13.9.13

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In Nonacho Lake, the emergent vegetation communities were fairly consistent and primarily comprised:

- water sedge (*Carex aquatilis*),
- beaked sedge (*Carex utriculata*),
- common cattail (*Typha latifolia*), and
- swamp horsetail (*Equisetum fluviatile*).

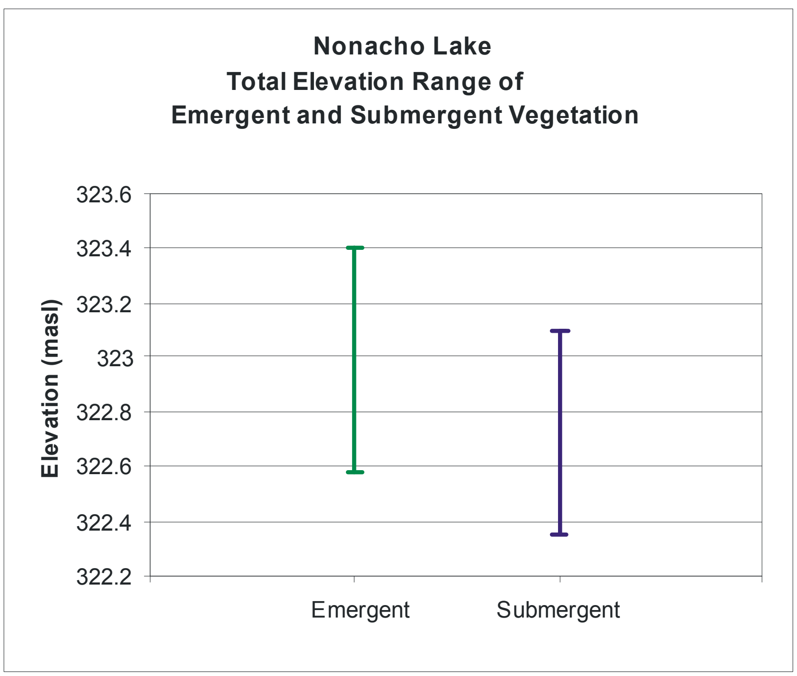
Transect measurements indicate that the emergent plant community ranged from 323.4 masl to 322.6 masl.

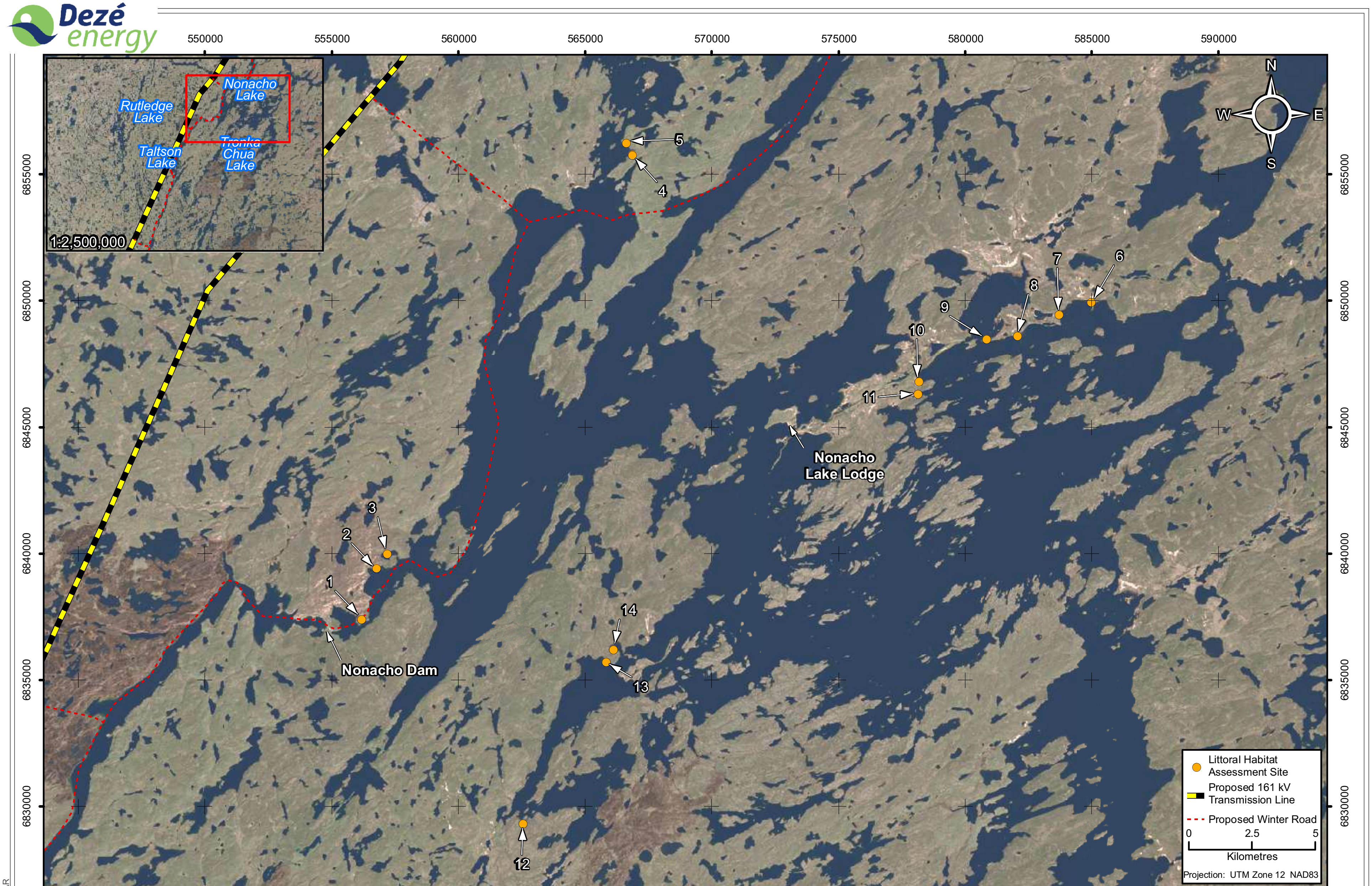
The submergent vegetation community was also fairly consistent throughout Nonacho Lake and primarily comprised Pondweed (*Potamogeton sp.*).

Transect measurements indicate that the submerged plant community ranged from 323.1 masl to 322.4 masl.

Submerged vegetation seedlings approximately 1 to 5 cm in height were also noted at many sites in Nonacho Lake. It is anticipated that the majority of these seedlings are submergent species which tend to have an annual growth pattern. The total elevation range of emergent and submergent vegetation in Nonacho Lake is illustrated in Figure 13.9.14. Nonacho Lake vegetation assessment locations are shown in Figure 13.9.15.

Figure 13.9.14 — Total Elevation Range of Emergent and Submergent Vegetation in Nonacho Lake





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TALTSON
Hydroelectric Expansion Project

Developer's Assessment Report 2009

Nonacho Lake Littoral Sampling Sites

Figure 13.9.15

13.9.5 Issues Affecting Population Abundance and Distribution

13.9.5.1 ANTHROPOGENIC FACTORS AFFECTING POPULATION AND DISTRIBUTION

Population abundance and distribution within the Taltson River is generally affected by natural cycles; however, fisheries pressures and past development along the Taltson River can be attributed to certain changes in the distribution and abundance of some species.

Arctic grayling were often caught by local fishermen in Nonacho Lake prior to the development of the Nonacho dam. Since this time, local knowledge indicates reduced observations of Arctic grayling within the lake.

Other anthropogenic factors that may have affected the fish population and distribution in the Taltson system include the installation of the Nonacho dam and spillway in 1966 and Twin Gorges dam in 1965, and the subsequent increase or introduction of flows to Trudel Creek.

At Twin Gorges, the historical condition of Elsie Falls is unknown. At the present time, it is considered to be an obstruction to fish. The falls may be passable under certain flow conditions to strong-swimming fish such as white sucker. It is unknown whether the falls were passable to fish prior to the development of Twin Gorges.

After the installation of Twin Gorges power facility, the distribution of fish populations in the Forebay area would have expanded into lowlands and pond areas that became flooded. In Trudel Creek, the distribution of species such as walleye and lake whitefish may have expanded due to greater habitat area and depths within the system.

After construction of the Nonacho dam and spillway, fish distribution would have expanded into the habitat newly created by flooding. The access from Taltson Lake to Nonacho Lake prior to construction is unknown, so stressors from the dam and spillway are unknowns. Access between Nonacho Lake and Tronka Chua Lake was non-existent prior to construction of Nonacho dam and spillway; therefore, abundance and distribution between Nonacho Lake, Tronka Chua Lake and connected water bodies may have been influenced, although Tronka Chua Lake naturally is confluent with the Taltson River at Lady Grey Lake.

The historical conditions at the site of the Nonacho dam are unknown and it is not clear whether the channel connecting Nonacho Lake and the Taltson River was passable by fish prior to development.

Other factors which have the potential to affect fish populations and distributions include fluctuations in water levels, water contamination, and changes in water temperature. Detailed information on water levels and the Taltson Basin hydrographs can be found in the Section 13.3. Information on water quality including mercury levels and water temperature can be found in the Sections 13.4 and 13.5.

13.9.5.2 HUMAN USE

Past pressures on the fisheries resources in the Project area include commercial and sport fisheries within the Taltson River. A walleye fishery existed on the lower Taltson River in the late 1960s for the people of Rocher River. However, since the majority of residents from Rocher River have relocated to Fort Resolution, participation in the fishery has declined (Bogdan 1972). A commercial fishery also existed on Nonacho Lake in the mid 1960s, early 1970s and early 1980s. Over the 10 active harvesting years, a total of approximately 212,000 lbs of lake whitefish and 106,000 lbs of lake trout were harvested (NWT Water Board 1981).

Since no commercial fisheries currently exist in the Project area, only sport, traditional and subsistence fisheries are considered a current, although minimal, pressure on fish populations. Sport fisheries for lake trout and northern pike currently exist on the Taltson River and in Nonacho Lake and are supported by fishing lodges on Nonacho Lake and Thekulthili Lake and the lower Taltson River. These lodges have no reportable catches and are not anticipated to have any influence on the fish populations within Nonacho Lake.

Traditional Knowledge suggests that citizens from the community of Łutsel K'e once carried out a subsistence fishery on Nonacho Lake. Although few people from Łutsel K'e currently fish in Nonacho Lake, it is still within the traditional fishing area.

A subsistence fishery also exists on the lower Taltson River.

13.9.6 Valued Components

13.9.6.1 VALUED COMPONENT SELECTION

Valued Components (VC) were selected based on the comments received by government and community agencies during the MVLWB and MVEIRB screening and scoping sessions, and based on the known fish and fish habitat conditions within Taltson River. Although flow reductions may affect a number of fish species, northern pike, lake whitefish and lake trout were selected as Valued Components due to their sensitivity to changes in habitat and their importance to regional user groups. Thus, the effects assessment and determination of significance was based on the preservation of northern pike, lake whitefish and lake trout populations and their distribution within the Taltson River watershed.

Northern pike was selected as a Valued Component as its habitat requirements overlap with other fish species within the Taltson River system, specifically along vegetated stream margins and/or shorelines. In addition, northern pike is a high-level predator and typically requires an ecologically productive habitat for foraging.

Lake whitefish and lake trout have been selected as Valued Components due to their relatively high abundance in the Taltson River basin and importance to the regional user groups. Additionally, lake whitefish and lake trout are predominately deep-water species, complementing the preferred habitat conditions of northern pike (a shallow-water species).

13.9.6.2 ASSESSMENT ENDPOINTS AND PATHWAYS

The Department of Fisheries and Oceans Canada (DFO) has developed Risk Assessment methods and created Pathways of Effects (POE) for common in-stream and land-based activities. These POEs describe cause-and-effect relationships and the mechanisms by which stressors lead to effects in the aquatic environment. Each cause-and-effect relationship is a pathway connecting the human activity to a potential stressor and a stressor to an ultimate effect on fish and fish habitat, known as an assessment endpoint. Each pathway represents an area where mitigation measures can be applied to reduce or eliminate a potential effect.

In total, DFO has identified 19 POE covering a range of in-stream activities. A complete review of the available DFO Risk Assessment Methodology, pathways and assessment endpoints is available on the DFO Fish Habitat Management website (DFO 2008). In addition to the available information on the DFO web site, Clarke et al. (2008) conducted an extensive review of the Flow Management pathway and assessment endpoints at the request of DFO. This information was also used in the assessment process.

The POEs potentially relevant to the construction of infrastructure and to the operation of North Gorge canal and Nonacho Lake control structure are described in Section 15.2 — Canal Construction and Section 15.3 — Turbine and Conveyance Canal Operation.

The POEs relevant to water fluctuations in the Taltson River watershed include *Flow Management (Altered Frequency, Amplitude, Duration, Timing and Rate of Change of Flow)* and *Fish Passage Issues* and are summarized in Figure 13.9.16 and Figure 13.9.17, respectively. As this Project would alter the discharge and the hydrograph of the Taltson River, all the issues presented in the *Changes in Timing, Duration and Frequency of Flow* flowchart, as well as some of the issues in the *Fish Passage Issues* flowchart are potentially relevant to this Project.

These pathways lead to 15 possible assessment endpoints, which are presented in Table 13.9.6. The endpoints would be evaluated in terms of their applicability to this Project in the following sections.

Figure 13.9.16 — Flow Management Pathway of Effect Flow Diagram (Source: Clarke et al. 2008)

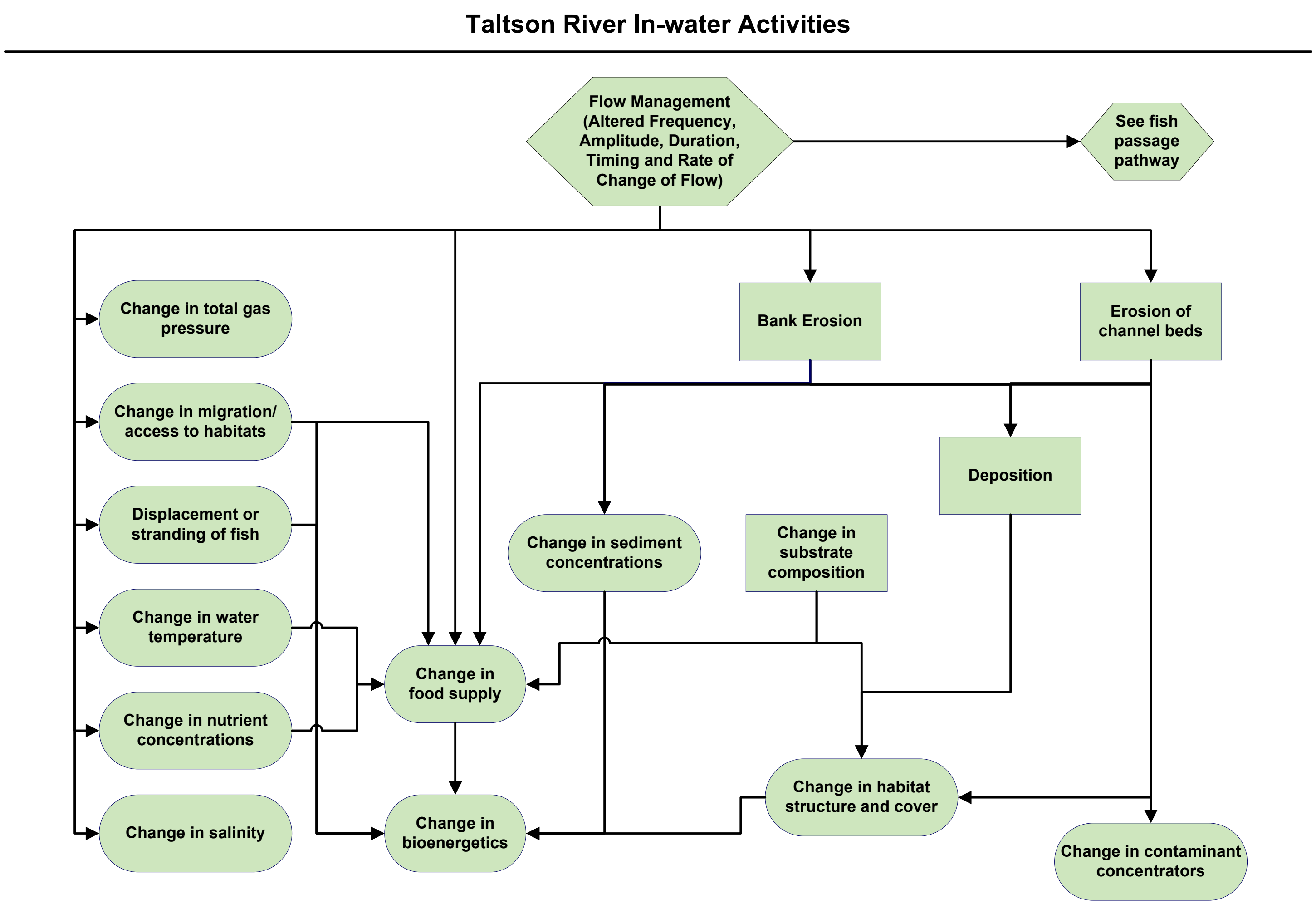


Figure 13.9.17 — Fish Passage Issues Pathway of Effect (Source: DFO Web Page)

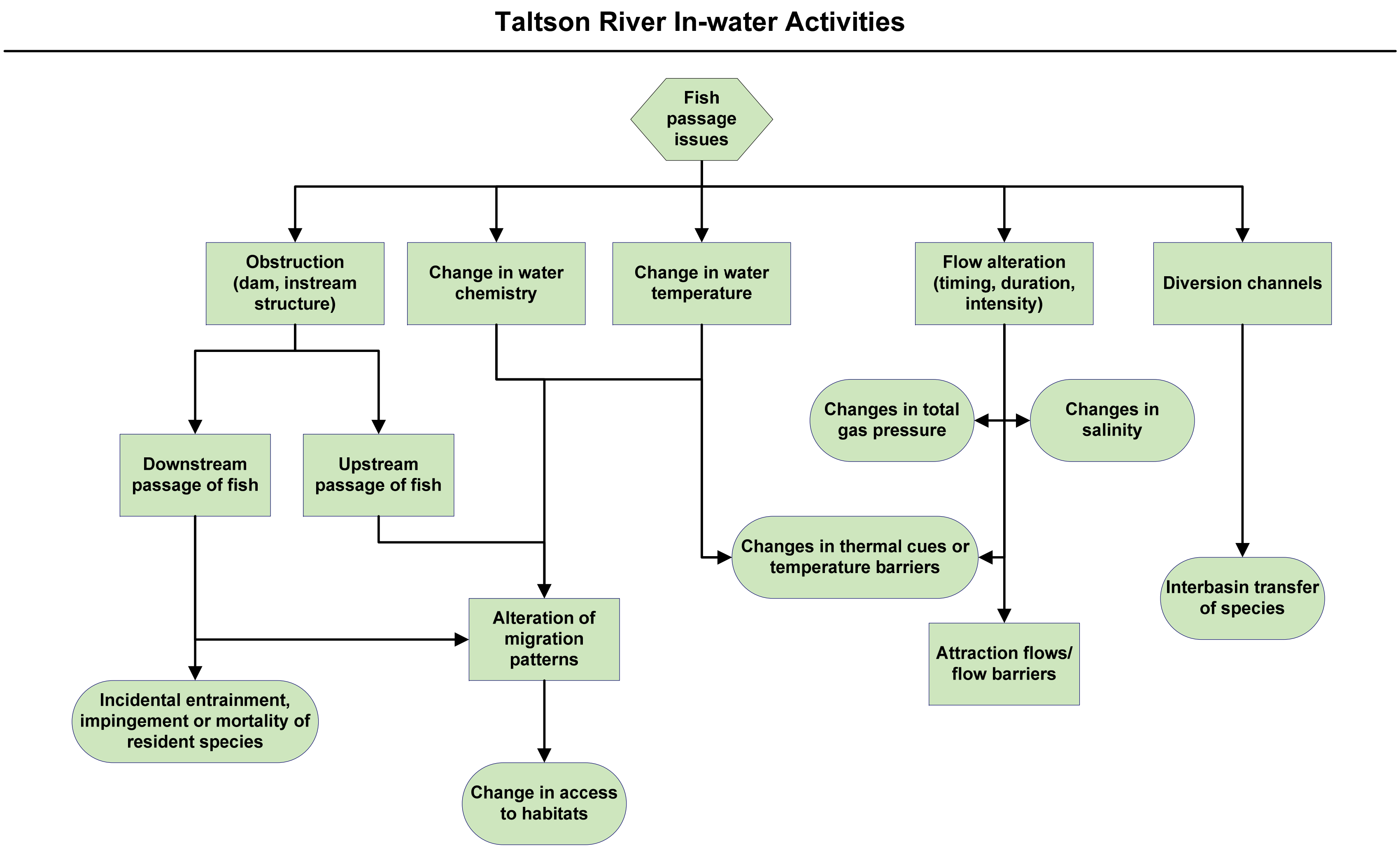


Table 13.9.6 — Possible Assessment Endpoints Resulting from Anticipated Operations of the Project

Valued Component	Assessment Endpoint	Pathway
Northern pike, Lake whitefish, Lake trout	Changes in water temperature	Flow management with respect to water temperature
	Changes in dissolved oxygen	Flow management: Alteration of depth conditions with respect to dissolved oxygen Flow management: Alteration of flow conditions with respect to dissolved oxygen
	Changes in food supply	Flow management: Bank erosion / deposition of channel bed with respect to food supply Flow management: Changes in migration / access to habitats with respect to food supply Flow management in respect to food supply
	Changes in nutrient concentration	Flow management: Alteration of flow conditions with respect to nutrient concentration
	Changes in sediment concentration	Flow management: Bank erosion / erosion of channel beds with respect to sediment concentration
	Changes in contaminant concentration	Flow management: Bank erosion / erosion of channel beds with respect to contaminant concentration Flow management: Flooding with respect to contaminant concentration (mercury)
	Changes in thermal cues or temperature barriers	Fish passage Issues: Change in water chemistry with respect to thermal cues
	Inter-basin transfer of fish species	Fish passage Issues: Diversion channels with respect to inter-basin fish migration
	Changes in habitat access / migration: spawning, rearing, overwintering	Flow management: as it relates to alteration of migration and/or access to habitat
	Changes in habitat structure and cover: spawning, rearing, overwintering	Flow management: Bank erosion / erosion of channel beds with respect to fish habitat structure and cover Flow management: Changes in flow with respect to fish habitat structure and cover
	Changes in total gas pressure	Flow management with respect to total gas pressure
	Change in salinity	Flow management with respect to salinity
	Displacement or stranding of fish	Flow management: Increased flows and ramping events as it relates to displacement or stranding of fish
	Change in access to habitats	Fish passage: Obstruction (dam, in-stream structure) with respect to habitat access
	Incidental entrainment, impingement or mortality of resident species	Fish passage: Obstruction (in-stream structure) with respect to entrainment

13.9.7 Spatial and Temporal Boundaries

The analysis of potential effects of the proposed Project on the aquatic environment in the Taltson River basin includes all in-stream habitats on the mainstem from (and including) Nonacho Lake to Great Slave Lake. The tributary drainages both downstream of Twin Gorges, such as the Rutledge River, and upstream of Twin Gorges, such as the Tazin River, were not included in this analysis. In-stream habitats were considered, including those periodically, sporadically, or rarely flooded.

For the purposes of this analysis, the Taltson Basin has been divided into five study zones plus Nonacho Lake. For a detailed description of the zones see Section 9.3 – Taltson Basin Hydrology. These zones include Nonacho Lake, the Taltson River between the outfall of Nonacho Lake and the Tazin River confluence (Zone 1), the flow between Tronka Chua Gap and Lady Grey Lake (Zone 2), the Taltson River between the Tazin River confluence and upstream of Tsu Lake (Zone 3) and the Taltson River from Tsu Lake and Great Slave Lake (Zone 4). Trudel Creek (Zone 5) is described in the Trudel Creek KLOI (Chapter 14). For this fisheries effects analysis, Zone 3 has been further subdivided into the area above the power facility, the power facility itself and the area downstream of the facility. The above zones were used to identify effects at a small-scale (single zone), medium-scale (multiple zones) and large-scale (Taltson Watershed). The reader is advised that the zones are quite large vis-à-vis fish populations and that these effects can be limited to a single lake in a zone that encompasses 4 or 5 lakes.

There are several time frames to consider within this Project:

- Some of the proposed changes would permanently alter the Taltson River watershed, for example, the proposed changes to the Nonacho Lake control structure and the Twin Gorges generating facility.
- Some aspects of the Project, such as the management of water flows, would have effects for the duration of its operating life.
- Some of the activities would have effects during construction period only (or for a short time after), for example, in-stream excavation of material and blasting. Construction activities and time frames are contained in Section 15.2 - Canal Construction.
- Finally, other activities are episodic and would occur at irregular time intervals, such as interruptions of water flow through the power plants due to scheduled and unscheduled shutdowns; unscheduled shutdowns are addressed in Chapter 17 - Accidents and Malfunctions. These events would result in short-term alterations of water flow, which could result in site-specific effect events, e.g., increases or decreases in water levels in the near-shore habitats downstream of the power plant.

There is also a consideration of the ecology of the Valued Components. The fish (the VCs) have different life cycles and thus the duration of an effect could affect a portion of an individual's life cycle, the entire life cycle, or multiple generations of that species. Given the relatively short life cycles of fish and aquatic resources, the ecological component of temporal boundaries focused on the time required for habitat that would be affected by the Project to return to baseline ecologic conditions. The rationale is that once the habitat recovered, the aquatic resources and fish would follow shortly given their short life cycles and ubiquitous nature. The definitions used for the temporal assessment boundaries are presented in the Effects Classification section below (Section 13.9.10 - Residual Effects Analysis).

The Project is expected to be in operation for 20 years to service the existing and proposed diamond mines; however, the Project infrastructure would have a lifespan of 40 years and it is the intent of Dezé Energy Corporation to solicit new customers to extend the Project operation beyond 20 years. Therefore, the total duration of the river basin alteration could be 40 years or greater.

Therefore, 40 years was defined as the longest reasonable duration of the operation phase for predicting and assessing effects from the Project. The details on decommissioning are not comprehensive enough to complete an effects assessment at this time; however, it is Dezé's plan to complete the necessary studies 7 to 10 years prior to closure. Closure and restoration details are provided in Section 6.8.

13.9.8 Project Components

The Project components that would affect the Taltson River basin hydrology are the Nonacho Lake control structure and the Twin Gorges powerhouse.

The Nonacho Lake control structure directly controls the water flows out of Nonacho Lake and indirectly affects the water flowing over the spillway into the Taltson River and into Tronka Chua Lake via Tronka Chua Gap.

The operation of the Twin Gorges power complex directly affects the downstream water flows, the water level in the Twin Gorges Forebay and the flow into Trudel Creek over the South Valley Spillway.

13.9.9 Pathway Analysis

13.9.9.1 Identification of Applicable Pathways

All the potential pathways presented by the DFO website were considered. Several of the pathways were not applicable to this Project, such as the *Changes to the Salinity*. All other pathways were considered and are presented in Table 13.9.6.

The primary effect of the Project on fisheries resources results from altered flows in the Taltson River watershed, including the changes in water surface elevation (water level) and changes in a magnitude of the flow. These changes could directly affect fish access to certain habitats or result in the changes to the structure of fish habitat. An example of altered access would be a decrease in water levels that prevents fish from reaching previously-accessible shoreline habitats. An example of indirect effects would be a change in water levels that could prevent the growth of riparian vegetation in the established location. Riparian vegetation is both an important component of near-shore fish habitats and a source of nutrient inputs to the aquatic ecosystem.

The applicability of the POEs may be affected by the mitigation aspects of the proposed Project. The relevant mitigation components are presented in the following section.

13.9.9.2 MITIGATION

The Project has been designed to minimize any new effects on the Taltson River watershed fluvial environment. It has also been designed to comply with the existing water licence permits so that it would not result in additional flooding. The full scope of mitigation measures incorporated directly into the Project design is described in Section 13.1 – Introduction and Section 6.10 – Design and Operational Mitigation.

The implications of the anticipated changes to the Taltson River hydrograph were considered for each pathway identified above, and suitable mitigation measures were proposed. The consideration of potential effects takes into account these mitigation measures (described in general terms below). It is not anticipated that any of the proposed mitigation measures (mitigation practices or mitigation designs) would eliminate the potential effects associated with any of the Valid or Minor pathways; however, the effects associated with many of the pathways would be reduced.

There are a number of key mitigating features incorporated into the generation facility design to reduce the effects of changes in flow:

- The completed power facility, including the existing facility, would house three turbines within two separate powerhouses. Therefore, at least one turbine would be in operation most of the time, resulting in a lower likelihood of complete flow interruptions.
- A by-pass spillway with 30 m^3/s capacity would minimize flow disruptions to the Taltson in the event of turbine shutdowns.
- Turbine designs would result in high survival rates of potentially entrained fish. Additionally, the conveyance canal leading to the turbines would be designed to provide minimal fish habitat values, with the intent of discouraging fish from entering the canal leading to the generators. This is discussed further in Section 15.3 – Turbine and Conveyance Canal Operation.

These design features are inherent in the design of the Project and would be effective for the operational life of the Project. They would not be changed (or eliminated) in response to future budget considerations.

Furthermore, the proponent is committed to developing and implementing operational plans for controlled and emergency shutdowns/start-ups to eliminate or reduce the effects of ramping (large changes in flow volume over short periods of time).

13.9.9.3 PATHWAYS VALIDATION

Pathways of effect were classified using an initial validity ranking. A pathway was considered Valid (v) if the effect could result in a change to an assessment endpoint. Minor (m) pathways recognize that there may be a change to an assessment endpoint; however, the resulting effect is anticipated to be negligible. A pathway classified as Invalid (i) is associated with typical hydroelectric project components; however is not applicable, or has no effect for this Project component. Some pathways were presented with a combination of two rankings. The results of the pathway validation assessment with a rationale for the ranking are summarized in Table 13.9.7.

The ranking given was based on site-specific information (e.g., vegetation elevation relative to lake water levels), relevant scientific literature (e.g., habitat preferences of the fish species comprising the Valued Components) and professional experience.

The ranking includes consideration of any mitigation measures proposed. Some pathways which initially appeared to have an effect were fully mitigated and were given a ranking of Invalid or Minor. Further explanation of the interpretation and evaluation of principal pathways is given below.

Flow Management as it Relates to Migration and/or Access to Habitats

This pathway refers to a change in fish access to parts of the river, such as side channels, previously contiguous ponds or lakes, due to lowering of water levels, rather than an access to previously-wetted shoreline habitats. The "rule-of-thumb" criteria used for evaluation of this pathway was to determine whether changes in water level would be within the range of baseline variation for that month, since fish access to off-channel habitats is primarily a function of water level. The pathway was ranked as Minor if the anticipated average water level was found to be within the baseline range. If the anticipated water level was found to be outside of that range, the pathway was ranked as Valid.

Flow Management as it Relates to Fish Habitat Structure and Cover

This pathway refers to the changes in the physical nature of the shoreline, such as substrate composition, amount of cover or state of riparian vegetation. The assigned ranking reflects whether the anticipated changes in water level or flow would induce changes to the physical nature of the habitat.

Flow Management as it Relates to Food Supply

This pathway includes factors such as transport of food into the existing system (from adjacent wetlands or marshes), the contribution of insect and detritus drop from riparian vegetation and from flows that were increased sufficiently to "flush" floating food items (phytoplankton or detritus) out of the river. The "rule-of-thumb" criteria used for evaluation of this pathway was to determine whether changes in water level would be within the range of baseline variation for that month. The pathway was ranked as Minor if the anticipated average water level was found to be within the baseline range. If the anticipated water level was found to be outside of that range, the pathway was ranked as Valid.

Obstruction as it Relates to Access to Habitats

This pathway relates to the construction of new barriers, such as dams, diversion structures, etc.

Flow Management as it Relates to Displacement or Stranding of Fish (Ramping)

This pathway relates to short, intense changes in water flow resulting from taking turbines on- and off-line.

Flow Management: Bank Erosion/Deposition as it Relates to Habitat Structure and Cover

This pathway is a subcomponent of *Flow management as it relates to habitat structure and cover* pathway discussed previously. It is included as a separate pathway according to the DFO classification. The pathway relates to changes in flow velocity and volume which may alter the fluvial bedload transport and, in turn, habitat conditions through changes in erosion or deposition patterns. The stream and river morphology is largely controlled by extreme events (i.e. high flows) rather than day-to-day conditions, as high flows can move bigger material. Once the large boulders are established in place, it takes another extreme event to move them again. The "rule-of-thumb" criteria used for an evaluation of this pathway was to determine whether anticipated flows would be within the range of baseline variation for that month.

Table 13.9.7 — Pathway Validation Ranking for the Taltson Valued Components

Assessment Pathway	Validity Rating by Zone					Rationale
	N	1	2	3	4	
Flow Management as it relates to total gas pressure	i	i	i	i	i	There would be no change in physical structure of any of the spillways - Nonacho Lake control structure, Tronka Chua Gap or South Valley Spillway. The new powerhouse and/or alteration of the underflow gates at the Nonacho Lake Control Structure would not result in an increased gas pressure.
Flow Management as it relates to migration and/or access to habitats	m	m	m	i	i	Migration or access to habitats may be changed via two mechanisms: - Fish access between Nonacho Lake and Taltson Lake and/or Tronka Chua Lake would be limited, as there would be no flow though either the spillway or Tronka Chua Gap during some periods. - Lowering the water level may preclude fish access to off-channel habitats.
Flow Management (ramping) as it relates to displacement or stranding of fish	i	i	i	v	i	Large Project related short-term changes in flow would occur only downstream of the Twin Gorges generating facility. Ramping would not occur at the Nonacho Lake control structure as rapid increases or decreases of flows at Nonacho are not required for operational needs.
Flow Management as it relates to water temperature	i	i	i	i	i	The anticipated change in the configuration of underflow gates at the Nonacho Lake control structure would not change the water temperature of the discharged water. The proposed configuration of the powerhouse and conveyance canal would not create any changes to water temperature.
Flow Management as it relates to nutrient concentrations	i	i	i	i	i	No proposed activities would lead to an increase in nutrients (i.e. discharges to river or excavations in channels, etc).
Flow Management as it relates to salinity	i	i	i	i	i	The Great Slave Lake and the Taltson River system contain fresh water.
Flow Management as it relates to habitat structure and cover	m	m	v	v/m	m	The long-term alteration of water surface elevation during the growing season could lead to changes in submergent and emergent riparian vegetation. As Zone 3 spans upstream and downstream of the power plant, the pathway for this zone is both Minor and Valid, depending on the location within the zone.

Assessment Pathway	Validity Rating by Zone					Rationale
	N	1	2	3	4	
Flow Management as it relates to food supply	m	m	v	v/m	m	The anticipated changes in water levels could lead to changes in the ecologic productivity of the shoreline. As Zone 3 spans upstream and downstream of the power plant, the pathway for this zone is both Minor and Valid, depending on the location within the zone.
Flow Management: flooding with respect to contaminant concentration (mercury)	i	i	i	i	i	The potential for bioaccumulation of mercury was assessed as negligible in Section 13.5.
Flow Management: bank erosion/erosion of channel bed as it relates to contaminant concentrations	i	i	i	i	i	Increases in flow are anticipated in late winter/early spring. These flows would be less than freshet flows and well within the natural annual variation; existing natural fluvial processes should not be altered. The Taltson River channel is largely bedrock controlled and robust to alterations of flows with respect to erosion and deposition.
Flow Management: bank erosion/erosion of channel bed as it relates to food supply	i	i	i	i	i	
Flow Management: bank erosion/erosion of channel bed as it relates to habitat cover and structure	i	i	i	m	i	
Flow Management: bank erosion / erosion of channel beds with respect to sediment concentration	i	i	i	i	i	
Obstruction as it relates to access to habitats	m	m	i	i	i	The proposed alterations at the Nonacho Lake control structure would not change the ecologic effect of that structure. There is no change in the potential for fish passage at Twin Gorges.
Obstruction as it relates to entrainment	v	i	i	v	i	Operation of Twin Gorges powerhouse may result in fish entrainment. Entrainment is possible via the underflow valves at the Nonacho Lake control structure. This is assessed in Chapter 15.3 – Turbine and Conveyance Canal Operation.
Fish Passage Issues: change in water chemistry with respect to thermal cues	i	i	i	i	i	None of the proposed changes would alter water temperature; see Section 13.4 (Alterations to Water Quality.
Fish Passage Issues: diversion channels with respect to inter-basin fish migration	i	i	i	i	i	No new diversion channels are being constructed. No new fish access routes would be established.

The pathways classified as Invalid were not discussed further. The rationale behind the ranking of Minor and Valid pathways is presented in more detail in Section 13.9.9.4 and Section 13.9.9.5. Only Valid pathways were carried forward to the effects analysis.

13.9.9.4 MINOR PATHWAYS

This section presents further details on the rationale behind the ranking of the Minor pathways. Pathways identified as Minor are not carried forward to the effects analysis or the cumulative effects discussion.

13.9.9.4.1 Nonacho Lake

The following pathways were ranked as Minor for Nonacho Lake: *Flow management as it relates to migration and/or access to habitats*, *Flow management as it relates to habitat structure and cover, Flow management as it relates to food supply* and *Obstruction as it relates to access to habitats*.

Flow management as it relates to migration and/or access to habitats

Two aspects of fish access to habitats were evaluated: access to deep water in the winter and off-channel marshes and wetlands in the summer.

Winter water levels in Nonacho Lake are anticipated to be lowered by 0.13 to 0.5 m. Nonacho Lake is large and deep, so the reduced winter water level is not anticipated to alter fish access to over wintering habitat.

The summer water levels are anticipated to be lowered by 0.44 to 0.15 m. These levels would be within the monthly baseline range of variation, except for June where the reduction would be 5 cm outside of that range. Therefore this reduction is not likely to induce a change in fish access to off-channel habitats. As such, this pathway was classified as Minor.

Flow management as it relates to fish habitat structure and cover

Preliminary data indicate that the existing riparian marsh vegetation in Nonacho Lake extends to the water depth of 0.8 m and that submergent vegetation can be found in less than 0.8 m of water. The proposed regulated water level in Nonacho Lake would be 0.44 to 0.15 m lower than baseline during the summer (June to September). This change in water level would be within the baseline annual variation range during late summer, except for June where the reduction would be 5 cm outside of that range. The reduction in water level is not expected to affect fish habitat structure. Therefore, this pathway was classified as Minor.

Flow management as it relates to food supply

Lowering of the water level would reduce fish access to shoreline riparian vegetation and limit food supply introduced via seed/detritus and insect drop. It would also reduce the introduction of those food items into the aquatic ecosystem, resulting in a reduction of the food items and nutrient inputs into the system.

The anticipated water levels would mainly be found within baseline range of annual variation during the open water season. Therefore, the proposed flow regulation through the Nonacho control structure is not anticipated to alter the available food supply for fish or their access to the food supply in Zone 1. As such, this pathway was classified as Minor.

Obstruction as it relates to access to habitats

The Project would raise the spillway by 0.5 m which may alter fish access to habitats, such as ability to traverse the spillway and access habitats downstream of Nonacho Lake.

Hydrological modelling (Section 13.3) indicates that in most years water would flow over the spillway channel adjacent to the Nonacho control structure during the late summer. The channel would be dry in late winter and spring during most years. Currently there is a continuous flow through the spillway, so the Project would result in a change to baseline conditions. However, fish would still have a similar access across the spillway during the time of year when they are most active and are most likely to use it. Therefore, change in fish access to habitats downstream of Nonacho Lake is expected to be negligible. As such, this pathway was classified as Minor.

13.9.9.4.2 Zone 1: Taltson River from Outfall of Nonacho Lake to Tazin River Confluence

This zone encompasses the Taltson River from the outfall of Nonacho Lake (downstream of the Nonacho Lake control structure) and the confluence of the Tazin River. The following pathways were ranked as Minor: *Flow management as it relates to migration and/or access to habitats, Flow management as it relates to habitat cover and structure*, *Flow management as it relates to food supply* and *Obstruction as it relates to access to habitats*.

Flow management as it relates to migration and/or access to habitats

Two aspects of fish access to habitats were evaluated: access to deep water in the winter and “off-channel” marshes and wetlands in the summer.

The anticipated water levels for Taltson, King, Lady Grey and Benna Thy Lakes would be found within the monthly baseline variation range during the summer. The exception is Taltson Lake where the calculated June average water level would be one cm lower than the baseline range. Therefore this reduction is not likely to induce a change in fish access to off-channel habitats.

The anticipated winter water levels for Taltson, King, Lady Grey and Benna Thy Lakes are, in all cases, higher than baseline water levels. Therefore, the anticipated change would have increase the amount of over-wintering habitat (i.e. deep water) available to fish in winter.

As such, this pathway was classified as Minor.

Flow management as it relates to habitat cover and structure

The anticipated water levels for Taltson, King, Lady Grey and Benna Thy Lakes would be found within the monthly baseline variation range during the summer season. The exception is Taltson Lake where the calculated June average water level would be one cm lower than the baseline range. Flow data indicate that all increased flows would be less than baseline freshet flows and would lie within baseline annual variation.

Therefore, flow regulation through the Nonacho control structure is not anticipated to alter fish habitat structure and cover conditions in Zone 1. As such, this pathway was classified as Minor.

Flow management as it relates to food supply

Lowering of the water level would reduce fish access to shoreline riparian vegetation and limit food supply introduced via seed/detritus and insect drop. It would also reduce the introduction of those food items into the aquatic ecosystem, resulting in a reduction of the food items and nutrient inputs into the system.

The anticipated water levels would mainly be found within monthly baseline range of variation during the summer. Therefore, the proposed flow regulation through the Nonacho control structure is not anticipated to alter the available food supply for fish or their access to the food supply in Zone 1. As such, this pathway was classified as Minor.

Obstruction as it relates to access to habitats

This pathway is similar to the pathway described *Flow management as it relates to habitat cover and structure*. The Project would raise the spillway by 0.5 m which may alter fish access to habitats, such as ability to traverse the spillway and access habitats downstream of Nonacho Lake.

Hydrological modelling (Section 13.3) indicates that in most years water would flow over the spillway channel adjacent to the Nonacho control structure during the late summer. The channel would be dry in late winter and spring during most years. Currently there is a continuous flow through the spillway, so the Project would result in a change to baseline conditions. However, fish would still have a similar access across the spillway during the time of year when they are most active and are most likely to use it. Therefore, change in fish access to habitats downstream of Nonacho Lake is expected to be negligible. As such, this pathway was classified as Minor.

13.9.9.4.3 Zone 2: Tronka Chua Gap to Outfall of Yatsore Lake

This zone encompasses the river channel and lakes between Tronka Chua Gap and the confluence of the Taltson mainstem. The following pathways were ranked as Minor for this section: *Flow management as it relates to migration and/or access to habitats*.

Flow management as it relates to migration and/or access to habitats

Hydrological modelling of the Taltson River (Section 13.3) indicates that the flow over Tronka Chua Gap would occur during most years. (i.e. the model output shows that, if the Project was in place between 1978 and 1990, the flow over Tronka Chua Gap would occur in late summer/fall for 9 out of the 14 years. Tronka Chua Gap would be dry in the winter, when fish are least active and are not likely to move from one body of water to another.

The fish species comprising Valued Components are not migratory (Richardson et al. 2001; Evans et al. 2002), spending their entire life in the same section of river and/or lake. Therefore, the removal of movement potential would not have a significant effect on the overall population of fish in the system.

The discussion of winter ice conditions (Section 13.6 — Alterations of Ice Structure) indicates that winter flow conditions are not expected to alter either the amount of overwintering habitat available to fish or their ability to access that habitat.

Therefore, the proposed alteration of flow could reduce fish access to habitats in Tronka Chua Lake; however, the effects of this pathway are expected to be minimal. As such, this pathway was classified as Minor.

13.9.9.4.4 Zone 3: Taltson River between the Tazin River and Upstream of Tsu Lake

For the purpose of this fisheries analysis, this zone is divided into three sub-zones: the Taltson River between the Tazin River and Twin Gorges Forebay, the Twin Gorges powerhouse to downstream of the Twin Gorges powerhouse, and the Taltson River from downstream of the powerhouse to upstream of Tsu Lake.

13.9.9.4.4.1 Taltson River between the Tazin River and Twin Gorges Forebay (Upstream of Twin Gorges)

This zone encompasses the Taltson River from the confluence of the Tazin to the Twin Gorges Forebay. No pathways ranked as Minor were identified in this section.

13.9.9.4.4.2 Twin Gorges

This zone encompasses the existing penstocks, powerhouse and tailrace pool and the proposed conveyance canal, new powerhouse and tailrace pool. No pathways ranked as Minor were identified in this section.

13.9.9.4.4.3 Taltson River Downstream of Twin Gorges to Upstream of Tsu Lake

This zone encompasses the Taltson River from downstream of Twin Gorges (i.e. the confluence of Trudel Creek) to upstream of Tsu Lake. The following pathways were ranked as Minor in this section: *Flow management as it relates to habitat cover and structure*, *Flow management as it relates to food supply and Flow management: bank erosion/deposition as it relates to habitat structure and cover*.

Flow management as it relates to habitat cover and structure

Anticipated water levels in Taltson River downstream of the power plant would be 0.01 to 0.2 m higher than baseline water levels in winter and less than 0.16 m lower than baseline water levels in summer.

Flow data indicate that the flows would be within 12% of baseline flows throughout the year. Increased flows would be less intense than freshet flows and all anticipated flows would be within the baseline annual variation range.

These changes in flow and water levels are not expected to have any effect on fish habitat structure. Therefore, this pathway was classified as Minor.

Flow management as it relates to food supply

In addition to change in access or habitat structure, flow management could affect the fish food supply if increased flows are high enough to flush floating food items (phytoplankton or detritus) out of the river.

Anticipated flows in the summer would be less intense than baseline flow, so the proposed flow regulation is not anticipated to alter the available food supply for fish. Therefore, this pathway was classified as Minor.

Flow management: Bank erosion/deposition as it relates to habitat structure and cover

The stream and river morphology is largely controlled by extreme events (i.e. high flows) rather than day-to-day conditions, as high flows can move bigger material.

Once the large boulders are established in place, it takes another extreme event to move them again.

Throughout the year the predicted maximum flows would be less intense than the baseline maximum flows, so the proposed flow regulation is not anticipated to result in increased erosion events.

The potential exists for increases in flow volume on start-up after a shutdown event, such as turbine shutdown for annual servicing. On start-up the flows in the Taltson River downstream of the power plant would increase. The flow would be effectively doubled as water would be flowing through both the turbine and via Trudel Creek. The hydrology modelling indicates that the increases in flows are well within pre-existing annual variation, so the proposed flow regulation is not anticipated to result in increased erosion events. Therefore, this pathway was classified as Minor.

13.9.9.4.5 Zone 4: Taltson River from Tsu Lake to Great Slave Lake

This zone encompasses the Taltson River from Tsu Lake to Great Slave Lake. The following pathways were ranked as Minor in this section: *Flow management as it relates to habitat cover and structure* and *Flow management as it relates to food supply*.

Flow management as it relates to habitat cover and structure

The hydrological model indicates that there would be almost no change in anticipated water levels or flow intensity in this section of the river. Therefore, this pathway was classified as Minor.

Flow management as it relates to food supply

The hydrological model indicates that there would be almost no change in anticipated water levels or flow intensity in this section of the river. Therefore, this pathway was classified as Minor.

13.9.9.5 VALID PATHWAYS

This section presents further details on the rationale behind the Valid classification for all remaining pathways. Note: only the rationale for the classification is discussed in this section. The discussion about the magnitude of the effects is presented in Section 13.9.10.

13.9.9.5.1.1 Nonacho Lake

The following pathway was ranked as Valid in this section: *Obstruction as it relates to entrainment.*

Obstruction as it relates to entrainment

The reconstruction of the Nonacho Lake control structure includes installing a mini-hydro power supply which would include a small conveyance canal and turbine system. The implications of this are assessed in Section 15.3 – Turbine and Canal Conveyance Operation.

13.9.9.5.2 Zone 1: Taltson River from Outfall of Nonacho Lake to Tazin River Confluence

No pathways ranked as Valid were identified for Zone 1.

13.9.9.5.3 Zone 2: Tronka Chua Gap to Outfall of Yatsore Lake

The following pathways were ranked as Valid in this section: *Flow management as it relates to food supply* and *Flow management as it relates to fish habitat structure and cover.*

Flow management as it relates to food supply

Lowering of the water level would reduce fish access to shoreline riparian vegetation and limit food supply introduced via seed/detritus and insect drop. Anticipated water levels would be lowered in summer by 0.38 to 0.53 m from the baseline water levels in Tronka Chua Lake and by 0.13 to 0.18 m in Thekulthili Lake. Initial field data from Nonacho Lake indicate that the sedge meadow vegetation extends to the water depth of 0.8 m. The anticipated lowering of the water level in Tronka Chua Lake would likely reduce the nutrient inputs into the lake ecosystem via shoreline riparian vegetation seed/detritus and insect drop, as the majority of those inputs would fall on dry land rather than in the water.

Northern pike use shoreline sedge habitats for cover and feeding, while lake trout and lake whitefish are typical deep-water habitat fish species that do not use these habitats. Therefore, the regulation of flows through the Nonacho control structure could alter the food supply for northern pike. As such, this pathway was classified as Valid.

Flow management as it relates to habitat cover and structure

Preliminary data from Nonacho Lake indicate that the sedge meadow vegetation extends to the water depth of 0.8 m and that submergent vegetation can be found in less than 0.8 m of water. This vegetation comprises a part of the riparian fish habitat. Anticipated water levels would be lowered in summer by 0.38 to 0.53 m from the baseline water levels in Tronka Chua Lake and by 0.13 to 0.18 m in Thekulthili Lake. Therefore, under the proposed water level regime, a significant portion of the riparian plants would no longer by wetted and would likely respond by either dying *in situ* or growing lower on the shore.

The regulation of flow through Tronka Chua gap (via the Nonacho control structure) could alter the fish habitat structure and cover conditions in Tronka Chua Lake. As such, this pathway was classified as Valid.

13.9.9.5.4 Zone 3: Taltson River between the Tazin River and Upstream of Tsu lake

This zone is further divided into three sub-zones: the Taltson River between the Tazin River and Twin Gorges Forebay, the Twin Gorges powerhouse to downstream of the Twin Gorges powerhouse, and the Taltson River from downstream of the powerhouse to Tsu Lake.

13.9.9.5.4.1 Taltson River between the Tazin River and Twin Gorges Forebay (Upstream of Twin Gorges)

The following pathways were ranked as Valid in this section: *Flow management as it relates to food supply, Flow management as it relates to habitat structure and cover,* and *Flow management as it relates to displacement or stranding of fish* (ramping).

Flow management as it relates to food supply

Anticipated water levels in the Twin Gorges Forebay would be lowered by 0.41 to 0.58 m from the baseline water levels during the open-water season (May to September). This would likely induce a change in food supply. The implications of this pathway are as discussed above. This pathway was classified as Valid.

Flow management as it relates to habitat structure and cover

Hydrological modelling of the Taltson River (Section 13.3) indicates that the summer water level in the Twin Gorges Forebay is anticipated to be 0.41 to 0.58 m lower than the baseline water levels during the open water season. This would likely induce a change in the riparian vegetation. The implications of this pathway are as discussed above. This pathway was classified as Valid.

13.9.9.5.4.2 Twin Gorges

Obstruction as it relates to entrainment is discussed in Section 15.3 — Turbine and Conveyance Canal Operation.

13.9.9.5.4.3 Taltson River Downstream of Twin Gorges to Tsu Lake

The following pathway was ranked as Valid in this section: *Flow management as it relates to displacement or stranding of fish (ramping).*

Flow management as it relates to displacement or stranding of fish (ramping)

Scheduled shutdown and start-up events associated with turbine maintenance may result in displacement or stranding of fish.

Water flow during a scheduled shutdown/start-up event changes via the following sequence. Initially, there is a decrease in total water flow through the generating facility when a turbine is taken off-line. After a period of time, water level in the Twin Gorges Forebay rises, increasing the water flow over the South Valley Spillway. The increased water flow then enters the Trudel Creek. The net effect is the reduction of water flow in the Taltson River downstream of the power facility for 6 to 10 hours, after which the flow returns to pre-event levels. The scenario is reversed when the turbine is brought back on line – initially water flow increases as water travels through both the turbine and Trudel Creek. The flow through Trudel Creek decreases only after the water level in the Forebay decreases and the flow over the South Valley Spillway is reduced. The water flow in the Taltson River then stabilizes at pre-event levels. The scheduled shutdown/start-up events are discussed in more detail in Section 13.3 — Alterations of Water Quantity.

There is a potential for fish stranding during the initial flow decrease at the shutdown event and during the decrease following the elevated flows at start-up. The stranding in pools during the initial decrease would likely not result in fish mortality, as those pools would be reconnected with the river when pre-event flows return. If, however, fish were moved by the elevated flows on start-up into areas that are normally not connected to the river, they would be stranded indefinitely when the flows returned to the pre-event levels. Fish that preferentially use near-shore habitats, such as northern pike, would be more susceptible to stranding.

This pathway was classified as Valid.

13.9.9.5.5 Zone 4: Taltson River from Tsu Lake to Great Slave Lake

No pathways ranked as Valid were identified from the anticipated changes to the hydrograph for Zone 4.

13.9.10 Effects Analysis

This section discusses the potential effects of Valid pathways on the fish populations of the Taltson River system. Only pathways ranked as Valid are discussed below.

There are two components to the overall effects of the proposed Project – the incremental effects of the Project and the cumulative effects in the context of previous developments in the system.

The incremental effects are discussed first and are presented separately for each zone. However, effects were classified based on the assessment endpoints; northern pike, lake whitefish and lake trout populations, and their distributions, within the Taltson River watershed. This section is followed by a discussion of the cumulative effects of the development on the Taltson River in Section 13.9.10.2.

The duration of effects were based on both the duration of Project activities, which are correlated with Project phases; and the duration of effects on measurement endpoints (e.g., habitat) which shadow effects on the assessment endpoints. Short-term was defined as less than 3 years, which corresponds to the predicted length of time required for submergent vegetation to re-establish following disturbance. Medium-term was defined as less than 10 years, which corresponds to the predicted length of time required for emergent vegetation to re-establish following disturbance. Long-term was defined as between 10 and 40 years which corresponds to the duration of the operations phase of the Project.

13.9.10.1 Incremental Effects

The anticipated effects of the identified Valid pathways are discussed in detail below as they pertain to each zone.

13.9.10.1.1 Nonacho Lake

The following pathway was ranked as Valid for Nonacho Lake: *Obstruction as it relates to entrainment.*

Obstruction as it relates to entrainment

The reconstruction of the Nonacho Lake control structure includes installing a mini-hydro power supply which would include a small conveyance canal and turbine system. The implications of this are assessed in Section 15.3 — Turbine and Canal Conveyance Operation.

The incremental effect of this pathway is anticipated to be Minor.

13.9.10.1.2 Zone 1: Taltson River from Outfall of Nonacho Lake to Tazin River Confluence

No pathways ranked as Valid were identified in this section.

13.9.10.1.3 Zone 2: Tronka Chua Gap to Outfall of Yatsore Lake

The following pathways were ranked as Valid for Zone 2: *Flow management as it relates to food supply* and *Flow management as it relates to fish habitat structure and cover*.

Flow management as it relates to food supply

The anticipated average summer water levels (June to August) in Tronka Chua Lake would be 0.81 to 0.95 m lower than baseline levels, with the attendant implications as discussed previously. This issue applies only to Tronka Chua Lake, as the anticipated water levels for Thekulthili Lake would be within 0.35 m of the monthly baseline levels and are not expected to affect the vegetation.

The overall effect in the Tronka Chua Lake is anticipated to be minimal. Although this pathway would reduce the access to riparian vegetated habitats and the attendant food supply associated with those habitats, other closely located habitats could serve similar function.

Additionally, the reduction in habitat productivity would be temporary and would return to pre-Project levels when the vegetation becomes re-established in response to the changed water levels. This system has responded to, and recovered from, similar effects in the past caused by the original hydro development in 1966 and change in management regime after the Pine Point Mine closure.

The incremental effect of this pathway is anticipated to be Minor.

Flow management as it relates to fish habitat structure and cover

Preliminary data indicate that the existing riparian marsh vegetation in Nonacho Lake extends to the water depth of 0.8 m and that submergent vegetation can be found in less than 0.8 m of water. This vegetation comprises a part of the physical component of riparian fish habitat. The proposed regulated water level in Tronka Chua Lake would be 0.81 to 0.95 m lower than baseline level during the growing season, affecting riparian habitat structure and cover. Note: the water level change in Thekulthili Lake is smaller and is not expected to affect riparian vegetation.

It is anticipated that this pathway would have a temporary effect on riparian vegetated habitats and the habitats would re-establish in response to the new water level regime in five to 10 years.

The incremental effect of this pathway is anticipated to be Minor.

13.9.10.1.4 Zone 3: Taltson River between the Tazin River and Upstream of Tsu Lake

The following pathways were ranked as Valid for Zone 3: *Flow management as it relates to habitat structure and cover* and *Flow management as it relates to food supply* (upstream of Twin Gorges), and *Flow management as it relates to displacement or stranding of fish* (downstream of Twin Gorges).

13.9.10.1.4.1 Taltson River between the Tazin River and Twin Gorges Forebay (Upstream of Twin Gorges)

Flow management as it relates to fish habitat structure and cover

Hydrological modelling of the Taltson River (Section 13.3) indicates that the water level during the summer in the Twin Gorges Forebay is anticipated to be 0.58 to

0.62 m lower than the baseline levels. The implications of these changes are as discussed in Section 13.9.11.

It is anticipated that this pathway would have a temporary effect on riparian vegetated habitats and the vegetation would re-establish in response to the new water level regime in 5 to 10 years.

The incremental effect of this pathway is anticipated to be Minor.

Flow management as it relates to food supply

Hydrological modelling of the Taltson River (Section 13.3) indicates that the water level during the summer in the Twin Gorges Forebay is anticipated to be 0.58 to 0.62 m lower than the baseline levels. The implications of these changes are as discussed in Section 13.9.11.2.

It is anticipated that this pathway would have a temporary effect on riparian vegetated habitats. The changes in food supply (insect and detritus drop) would diminish in 5 to 10 years, when the vegetation would re-establish in response to the new water level regime.

The incremental effect of this pathway is anticipated to be Minor.

13.9.10.1.4.2 Taltson River downstream of Twin Gorges to upstream of Tsu Lake

Flow management as it relates to displacement or stranding of fish

As noted previously, this issue relates to shutdown and start-up events; the sequences of those events are presented in Section 13.3 - Alterations of Water Quantity.

There is a potential for fish stranding during the initial decrease in flows at the start of the shutdown and during the decrease in the elevated flows incurred on start-up. The decrease in water elevation is a potential concern to northern pike, which use near-shore habitats for spawning and rearing. Pike often spawn on riparian vegetative substrates in water less than 0.3 m deep and remain near those habitats during their natal year.

Pike spawn shortly after break-up, usually in May. The eggs incubate for 6 to 10 days and the newly-hatched larvae remain attached to the spawning substrate for another 8 to 10 days while they absorb nutrients from the yolk sac. So, it is two to three weeks before the new generation is free-swimming. Given that northern pike spawn on vegetative mats in less than 0.3 m of water, the mats and eggs or larvae could be de-watered during a shutdown event, if that event occurred within three weeks of spawning, i.e. in May/June.

The predicted initial decrease in water level has been calculated for low-, mid- and high-flow conditions as a maximum of 20 cm. The water levels are anticipated to remain low for 6 to 10 hours, after which they return to pre-shutdown levels.

Clearly, a 20 cm lowering of water level in areas where northern pike have spawned thus poses a risk to their eggs and larvae in the affected section of the river.

The spawning habitat used by pike would likely be mats of dead emergent vegetation – the remnants of the previous year's growth – as early May is prior to the onset of the current year's growth. On de-watering, these mats would retain water for a period of time, and it is likely that eggs, larvae and/or very small fish could survive while the mat retains water. How long they might survive would depend on factors such as the characteristics of the vegetation itself, the external temperature, exposure to sunlight, and so on.

Also, it is possible that the spawning habitat would not be completely de-watered – the anticipated water level lowering is 20 cm whereas the total water depth of the preferred habitat is up to 30 cm. If the spawning area is not completely de-watered (and the vegetation mats remain wetted) there could be no, or at least minimal, effect on the survivorship of the northern pike eggs and/or larvae there.

It seems reasonable that the risk to northern pike reproductive success is not an absolute risk because the potential effects could be mitigated by the characteristics of the preferred spawning substrate and by the duration of the reduced water levels. It does, however, seem almost certain that there would be an effect on reproductive success and if such a lowering of the water was incurred in all years.

With respect to the duration and geographic extent of the reduced water levels, the initial decrease happens very quickly and the decreased water levels would propagate downstream as the continued flow in the Taltson River drains water from the river channel.

At the time of writing, scheduled shutdowns are anticipated to coincide with the minimum annual flow (i.e., the onset of freshet – in April/May). In the years when the turbines are operating below full capacity, the generating flow of the turbine taken out of service would be picked up by the remaining two operational turbines. Consequently, there would be no change in the total flow through the Twin Gorges power plant and no change to the water level downstream.

If the shutdown is completed before the onset of spawning there would be no effect on northern pike survivorship. However, considering the frequency of anticipated reduction in water levels (i.e. every second year) and assuming a "worst-case" scenario, this pathway is ranked as having a moderate effect on northern pike spawning success.

13.9.10.1.5 Zone 4: Taltson River from Tsu Lake to Great Slave Lake

No pathways ranked as Valid were identified for Zone 4.

13.9.10.2 CUMULATIVE EFFECTS

This section discusses the anticipated cumulative effects of Valid pathways that may have a residual effect. Pathways are discussed in the context of the pristine (i.e. unaltered) river system and the residual effects of previous and existing developments, as they pertain to each zone.

13.9.10.2.1 Previous and Existing Developments

There are two major existing developments that have affected the Taltson River. These are the diversion of the Tazin River and the original development of the Twin Gorges power-generating facility. Additionally, an active commercial fishery took place on Taltson Lake from 1962 to 1981.

13.9.10.2.1.1 Tazin River Diversion

The Tazin River was dammed as part of the Churchill-Nelson Hydroelectric power development in the 1960s. A dam was built across the outlet of Tazin Lake and the baseline flows in the Tazin River were diverted south into the Churchill River system. This significantly reduced the flow into the Taltson River, although the Tazin River still remains a major tributary. The Tazin River enters the Taltson upstream of Twin Gorges and its confluence is used to define the upstream limit of Zone 3 in the Rescan hydrographical model.

13.9.10.2.1.2 Twin Gorges Power Development

The original development of the Twin Gorges occurred in 1966. It involved the construction of the powerhouse and the installation of the Nonacho Lake control structure.

The construction of the powerhouse entailed a number of effects to the lower Taltson River system, namely, alteration of the channel at Twin Gorges itself, the flooding of the Forebay area upstream of the powerhouse, and the creation of the South Valley Spillway with its attendant transformation of Trudel Creek from a small tributary of the Taltson River into an alternate river channel. The effects of this development on Trudel Creek are discussed in Chapter 14.

The construction of the powerhouse had affected fish populations via pathways from the *Flow management (altered frequency, amplitude, duration, timing and rate of change of flow)*, *Placement of materials or structures in water* and *Fish passage issues* flowcharts, with ongoing residual effects.

The pathways with ongoing residual affects resulting from an alteration of water level at the Forebay site include: *Flow management as it relates to access to habitat structure and cover* and *Flow management as it relates to access to habitats*. The water level elevation in the Forebay area increased, changing the riparian vegetation, shoreline habitats and fish access to those habitats.

The pathways with ongoing residual effects at the Twin Gorges site include *Obstruction as it relates to access to habitats* and *Obstruction as it relates to* *entrainment*. The imposition of the power plant in the Taltson River channel affected fish that were residing or moving through this section of the river.

The pathways with ongoing residual effects resulting from an alteration of flow downstream of Twin Gorges include: *Flow management as it relates to access to habitat structure and cover*, *Flow management as it relates to access to habitats*, *Flow management as it relates to displacement or stranding of fish (ramping)* and *Flow management: bank erosion/erosion of channel bed, as it relates to access to habitats and habitat structure and cover*. The construction of the power facility changed the downstream flow regime, especially during shutdowns and start-up events.

13.9.10.2.1.3 Nonacho Lake Control Structure

The creation of the Nonacho Lake control structure included damming of the Taltson River, installation of the underflow gates and creation of the spillway channel. The construction of the control structure had affected fish populations via pathways from the *Flow Management (Altered frequency, amplitude, duration, timing and rate of change of flow)*, *Placement of materials or structures in water* and *Fish passage issues* flowcharts, with ongoing residual effects.

The pathways with ongoing residual affects resulting from the alteration of water level in Nonacho Lake include *Flow management as it relates to access to habitat structure and cover* and *Flow management as it relates to access to habitats*.

Water Survey Canada data indicate that the water level elevation in Nonacho Lake increased almost 3 m from 320.5 m in March-May 1968 to 323.4 m in August 1968 (WSC 2008) in response to the original installation of the Nonacho Lake control structure. This increase led to changes in riparian vegetation and shoreline habitats and fish access to those habitats. Currently those habitats appear to have stabilized and the riparian habitats have been re-established.

A 1998 analysis (Northwest Territories Power Corporation 1998) states that the area of shoreline flooding was estimated as 80 km^2 (± 8 km^2) and the length of shoreline increased by nearly 200 km (to 2,198 km from 2,010 km). Currently it is impossible to compare (in terms of quantity or quality) the existing riparian habitats to those of the pristine lakeshore.

The proposed water level management would reduce the water level in Nonacho Lake by approximately 0.7 m. The direction of this change is towards the pristine water level and could potentially be viewed as a beneficial effect.

The pathways with ongoing residual effects pertaining to fish passage at the outlet of Nonacho Lake and at Tronka Chua Gap include *Obstruction as it relates to access to habitats* and *Flow management as it relates to migration and/or access to habitats*.

Information used in the related engineering studies indicates that originally the water in Nonacho Lake could have passed through Tronka Chua Gap in "a really big flood year …, but it was far from a regular occurrence" (T. Vernon, personal communication 2008). The creation of regular flows through Tronka Chua Gap, as has occurred since the Pine Point Mine closed, was a major change to the drainage patterns of the watershed, affecting fish populations.

The nature of original outflow channel at the Taltson River in not known. It is possible that the channel contained either a waterfall or a steep cascade that could have been a barrier or an obstruction to fish movement. It seems likely that fish movement out of Nonacho Lake to the Taltson River was directed largely downstream under pre-Twin Gorges development conditions.

13.9.10.2.1.4 Nonacho Lake Commercial Fishery

The existing information on the historical commercial fishery is sparse. The fishery focused on whitefish and lake trout and was most active from 1960 to 1971. The amount of fish taken was measured in the tens of thousands of pounds, but the exact catch amounts from individual years are not known.

The disclosed records detail the catch as follows:

> *"Nonacho Lake produced the following: in 1962-66 winter fishery, 88,269 pounds of whitefish and 9,897 pounds of trout. From December 1971-72, 110,000 pounds of whitefish and 76,800 pounds of trout were produced. In 1979 the quota of 60,000 pounds totalled to 10,600 pounds of whitefish and 18,000 pounds of trout were taken. In August/September of 1980, 9,100 pounds of whitefish and 480 pounds of trout were caught. In January and February 1981, a total of 1,900 pounds of whitefish and 825 pounds of trout were taken."* (Azzolini, L. personal communication 2008).

The decline of the fishery was apparently due to the high cost of flying the product to the market, although there is also mention of "mercury in trout and infestation in whitefish" (Azzolini, L. personal communication 2008).

13.9.10.3 EFFECTS CLASSIFICATION

The assessment of the overall potential effects of the proposed Project largely depends on the criteria used to determine the direction (adverse or beneficial) of the effect. If the objective of the study is preservation or management of the specific resource as observed today, the criteria would depend on the changes to that resource from current (baseline) conditions. If the goal of the study is to maintain the health and stability of the ecosystem, then the criteria would relate to the change of the system towards or away from the pristine conditions. Incremental effects of the Expansion Project are assessed relative to current conditions, whereas cumulative effects are assessed relative to pristine conditions.

For residual effects relating to lowered water levels (Zones 1 and 2), the incremental effects are not predicted to affect long-term fish populations within the watershed (Table 13.9.8). Effects are predicted but would be reversible in the medium-term (less than 10 years) as vegetation within the new water level regime establishes. In terms of cumulative effects, it is difficult to determine if ongoing residual effects are present. The populations of fish within the Taltson River watershed have likely stabilized following past disturbance. However, it is not known if past disturbances created a beneficial or adverse residual effect in terms of population size, distribution, health, etc. It can be inferred that the past disturbance caused a beneficial effect given that habitat extent increased and a direct link to Tronka Chua was made, though it is not known if the Nonacho structures were beneficial or adverse for fish movement. If it is assumed that past disturbances were beneficial, then the incremental effects of the Expansion Project would be slightly adverse relative to pristine, in the medium-term only.

Given the uncertainty in the direction and magnitude of residual effects from past development in the Taltson River watershed, cumulative residual effects were discussed but not classified. Thus the effects classification focused on incremental effects relative to current conditions. In terms of fish populations, the incremental effects are not predicted to have any long-term effects on populations. Thus, although the hydrologic conditions are predicted to shift back toward pristine, the Expansion Project is not predicted to change current fish population towards or away from pristine. The incremental effects on the northern pike, lake whitefish and lake trout populations within the Taltson River watershed relative to current conditions are presented in Table 13.9.8.

Table 13.9.8 — Incremental Effects Classification for Pathways to Valued Components

Valued Component	Pathway	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Overall Residual Effect
Northern pike, Lake trout, Lake whitefish	Obstruction as it relates to fish entrainment	Adverse	Minor	Nonacho Lake and Zone 3: - Nonacho Lake, Control structure only - Zone 3, Twin Gorges power plant only	Long- term	Reversible	Continuous	High	Low
Northern pike, Lake trout, Lake whitefish	Flow management as it relates to habitat structure and cover	Adverse	Minor	Zones 2 & 3: - Zone 2, Tronka Chua Lake only - Zone 3, Twin Gorges Forebay only	Medium- term	Reversible	Continuous	High	Low
Northern pike, Lake trout, lake whitefish	Flow management as it relates to food supply	Adverse	Minor	Zones 2 & 3: - Zone 2, Tronka Chua Lake only - Zone 3, Twin Gorges Forebay only	Medium- term	Reversible	Continuous	High	Low
Northern pike	Flow management as it relates to displacement or stranding of fish (ramping)	Adverse	Moderate	Zone 3, downstream of Twin Gorges power plant only	Long-term	Reversible	Continuous	High	Moderate

13.9.10.4 SIGNIFICANCE DETERMINATION

The overall significance of the potential effects of the Project is presented in Table 13.9.9. This includes potential effects identified during the effects assessment for Trudel Creek (see Section 14.8 for details). The residual effects on fish within Trudel Creek were included in the determination of significance of Project effects within the Taltson River watershed because Trudel Creek fish have the potential to interact with fish within the Taltson River. Moreover, the determination of significance thus addresses both effects on populations and the distribution of the VCs with the entire Taltson River watershed.

Table 13.9.9 — Significance of Potential Effects to the Valued Components.

Valued Component	Assessment Endpoint	Pathway	Overall Residual Effect	Overall Significance	Uncertainty
Northern pike	Fish mortality	Obstruction as it relates to entrainment	Low	Not significant	Medium
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate		
	Changes in food supply	Flow management as it relates to food supply	Low		
	Displacement or stranding of fish	Flow management as it relates to displacement or stranding of fish (ramping)	Moderate		
	Changes to depositional zones	Flow management as it relates to fish habitat and structure (Trudel Creek)	Low		
Lake trout	Fish mortality	Obstruction as it relates to entrainment	Low	Not significant	Medium
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Low		
	Changes in food supply	Flow management as it relates to food supply	Low		
Lake whitefish	Fish mortality	Obstruction as it relates to entrainment	Low	Not significant	Medium
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate		
	Changes in food supply	Flow management as it relates to food supply	Low		
	Changes to depositional zones	Flow management as it relates to fish habitat and structure (Trudel Creek)	Low		
	Displacement or stranding of fish	Flow management as it relates to displacement or stranding of fish	Low		

Valued Component	Assessment Endpoint	Pathway	Overall Residual Effect	Overall Significance	Uncertainty
		(ramping) (Trudel Creek)			
Walleye (Trudel Creek)	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate	Not significant	Medium
	Changes in habitat structure and cover	Changes to depositional zones	Low		
	Displacement or stranding of fish	Flow management as it relates to displacement or stranding of fish (ramping)	Low		

13.9.10.4.1 Overall Significance of Project Effects

The Project is not anticipated to have any overall significant effect on fish populations in the Taltson River system.

13.9.11 56 MW Scenario

Dezé Energy Corporation would like to maintain the option of re-developing the Twin Gorges power facility to generate 56 MW of power rather than 36 MW. The differences between the two scenarios would mainly involve the changes to water flow management regime. The changes to the size and configuration of the power house would not directly affect the river system and there would be no changes to the conveyance or tailrace canals.

The major difference between the two regimes would involve anticipated changes in water levels in Nonacho Lake. Water levels would be lower under the 56 MW management regime than they would under the 36 MW regime. This could alter the potential effects on the lakeshore habitats and the ability of fish to move between Nonacho Lake and either Taltson Lake via Nonacho spillway or Tronka Chua Lake via Tronka Chua Gap.

Only those aspects of the 56 MW development scenario that were not covered under, or are different than, the 36 MW scenario are discussed below.

13.9.11.1.1 Nonacho Lake

Under 56 MW development scenario, the following three pathways were changed from Minor to Valid for Nonacho Lake: *Flow management as it relates to migration and/or access to habitats, Flow management as it relates to food supply* and *Flow management as it relates to fish habitat structure and cover.*

Flow management as it relates to migration and/or access to habitats

Hydrological modelling of the Taltson River (Section 13.3) indicates that the flow over the spillway channel adjacent to the Nonacho control structure would occur during summer/fall of high-water years only (i.e. the model output shows that, if the Project was in place between 1978 and 1991, the flow through the Nonacho spillway would occur in 1982, 1985 and 1988). The flow via Tronka Chua Gap would continue in late summer and fall during most years.

The alteration of flows through the spillway channel and Tronka Chua Gap would affect the potential for fish movement between Nonacho Lake and Taltson and Tronka Chua Lakes.

Therefore, the proposed alteration of flow could reduce fish access to habitats downstream of Nonacho Lake and to shoreline habitats. As such, this pathway was classified as Valid.

Flow management as it relates to food supply

The water level in Nonacho Lake is expected to be 0.6 to 0.75 m lower than the baseline levels during the open-water season (May to September). Lowering of the water level would reduce fish access to shoreline riparian vegetation and limit food supply introduced via seed/detritus and insect drop.

Northern pike use shoreline sedge habitats for cover and feeding purposes, while lake trout and lake whitefish are typical deep-water habitat fish species that do not use these habitats.

Therefore, the regulation of flows through the Nonacho control structure could alter the food supply to northern pike. As such, this pathway was classified as Valid.

Flow management as it relates to fish habitat structure and cover

Preliminary data from Nonacho Lake indicate that the sedge meadow vegetation extends to the water depth of 0.8 m and that submergent vegetation can be found in less than 0.8 m of water. This vegetation comprises a part of the riparian fish habitat. Anticipated water levels would be lowered by 0.6 to 0.75 m throughout the year. Therefore, under the proposed water level regime, a significant portion of the riparian plants would no longer by wetted and would likely respond by either dying *in situ* or growing lower on the shore.

The regulation of flow through the Nonacho control structure could alter the fish habitat structure and cover conditions in Nonacho Lake. As such, this pathway was classified as Valid.

13.9.11.1.2 Zone 1: Taltson River from outfall of Nonacho lake to Tazin River confluence

Under the 56 MW development scenario, the following pathway classification was changed from Minor to Valid for Zone 1: *Flow management as it relates to migration and/or access to habitats.*

Flow management as it relates to migration and/or access to habitats

The proposed changes to flow patterns over the spillway channel would affect the potential fish movement between Nonacho Lake and Taltson Lake. This pathway and its potential effects are similar to the Nonacho Lake pathway discussed in Section 13.9.9.4. As such, this pathway was classified as Valid.

13.9.11.1.3 Zone 2: Tronka Chua Gap to outfall of Yatsore Lake

Under the 56 MW development scenario, the following pathway classification was changed from Minor to Valid for Zone 2: *Flow management as it relates to migration and/or access to habitats.*

Flow management as it relates to migration and/or access to habitats

The proposed changes to flow patterns over the Tronka Chua Gap would affect the potential fish movement between Nonacho Lake and Taltson Lake. This pathway and its potential effects are similar to the Nonacho Lake pathway discussed in Section 13.9.9.4. As such, this pathway was classified as Valid.

13.9.11.2 INCREMENTAL EFFECTS

The anticipated effects of the Valid pathways are discussed below.

13.9.11.2.1 Nonacho Lake

Under the 56 MW development scenario, the following three pathways were classified as Valid for the Nonacho Lake: *Flow management as it relates to migration and/or access to habitats, Flow management as it relates to food supply* and *Flow management as it relates to fish habitat structure and cover.*

Flow management as it relates to migration and/or access to habitats

Hydrological modelling of the Taltson River (Section 13.3) indicates that the flow over the spillway channel adjacent to the Nonacho control structure would occur during summer/fall of high-water years only. The flow via Tronka Chua Gap would continue in late summer and fall during most years. Currently, there is a continuous flow via Nonacho spillway and Tronka Chua Gap. Therefore, fish movement between Nonacho and both Taltson and Tronka Chua lakes would be more restricted than current conditions.

The fish species comprising the Valued Components are lake trout, lake whitefish and northern pike. Unlike some fish such as arctic char, the VC species do not require long-distance migrations to complete any part of their life cycles.

Additionally, these fish populations are likely self-sustaining, because both Nonacho Lake (upstream of the control structure) and the Taltson, King, Lady Grey and Benna Thy lakes (downstream of the control structure) are large systems that provide all the necessary critical habitats for the life cycles of these fish species. Therefore, restriction of the potential for fish movement via the Nonacho spillway or Tronka Chua Gap is not anticipated to result in an ongoing effect on the fish populations either upstream or downstream of the Nonacho Lake control structure.

Flow management as it relates to food supply

The proposed decrease in water level would reduce direct fish access to riparian vegetation habitat and food supply via insect and plant detritus drop associated with that habitat. Additionally, the insect and detritus drop outside the wetted perimeter of the lake would not directly contribute to the lake ecosystem. Therefore, it is anticipated that the decrease in water levels would lead to a reduction in food supply for the fish populations of the Nonacho Lake.

This effect is anticipated to be temporary, as the riparian vegetation would re-establish at a lower elevation appropriate to the new water level regime

Northern pike actively uses riparian habitats by foraging amongst the stems, especially in the first year of life (Richardson et al. 2001; Evans et al. 2002). It is expected that northern pike would use alternative habitats, such as submergent vegetation. It is also expected some riparian vegetation communities, such as annual plants, would re-establish at the new water levels within the first year, providing forage and cover habitat for northern pike.

It is anticipated that the effect of water level changes would be minimal as there are other habitats that can serve as rearing and spawning habitats for northern pike. It can also be assumed that the reduction of habitat productivity would be temporary and would be restored when the vegetation becomes re-established in response to the changed water levels.

Flow management as it relates to fish habitat structure and cover

Preliminary data from Nonacho Lake indicate that the sedge meadow vegetation extends to the water depth of 0.8 m and that submergent vegetation can be found in less than 0.8 m of water. This vegetation comprises a part of the riparian fish habitat. The proposed regulated water level in Nonacho Lake would be 0.59 to 0.7 m lower than baseline levels throughout the year.

The potential effect of this change in water level is greatest in areas of gently sloping vegetated shoreline. In these areas the water level controls the degree of inundation of the vegetation.

Water level dropping below the existing footprint of riparian vegetation, would exclude fish form these areas. This can represent a loss of cover leaving fish more exposed to predators, as well as a loss of access to other important characteristics of that habitat.

In the longer term, an ongoing lowering of the water level would lead to an adjustment of the shoreline vegetation, as has been documented elsewhere (Patrick et al. 2002; Odland & del Moral 2002; Odland 2002). Emergent and submergent vegetation would likely re-establish the original inundation conditions, provided there is suitable substrate at the lower elevations.

The re-establishment of the existing vegetation under the new water level regime depends on the currently submerged substrate and the inundation characteristics of the proposed water management scheme.

The preliminary assessment of meadow-like riparian vegetation of Nonacho Lake found two variations of the lake margin vegetation conditions. At some sites there was a relatively abrupt drop-off at the open water margin (about 0.3 m) while at others the vegetation stems gradually decreased in density with water depth. Water depth is likely the controlling factor at the later sites and the vegetation would likely re-establish on the exposed substrate if the water level decreases. However, at the sites with a distinct edge to a meadow, it is likely that water depth is not the controlling factor to vegetation growth and it cannot be assumed that existing vegetation would colonize exposed substrates as the water level drops.

The riparian vegetation would, however, colonize appropriate substrates that would become available. Nonacho Lake is a large lake with many islands and bays, so it is likely that the riparian habitats would re-establish to be approximately equivalent to the existing conditions.

Current records indicate a wide range of annual water levels, so the vegetation is pre-adapted to varying conditions. Vegetative communities, particularly annual plants such as aquatic pondweeds, would likely grow opportunistically as suitable conditions arise. Therefore, the changes to aquatic vegetation (fish habitat) caused by minor changes in water level (i.e. < 1 m) would be minimal.

The water system in the study area has been managed for 40 years. Therefore, present vegetation exists under managed conditions. The proposed Project would not dramatically alter the established management regime. Shoreline vegetation would be subject to conditions similar to those of the past 40 years, with the exception of a lower water elevation.

Northern pike use riparian vegetation primarily for spawning and rearing. Pike are known to use submergent vegetation as well as emergent vegetation. It is anticipated that there would be a lower effect on the area of submergent vegetation communities. The northern pike are anticipated to use this habitat until the riparian marshes respond to the altered water level.

It is important to note that some riparian vegetation is anticipated to grow shortly after the changes in water level. This re-vegetation would be caused by germination and growth of dormant seeds in the nearshore sediments and opportunistic growth of annual plants from nearby seed sources. Although climax riparian vegetative communities may re-establish after 5 to 10 years, riparian vegetation would be present on the shoreline after a short period of time.

Therefore, this pathway would have a residual effect on riparian vegetated habitats, but the habitats would re-establish in response to the new water level regime within 5 to 10 years.

13.9.11.2.2 Zone 1: Taltson River from Outfall of Nonacho Lake to Tazin River Confluence

Under the 56 MW development scenario, the following pathway was classified as Valid for Zone 1: *Flow management as it relates to migration and/or access to habitats*.

Flow management as it relates to migration and/or access to habitats

This pathway is the same as *Flow management as it relates to migration and/or access to habitats* pathway for Nonacho Lake discussed previously in Section.13.9.9.4.

The restriction of the potential for fish movement is not anticipated to result in an ongoing effect on the fish populations downstream of the Nonacho Lake control structure.

13.9.11.2.3 Zone 2: Tronka Chua Gap to Outfall of Yatsore Lake

Under the 56 MW development scenario, the following pathway was classified as Valid for Zone 2: *Flow management as it relates to migration and/or access to habitats.*

Flow management as it relates to migration and/or access to habitats

This pathway is the same as *Flow management as it relates to migration and/or access to habitats* pathway for Nonacho Lake discussed previously in Section 13.9.9.4.

The restriction of the potential for fish movement is not anticipated to result in an ongoing effect on the fish populations downstream of the Tronka Chua Gap.

13.9.11.2.4 Zone 3: Taltson River between the Tazin River and Upstream of Tsu Lake

There is a change in the magnitude of potential effect of the pathway *Flow management as it relates to the displacement or stranding of fish (ramping)* downstream of the Twin Gorges power plant.

Flow management as it relates to displacement or stranding of fish

All the previous discussion (see Section 13.9.10.1.4.2) is germane to the 56 MW development scenario. The difference is that rather than being a one in two year event the reduction in water levels downstream of the power plant would become a one in five year event. This is because the generating flow capacity would be a greater proportion for the same total flow and hence, it is more likely that the plant would be operating at reduced capacity at the time of the scheduled shutdowns. At the time of writing, scheduled shutdowns are anticipated to coincide with the minimum annual flow (i.e. before the onset of freshet, in April/May). A detailed review of daily records indicates the turbines would be operating at full capacity every second year. In the years when the turbines are operating below capacity, the generating flow of the turbine taken out of service would be picked up the remaining two operational turbines. This means that there would be no change in the total flow through the Twin Gorges power plant and no change to the water level downstream.

Therefore, considering the frequency of anticipated reduction in water levels (i.e. every fifth year from every second year), the ranking of the potential effect of this pathway is reduced to Minor.

13.9.12 Effect Classification

As per the effects classification for the 36 MW expansion, incremental effects on northern pike, lake whitefish and lake trout were assessed relative to current conditions. Cumulative effects were discussed above but not assessed given the uncertainty of pristine conditions.

Three pathways of effect related to the Nonacho Lake control structure and two pathways of effect related to the Twin Gorges power facility may have a residual effect of fish population. The proposed water level management would reduce the water level in Nonacho Lake by approximately 0.7 m for the year. The change in flow over Nonacho spillway would restrict fish movement into and out of Nonacho Lake. However, this change is not expected to have any long-term effect on the fish populations in Nonacho Lake or the downstream lakes.

The incremental effects classification is summarized in Table 13.9.10.

Table 13.9.10 — Incremental Effect Classification for Pathways to Valued Components

Valued Component	Pathway	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Overall Residual Effect
Northern pike, Lake trout, Lake whitefish	Obstruction as it relates to fish entrainment	Adverse	Minor	Nonacho Lake and Zone 3: - Nonacho Lake, control structure only - Zone 3, Twin Gorges power plant only	Long-term	Reversible	Continuous	High	Low
Northern pike, Lake trout, Lake whitefish	Flow Management as it relates to migration and/or access to habitats	Adverse	Minor	Nonacho Lake, Zone 1 and Zone 2	Long-term	Reversible	Continuous	High	Low
Northern pike, Lake trout, Lake whitefish	Flow management as it relates to habitat structure and cover	Adverse	Minor	Nonacho Lake and Zones 2 & 3: - Zone 2, Tronka Chua Lake only - Zone 3, Twin Gorges Forebay only	Medium-term	Reversible	Continuous	High	Low
Northern pike, Lake trout, Lake whitefish	Flow management as it relates to food supply	Adverse	Minor	Nonacho Lake and Zones 2 & 3: - Zone 2, Tronka Chua Lake only - Zone 3, Twin Gorges Forebay only	Medium-term	Reversible	Continuous	High	Low

Valued Component	Pathway	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Overall Residual Effect
Northern pike	Flow management as it relates to displacement or stranding of fish (ramping)	Adverse	Minor	Zone 3: downstream of Twin Gorges power plant only	Long term	Reversible	Continuous	High	Low

The changes in hydrologic conditions are not predicted to change fish populations from current conditions. Thus, there are no predicted cumulative effects.

13.9.12.1 SIGNIFICANCE DETERMINATION

The overall significance of the potential effects of the Project is presented in Table 13.9.11.

Table 13.9.11 — Significance of Potential Effects to the Valued Components

Valued Component	Assessment Endpoint	Pathway	Overall Residual Effect	Overall Significance	Uncertainty
Northern pike	Fish mortality	Obstruction as it relates to entrainment	Low	Not significant	Medium
	Changes in fish access over Tronka Chua Gap and the Nonacho Lake spillway	Flow Management as it relates to migration and/or access to habitats	Low		
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate		
	Changes in food supply	Flow management as it relates to food supply	Low		
	Displacement or stranding of fish	Flow management as it relates to displacement or stranding of fish (ramping)	Low		
	Changes to depositional zones	Flow management as it relates to fish habitat structure and cover (Trudel Creek)	Low		
Lake Trout	Fish mortality	Obstruction as it relates to entrainment	Low	Not significant	Medium
	Changes in fish access over Tronka Chua Gap and the Nonacho Lake spillway	Flow management as it relates to migration and/or access to habitats	Low		
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Low		
	Changes in food supply	Flow management as it relates to food supply	Low		
Lake whitefish	Fish mortality	Obstruction as it relates to entrainment	Low	Not significant	Medium

Valued Component	Assessment Endpoint	Pathway	Overall Residual Effect	Overall Significance	Uncertainty
Lake whitefish	Changes in fish access over Tronka Chua Gap and the Nonacho Lake spillway	Flow Management as it relates to migration and/or access to habitats	Low	Not significant	Medium
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate		
	Changes in food supply	Flow management as it relates to food supply	Low		
	Changes to depositional zones	Flow management as it relates to fish habitat structure and cover (Trudel Creek)	Low		
	Displacement or stranding of fish	Flow management as it relates to displacement or stranding of fish (ramping) (Trudel Creek)	Low		
Walleye (Trudel Creek)	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate	Not significant	Medium
	Changes to depositional zones	Flow management as it relates to fish habitat structure and cover	Low		
	Displacement or stranding of fish	Flow management as it relates to displacement or stranding of fish (ramping)	Low		

The *Changes in riparian habitats*" and "C*hanges in accessibility of riparian habitats and vegetation comprising those habitats* endpoints both relate to the effect of water level changes on the riparian vegetation of Nonacho Lake. Lowering of water levels would decrease fish access to riparian habitats and, in the longer term, alter the characteristics of those habitats because the vegetation comprising them is dependant on the water level. The location of current habitats was determined by the previous alteration in water level. It is likely that the vegetation would similarly re-establish at the appropriate new elevations in response to the water management regime after some period of time.

The riparian habitats are used by northern pike for spawning and rearing. Current research indicates that, while these are preferred habitats, northern pike would also use other available habitats (Casselman and Lewis 1996). It is expected that the alternate habitats would be sufficient until the riparian vegetation becomes re-established.

The *Changes in fish movement (into and out of Nonacho Lake)* endpoint also relates to the lowering of the water level in Nonacho Lake. The water flow over the spillway or through Tronka Chua Gap would stop during some parts of the year, restricting fish passage from Nonacho Lake to downstream lakes.

Changes in Tronka Chua Gap flows represent return to the pristine conditions, as it is unlikely that there was regular flow through the Gap prior to the initial development.

The overall effect of changes in flows over Nonacho spillway is limited. Prior to the initial development, the river channel at the outlet of Nonacho Lake was likely an impediment or a barrier to fish movement, as it was either a waterfall or a steep cascade (T. Vernon & D. Grabke, personal communication 2008). Therefore, fish movement through this channel was likely directed primarily downstream. It is anticipated that there would be flows over the SVS in approximately one out of every four years, allowing some downstream fish movement.

It is important to note that the fish species of the Taltson River system do not need to migrate into Nonacho Lake to complete a part of their lifecycle (unlike arctic char, which must migrate upstream to spawn). The fish species would have access to the critical habitats throughout their life cycle independent of their location relative to Nonacho Lake control structure.

The residual effect is isolating the fish populations on either side of the control structure. There is no indication that these populations are not self-sustaining, so this change is not anticipated to have any lasting effect.

13.9.12.1.1.1 *Overall Significance of Project Effects*

The Project is not anticipated to have a significant overall effect on fish populations in the Taltson River system.

13.9.12.2 COMPARISON BETWEEN 56 MW AND 36 MW DEVELOPMENT SCENARIOS

The differences between the 56 MW development scenario and the 36 MW development scenario relate to the management of the Nonacho Lake control structure and the resulting effects on the water levels in Nonacho Lake and flows out of Nonacho Lake. The following differences were identified for the 56 MW development scenario:

- lower water level in Nonacho Lake,
- reduced flow over the Nonacho Lake spillway and Tronka Chua Gap, and
- reduced range of annual water level variation in Taltson and Tronka Chua lakes.

The operations of the 56 MW regime would likely result in the changes to riparian habitats in Nonacho Lake, while no such changes are anticipated under the 36 MW water management regime. The 56 MW regime would not result in changes to riparian habitats in Taltson and Tronka Chua Lakes, which are anticipated under the 36 MW water management regime.

All of the differences between the two development scenarios would be medium-term in duration, as they relate to anticipated changes in riparian vegetation. The vegetation is expected to return to a state analogous to its current condition within 5 to 10 years. Therefore, the long-term implications of the Project remain minimal.

13.9.13 Uncertainty

There are two areas of uncertainty in this discussion. The first uncertainty is whether the riparian vegetated habitats would become re-established in response to the lowered water level and altered water management regime in Nonacho Lake. The second is associated with the effect of the isolation of Nonacho Lake fish populations on the overall fish populations of the Taltson River system.

13.9.13.1 Riparian Vegetation

It is possible that the altered water level regime would preclude the re-establishment of shoreline vegetation if the high water would cover the shoreline vegetation throughout the growing season. If this happens periodically (e.g., once every five years) some riparian vegetation may not have a chance to recover sufficiently, which could lead to extensive bare areas on the banks.

The proposed water management regime would store Nonacho freshet in Nonacho Lake while the Tazin River freshet would be used for power production. Water from Nonacho Lake would be released when the Tazin freshet water can no longer generate the needed power. Nonacho Lake would be held at higher water levels through the early summer (anticipated peak is July-August) with water being released slowly in the fall.

Water Survey Canada data for the years 1998 through 2007 show that the water level usually peaks in June and then gradually decreases until late September or October. The range of high water varies from 323.9 m to 323.2 m. Under the proposed water management regime, average high water would occur in July and would be 322.6 m. However, the longitudinal hydrograph model output indicates that high water could vary from 322.0 to 323.8 m in any particular year, with the water level of 322.4 m or lower in the majority of the years. The hydrograph also indicates that there would be years when the water level would be higher than 323 m and that these events would generally occur two or more years apart. Therefore, some high water events would cause water level to be up to 1.5 m higher than the average 322.6 m. It is likely that most of the riparian vegetation would be inundated during these events. Some uncertainty is associated with whether the plants can survive that amount of inundation. More detailed analysis of the pre-existing water level changes as compared to the proposed water level regime in Nonacho Lake would decrease this uncertainty. If the pre-existing year-to-year variation is comparable to the variation anticipated under the proposed water management regime, it can be expected that the existing vegetation would re-establish with time.

The quality of vegetated riparian habitats is an issue for northern pike, which use these habitats preferentially for spawning and rearing. Research indicates that while these habitats are preferred, northern pike would use other habitats if emergent vegetation is not available. This suggests that the northern pike population in Nonacho Lake is not completely dependant on riparian vegetation and a reduction in the amount of that habitat might not adversely affect the fish population in the long term.

13.9.13.2 ISOLATING NONACHO LAKE FISH POPULATIONS FROM DOWNSTREAM POPULATIONS

There is uncertainty associated with the isolation of fish populations in Nonacho Lake from the downstream populations. It seems likely that both populations are self-sustaining and that anticipated isolation would result in reversion to pristine conditions. However, it is recognized that this would change the potential corridor for fish movement used for the last 20 years. It is likely that the fluvial conditions at the pristine outlet of Nonacho Lake comprised an impediment or a barrier to fish migration; however, it is difficult to determine this at the given time.

13.9.14 Monitoring

A monitoring program would be developed in detail with regulatory agencies that focuses on the key areas of concern and areas that are predicted to experience the greatest change from current conditions. Following review of the DAR, the areas of greatest concern would be identified via discussions with the Board, federal and territorial agencies, Aboriginal groups and the public.

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

APPENDICES

13. WATER FLUCTUATIONS IN THE TALTSON RIVER WATERSHED

13.10 WILDLIFE

13.10.1 Existing Environment

13.10.1.1 ECOLOGICAL CONTEXT

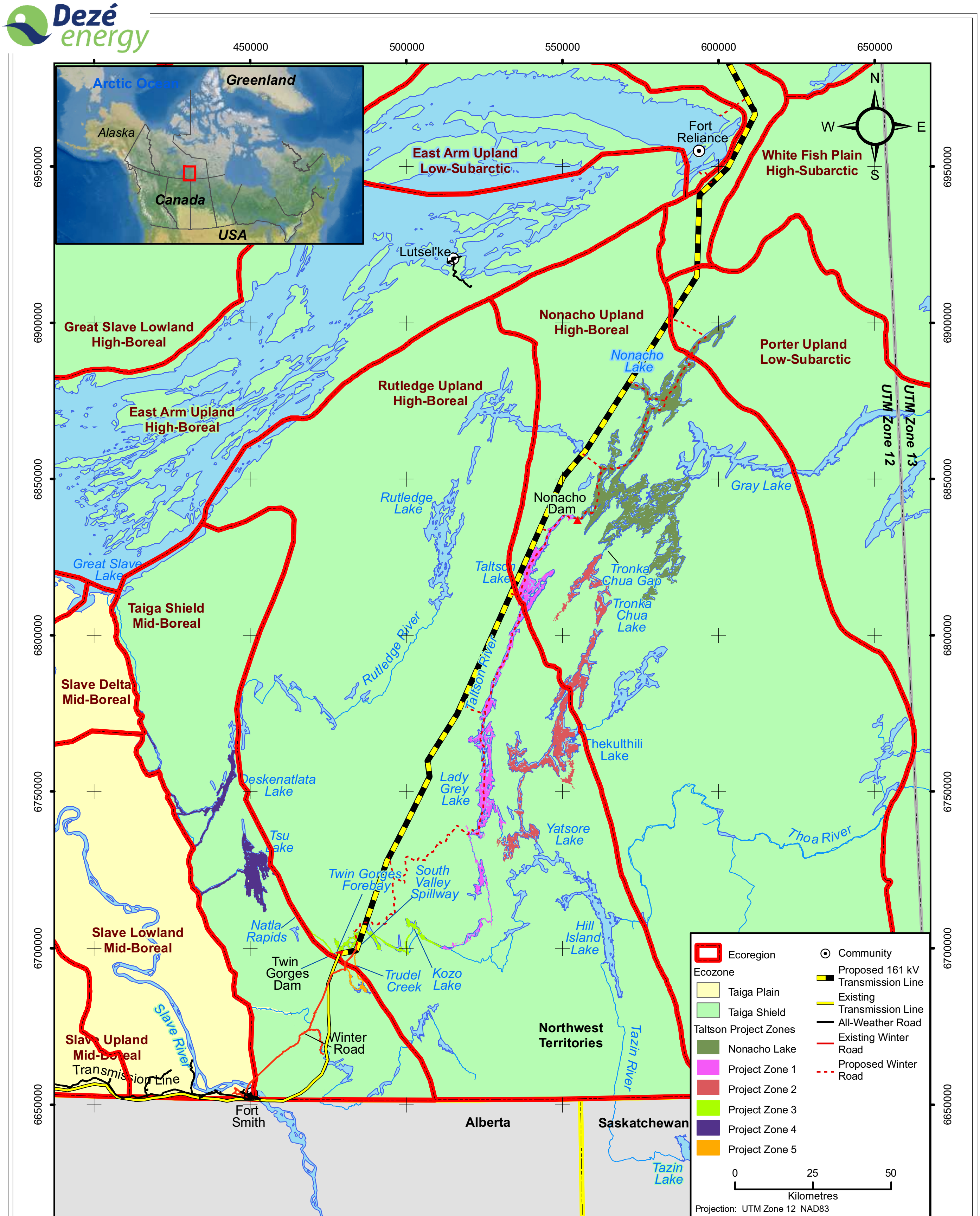
The Taltson Hydroelectric Expansion Project ("Project" or "Expansion Project") falls within the Taiga Shield ecozone (Figure 13.10.1; Environment Canada 2005; Ecosystem Classification Group 2007). Ecozones are large, generalized units at the top of the ecological hierarchy as defined by the Canada Committee on Ecological Land Classification (Ecological Stratification Working Group 1995). Ecozones are further subdivided into ecoprovinces and ecoregions (see Table 9.1.1). An ecoregion is part of an ecozone characterized by distinctive regional ecological factors, including climate, physiography, vegetation, soil, water, fauna, and land use. The ecoregions that overlap the Project area are the Taiga Shield Mid-Boreal, Rutledge Upland High-Boreal, Nonacho Upland High-Boreal, and Porter Upland Low-Subarctic ecoregions.

13.10.1.1.1 Rutledge and Nonacho Upland High-Boreal Ecoregions: Project Zones 1, 2, 3, and Nonacho Lake

The majority of the Project area assessed for hydrological changes lies within the Upland High-Boreal (HB) ecoregions, Rutledge and Nonacho. These ecoregions are characterized by a sub-humid, high boreal ecoclimate. The mean annual temperature ranges between -3°C and -6°C (Environment Canada 2005). The mean annual precipitation ranges from 280 mm to 360 mm, with most of the precipitation falling as rain during the summer months. Permafrost is extensive but discontinuous throughout most of this area. This ecoregion contains hummocky, gently-sloping bedrock ridges and plains. Organic landforms are not common because terrain is hummocky to rolling bedrock or bouldery till. Common peatland types are peat plateaus, peat palsas, floating fens, and shore fens.

Continuous till blankets and extensive fires have produced a landscape dominated by jack pine regeneration; young jack pine stands are common on recently burned outwash and bedrock. Elsewhere, closed black spruce stands with lichen and shrub understories are dominant; paper birch or dwarf birch regeneration are common on recent burns. Moss forests with a moderately dense black spruce, white spruce, or jack pine canopy occur in areas with deeper, moister soils such as the thicker till deposits in the southeast and lacustrine pockets along the western boundary. These forests usually have a shrubby or feather moss understorey. These ecoregions contain numerous small lakes linked by fast-flowing streams that eventually drain into Great Slave Lake. Strongly glaciated rock outcrops are common.

Within the Taiga Shield ecozone, the abundance of water attracts hundreds of thousands of waterfowl, which either rest and feed on their way to Arctic breeding grounds or nest in the ecozone. Bird species include the Arctic and red-throated loon and the northern phalarope (Environment Canada 2005). Wildlife includes moose, black bear, woodland caribou, wolf, beaver, muskrat, snowshoe hare, and spruce grouse. Mink are common near water bodies and wetlands that provide suitable habitat. Otters are found near fish-bearing streams.



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Ecoregions that fall within the Taltson Hydroelectric Expansion Project Area**	**Figure 13.10.1**

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13.10.1.1.2 Porter Upland Low-Subarctic Ecoregion — Nonacho Lake Project Zone

The Taiga Shield Low-Subarctic (LS) ecoprovince extends from the northwest to southeast in a broad band across the Taiga Shield. Level to rolling and hilly bedrock with thin bouldery till veneers, open black spruce stands, and large burned areas are characteristic landscapes. Bouldery till and outwash are dominant on the southern two-thirds, with more rugged, bedrock-dominated topography in the northern third. Black-spruce-lichen, fire-successional jack pine, and paper birch stands are the dominant vegetation cover. Peat plateaus and slow-growing open conifer stands across most of the region are indicative of an LS climate, as defined by the Ecoregions Working Group (1989) and Bradley et al. (1982). The mean annual temperature ranges from -3.5˚C to -9˚C. The mean temperature ranges from -27˚C to -29˚C in January, the coldest month, and from 11˚C to 16˚C in July, the warmest month. Mean annual precipitation is between 230 mm and 430 mm, with the wettest period occurring between June and October; about 60% falls as rain and 40% as snow.

The Porter Upland LS ecoregion is a gently north-sloping low-relief plain with thin bouldery till deposits overlying Precambrian metamorphic rock. Vegetation patterns within this ecoregion consist of open black spruce —Labrador tea —dwarf birch —lichen communities dominant on till and outwash, along with white spruce —lichen stands. Much of the ecoregion has burned in the recent past and is now vegetated by young jack pine and paper birch forests, with understories of dwarf birch, Labrador tea, and lichens.

This ecoregion provides important habitat for a variety of wildlife including barren-ground caribou, wolves, and red foxes. In the winter, otters can be found near open river sections that provide access to fish.

13.10.1.1.3 Slave Plain Mid-Boreal Ecoregion — Project Zone 4

The Taiga Shield Mid-Boreal (MB) ecoprovince lies within the Taiga Shield ecozone. It is bounded on the east by the Rutledge Upland High —Boreal ecoregion and the Taiga Plain ecozone on the west (Ecosystem Classification Group 2007). This ecoprovince contains the most south-western Project area. It has a mid-boreal climate with the mildest conditions in the NWT. The mean annual temperature ranges from —3.0˚C to —4.0°C. The mean temperature is —22°C in January, the coldest month, and 16°C in July, the warmest month. Mean annual precipitation is between 330 mm and 360 mm, with the wettest period occurring between May and October and the driest period between November and April. About 60% of the precipitation falls as rain and 40% as snow. Permafrost is uncommon.

Peatlands cover nearly a third of the Taiga Shield MB ecoprovince. Fens are the characteristic wetland; they cover large areas and are interspersed with sedge and grass meadows and upland forests. Productive mixed-wood, deciduous, and coniferous stands occur on imperfectly- to well-drained lacustrine and fluvial deposits, which are most extensive in the southern half of the ecoregion. The dominant tree species are trembling aspen, Jack pine, and white and black spruce. The understorey consists of typical boreal species such as low-bush cranberry, prickly rose, and reed-bentgrass. The species found within moist meadows are awned sedge, reed-bentgrass, and other grasses, sedges, and forbs. The grass and sedge meadows found in this ecoregion provide habitat for bison and moose.

Wildlife species in the Slave Plain ecozone include moose, woodland caribou, wood bison, wolf, black bear, marten, lynx, muskox, and Arctic ground squirrel (Environment Canada 2005). Mink and otters are also common near water bodies and other wetlands with suitable habitat. The Taiga Shield MB ecoprovince contains the highest diversity of vegetation and avian habitats in the Taiga Shield. Reported bird observations are highest along the shores of Great Slave Lake at the northern boundary of the ecoregion and near the community of Fort Smith, close to the south-western corner. Common raptors include: bald eagles, ospreys, northern goshawks, sharp-shinned hawks, red-tailed hawks, American kestrels, merlins, and northern harriers. Rough-legged hawks (a variety of owl species) and shorebirds are among the many avian migrants using the area as they travel farther north. The many lowland wetlands within the Taiga Shield MB ecoprovince provide prime habitat for a large variety and abundance of dabbling ducks. Diving ducks and other fish-eating birds frequently nest on the shorelines of Great Slave Lake and along the Taltson River, where fish are readily available. The Mackenzie Valley also forms one of the most travelled migratory routes for waterfowl in North America.

13.10.1.2 Land and Resource Management

Land uses within these ecoregions include hunting, fishing, wildlife trapping, outdoor recreation, and limited local saw-log forestry (Environment Canada 2005). The main activities are mining, oil and gas extraction, and some forestry and tourism. Nonacho Lake has a fishing lodge used by Łutsel K'e residents (Rescan 2004b), and used to have a commercial fishery. Taltson Lake and River in Zone 3 support sport fisheries; recreationists and local hunters and trappers also use the river.

13.10.1.3 Data Sources and Local Wildlife Information

Wildlife surveys were conducted in the Project area as part of baseline studies and the Northwest Territories Power Corporation's (NTPC) Water Effects Monitoring Program (WEMP). Aerial surveys were conducted for beaver and muskrat in 2000 and 2001, respectively, as part of the WEMP (Rescan 2000; 2001). In 2003, a follow-up aerial beaver survey was conducted as part of the WEMP (Rescan 2004b). Aerial surveys were flown in 2003 and 2004 to document raptors, waterfowl, ungulates, and carnivores as part of baseline studies (Rescan 2004a). In 2008, baseline studies were conducted to document the presence of yellow rail, waterfowl, and northern leopard frogs within the Taltson Basin (Rescan 2008a). However, the majority of the data, though still partial, were collected within Nonacho Lake and sections of Zone 1 and Zone 3. There are no baseline data for wildlife groups in Zone 2 and Zone 4.

13.10.1.3.1 Modelling

Many of the wildlife effects addressed in this section rely on models developed for this Project. This includes the hydrological model for Nonacho Lake and Zones 1 to 4 (Section 13.3) and the wetlands model that was developed for Nonacho Lake and Zone 1 (Section 13.6).

13.10.1.4 FURBEARERS

Several stream-resident mammals occur in the study area, including beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), river otter (*Lontra canadensis*), and American mink (*Neovison vison*). Beaver and muskrat are both important food and economic resources and concerns regarding their continued abundance in the Project area have been expressed (see Section 9.6).

13.10.1.4.1 Beaver (*Castor canadensis*)

For background biological information on the beaver, including results from baseline studies, refer to Section 9.5.5.9. Beaver abundance within the surveyed Project zones is shown in Table 13.10.1.

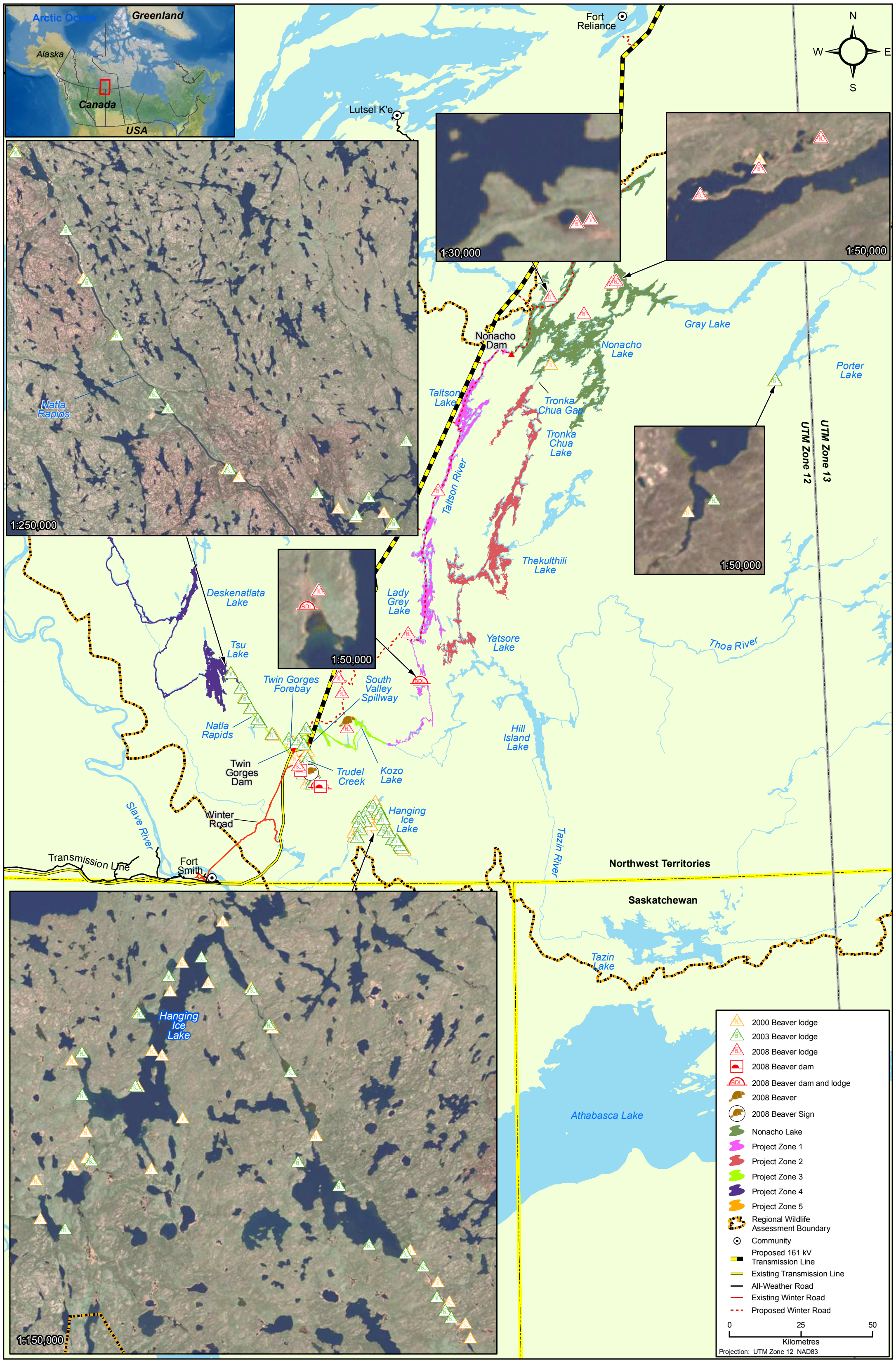
Beaver typically build lodges on lake or river margins; their underwater entrances are made from sticks and mud where water is deep enough to prevent winter freeze-up. Bank-dwelling beavers are exposed to greater changes in water levels. Peak flow in arctic rivers occurs in spring and can be greater than 10 times the base flow compared to the remainder of a year. Peak flow increases water levels, which often flood the dens inside beaver lodges and can remove beaver dams and food piles (Hill 1982). They may also build burrows in the banks of fast-flowing streams, particularly at southern latitudes. In areas where water levels are low, beavers build dams, which provide a constant water depth. In the resulting ponds they build lodges and food piles.

Beavers are considered a landscape keystone species. Dam-building modifies riparian habitats to include more wetlands, more open-water areas in existing wetlands, and significantly changes vegetation structure surrounding wetlands (Merritt & Cooper 2000). Bank-dwelling beavers have fewer significant effects on habitats than dam-building beavers, but can significantly alter the composition of woody plants along lake and riverbanks. The relative numbers of dam-building and bank-living beavers in the Project area is unknown.

Table 13.10.1 — Results of Aerial Beaver Surveys

Water body	# Active Lodges (2000)	# Active Lodges (2003)	# Active Lodges/Linear km Flown Shoreline (2000)	# Active Lodges/Survey Hour (2003)
Nonacho Lake	2	0	0.008	0
Taltson River (Zone 3)	5	7	0.133	13.1
Twin Gorges Forebay (Zone 3)	4	5	0.180	6.3
Porter Lake[1]	1	1	0.015	1.2
Hanging Ice Lake and Tethul River[1]	24	19	0.662	17.5

[1] Selected as reference/control sites.



TALTSON HYDROELECTRIC EXPANSION PROJECT	Developer's Assessment Report 2009	Beaver Observations within the Taltson River Watershed	Figure 13.10.2

13.10.1.4.2 Muskrat (*Ondatra zibethicus*)

For background biological information on the muskrat, including baseline survey results refer to Section 9.5.5.10. Muskrat abundance within the surveyed Project zones is shown in Table 13.10.2.

Muskrat occur in marshes, ponds, lakes, and slow-moving rivers. The Project area falls at the edge of their range, which follows the treeline (Erb & Perry Jr. 2003). Muskrats in southern populations can have multiple litters a year; litter number decreases with increasing latitude, and populations at the northern edge of the range may only have a single litter per year (Erb & Perry Jr. 2003; Simpson & Boutin 1993). Muskrats build a variety of structures depending on available habitat. Along rivers, where bank substrate is appropriate for digging, they dig extensive burrows with underwater entrances as a defence against predators. The entrances to these burrows are usually 15 cm below the water surface (Rezendes 1999). In marshes, muskrat build lodges out of vegetation and mud. Lodges vary in height from 40 cm to 180 cm (Kiviat 1978; Rezendes 1999). Lodge construction occurs in areas with water depths that average 30 to 40 cm and may be as low as 10 to 15 cm (Erb & Perry Jr. 2003). They also build feeding platforms and "push-ups" (i.e. shelters made of vegetation that cover a hole in the ice used for feeding and breathing holes). Push-ups are typically more numerous and smaller than muskrat lodges (Rezendes 1999). Push-ups vary from 30 to 46 cm in height above the ice (Erb & Perry Jr. 2003).

Table 13.10.2 — Results of Aerial Muskrat Survey

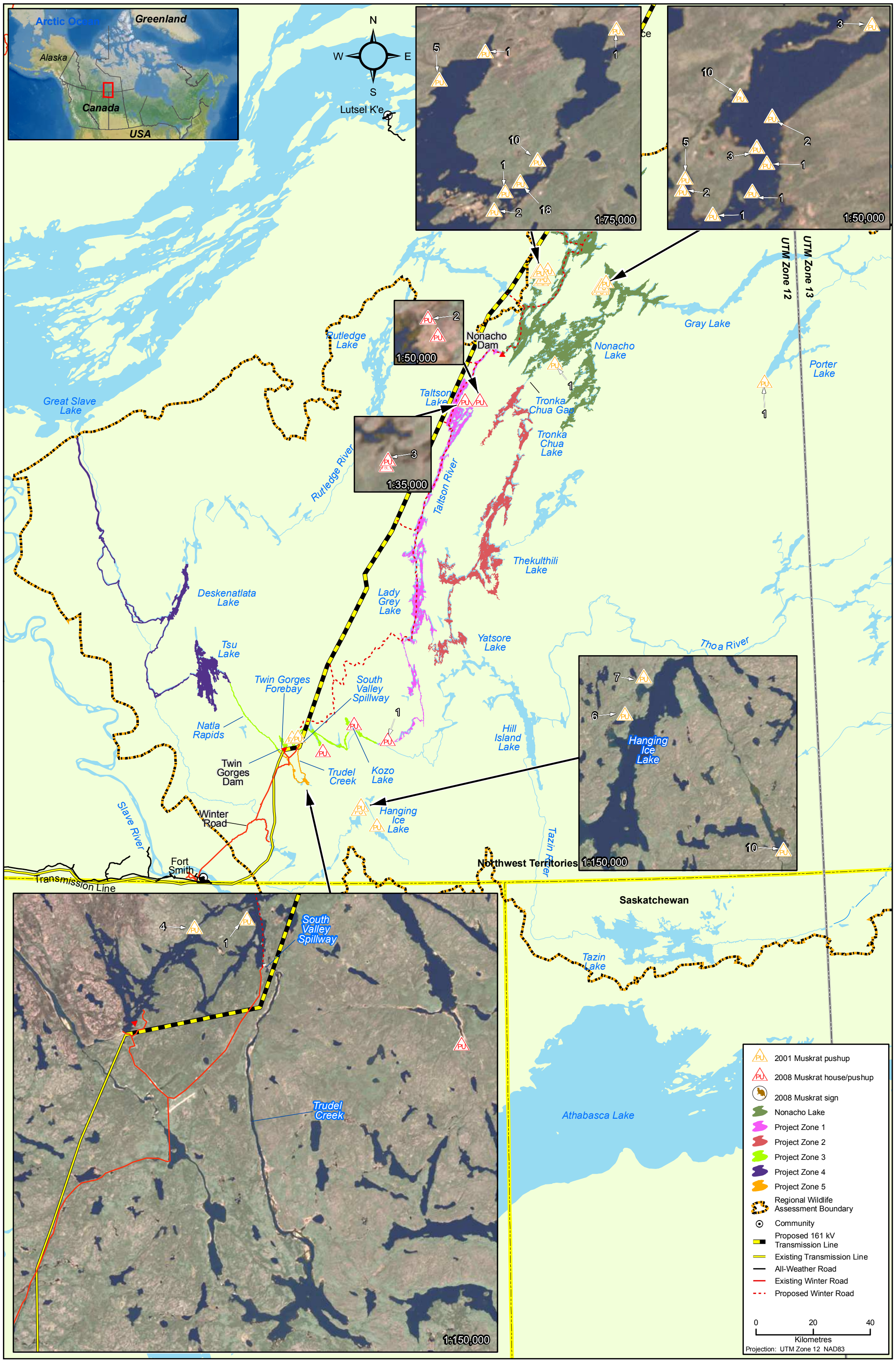
Water body	# Muskrat Push-ups	# Muskrat Push-ups/linear km Flown Shoreline
Nonacho Lake	67	0.282
Twin Gorges Forebay (Zone 3)	5	0.225
Porter Lake[1]	1	0.151
Hanging Ice Lake and Tethul River[1]	23	0.634

[1] Selected as reference/control sites.

13.10.1.4.3 River Otter (*Lontra canadensis*)

For background biological information on the river otter including results from an aerial carnivore track survey, refer to Section 9.5.5.8 — Key Mammals: River Otter.

River otters exploit a variety of wetlands including lakes and ponds, as well as riverine habitat; they are capable of travelling long distances over land to access aquatic environments. Riparian habitat, particularly areas with fallen trees and woody debris, is important for otters (Melquist 1997). Structural complexity in stream or shoreline areas often promotes prey species diversity by providing shelter for fish and aquatic invertebrates. These areas are then used as foraging grounds by otters. Fish form the largest part of their diet; when fish are limited, they may eat crayfish, amphibians, reptiles, birds, or terrestrial vertebrates (Melquist 1997). Otters do not build houses or burrows (Ontario Fur Managers Federation 2008), but use abandoned beaver dams or established burrows and cavities along the shore for security and overwinter denning (Melquist 1997; Ontario Fur Managers Federation 2008). In Melquist & Hornocker (1983; as cited in Melquist 1997) and Martin (2001), beaver presence was shown as important for otters because beaver dams create foraging and secure habitat for otters.



TALTSON
HYDROELECTRIC EXPANSION PROJECT

Developer's Assessment Report 2009

Muskrat Observations within the Taltson River Watershed

Figure 13.10.3

13.10.1.4.4 American Mink (*Neovison vision*)

For background biological information on the American mink including results from an aerial carnivore track survey, refer to Section 9.5.5.9 — Key Mammals: Mink.

Mink are active hunters in both upland and aquatic habitats; their diet includes aquatic invertebrates, fish, insects, and a variety of small mammals and amphibians. Mink build shallow burrows along rivers and under logs and will often usurp burrows dug by other species, particularly muskrats (Melquist 1997). Riparian areas provide the necessary food and security elements required by mink, making them a determining factor in mink habitat quality (Martin 2001; Melquist 1997). In particular, mink often use streamside areas with fallen trees and logjams, i.e. banks with high proportions of woody debris, as foraging sites for aquatic invertebrates and temporary security habitat from predators (Melquist 1997; Ontario Fur Managers Federation 2008). The woody debris provides excellent security and cover while hunting. Along the shoreline, these areas also provide suitable burrowing habitat.

13.10.1.5 Moose (*Alces alces*)

For background biological information on moose including results of baseline surveys, refer to Section 9.5.5.7.

Evidence of moose has been documented in Zone 1, Zone 3, and at Nonacho Lake (Figure 13.10.4). Moose observations were recorded during aerial surveys for raptors, waterfowl, and ungulates in 2003, 2004, and 2006 (Rescan 2004a). Moose and moose sign (tracks and pellets) were incidentally observed during wildlife and wetland surveys in 2008 (Figure 13.10.4; Appendix 13.10A).

13.10.1.6 Birds

13.10.1.6.1 Waterfowl

For background biological information on waterfowl including baseline studies in the Project area, refer to Section 9.5.3.4.

Waterfowl that build their nests on the ground close to water, feed primarily on fish, and/or feed on submerged aquatic plants within the littoral zone may be particularly affected by hydrological changes. Bird species observed in the Project area that may be affected by hydrological changes are listed in Table 13.10.3. There were 37 species observed in the Project area that fit one or more of the criteria described above. Ground-nesters may be affected by changes to the riparian habitat. Piscivorous species may be affected by bioaccumulation of methylmercury. The common loon is an example of a species that falls under both of these criteria.

13.10.1.6.2 Whooping Crane (*Grus americana*)

For background biological information on whooping crane including incidental observations during baseline studies within the Project area, refer to Section 9.5.7.3.10.

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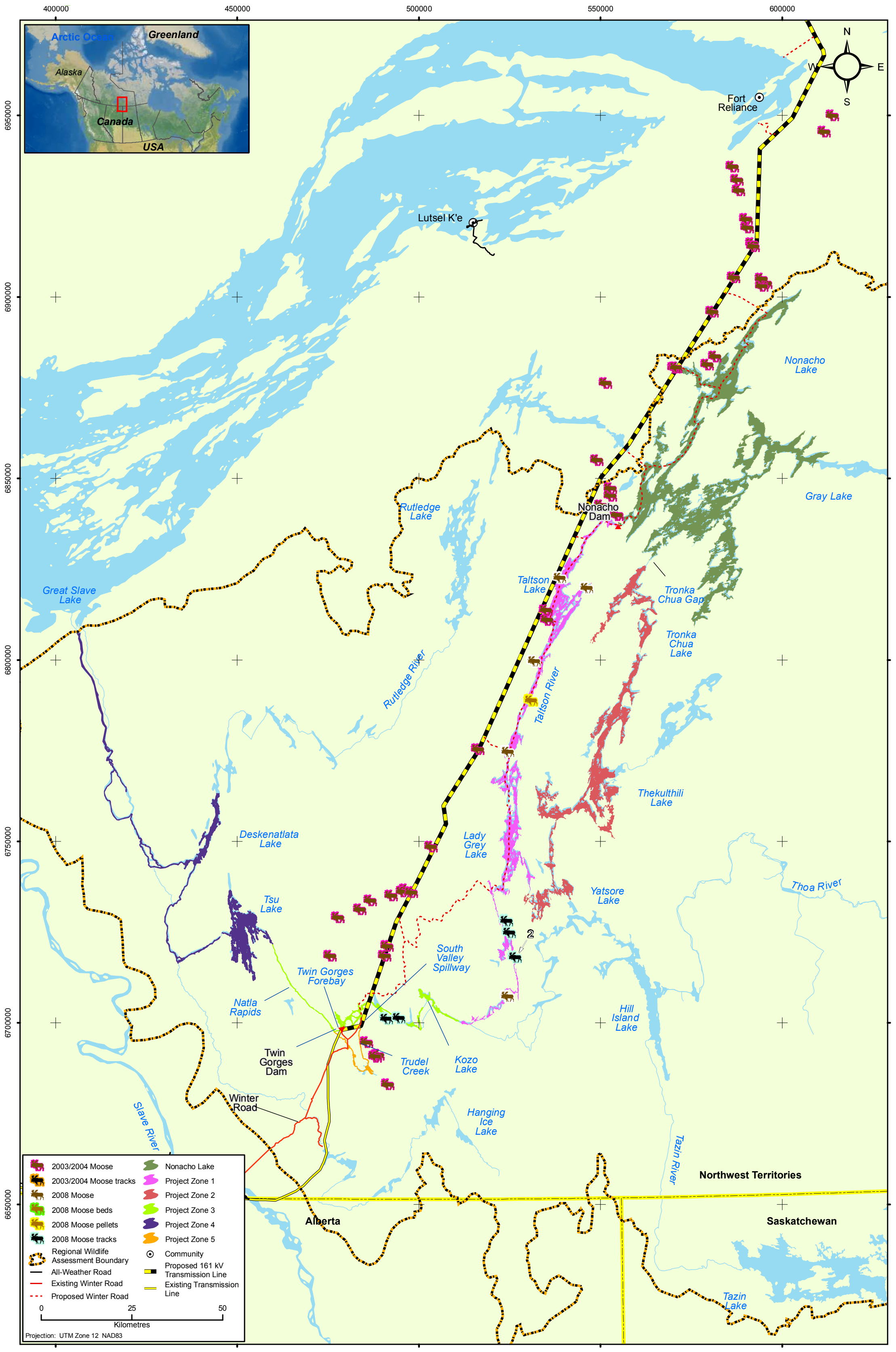


TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Moose Observations within the Taltson River Watershed**	**Figure 13.10.4**

Table 13.10.3 — Bird Species Observed within the Taltson River Watershed that are Ground-nesting or Have a Piscivorous or Aquatic Vegetation Diet

Avian Group	Common Name	Scientific Name	Ground-Nesting	Piscivorous Diet	Aquatic Plant Diet
Loons	Common loon	*Gavia immer*	X	X	
	Pacific loon	*Gavia pacifica*	X	X	
	Red-throated loon	*Gavia stellata*	X	X	
Grebes	Horned grebe	*Podiceps auritus*	X	X	
	Red-necked grebe	*Podiceps grisegena*	X	X	
Pelicans	American white pelican	*Pelecanus erythrorhynchos*	X	X	
Bitterns	American bittern	*Botaurus lentiginosus*	X		X
Swans	Tundra swan	*Cygnus columbianus*	X		X
Geese	Canada goose	*Branta canadensis*	X		X
	Greater white-fronted goose	*Anser albifrons*	X		X
	Snow goose	*Chen caerulescens*	X		X
Waterfowl	American wigeon	*Anas americana*	X		X
	Blue-winged teal	*Anas discors*	X		X
	Bufflehead	*Bucephala albeola*		X[1]	
	Common goldeneye	*Bucephala clangula*		X	
	Common merganser	*Mergus merganser*	X	X	
	Eurasian wigeon	*Anus Penelope*	X		X
	Greater scaup	*Aythya marila*	X	X[1]	X
	Green-winged teal	*Anas crecca*	X		X
	Hooded merganser	*Lophodytes cucullatus*		X	
	Lesser scaup	*Aythya affinis*	X	X[1]	X
	Long-tailed duck	*Clangula hyemalis*	X	X	X
	Mallard	*Anas platyrhynchos*	X		X
	Northern pintail	*Anas acuta*	X		X
	Northern shoveler	*Anas clypeata*	X		X
	Red-breasted merganser	*Mergus serrator*	X	X	
	Ring-necked duck	*Aythya collaris*	X		X
	Surf scoter	*Melanitta perspicillata*	X	X[1]	
	White-winged scoter	*Melanitta fusca*	X	X[1]	

Avian Group	Common Name	Scientific Name	Ground-Nesting	Piscivorous Diet	Aquatic Plant Diet
Gruids	Sandhill crane	*Grus canadensis*	X		
	Sora	*Porzana carolina*	X		
	Whooping crane	*Grus americana*	X		
Shorebirds	Greater yellowlegs	*Tringa melanoleuca*	X	X	
	Lesser yellowlegs	*Tringa flavipes*	X	X	
	Solitary sandpiper	*Tringa solitaria*	X	X	
	Spotted sandpiper	*Actitis macularia*	X		
	Wilson's snipe	*Gallinago delicata*	X	X[1]	

[1] molluscs/clams more than fish.

13.10.1.6.3 Songbirds

For background biological information on songbirds, refer to Section 9.5.3.3.

13.10.1.6.4 Rusty Blackbird (*Euphagus carolinus*)

For background biological information on rusty blackbird, refer to Section 9.5.7.3.13.

13.10.1.6.5 Raptors

For background information on raptors, refer to Section 9.5.3.2.

Any species that consumes fish and may be affected by bioaccumulation of methylmercury could be affected by hydrological changes. Two species observed in the Project area that have a piscivorous diet are the bald eagle and osprey. Bald eagles were observed at Nonacho Lake and in Zone 1 (Appendix 13.10A). Osprey were detected within the RAB (Rescan 2004a).

13.10.1.7 AMPHIBIANS

Two amphibian species were observed within the Project area, the wood frog (*Lithobates sylvaticus*) and the northern leopard frog (*L. pipiens*). The wood frog has the largest range of any amphibian within Canada and is considered widespread and abundant (CARCNET 2008). The northern leopard frog is a federal Species of Special Concern (Committee on the Status of Endangered Wildlife in Canada [COSEWIC] 2000) and is discussed further below.

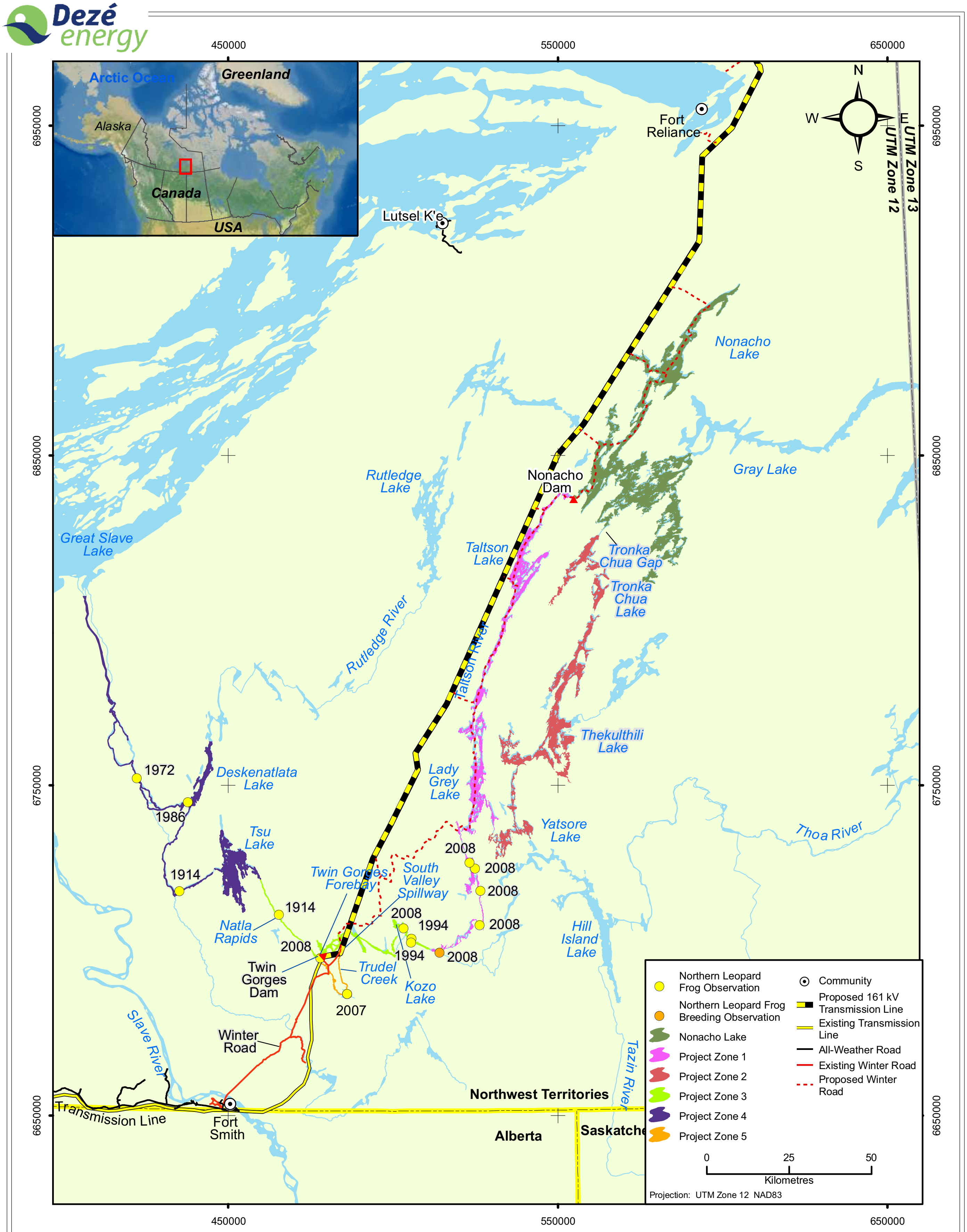
13.10.1.7.1 Northern Leopard Frog (*Lithobates pipiens*)

For background biological information on the northern leopard frog, refer to Section 9.5.7.3.6.

The Prairie populations of the northern leopard frog that extend into the NWT are federally designated as a species of Special Concern by COSEWIC (2000) because of population losses, range contraction, and increased isolation of remaining populations. The GNWT has designated this species as sensitive (Working Group on General Status of NWT Species 2006). Threats and their degree vary greatly across its range. Threats include habitat loss, commercial over-exploitation, and in some areas, probably competition/predation by bullfrogs or other introduced species.

Laboratory results suggest that there might be an interaction between crowding, temperature, and mortality from bacterial infection (e.g., red-leg disease). Agricultural chemicals such as atrazine have caused frog feminization in agricultural areas (Seburn & Seburn 1998). Although the range of the northern leopard frog is limited in the NWT, it has been documented in the Taltson River basin (Figure 13.10.5; Fournier 1997; Government of Northwest Territories [GNWT] 2008; R. Gau, personal communication, Sept. 30, 2008). The Taltson River basin is at the very northern edge of the species' range. Wildlife populations at the edge of their ranges are particularly important because of potential genetic differences and adaptations compared to populations within the center of their range; therefore, such populations are considered potential contributors to future speciation events (Lesica & Allendorf 1995).

Northern leopard frogs were observed at two sites along the Taltson River in Zone 3 and five along the Taltson River in Zone 1. One of the locations detected in Zone 1 was a breeding site. The breeding pond habitat was isolated from regular inundation from the Taltson River but was within the floodplain area and might become flooded in high-water years. Northern leopard frogs primarily use riparian habitat along the Taltson River as summer foraging habitat and not as breeding habitat. The Taltson River system's flows continue throughout the winter and therefore may provide important overwintering habitat because the aquatic environment would not freeze solid.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Observations of Northern Leopard Frogs in the Taltson River Watershed	Figure 13.10.5

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13.10.1.8 WETLANDS

Detailed wetland information can be found in Section 13.7. Dominant wetland types within Zone 1 and Nonacho Lake include riparian marshes, fens, and bogs. Riparian marshes were the most common wetlands observed during wetland surveys in 2008, and *Carex utriculata, Carex aquatilis, Carex lasiocarpa, Equisetum hyemale*, and/or *Calamagrostis Canadensis* tend to dominate the environment. Marsh communities occur on riverbanks in the riparian area. A few scattered bogs and fens were also observed adjacent to rivers at the northern end of the Project area and were composed of floating sedge-sphagnum mats.

13.10.2 Valued Components

13.10.2.1 VALUED COMPONENT SELECTION

Species or wildlife communities were chosen as Valued Components (VCs) based a number of different criteria. They were included if they:

- were identified in the Terms of Reference (TOR),
- were identified as important species through community consultation (i.e. identified as socially, culturally, or economically important), or
- if they were species at risk that are federally listed by COSEWIC, the Species at Risk Act (SARA), or designated as At Risk by the GNWT General Status Ranking (GNWT 2008; see Section 9.5.7.3).

Semi-aquatic furbearers that use riparian habitat were identified within the TOR as a wildlife community to consider. Furbearer species that were chosen as VCs were beaver and muskrat. Beaver and muskrat were both identified as valued ecosystem components during the community consultation with local stakeholders performed for the 1999 WEMP (Clark 1999) and are harvested as a food item and for commercial purposes (see Chapter 9.6).

Moose were selected as a VC because they are an important dietary component for the residents of Fort Resolution, Fort Smith, and Łutsel K'e (see Section 9.6). Moose are also associated with wetland and riparian habitat and are an important prey species for wolves in the Taiga Shield High-Boreal Ecoregion (Ecosystem Classification Group 2008). Moose use riparian habitat for foraging and seasonal cover.

Waterfowl that use riparian habitat were also identified within the TOR as a wildlife community to assess (see Section 9.6). Ground-nesting shorebirds were included with ground-nesting waterfowl as they have overlapping habitat requirements. Waterfowl and shorebirds use riparian habitat for foraging, cover, and reproduction. Migratory birds including waterfowl, cranes, and shorebirds are protected under both the NWT Wildlife Act (1988) and the Migratory Birds Convention Act (1994). The Migratory Birds Convention Act (1994) states "no person shall disturb, destroy or take a nest, egg…of a migratory bird." Waterfowl, such as the common loon, and raptors that primarily rely on fish for their diet were also assessed because of concerns regarding potential mercury bioaccumulation.

The federally-listed species at risk that were chosen as VCs were northern leopard frog, whooping crane, and rusty blackbird, because these species use riparian and wetland habitat (see Section 9.5.7.3). These species are all afforded protection under

SARA (2002). The northern leopard frog in the Project area is thought to primarily use riparian habitat for summer foraging and possibly overwintering. Whooping cranes use riparian habitat for foraging and roosting. Rusty blackbirds use riparian habitat for foraging, reproduction, and roosting.

13.10.2.1.1 Rationale for Excluding Assessment of Effects on a Species

The federally listed species that were not included as VCs for this Key Line of Inquiry (KLOI) were short-eared owl, common nighthawk, olive-sided flycatcher, and peregrine falcon. None of these species are solely dependent on aquatic or riparian habitat (see Section 9.5.7.3), and therefore were not included for assessing effects caused by hydrological changes. The yellow rail was not chosen as a VC because documentation of this species within the Project RAB has not been confirmed.

13.10.2.2 Assessment Endpoints

The assessment endpoint for furbearers, moose, and waterfowl is preservation of harvesting opportunities within the Taltson River watershed (excluding Trudel Creek; Table 13.10.4). This implies preservation of habitat and populations to maintain abundance levels in order that harvesting opportunities may continue. The assessment endpoints for waterfowl, shorebirds, raptors that primarily consume fish, whooping crane, rusty blackbird, and northern leopard frog are preservation of habitat and populations within the Taltson River watershed (excluding Trudel Creek). The wildlife VCs occur throughout the Taltson River watershed and are not restricted to only the Project zones. Therefore, preservation of harvesting opportunities, habitat, and populations were considered within the broader regional context.

Table 13.10.4 — Wildlife Valued Components and Assessment Endpoints

Key Line of Inquiry	Valued Component	Assessment Endpoint
Water fluctuations in the Taltson River watershed	Furbearers	Preservation of furbearer harvesting opportunities within the Taltson River watershed
	Moose	Preservation of moose harvesting opportunities within the Taltson River watershed
	Waterfowl and shorebirds	Preservation of waterfowl harvesting opportunities within the Taltson River watershed
		Preservation of habitat and populations within the Taltson River watershed.
	Raptors that primarily consume fish	Preservation of populations within the Taltson River watershed
	Whooping crane	Preservation of habitat and populations within the Taltson River watershed.
	Rusty blackbird	Preservation of habitat and populations within the Taltson River watershed
	Northern leopard frog	Preservation of habitat and populations within the Taltson River watershed

13.10.3 Assessment Boundaries

The assessment boundaries for this Project are both spatial and temporal, as discussed below.

13.10.3.1 SPATIAL BOUNDARY

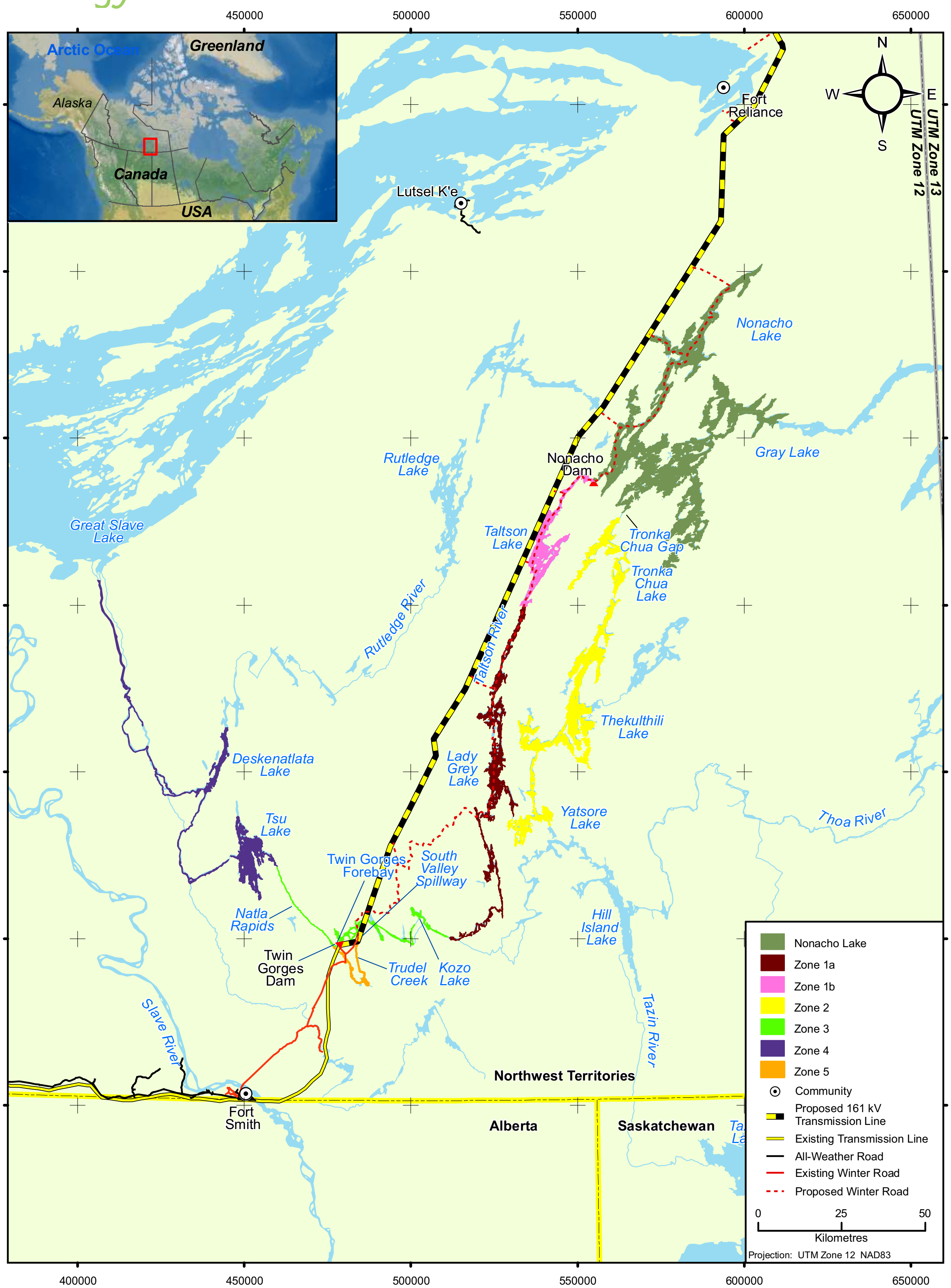
Small-scale spatial boundaries for wildlife were defined by zones within the Taltson watershed including a 500 m buffer from the hydrologic zones (Nonacho Lake and Zones 1 to 4; Figure 13.10.6). This area is considered appropriate for assessing effects to wildlife that are dependent on riparian habitat, as some wetland areas within the Project area extend far beyond the waterline. The regional assessment boundary (RAB) for wildlife is the Taltson River watershed, which includes Nonacho Lake and Zones 1 to 5 (Figure 13.10.7). The watershed boundary was used because the KLOI examines water level fluctuations within the Taltson River watershed and because this boundary encompasses population ranges of the VCs selected. A medium-scale boundary between local and regional that included multiple zones of the watershed (but not the entire watershed) was also used for effects classification.

13.10.3.2 TEMPORAL BOUNDARY

Two components were considered when selecting the temporal assessment boundaries for the effects assessment:

1. Duration of Project Activities. Project activities are highly correlated with the various phases of the Project; construction, operations and decommissioning and closure. Construction is not covered in the Taltson KLOI but is addressed in the Section 15.2 — Canal Construction. Currently, the Project is expected to operate for 20 years to service the existing and proposed diamond mines. However, the infrastructure would have a lifespan of at least 40 years, and it Dezé's intent to solicit new customers to extend the Project beyond 20 years. Subsequently, the expected length of time that Project-related stressors would influence VCs during the operation phase is assumed to be 40 years. Although Dezé intends to operate the Project longer than 40 years if customers can be found, increasing the duration of the operation phase of the Project would increase the uncertainty in the effects predictions. The details on decommissioning are not comprehensive enough to complete an effects assessment at this time; however, it is the plan of the Dezé Energy Corporation to complete the necessary studies seven to ten years prior to closure. Abandonment and restoration details are provided in Section 6.8 (Project Closure).

2. Ecology of the Valued Components. For wildlife there were many VCs selected. The VCs have different life cycles and thus the duration of an effect could affect a portion of an individual's life cycle, the entire life cycle, or multiple generations. As such, different temporal assessment boundaries were used for different VCs. The temporal assessment boundaries are presented below in the Effects Classification section.



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Small-Scale (Zones) Wildlife Assessment Boundary in the Taltson Basin**	**Figure 13.10.6**

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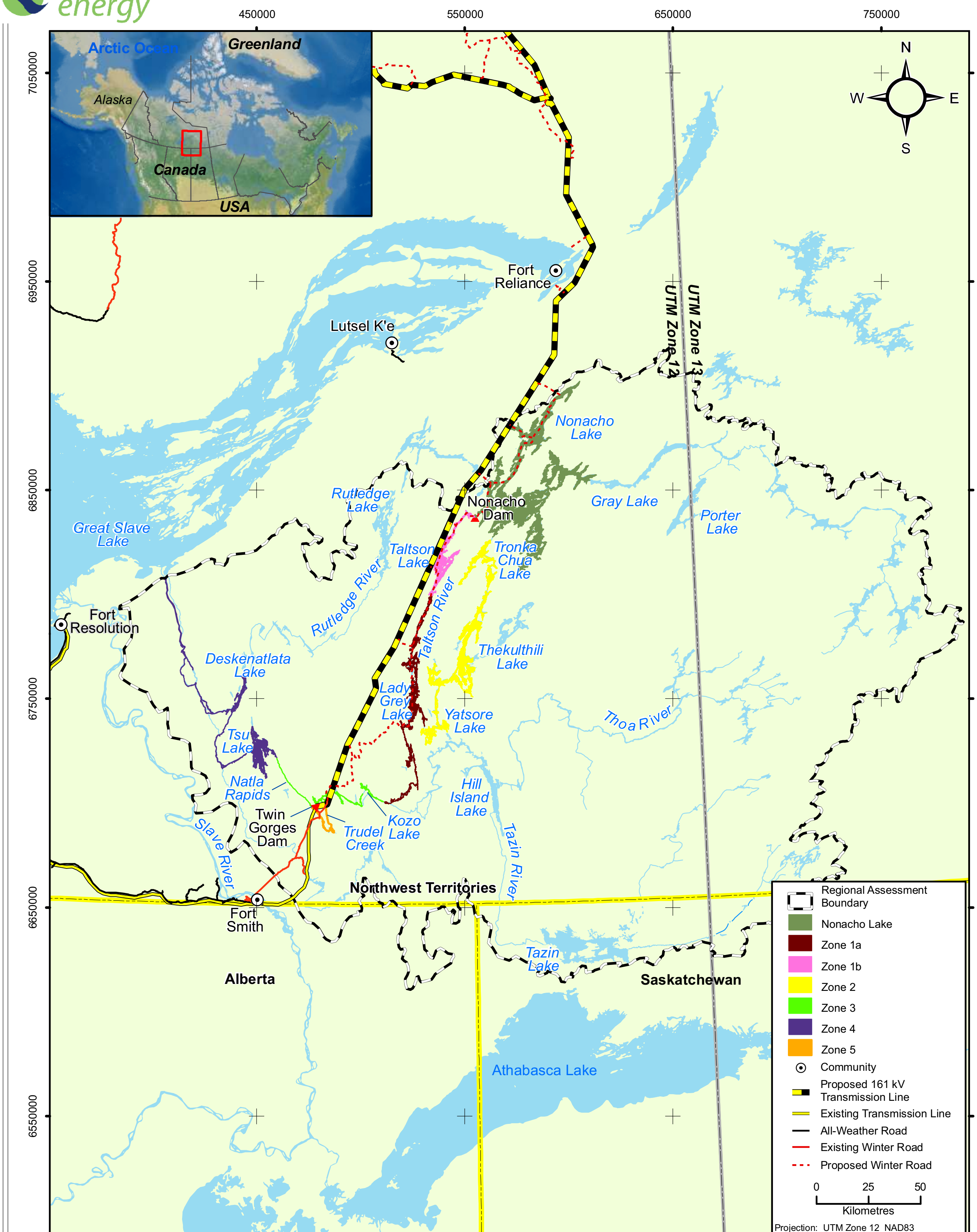

TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Regional Wildlife Assessment Boundary in the Taltson River Basin	Figure 13.10.7

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13.10.4 Project Components

The main activity to assess is the proposed changes to the hydrological regime of the Taltson River basin during construction (Nonacho Lake Zone) and operation periods. Construction activities on Nonacho Lake and any resulting individual effects on wildlife are addressed in Section 15.2 — Canal Construction. Both the 36 and 56 MW expansion options were selected for assessment. Of the identified Project components, the operation of the power-generating facilities, including the flow release at the Nonacho control structure and/or flow through the generating facilities, would result in flow and water level alterations. This section assesses the effects under normal operating conditions. The effects of unscheduled total generation facility shutdowns were not assessed in this section but can be found in Chapter 17 — Accidents and Malfunctions. Other Project components that may affect wildlife that are not related to changes in the hydrological regime were assessed in other KLOIs and SONs.

13.10.5 Pathway Analysis

13.10.5.1 Identification of Pathways

The main pathways that could negatively affect the wildlife assessment endpoints are direct mortality, sublethal effects through changes to diet (i.e. type or quality of diet), reduced reproductive success, and habitat loss or modification. All of these could lead to changes in population abundance. A beneficial pathway for muskrat was also identified in association with stabilized water levels.

Direct mortality occurs when Project activities result in the death of an individual VC. This could occur through altered water levels that create inhospitable conditions at sites used for nesting, denning, or shelter, or through increased exposure of these sites to predators.

Sublethal effects, such as changes to diet, habitat alteration, or disturbance to feeding and breeding habitats, may not cause direct mortality but may reduce physical condition and reproductive success. Reproductive success is measured as the number of young that each female produces that reach reproductive age. Reduced reproductive success can lead to declines in abundance. Females in good condition will often have more, fatter, healthier offspring who have an increased chance of surviving to adulthood. Females in poor condition will produce fewer or less healthy young. When adult females are displaced into lower quality habitat, the young may be subjected to lower feeding rates and thus lower body mass, decreasing their likelihood of successfully surviving the winter. Poor-quality habitats with little refuge from predators may also increase juvenile mortality, as juveniles are often preferred prey. Thus, alterations to the hydrological regime of the Taltson Basin may not be lethal for adults but may have an effect on reproductive success and thus population sizes. Reduced reproductive success occurs when Project activities result in the destruction of nests or denning sites, disruption of mating and/or breeding, and increased mortality of young.

Habitat loss occurs when Project infrastructure or activities directly displace or destroy existing habitat for wildlife species. Habitat loss can be classified as temporary or permanent or as habitat alteration/modification. Temporary loss occurs when vegetation and/or abiotic cover components are removed but subsequently recover or are reclaimed to near-original condition. Permanent loss can occur when natural areas are used to support development facilities and cannot be reclaimed. Habitat alteration occurs by design, by accident, or by natural vegetation responses to temporary or permanent habitat losses nearby (e.g., edge effects, invasive species), which may change wildlife use patterns, vulnerability to winds, moisture regime, competition, and/or nutrient cycling. Of these three types of habitat loss, the most serious effects are typically from permanent loss of habitat, which can involve the removal of high-quality habitat, easily-disturbed habitat, large areas of habitat, or critical habitat.

For example, lower water levels in Nonacho Lake and the Twin Gorges Forebay would result in a temporary loss of riparian habitat specifically for submerged aquatic vegetation (see Section 13.7). Although the riparian habitat loss associated with this Project is thought to be temporary and reversible upon re-establishment of new hydrological regimes and vegetation, the length of time it would take the vegetation community to stabilize is unknown. Plant species can begin colonizing areas exposed by water drawdowns within years, but may still not have stabilized after a decade or more (Odland & Moral 2002; Shafroth, Friedman, Auble, Scott, & Braatne 2002).

The VCs, assessment endpoints, and pathways are presented in Table 13.10.5. The rest of this section describes the pathways per VC.

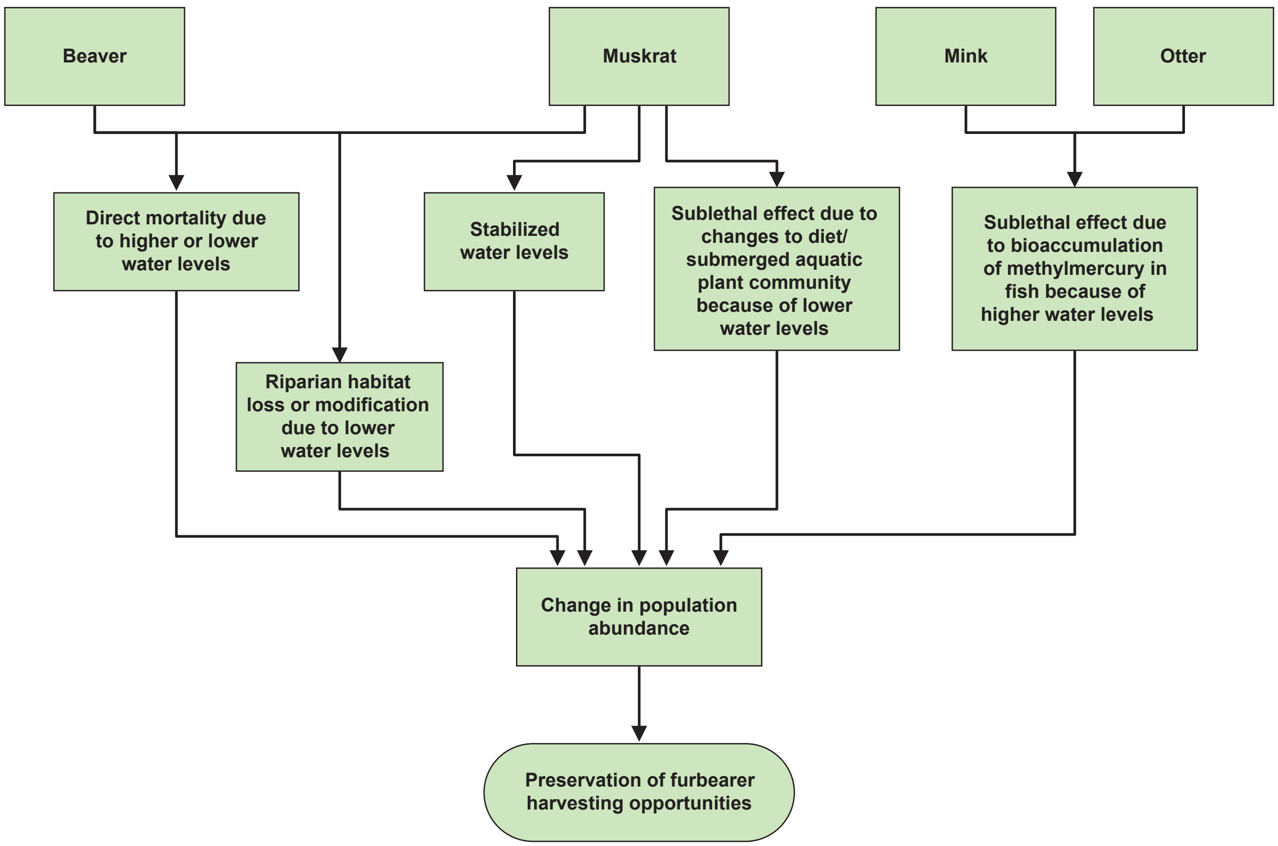
13.10.5.1.1 Furbearers

Beaver and muskrat rely on riparian and aquatic habitat for all their life history stages and requirements, including foraging, shelter, and reproduction. The two pathways that pertain to both these species are direct mortality and riparian habitat loss/modification leading to reduced population abundance (Figure 13.10.8). Direct mortality to furbearers could potentially occur from elevated or lowered water levels affecting lodges, food caches, and shelter entrances. Riparian habitat loss or modification could lead to a change in the availability of foraging and shelter resources.

Table 13.10.5 — Wildlife Assessment Pathways

Project Component/Phase	Valued Component	Assessment Endpoint	Pathway
Operations	Furbearers (beaver and muskrat)	Preservation of furbearer harvesting opportunities	Direct mortality leading to reduced population abundance
Operations	Furbearers (beaver and muskrat)	Preservation of furbearer harvesting opportunities	Riparian habitat loss/modification leading to change in population abundance
Operations	Furbearers (muskrat)	Preservation of furbearer harvesting opportunities	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance
Operations	Furbearers (muskrat)	Preservation of furbearer harvesting opportunities	Stabilized water levels leading to increased abundance
Operations	Furbearers (mink and otter)	Preservation of furbearer harvesting opportunities	Sublethal effect from bioaccumulation of methylmercury in fish
Operations	Moose	Preservation of moose harvesting opportunities	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance
Operations	Moose	Preservation of moose harvesting opportunities	Riparian habitat loss/modification leading to change in population abundance
Operations	Waterfowl (Canada goose, mallard, loons) and shorebirds	Preservation of waterfowl harvesting opportunities	Reduced reproductive success leading to reduced population abundance
Operations	Waterfowl (dabbling ducks and aquatic vegetation feeders)	Preservation of waterfowl harvesting opportunities	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance
Operations	Waterfowl (fish eating species)	Preservation of waterfowl harvesting opportunities	Sublethal effect from bioaccumulation of methylmercury in fish
Operations	Raptors that primarily consume fish (bald eagle, osprey)	Preservation of habitat and populations	Reduced reproductive success
Operations	Raptors that primarily consume fish (bald eagle, osprey)	Preservation of habitat and populations	Sublethal effect from bioaccumulation of methylmercury in fish
Operations	Whooping crane	Preservation of habitat and populations	Riparian habitat loss/modification leading to change in population abundance

Project Component/Phase	Valued Component	Assessment Endpoint	Pathway
Operations	Whooping crane	Preservation of habitat and populations	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance
Operations	Whooping crane	Preservation of habitat and populations	Reduced reproductive success
Operations	Rusty blackbird	Preservation of habitat and populations	Riparian habitat loss/modification leading to change in population abundance
Operations	Rusty blackbird	Preservation of habitat and populations	Reduced reproductive success
Operations	Northern leopard frog	Preservation of habitat and populations	Direct mortality leading to reduced population abundance: drawdown of water level during winter when frogs are potentially overwintering in riparian areas
Operations	Northern leopard frog	Preservation of habitat and populations	Riparian habitat loss/modification leading to change in population abundance



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wildlife Assessment Pathways — Effects of Altered Water Levels on Furbearers	Figure 13.10.8

Two additional pathways were identified specifically for muskrat. There may be sublethal effects caused by changes to the submerged plant community, and therefore the muskrat's diet. A stabilized water level leading to increased abundance was identified as a beneficial effect for muskrat (Messier, Virgl, & Marinelli 1990).

Sublethal effects from changes to American mink and river otter diet as a result of mercury bioaccumulation in fish was identified. Otters and mink have been identified as sensitive bioindicators of mercury levels (Kucera 1983). Habitat requirements for otters and mink overlap with beaver and muskrat; therefore, the pathways identified for beaver and muskrat would capture their other life-cycle requirements.

Altered water levels in rivers and lakes can negatively affect resident mammals depending on the flow characteristics and the time of year. If flow or water levels drop below baseline conditions during the winter, freeze-out (when there is insufficient water under the ice for beaver and muskrat survival) can occur (Ontario Fur Managers Federation 2008). Muskrats require 30 cm to 60 cm of water to avoid freeze-out, and therefore shallow water levels are associated with lowered overwintering success for muskrats (Messier et al. 1990). Winter drought conditions can also cause water to freeze deeper and cut off access to food resources that become frozen in the water and mud (Erb & Perry Jr. 2003). Muskrat populations may decline following dam creation because of the loss of overwintering habitat in shallow marshes (Rosenberg, Bodaly, & Usher 1995; Rosenberg et al. 1997).

Water levels were artificially lowered by 40 cm for a six-month survey of muskrat lodges and bank burrows in the spring and summer. The number of active dwellings decreased from 105 to 55 (Messier et al. 1990). This was thought to be caused by mink predation, which has been found to increase when water levels are lower (Proulx, McDonnell, & Gilbert 1987). Entrances to muskrat bank burrows would be particularly susceptible to lowered water levels because they are within 15 cm of the water's surface. Lowered water levels can also expose entrances to beaver lodges, making them more susceptible to wolf predation (Cott et al 2008; Nolet & Rosell 1998). Lowered winter water levels led to increased foraging activity away from lodges for beavers, decreased condition of juveniles, and lodge abandonment in the spring (Smith & Peterson 1991). Smith and Peterson (1991) recommended that overwinter drawdowns be maintained at 50 cm to 70 cm at the most.

Increased flows or water levels during the fall and winter can flood muskrat and beaver out of their lodges. Increased water levels can limit muskrat populations because water fills burrows and drowns the young (Erb & Perry, Jr. 2003). Higher water levels can destroy muskrat dwellings, leading to increased movements and subsequent increased predation. Higher water levels during the winter can raise ice and any muskrat lodges embedded in the ice layer are torn apart (Shaun Freeman, B.Sc., R.P.Bio, personal communication, October 23, 2008). If flows are very high during the fall and winter, beaver dams and food piles can be removed, resulting in reduced overwinter survival. In areas where beaver and muskrat populations are expected to decline, predator populations such as mink, otter, and fisher (*Martes pennanti*) may also be negatively affected.

13.10.5.1.2 Moose

Two pathways were identified for moose, changes to their diet from alterations of the submerged aquatic vegetation community and riparian habitat loss/modification. Both of these pathways could lead to changes in population abundance (Figure 13.10.9). Riparian areas are important to moose for foraging during the spring and summer as well as for calving and seasonal cover.

13.10.5.1.3 Birds

The pathways that could affect waterfowl, shorebirds, raptors, whooping crane, and rusty blackbird are presented in Figure 13.10.13.

The pathways include reduced reproductive success either through lower or higher water levels, sublethal changes to diet, and riparian habitat loss/modification. For ground-nesting waterfowl, such as the common loon, stable water levels are important for reproductive success. Rapidly increasing water levels (ramping events) can flood nests, and falling water levels can leave nests stranded. Loon nests are most successful when water levels do not increase by more than 15 cm or decrease by more than 30 cm during the peak nesting season (Evers 2004). Nests stranded by drawdowns are also more susceptible to nest predation.

Changes to the submerged aquatic plant communities within the littoral zone could affect dabbling ducks' diets. The bioaccumulation of methylmercury in fish could affect the diet of piscivorous waterfowl and raptors. Mercury can occur naturally in aquatic systems, but atmospheric deposition of mercury from sources such as coal combustion, incinerators, and industries have caused increased mercury levels in water bodies. Elevated levels in fish can bioaccumulate and have deleterious effects to piscivorous waterfowl. Mercury toxicity has been associated with loon mortality and even at non-lethal levels, loon and raptor reproductive success and behaviour can be negatively affected by increased mercury concentrations in the blood. Riparian habitat loss/modification could result in the loss of nesting habitat.

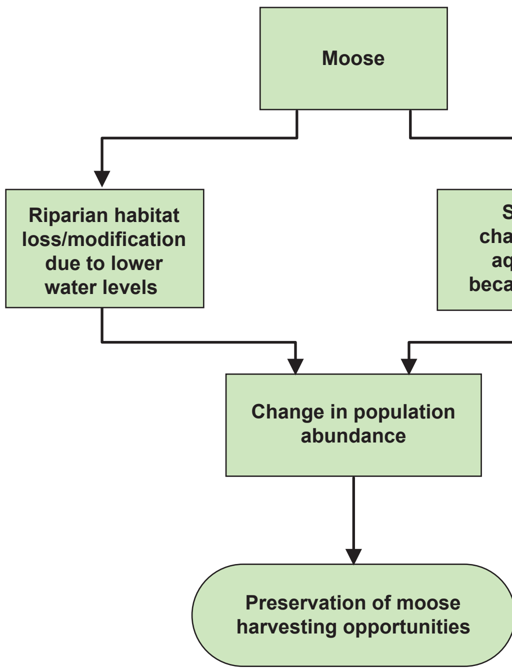
13.10.5.1.4 Northern Leopard Frog

Two pathways were identified for northern leopard frogs, direct mortality from lowered water levels during the winter and riparian habitat loss/modification (Figure 13.10.14). Northern leopard frog mortality during the winter from insufficient oxygen levels, freezing, disease, and toxic exposure has been reported (Seburn & Seburn 1998). Northern leopard frog is the only frog in the NWT that overwinters underwater. Individuals are more vulnerable to mortality during winter by drought conditions, as shallower wetlands may be more prone to freeze completely to the bottom. Riparian habitat loss/modification could reduce population abundance, as these areas are used for foraging and seasonal cover during the spring and summer.

13.10.5.2 MITIGATION

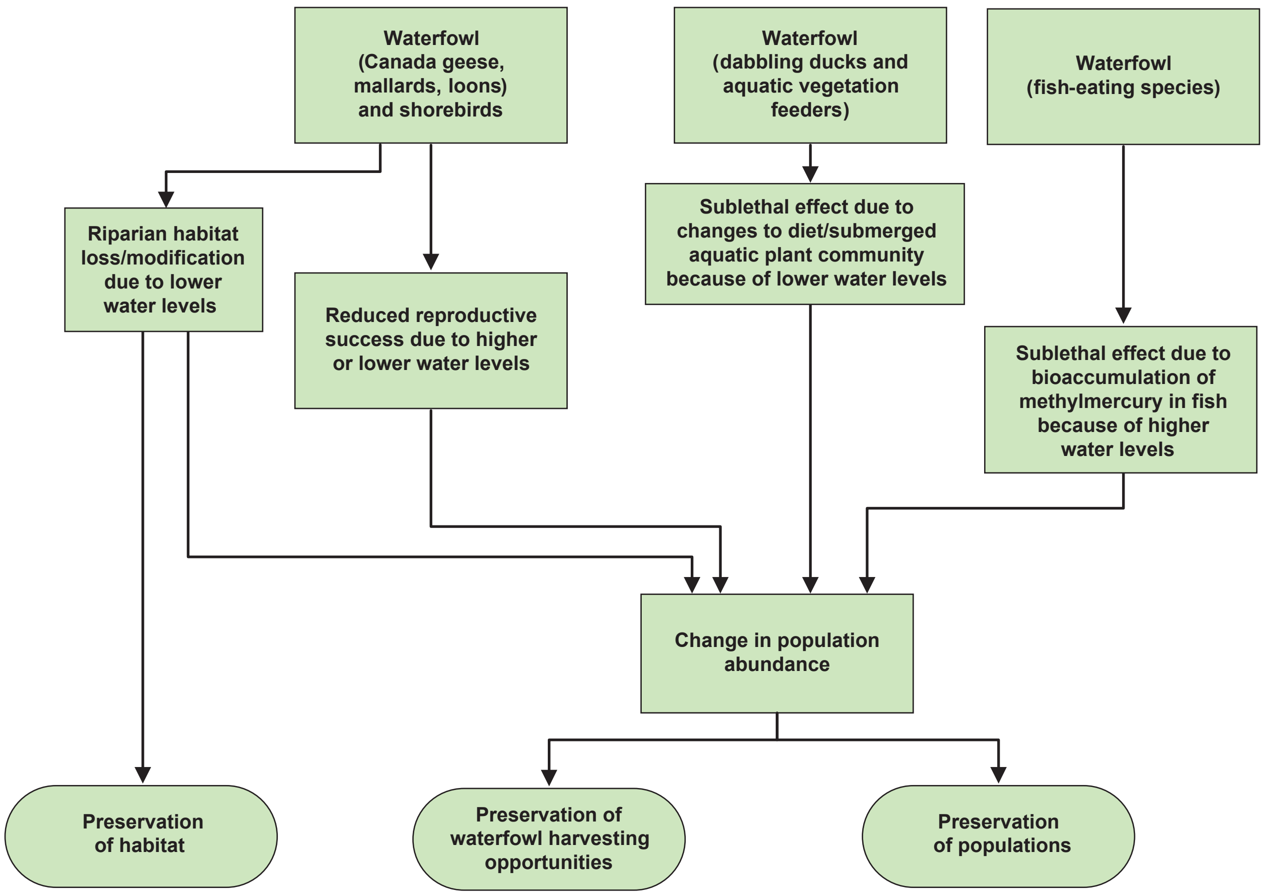
Effects of the Project would be minimized through two primary mitigation measures, mitigation practice and mitigation design. Mitigation practice includes activities and strategies that would reduce or avoid a negative effect. Mitigation design refers to a component incorporated into the Project to reduce or avoid a negative effect. Design mitigations for Project activities within the Taltson River watershed are presented in Section 13.1 (Introduction). Mitigative measures of the Expansion Project as they relate to wildlife include maintaining water levels within the current water licence levels, continued release through the Tronka Chua Gap, construction of a by-pass spillway at the Twin Gorges power facilities, staggered start-up following plant outages to reduce flow ramping events, and multiple power units to minimize changes in water levels through operations.

Potential scheduled ramping effects have been mitigated by planning the required annual servicing of the three turbines so that only one turbine would be shut down at any time. This would prevent one large pulse from travelling down Trudel Creek and subsequently causing effects to wildlife living or nesting along the banks of the river.

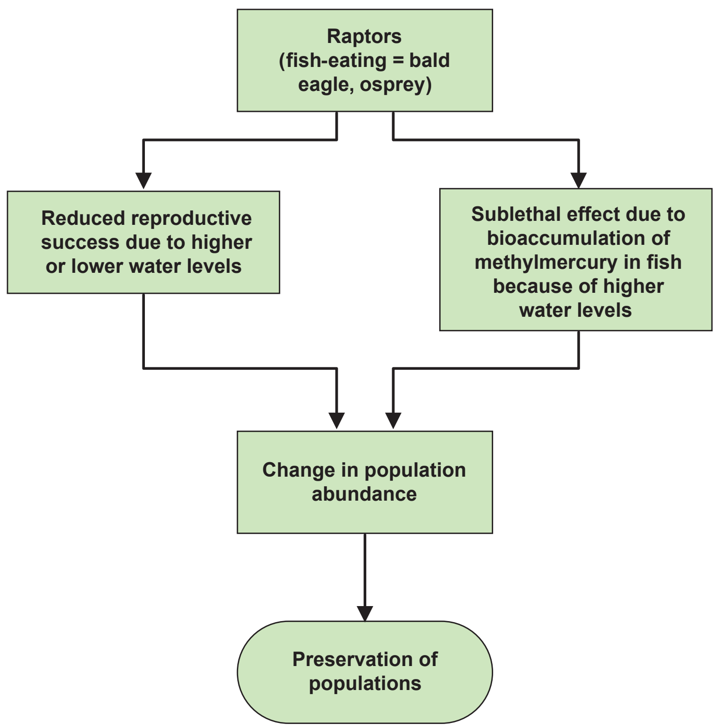


Wildlife Assessment Pathways — Effects of Altered Water Levels on Moose

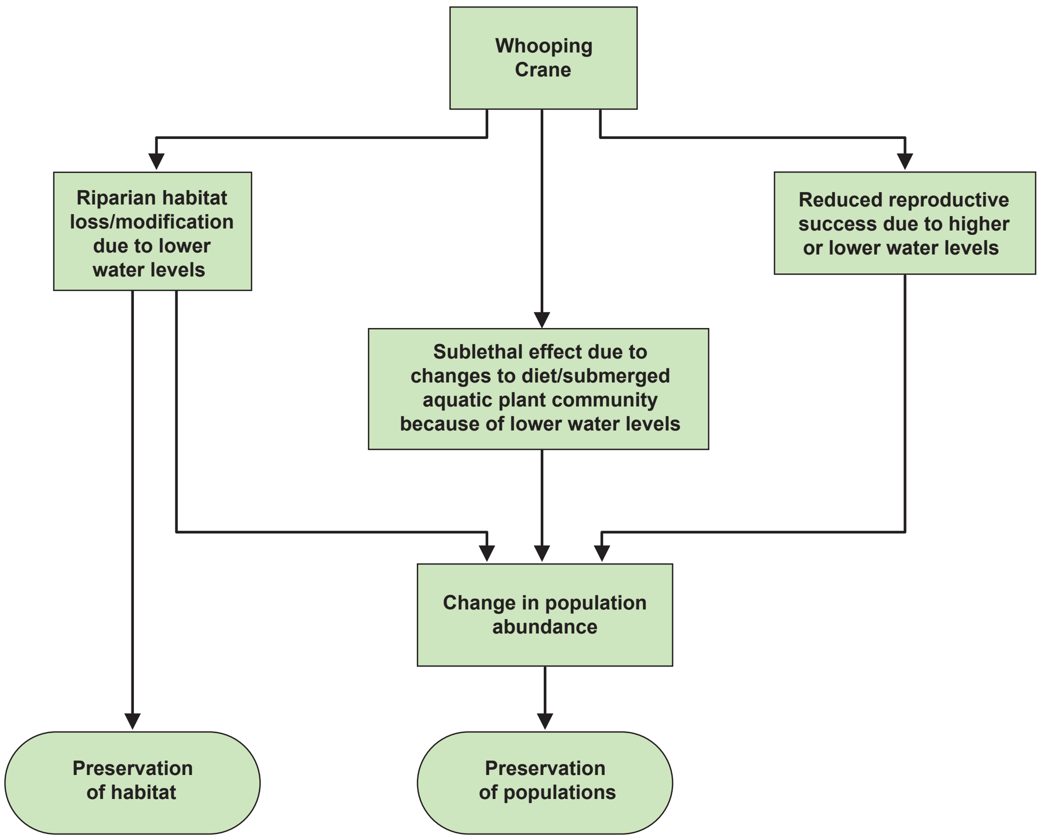
Figure 13.10.9



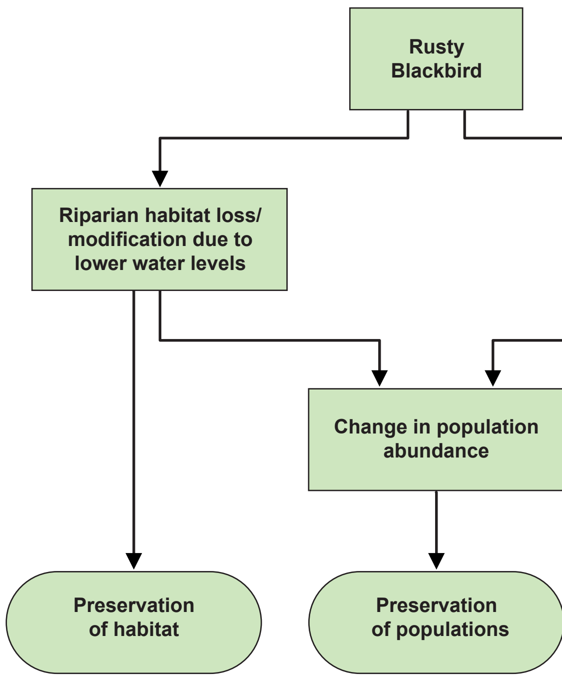
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wildlife Assessment Pathways — Effects of Altered Water Levels on Waterfowl and Shorebirds	Figure 13.10.10



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wildlife Assessment Pathways — Effects of Altered Water Levels on Raptors	Figure 13.10.11

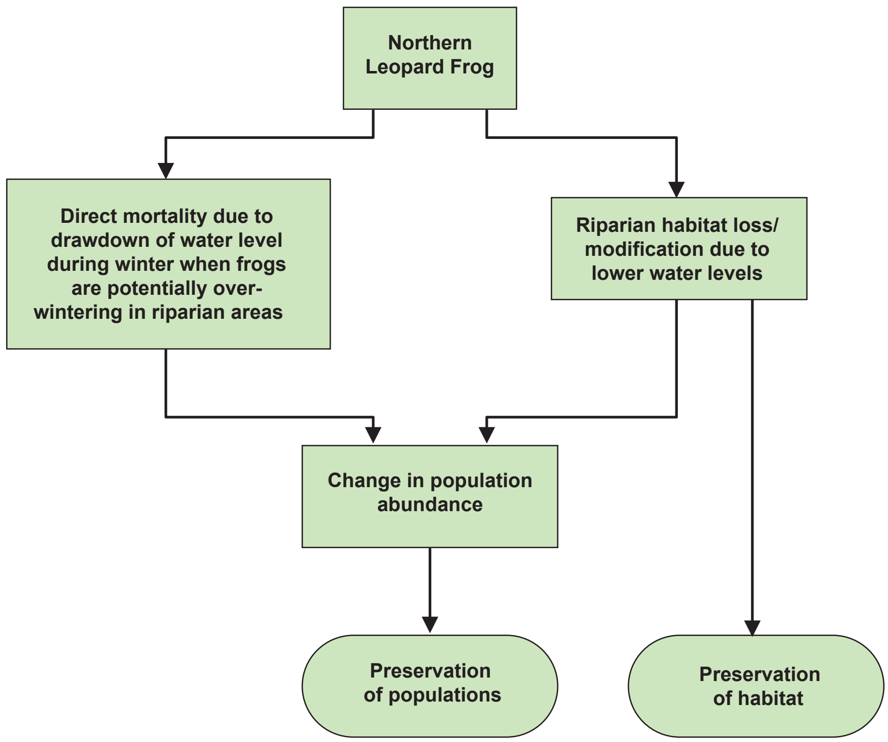


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wildlife Assessment Pathways — Effects of Altered Water Levels on Whooping Crane	Figure 13.10.12



Wildlife Assessment Pathways — Effects of Altered Water Levels on Rusty Blackbird

Figure 13.10.13



TALTSON HYDROELECTRIC EXPANSION PROJECT	Developer's Assessment Report 2009	Wildlife Assessment Pathways — Effects of Altered Water Levels on Northern Leopard Frogs	Figure 13.10.14

13.10.6 Pathway Validation

For operations, pathways were validated separately.

13.10.6.1 OPERATIONS

The hydrological modelling results (Figures 13.3.4 to 13.3.41) and the wetlands effects assessment (Section 13.7) were used to determine pathway validity during operations. For zones where hydrological modelling results differed between lakes within the same zone (e.g., Tronka Chua and Thekulthili Lakes in Zone 2), effects were assessed within the separate water bodies rather than within the whole zone itself. Table 13.10.6 to Table 13.10.9 present a summary of the pathway validation in order of VC.

13.10.6.1.1 Furbearers

13.10.6.1.1.1 Direct Mortality from Higher Water Levels

Muskrat

Under the 36 MW option, modelled water levels in Zone 1 were higher during winter than baseline conditions, validating this pathway for muskrat in the area (Table 13.10.6; Figures 13.3.10, 13.3.12, 13.3.14, 13.3.16). The seasonality of water level minimums and maximums would also change. Model results for Zone 1 indicate that water levels would be highest during the winter over the course of the annual hydrological cycle; under baseline conditions, the highest levels were observed during the summer. Muskrats build their lodges during the fall, so rising water levels during the winter could flood the lodges.

Water levels were also modelled to be higher during the winter for Zone 3 (excluding Twin Gorges Forebay) and Zone 4 (Figures 13.3.27, 13.3.37, 13.3.41), but the hydrograph seasonality would not change. Subsequently, the pathway for direct mortality from higher water levels is not Valid for these zones.

Higher water levels on the Forebay (up to 0.2 m) and on the Taltson River downstream of Elsie Falls (roughly 0.3 m) were predicted from the Flow Model for ramping from a scheduled power outage. These increases were considered Minor as they would coincide with freshet when water levels would normally increase.

Water levels for Nonacho Lake, Twin Gorges Forebay (Zone 3), and Zone 2 were all modelled to be lower than baseline conditions (Figures 13.3.4, 13.3.21, 13.3.23, 13.3.33); therefore, this pathway is Invalid in these zones.

Table 13.10.6 — Furbearer Pathway Validation for the 36 and 56 MW Options

Valued Component	Pathway	Pathway Validation 36 MW Option	Pathway Validation 56 MW Option
Furbearers (beaver and muskrat)	Direct mortality leading to reduced population abundance through higher water levels	Valid: Zone 1 for muskrat. Minor or Invalid: Nonacho Lake, Zone 1 (beaver), 2, 3, 4	Invalid or Minor for Nonacho Lake and Zones 1, 2, 3, 4
Furbearers (beaver and muskrat)	Direct mortality leading to reduced population abundance through lower water levels	Valid (muskrat): Nonacho Lake, Tronka Chua Lake (Zone 2), Twin Gorges Forebay (Zone 3) Invalid (muskrat): Zone 1, Thekulthili Lake (Zone 2), Zone 3 (excluding Twin Gorges Forebay), Zone 4 Minor: Thekulthili Lake (Zone 2) Beaver: Invalid or Minor in all zones	Valid: Nonacho Lake, Zone 2, Twin Gorges Forebay (Zone 3) Invalid: Zone 1, Zone 3 (excluding Twin Gorges Forebay), Zone 4 (Tsu Lake)
Furbearers (beaver and muskrat)	Riparian habitat loss/modification leading to change in population abundance	Valid: Nonacho Lake, Zone 1, Zone 2, Zone 3. Minor: Zone 4	Valid: Nonacho Lake, Zone 2, Zone 3 Invalid: Zone 1, Zone 4
Furbearers (muskrat)	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Valid: Nonacho Lake, Zone 1, Zone 2, Zone 3. Minor: Zone 4	Valid: Nonacho Lake, Zone 2, Zone 3 Invalid: Zone 1, Zone 4
Furbearers (muskrat)	Stabilized water levels leading to increased abundance	Valid: Zone 3, 4 Invalid: Nonacho Lake, Zone 1, 2	Valid Zone 2, Twin Gorges Forebay (Zone 3). Invalid: Nonacho Lake, Zone 1, Zone 3 (excluding Twin Gorges Forebay)
Furbearers (mink and otter)	Sublethal effect from bioaccumulation of methylmercury in fish	Invalid: mercury model shows negligible changes; see Section 14.4	Invalid: mercury model shows negligible changes see Section 14.4

Under the 56 MW option, this pathway is:

- Invalid in Nonacho Lake and Zone 2, where modelled water levels were lower than baseline (Figures 13.3.4, 13.3.21, 13.3.23, 13.3.33).
- a Minor pathway in Zones 1, 3, and 4, where modelled water levels were a maximum of 30 cm higher than baseline conditions and the seasonality of the hydrograph did not change with regard to timing of minimum and maximum monthly averages (Figures 13.3.10, 13.3.12, 13.3.14, 13.3.16, 13.3.27, 13.3.37, 13.3.41). Note that Twin Gorges Forebay is only expected to have increased water levels during scheduled outages for turbine maintenance.

Beaver

Under the 36 MW option this pathway is Invalid or Minor for:

- Nonacho Lake, Twin Gorges Forebay (Zone 3), and Zone 2, where water levels were modelled lower than baseline conditions.
- Zones 3 (excluding Twin Gorges Forebay) and 4, where water levels were modelled to be higher during the winter but still within the range of baseline monthly averages.

Water levels were modelled to be higher by a maximum of 60 cm during the winter in Zone 1, and the hydrograph seasonality was shown to change. The level falls within the annual baseline range of monthly averages and is lower than the modelled fall water levels under the 36 MW option. The larger size and greater permanence of beaver lodges compared to muskrat lodges combined with these factors makes the pathway Minor for beavers.

Under the 56 MW option this pathway is:

- Invalid in Nonacho Lake and Zone 2, where modelled water levels were lower than baseline.
- Minor in Zones 1, 3, and 4, where modelled water levels were a maximum of 30 cm higher than baseline conditions. Note that Twin Gorges Forebay is only expected to have increased water levels during scheduled outages for turbine maintenance.

13.10.6.1.1.2 Direct Mortality from Lower Water Levels

Muskrat

The entrances to underground muskrat burrows are typically 15 cm below the water surface, and muskrat declines have been observed to be associated with a water level drop of 40 cm (Messier et al. 1990; Rezendes 1999). Therefore, this pathway is Valid for any zone in which average monthly water levels for the 36 and 56 MW options were modelled to be 15 cm or more below baseline conditions and below the lowest monthly average for the annual baseline hydrograph. If water levels stay within the range of monthly baseline averages over the course of the annual hydrological regime, it was assumed that this did not represent a change from baseline conditions unless there was an accompanying seasonal change of the monthly average minimums and maximums.

Under the 36 MW option this pathway is:

- Valid for Nonacho Lake, Tronka Chua Lake (Zone 2), and Twin Gorges Forebay (Zone 3), where water levels were modelled to be lower than 15 cm below the lowest monthly average for baseline conditions (Figures 13.3.4, 13.3.21, 13.3.33).
- Invalid and Minor for Zone 3 (excluding Twin Gorges Forebay).
- Invalid for Zone 4, where water levels may be lower than baseline during some months, but were not modelled to fall below the lowest monthly baseline average (Figures 13.3.23, 13.3.27, 13.3.37, 13.3.41).
- Minor for Thekulthili Lake (Zone 2), where water levels were modelled to be lower than baseline conditions. The average water levels drop to a maximum of 18 cm for two months during the summer, and 15 cm or less difference from baseline in the remainder of the year.

Under the 56 MW option this pathway is:

- Valid for Nonacho Lake, Zone 2, and Twin Gorges Forebay (Zone 3), where water levels were modelled to be lower than baseline conditions and below the lowest monthly average for baseline conditions.
- Invalid and Minor for Zone 1, Zone 3 (excluding Twin Gorges Forebay), and Zone 4, where modelled water levels would not drop below the lowest monthly average for baseline conditions.

Beaver

Lower water levels for beaver would only be a concern when they drop below 60 cm from the lowest average for the baseline hydrograph.

Under the 36 MW option this pathway is:

- Invalid for Thekulthili Lake (Zone 2), Zone 3 (excluding Twin Gorges Forebay), and Zone 4, where water levels may be lower than baseline condition during some months but were not modelled to fall below the lowest monthly baseline average.
- Minor for Nonacho Lake and Tronka Chua Lake (Zone 2), where water levels were modelled to fall lower than 50 cm below baseline conditions for only two months per year and to a maximum of 60 cm.

Under the 56 MW option this pathway is:

- Valid at Nonacho Lake, Tronka Chua Lake (Zone 2), and the Twin Gorges Forebay (Zone 3), where modelled monthly average water levels reach more than 50 cm below baseline conditions. Average modelled monthly water levels are greater than 50 cm below baseline conditions for all months at Nonacho Lake and Tronka Chua Lake and for six months at the Twin Gorges Forebay. Average monthly water levels were modelled to drop up to 76 cm, 95 cm, and 63 cm for Nonacho Lake, Tronka Chua Lake, and Twin Gorges Forebay, respectively.

Under both options, this pathway is Invalid for Zone 1, Thekulthili Lake (Zone 2), Zone 3 (excluding Twin Gorges Forebay), and Zone 4, where modelled water levels do not drop below the lowest monthly average for baseline conditions or as much as 50 cm as compared to baseline conditions.

13.10.6.1.1.3 *Riparian Habitat Loss/Modification*

Muskrat

Wetland modelling results indicated that a drop in water levels of more than 20 cm below baseline conditions during growing seasons would cause a change in riparian habitat (Section 13.7). Zones where the incremental magnitude of alteration of wetland extent was either moderate or high were carried forward as Valid for this pathway.

Under the 36 MW option this pathway is:

- Valid for Nonacho Lake and Zones 1 to 3, where the incremental magnitude of the effect classification was either high or moderate (Table 13.7.10).
- Minor for Zone 4, where the alteration of wetland extent was classified as low.

Under the 56 MW option this pathway is:

- Valid for Nonacho Lake and Zones 2 and 3, where the incremental magnitude of the effect classification was either high or moderate (Table 13.7.11).
- Invalid for Zones 1 and 4, where alteration to wetland extent was not carried forward as a Valid pathway.

13.10.6.1.1.4 *Change in Diet/Submerged Vegetation Community*

Muskrat

Lowered water levels would change the amount of time emergent and submergent vegetation communities would be flooded. Wetland modelling results indicated that riparian habitat would change in areas experiencing water level drops of more than 20 cm below baseline conditions during the growing season (Section 13.7). This pathway was considered Valid wherever wetland modelling indicated a change to the amount of time flooding would occur at the submergent vegetation boundary (Table 13.7.6) or in zones where wetland modelling was not possible but the incremental magnitude of alteration of wetland extent was either moderate or high.

Under the 36 MW option this pathway is:

- Valid for Nonacho Lake and Zone 1, where the change in the percentage of time the boundary of emergent/submergent vegetation would be flooded was assessed with a high incremental magnitude (Tables 13.7.6 and 13.7.9).
- Valid in Zones 2 and 3, where the effect classification was moderate (Table 13.7.10).
- Minor for Zone 4, where the alteration of wetland extent was classified as low.

Under the 56 MW option this pathway is:

- Valid for Nonacho Lake, where the change in the percentage of time the boundary of emergent/submergent vegetation is flooded was assessed as with a high incremental magnitude (Tables 13.7.6 and 13.7.9).
- Valid in Zones 2 and 3, where the incremental magnitude of the effect classification was high and moderate, respectively (Table 13.7.11).
- Invalid for Zones 1 and 4, where alteration to wetland extent was not carried forward as a Valid pathway.

13.10.6.1.1.5 Stabilized Water Levels Leading to Increase in Population Abundance Muskrat

This pathway was identified for muskrat as they are known to benefit from stable water levels. Under the 36 MW option this pathway is Valid for Zones 3 and 4, where the modelled hydrograph would be flattened compared to baseline conditions (Figures 13.3.27, 13.3.33, 13.3.41).

Under the 56 MW option this pathway is Valid for Zone 2 and the Twin Gorges Forebay (Zone 3) as the hydrographs would flatten when compared to baseline conditions (Figures 13.3.21, 13.3.23, 13.3.33).

13.10.6.1.1.6 Change in Diet/Bioaccumulation of Mercury in Fish Otter and Mink

This pathway is Invalid for otter and mink as changes to fish tissues concentrations of mercury were predicted to be low or negligible for both the 36 and 56 MW options (see Section 13.5).

13.10.6.1.2 Moose

13.10.6.1.2.1 Riparian Habitat Loss/Modification

Wetland modelling results indicated that riparian habitat would change in areas experiencing water level drops of more than 20 cm below baseline conditions during the growing season (Section 13.7). Zones where the incremental magnitude of alteration of wetland extent was either moderate or high were considered Valid for this pathway.

Under the 36 MW option, this pathway is Valid for moose at Nonacho Lake and Zones 1 to 3, where the incremental magnitude of the effect classification was either high or moderate (Table 13.10.7; Table 13.7.9). This pathway was considered Minor for Zone 4 where the alteration of wetland extent was classified as low.

Table 13.10.7 — Moose Pathway Validation for the 35 and 56 MW Options

Valued Component	Pathway	Pathway Validation 36 MW Option	Pathway Validation 56 MW Option
Moose	Riparian habitat loss/modification leading to change in population abundance	Valid: Nonacho Lake, Zone 1, Zone 2, Zone 3 Minor: Zone 4	Valid: Nonacho Lake, Zone 2, Zone 3 Invalid: Zone 1, Zone 4
Moose	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Valid: Nonacho Lake, Zone 1, Zone 2, Zone 3 Minor: Zone 4	Valid: Nonacho Lake, Zone 2, Zone 3 Invalid: Zone 1, Zone 4

Under the 56 MW option this pathway is:

- Valid for Nonacho Lake and Zones 2 and 3, where the incremental magnitude of the effect classification was either high or moderate (Table 13.7.11).
- Invalid for Zones 1 and 4 where, alteration to wetland extent was not carried forward as a Valid pathway.

13.10.6.1.2.2 Change in Diet/Submerged Vegetation Community

Lowered water levels would change the amount of time emergent and submergent vegetation communities would be flooded. Wetland modelling results indicated that riparian habitat would change in areas experiencing water level drops of more than 20 cm below baseline conditions during the growing season (Section 13.7). This pathway was considered Valid wherever wetland modelling indicated a change in the amount of time the submergent vegetation boundary would be flooded (Table 13.7.6) or in zones where wetland modelling was not possible but the incremental magnitude of alteration of wetland extent was either moderate or high.

Under the 36 MW option this pathway is:

- Valid for Nonacho Lake and Zone 1, where the change in the percentage of time the boundary of emergent/submergent vegetation is flooded was assessed as high (Tables 13.7.6 and 13.7.9).
- Valid in Zones 2 and 3, where the incremental magnitude of the effect classification was moderate (Table 13.7.10).
- Minor for Zone 4, where the alteration of wetland extent was classified as low.

Under the 56 MW option this pathway is:

- Valid for Nonacho Lake, where the change in the percentage of time the boundary of emergent/submergent vegetation is flooded was assessed as high (Tables 13.7.6 and 13.7.9).
- Valid in Zones 2 and 3, where the incremental magnitude of the effect classification was high and moderate, respectively (Table 13.7.11).
- Invalid for Zones 1 and 4, where alteration to wetland extent was not carried forward as a Valid pathway.

13.10.6.1.3 Birds

13.10.6.1.3.1 Direct Mortality and Reduced Reproductive Success from Higher Water Levels

Higher water levels are only concerning during the nesting season for ground-nesting waterfowl and shorebirds (June to August). Modelled water levels under both the 36 and 56 MW options were less than 20 cm higher than baseline conditions over these months. Thus, for waterfowl and shorebirds, these pathways are Invalid in all zones under both options (Table 13.10.8). These pathways are Invalid for raptors and rusty blackbird as they do not nest on the ground and for whooping cranes because they do not breed in the Project area.

Table 13.10.8 — Bird Pathway Validation for the 36 and 56 MW Options

Valued Component	Pathway	Pathway Validation 36 MW Option	Pathway Validation 56 MW Option
Waterfowl (Canada goose, mallard, loons) and shorebirds	Direct mortality from higher water levels leading to reduced population abundance	Invalid or Minor: Nonacho Lake, Zones 1, 2, 3, 4 as water levels within 20 cm of baseline during nesting season	Invalid or Minor: Nonacho Lake, Zones 1, 2, 3, 4 as water levels within 20 cm of baseline during nesting season
Waterfowl (Canada goose, mallard, loons) and shorebirds	Reduced reproductive success from higher water levels leading to reduced population abundance	Invalid or Minor: Nonacho Lake, Zones 1, 2, 3, 4 as water levels within 20 cm of baseline during nesting season	Invalid or Minor: Nonacho Lake, Zones 1, 2, 3, 4 as water levels within 20 cm of baseline during nesting season
Waterfowl (Canada goose, mallard, loons) and shorebirds	Reduced reproductive success from lower water levels leading to reduced population abundance	Invalid or Minor: Nonacho Lake, Zones 1, 2, 3, 4 as water levels within 20 cm of baseline during nesting season	Invalid or Minor: Nonacho Lake, Zones 1, 2, 3, 4 as water levels within 20 cm of baseline during nesting season
Raptors that primarily consume fish (bald eagle, osprey)	Reduced reproductive success	Invalid: not using riparian habitat for nesting and mercury model shows negligible changes. See Section 14.4	Invalid: not using riparian habitat for nesting and mercury model shows negligible changes. See Section 14.4
Whooping crane	Reduced reproductive success	Invalid: whooping crane breeding has not been documented in the Project area	Invalid: whooping crane breeding has not been documented in the Project area
Rusty blackbird	Reduced reproductive success from higher or lower water levels leading to reduced population abundance	Invalid	Invalid
Waterfowl (dabbling ducks and aquatic vegetation feeders)	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Valid: Nonacho Lake, Zone 1, Zone 2, Zone 3 Invalid: Zone 4	Valid: Nonacho Lake, Zone 2, Zone 3 Invalid: Zone 1, Zone 4
Whooping crane	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Invalid: diet not primarily aquatic plants	Invalid: diet not primarily aquatic plants
Waterfowl (fish-eating species)	Sublethal effect from bioaccumulation of methylmercury in fish	Invalid: mercury model shows negligible changes. See Section 14.4	Invalid: mercury model shows negligible changes See Section 14.4
Raptors that primarily consume fish (bald eagle, osprey)	Sublethal effect from bioaccumulation of methylmercury in fish	Invalid: mercury model shows negligible changes. See Section 14.4	Invalid: mercury model shows negligible changes See Section 14.4

Valued Component	Pathway	Pathway Validation 36 MW Option	Pathway Validation 56 MW Option
Waterfowl (Canada goose, mallard, loons) and shorebirds	Riparian habitat loss/modification leading to change in population abundance	Invalid: assessed under direct mortality and reduced reproductive success pathways from altered water levels	Invalid: assessed under direct mortality and reduced reproductive success pathways from altered water levels
Whooping crane	Riparian habitat loss/modification leading to change in population abundance: loss of nesting habitat	Invalid: species does not breed in Project area	Invalid: species does not breed in Project area
Rusty blackbird	Riparian habitat loss/modification leading to change in population abundance	Invalid: species nests in trees and shrub communities would not be flooded	Invalid : species nests in trees and shrub communities would not be flooded

Higher water levels downstream from Twin Gorges dam and in the Twin Gorges Forebay were modelled for ramping from a scheduled power outage. Water level increases were 25 and 22 cm respectively. This change in water level was considered Minor for ground-nesting waterfowl and shorebirds. The pathway is Invalid during ramping conditions for raptors and rusty blackbirds as they do not nest on the ground within the riparian zone. It is Invalid for whooping cranes as they are not known to breed in the Project area.

13.10.6.1.3.2 Reduced Reproductive Success from Lower Water Levels

Lowered water levels for ground-nesting waterfowl such as loons are only a concern during nesting season (June to August). Although water levels under both the 36 and 56 MW options would be lower than baseline conditions, the water levels over the course of the breeding and nesting period (May to August) would not drop. Reduced reproductive success from lower water levels is an Invalid pathway. The pathway is Invalid for raptors and rusty blackbirds as they do not nest on the ground within the riparian zone. It is Invalid for whooping cranes as they are not known to breed in the Project area.

13.10.6.1.3.3 Change in Diet/Submerged Vegetation Community

Lowered water levels would change the amount of time emergent and submergent vegetation communities would be flooded. Wetland modelling results indicated that riparian habitat would change in areas experiencing water level drops of more than 20 cm below baseline conditions during the growing season (Section 13.7). This pathway was considered Valid for dabbling ducks and aquatic vegetation feeders wherever wetland modelling indicated a change to the amount of time flooding would occur at the submergent vegetation boundary (Table 13.7.6) or in zones where wetland modelling was not possible but the incremental magnitude of alteration of wetland extent was either moderate or high.

Under the 36 MW option this pathway is:

- Valid for Nonacho Lake and Zone 1, where the change in the percentage of time the boundary of emergent/submergent vegetation would be flooded was assessed as high (Tables 13.7.6 and 13.7.9).
- Valid in Zones 2 and 3, where the magnitude of the effect classification was moderate in the wetlands effects assessment section (Table 13.7.10).
- Minor for Zone 4, where the magnitude of the alteration of wetland extent was classified as low.
- Invalid for the other bird VCs, as their diet does not consist of primarily aquatic vegetation.

Under the 56 MW option this pathway is:

- Valid for Nonacho Lake, where the change in the percentage of time the boundary of emergent/submergent vegetation that would be flooded was assessed as high (Tables 13.7.6 and 13.7.9).
- Valid in Zones 2 and 3, where the magnitude of the effect was high and moderate, respectively (Table 13.7.11).
- Invalid for Zones 1 and 4, where alteration to wetland extent was not carried forward as a Valid pathway.
- Invalid for the other bird VCs, as their diet does not consist of primarily aquatic vegetation.

13.10.6.1.3.4 Change in Diet/Bioaccumulation of Mercury in Fish

This pathway is Invalid for piscivorous waterfowl and raptors as changes in mercury levels in fish were predicted to be low or negligible for both the 36 and 56 MW options (see Section 13.5).

13.10.6.1.3.5 Riparian Habitat Loss/Modification

This pathway is Invalid for all bird VCs. The change within the riparian zone that would be most adverse for ground-nesting waterfowl and shorebirds is the water level, which is addressed above. Change to riparian habitat is considered Invalid for whooping crane because this species does not breed in the Project area. It is an Invalid pathway for rusty blackbird, which nest in trees. There would not be a loss of wetland shrub communities associated with this Project, as no new flooding would occur.

13.10.6.1.4 Northern Leopard Frog

13.10.6.1.4.1 Riparian Habitat Loss/Modification

Wetland modelling results indicated that riparian habitat would change in areas experiencing water level drops of more than 20 cm below baseline conditions during the growing season (Section 13.7). Zones where the incremental magnitude of alteration of wetland extent was either moderate or high were considered Valid for this pathway.

Under the 36 MW option this pathway is:

- Valid for Zone 1, Thekulthili Lake (Zone 2), and Zone 3, where the magnitude of the effect on wetlands was either high or moderate.

- Minor for Zone 4, where the magnitude of the alteration of wetland extent was classified as low.
- Invalid at Nonacho and Tronka Chua Lake (Zone 2), as the species has not been documented that far north.

Table 13.10.9 — Northern Leopard Frog Pathway Validation for the 36 and 56 MW Option

Valued Component	Pathway	Pathway Validation 36 MW Option	Pathway Validation 56 MW Option
Northern leopard frog	Riparian habitat loss/modification leading to change in population abundance	Valid: Zone 1, Thekulthili Lake (Zone 2), Zone 3 Invalid: Nonacho Lake, Tronka Chua Lake (Zone 2) Minor: Zone 4	Valid: Thekulthili Lake (Zone 2), Zone 3 Invalid: Nonacho Lake, Zone 1, Tronka Chua Lake (Zone 2), Zone 4
Northern leopard frog	Direct mortality leading to reduced population abundance: lower water levels during winter when frogs are potentially overwintering in riparian areas	Invalid or Minor: Nonacho Lake, Zones 1, 2, 3, 4	Invalid or Minor: Nonacho Lake, Zones 1, 2, 3, 4

Under the 56 MW option this pathway is:

- Valid for Thekulthili Lake (Zone 2) and Zone 3, where the magnitude of the effect on wetlands was either high or moderate, respectively.
- Invalid for Zones 1 and 4, where alteration to wetland extent was not carried forward as a Valid pathway.
- Invalid at Nonacho and Tronka Chua Lake (Zone 2), as the species has not been documented that far north.

13.10.6.1.4.2 *Direct Mortality from Lower Water Levels*

Northern leopard frogs primarily use the riparian zone for summer foraging and may use it for overwintering (Appendix 13.10-A). Lower water levels might be a concern if breeding areas were within this area. Direct mortality would be concerning if there were a drop in water levels between the fall, when frogs would be moving into overwintering sites, and the winter, when they would be below the ice of streams or rivers. The modelled water levels under both the 36 and 56 MW options would be lower than baseline conditions for Nonacho Lake, Tronka Chua Lake (Zone 2), and Twin Gorges Forebay (Zone 3). However, this pathway is Invalid for Nonacho and Tronka Chua Lakes (Zone 2) as the northern leopard frog has not been documented that far north. For the Twin Gorges Forebay, the new hydrographs under both options would be fairly stable over the course of the year. Therefore, this pathway is also Invalid for Zone 3. For Zones 1, 2 and 4, water levels were modelled to increase during the winter as compared to baseline conditions, so this pathway is also Invalid.

13.10.7 Effect Classification

For the purpose of this effect classification, the definition of duration was changed from that presented in Section 13.2 and Chapter 10. To suit the wildlife VCs, the definitions for duration were changed to the following:

- Short term: effects that last as long as the generation time of a VC or less;

- Medium-term: effects that last as long as a few generation times of a VC;
- Long term: effects that last the duration of the Project (>40 years); and
- Indefinite.

The geographic extent was based on the extent of the effect: a single zone, multiple zones, or the entire Taltson River watershed (regional scale). The reversibility was assessed based on whether the effect is reversible if the stressor remains or if removed. That is, the pathway could remain (e.g., decreased water levels) but the effect could be reversed over time (new willow-sedge community boundary). Alternatively, an effect could reoccur as the stressor reoccurs (e.g., ramping events cease at the end of operations). The overall residual effect considers the qualitative ratings of effects on the assessment endpoint for each pathway.

13.10.7.1 OPERATIONS UNDER THE 36 MW OPTION

13.10.7.1.1 Furbearers

13.10.7.1.1.1 Direct Mortality

In Zone 1, muskrat direct mortality caused by higher water levels during the winter was assessed as moderate in magnitude for Taltson, King, and Lady Grey lakes, and low for Benna Thy Lake (Table 13.10.10). In the model, the highest annual water levels occurred in the winter in the 36 MW option, thus water levels would increase from fall to winter during every average operating year. Because muskrats construct their lodges in the fall, increased water levels in the winter are of primary concern. The modelled increase in water levels between September and the highest winter water levels ranges from 19 to 30 cm. This range is equivalent to the height of push-ups and small lodges, and therefore it is likely that some flooding would occur. This effect would be short-term, periodic, and reversible as the population is expected to recover from the resulting effect even though the stressor would occur annually based on average conditions.

The effect of lower water levels causing direct mortality through freeze-out or exposing entrances and increasing predation rates was classified as likely with a moderate magnitude for Nonacho Lake, Tronka Chua Lake (Zone 2), and the Twin Gorges Forebay (Zone 3). For Nonacho Lake, water levels during the fall, when muskrat lodge construction would occur, were modelled within 10 cm of baseline conditions, but would drop to 59 cm below baseline conditions by April. The total difference between modelled water levels in September and April is 86 cm. This is in comparison to a 36 cm difference between the two months under baseline conditions. For both Nonacho Lake and Tronka Chua Lake, the hydrograph under the 36 MW option is steeper with a greater difference between average water levels in the winter versus the summer. The effects from the new hydrological regime under the 36 MW option for Nonacho and Tronka Chua Lakes would be short-term, periodic, and reversible as the population is expected to recover from the resulting effect even though the stressor would occur annually based on average conditions. Muskrat habitat within Zone 1 may become “sink” habitat: annual winter mortality would cause negative local population growth (Battin 2004). It is possible that local populations would only be maintained through immigration of individuals from other regional populations where the growth rate is positive. The residual effect was assessed as moderate.

Table 13.10.10 — Wildlife Effects Classification under the 36 MW Option

Pathways	Zone	Direction	Likelihood	Magnitude	Geographic Extent	Duration)	Reversibility	Frequency	Regional Residual Effect
Effects on Furbearers									
Direct mortality through higher water levels leading to reduced population abundance (muskrat)	Taltson, King, Lady Grey Lakes (Zone 1)	Adverse	Likely	Moderate	Local (single zone)	Short-term	Reversible	Periodic	Low
	Benna Thy Lake (Zone 1)			Low					
Direct mortality through lower water levels leading to reduced population abundance (muskrat)	Nonacho Lake	Adverse	Likely	Moderate	Medium (multiple zones)	Short-term	Reversible	Periodic	Low
	Tronka Chua Lake (Zone 2)		Possible	Moderate					
	Twin Gorges Forebay (Zone 3)		Likely	Moderate					
Riparian habitat loss/modification leading to change in population abundance (muskrat and beaver)	Nonacho Lake, Zone 1	Adverse	Highly likely	Moderate	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low
	Zone 2, Zone 3		Possible	Low	Local				
Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance (muskrat)	Nonacho Lake, Zone 1	Adverse	Highly likely	Moderate	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low
	Zone 2, Zone 3		Possible	Low					
Stabilized water levels leading to increased abundance (muskrat)	Zone 3, Zone 4	Beneficial	Likely	Moderate	Medium (multiple zones)	Long-term	Reversible	Continuous	Low
Effects on Moose									
Riparian habitat loss/modification leading to change in population abundance	Nonacho Lake, Zone 1	Adverse	Highly likely	Low	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low
	Zone 2, Zone 3		Possible	Low					
Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Nonacho Lake, Zone 1	Adverse	Highly likely	Low	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low
	Zone 2, Zone 3		Possible						
Effects on Waterfowl and Shorebirds									
Sublethal effects for dabbling ducks (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Nonacho Lake, Zone 1	Adverse	Highly likely	Moderate	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low
	Zone 2, Zone 3		Possible	Moderate					
Effects on Northern Leopard Frog									
Riparian habitat loss/modification leading to change in population abundance	Zone 1	Adverse	Highly likely	Low	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low
Direct mortality leading to reduced population abundance: drawdown of water level during winter when frogs are potentially overwintering in riparian areas.	Thekulthili Lake (Zone 2), Zone 3		Possible	Low					

The lowered water levels at Twin Gorges Forebay would have a moderate adverse effect initially but the effect is reversible in the medium-term as riparian vegetation establishes to the new hydrologic regime. The new hydrological regime under the 36 MW option might benefit muskrat populations once riparian vegetation communities re-established themselves when the modelled water levels stabilize (see Beneficial Pathway below).

13.10.7.1.1.2 Riparian Habitat Loss/Modification

The likelihood of riparian habitat loss or modification is the same as the likelihood of alteration to wetland extent as described in Section 13.7, but the magnitude of the effect of this loss was classified differently for the wildlife VCs. Riparian habitat loss or modification was assessed as highly likely for Nonacho Lake and Zones 1 and possible for Zones 2 and 3 (Table 13.10.10). In Section 13.7, the alteration to wetland extent was classified as high for Nonacho Lake and Zone 1 and moderate for Zones 2 and 3 (Table 13.7.10). The effect on furbearers was assessed at a lower magnitude because other wetlands are available within the distance that muskrat and beaver are known to disperse.

In each of these areas, the effects were considered continuous, medium-term, and reversible as vegetation communities would re-establish themselves once the new hydrological regime was established. Riparian plant communities can take longer than a decade to stabilize following a water level drawdown, even though plant colonization would occur sooner (Section 13.7). The residual effect was assessed as low.

13.10.7.1.1.3 Sublethal Effects

The likelihood of changes to submerged vegetation communities was the same as the likelihood of the alteration of wetland extent, but the magnitude of the effect of this loss was classified differently for the wildlife VCs. Sublethal effects for muskrat from changes to submerged vegetation communities were assessed as highly likely for Nonacho Lake, Zone 1, and possible for Zones 2 and 3 (Table 13.10.10). In the wetlands section (Section 13.7), the incremental magnitude of alteration of wetland extent was assessed as high in Nonacho Lake and Zone 1 and moderate in Zones 3 and 4. The magnitude of this effect on muskrat was classified as moderate in Nonacho Lake and Zone 1 and low in Zones 3 and 4. The effect on muskrat was classified at a lower magnitude because the alteration of wetland extent, and therefore the change to submerged aquatic food resources, would change but was not assumed to be lost entirely. Once a new hydrological regime is established, submerged vegetation communities would re-establish. Thus, the effect would be continuous, medium-term, and reversible. The residual effect was assessed as low.

13.10.7.1.1.4 Beneficial Pathway

The difference between yearly water level maximums and minimums would decrease by half in the Taltson River downstream of the Tazin River and downstream of Twin Gorges in Zones 3 and 4. This change was classified as beneficial for muskrat and was assessed as likely with moderate magnitude. Winter mortality from freeze-outs and increased susceptibility to predators from exposed entrances would be reduced because of the new flattened hydrological regime. This effect would be continuous, and long-term. However it would be reversible following operations of the Expansion

Project. The residual effect was assessed as low because it would not noticeably increase muskrat populations.

13.10.7.1.2 Moose

13.10.7.1.2.1 Riparian Habitat Loss/Modification

The likelihood of riparian habitat loss or modification was the same as the likelihood of alteration to wetland extent. Riparian habitat loss or modification was assessed as highly likely for Nonacho Lake and Zone 1, and possible for Zones 2 and 3, based on the likelihood of change in wetland extent (Table 13.10.10). Because of the abundance of wetland habitat within the Project RAB and the capability of moose to travel farther than furbearers to access other available habitat, the magnitude of the effect was assessed as low. Once a new hydrological regime is established, vegetation communities would re-establish. This effect would be continuous, medium-term and reversible. Thus, the residual effect was also low.

13.10.7.1.2.2 Sublethal Effects

The likelihood of changes to submerged vegetation communities was the same as the likelihood of alteration of wetland extent. Sublethal effects from a change in the riparian vegetation communities was assessed as highly likely for Nonacho Lake and Zone 1, and possible for Zones 2 and 3, based on the likelihood of change in wetland extent (Table 13.10.10). Given the same rationale as above, the magnitude was classified as low. This effect would also be continuous, medium-term and reversible with a low residual effect.

13.10.7.1.3 Waterfowl and Shorebirds

13.10.7.1.3.1 Sublethal Effects

The likelihood of changes to submerged vegetation communities was the same as the likelihood of alteration of wetland extent. Sublethal effects from a change in the riparian vegetation communities were assessed for dabbling ducks and other waterfowl that feed on aquatic vegetation as highly likely for Nonacho Lake and Zone 1, and possible for Zones 2 and 3, based on the likelihood of change in wetland extent (Table 13.10.10). The magnitude was classified as moderate because of high uncertainty levels regarding breeding waterfowl populations. This effect would be continuous, medium-term and reversible. The residual effect was assessed as low.

13.10.7.1.4 Northern Leopard Frog

13.10.7.1.4.1 Riparian Habitat Loss/Modification

The likelihood of riparian habitat loss or modification was the same as the likelihood of alteration to wetland extent. Riparian habitat loss or modification was assessed as possible for Thekulthili Lake (Zone 2) and Zone 3 and highly likely for Zone 1 (Table 13.10.10). The magnitude for Zones 1 and 3 was classified as low because the amphibians primarily use riparian habitat for foraging during the summer. The effect would have been classified as more severe if the riparian habitat also provided breeding habitat, but baseline surveys did not document extensive breeding habitat within the riparian zone. The effect would be continuous, medium-term, and reversible. The residual effect was assessed as low.

13.10.7.2 Operations Under the 56 MW Options

13.10.7.2.1 Furbearers

13.10.7.2.1.1 Direct Mortality

Lowered water levels at the onset of operations causing freeze-out or exposing entrances for Nonacho Lake, Tronka Chua Lake (Zone 2), and Twin Gorges Forebay (Zone 3) was classified as likely for muskrat and possible for beaver (Table 13.10.11). The magnitude for muskrats was classified as high at Nonacho and Tronka Chua Lakes where modelled water levels indicated a drop of over 70 cm. It was classified as moderate for muskrat at Twin Gorges where modelled water levels indicated a drop of 50 cm. It was classified as moderate for beaver at Nonacho and Tronka Chua lakes and low at Twin Gorges Forebay. Mortality would be primarily associated with the first winter of operations when the water levels would first be lower. However, it was assumed that the furbearers would adapt to the new hydrological regime and lowered water level. This effect was classified as continuous, short-term, and reversible. The residual effect was classified as low.

13.10.7.2.1.2 Riparian Habitat Loss/Modification

The likelihood of riparian habitat loss or modification was the same as the likelihood of alteration to wetland extent. Loss or modification of riparian habitat was assessed as highly likely for Nonacho Lake and possible in Zones 2 and 3 (Table 13.10.11). The effect on wetlands was classified with moderate magnitude at Nonacho Lake and Zone 2, and low in Zone 3. The effect on furbearers was assessed as having a lower magnitude than alteration of wetland extent because other wetlands are available within the distance that these species are known to disperse. This effect would be continuous, medium-term, and reversible because vegetation communities would re-establish themselves once the new hydrological regime occurred. The residual effect was assessed as low.

13.10.7.2.1.3 Sublethal Effects

The likelihood of changes to submerged vegetation communities was the same as the likelihood for the alteration of wetland extent. Loss or modification of riparian habitat was assessed as highly likely for Nonacho Lake and possible in Zones 2 and 3 (Table 13.10.11). In the wetlands section (Section 13.7), the incremental magnitude of alteration of wetland extent was assessed as high in Nonacho Lake and Zone 1 and moderate in Zone 3. The effect on muskrat was classified with moderate magnitude at Nonacho Lake and Zone 2 and low in Zone 3. The effect on muskrat was classified at a lower magnitude since the alteration of wetland extent, and therefore the change to submerged aquatic food resources, would change, but was not assumed to be lost entirely. Once a new hydrological regime was established, submerged vegetation communities would re-establish themselves, and thus the effect would be continuous, medium-term, and reversible. The residual effect was assessed as low.

Table 13.10.11 — Wildlife Effects Classification under the 56 MW Option

Pathways	Zone	Direction	Likelihood	Magnitude	Geographic Extent	Duration[1]	Reversibility	Frequency	Regional Residual Effect
Effects on Furbearers									
Direct mortality through lower water levels leading to reduced population abundance (muskrat and beaver)	Nonacho Lake	Adverse	Muskrat; likely; Beaver; possible	Muskrat; high Beaver; moderate	Medium (multiple zones)	Short-term	Reversible	Continuous	Low
	Zone 2			Muskrat; high Beaver; moderate					
	Twin Gorges Forebay (Zone 3)			Muskrat; moderate Beaver; low					
Riparian habitat loss/modification leading to change in population abundance (muskrat and beaver)	Nonacho Lake, Zone 2	Adverse	Highly likely	Moderate	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low
	Zone 3		Possible	Low					
Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance (muskrat)	Nonacho Lake, Zone 2, 3	Adverse	Highly likely	Moderate	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low
			Possible	Low					
Stabilized water levels leading to increased abundance (muskrat)	Zone 2, Twin Gorges Forebay (Zone 3)	Beneficial	Possible	Low	Local (single zone)	Long-term	Reversible	Continuous	Low
Effects on Moose									
Riparian habitat loss/modification leading to change in population abundance	Nonacho Lake, Zone 2	Adverse	Highly likely	Low	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low
	Zone 3		Possible	Low					
Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Nonacho Lake, Zone 2	Adverse	Highly likely	Low	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low
	Zone 3		Possible	Low					
Effects on Waterfowl and Shorebirds									
Sublethal effects for dabbling ducks (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Nonacho Lake	Adverse	Highly likely	Moderate	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low
	Zone 2 and 3		Possible	Moderate					
Effects on Northern Leopard Frog									
Riparian habitat loss/modification leading to change in population abundance Direct mortality leading to reduced population abundance: drawdown of water level during winter when frogs are potentially overwintering in riparian areas	Thekulthili Lake (Zone 2), Zone 3	Adverse	Possible	Moderate	Medium (multiple zones)	Medium-term	Reversible	Continuous	Low

[1] Duration: Short-term: one generation or less; medium-term: a few generations; long-term: >40 years.

13.10.7.2.1.4 *Beneficial Pathway*

The difference between yearly maximums and minimums was modelled to decrease in the range of 11 to 27 cm in Zone 2 and at Twin Gorges Forebay (Zone 3). This was classified as a beneficial effect for muskrat and was assessed as possible with low magnitude. Winter mortality because of freeze-outs and increased susceptibility to predation from exposed entrances would be reduced because of the new flattened hydrological regime. This effect would be continuous, long-term, and reversible. The residual effect was assessed as low; it would not increase muskrat populations noticeably.

13.10.7.2.2 Moose

13.10.7.2.2.1 *Riparian Habitat Loss/Modification*

The likelihood of riparian habitat loss or modification was the same as the likelihood of alteration to wetland extent. Riparian habitat loss or modification was assessed as highly likely for moose in Nonacho Lake, and possible in Zones 2 and 3 (Table 13.10.11). Because of the abundance of wetland habitat within the Project RAB and the capability of moose to travel farther than furbearers to access this habitat, the magnitude of the effects was classified as low. The effect would be continuous, medium-term, and reversible. The residual effect was assessed as low.

13.10.7.2.2.2 *Sublethal Effects*

The likelihood of riparian habitat loss or modification was classified the same as the likelihood of alteration to wetland extent. Sublethal effects caused by a change in the submerged vegetation communities was assessed as highly likely for Nonacho Lake and possible for Zones 2 and 3, based on the likelihood of change in wetland extent (Table 13.7.11; Table 13.10.10). Given the same rationale as above, the magnitude was classified as low. The effect would be continuous, medium-term, and reversible. The residual effect was assessed as low.

13.10.7.2.3 Waterfowl and Shorebirds

13.10.7.2.3.1 *Sublethal Effects*

The likelihood of changes to submerged vegetation communities was the same as the likelihood of alteration of wetland extent. Sublethal effects from a change in the submerged vegetation communities was assessed as highly likely for Nonacho Lake and possible for Zones 2 and 3 (Table 13.10.11). The magnitude was classified as moderate for all areas because a lack of comprehensive waterfowl surveys and wetlands baseline data increases uncertainty levels. This effect would be continuous, medium-term, and reversible. The residual effect was assessed as low.

13.10.7.2.4 Northern Leopard Frog

13.10.7.2.4.1 *Riparian Habitat Loss/Modification*

The likelihood of riparian habitat loss or modification was the same as the likelihood of alteration to wetland extent. Riparian habitat loss or modification was assessed as possible for Thekulthili Lake (Zone 2) and Zone 3 (Table 13.10.11). Effects were classified as moderate primarily because of limited baseline data and a higher degree of uncertainty. Northern leopard frog baseline data were only available for a section of Zone 3 and no wetland baseline data were available for Zones 2 and 3. This effect would be continuous, medium-term, and reversible. The residual effect was classified as low.

13.10.7.3 CUMULATIVE EFFECTS

Other historic or existing disturbances within the watershed, such as mineral exploration and forestry activities, have little or no interaction with the hydrological regime of Nonacho Lake and Zones 1 to 4. The greatest effect to the pristine conditions of the assessment area was the construction and operation of the original Twin Gorges dam and Nonacho Lake control structure. Traditional knowledge indicates that the original dam had adverse effects on furbearer populations, and survey data at a reference site for beavers and muskrat suggest the same (Rescan 2000; 2001). Beaver abundance at Porter Lake, used as a reference site, only had one active beaver lodge (Table 13.10.1); it is possible that beaver abundance at the Nonacho Lake latitude may always have been low. Hanging Ice Lake and a portion of the Tethul River, which are outside the zone of influence of the Nonacho Lake control structure and the Twin Gorges dam, were chosen as reference sites for the Taltson River (Zone 3) and Trudel Creek (Zone 5). Data showed that the abundance of beaver lodges in the reference area is greater in absolute numbers, number of lodges detected per flown kilometre, and number of lodges per survey hour than any of the other surveyed areas (Table 13.10.1). In addition, a higher abundance of muskrat push-ups per linear kilometre of shoreline flown was also found (Table 13.10.2). The beaver and muskrat data may suggest that areas within the Taltson River system that were surveyed may have had lower beaver abundance (as determined through number of lodges) because of effects from the original Twin Gorges dam and accompanying hydrological changes.

During community scoping sessions, personal testimonials were recorded that reflect changes to furbearer populations observed following construction of the original Twin Gorges dam in the 1960s. Most of the statements were generalized to the Taltson River, which could correspond anywhere within Zones 1, 3, and 4. However, one statement was specific to Zone 4. Following construction of the original dam, one individual observed beaver lodges flooding during the winter and a decline in the muskrat and beaver populations (Rescan 2004a). This flooding occurred along the Taltson River, seven miles south of the confluence with the Rat River. Another person, who traps along the Taltson River, also stated that beavers were flooded out and died, and that muskrat populations had declined following dam construction (Rescan 2004a). This individual was a resident of Rocher River, close to where the Taltson River empties into Great Slave Lake; his observations may also come from the surrounding area of the Taltson River, which would fall within Zone 4. A newspaper article included in the appendix of the *Taltson Hydro Expansion Project 2003 Baseline Report* (2004a) referred to photos showing a trapper's flooded log cabin. This is also evidence for a changed hydrological regime. A resident of Fort Smith observed a decline in beaver populations from winter flooding that washes away food caches or drowns the beavers (see Section 9.6). During community consultation in Fort Resolution in 2006, changes to waterfowl populations and significant declines in muskrat populations as a result of the original dam were also mentioned (Boucher 2006).

Subsequently, there appears to be a residual effect on furbearers from the construction of the original dam, which must be considered cumulatively with the incremental residual effects identified for furbearers in this assessment.

13.10.7.3.1 Cumulative Effects Assessment

Construction of the original Nonacho Lake control structure resulted in a 2 m water level rise, 80 km^2 of flooded land, and shoreline increased by approximately 200 km (Northwest Territories Power Corporation 1998). This would have resulted in riparian habitat loss for furbearers and waterfowl, and particularly emergent vegetation communities. However, the flooding would have been an isolated event that may have then been compensated by the creation of marsh habitat.

Depending on the time of year when the flooding occurred, various effects may have been experienced by local wildlife. Evidence suggests that beaver populations in the area surrounding Nonacho Lake may not be very abundant, perhaps because of its high latitude. Survey data from Porter Lake, a reference site for Nonacho Lake, only had one active lodge (Table 13.10.1). In addition, a small number of beaver pelts are harvested in this area by residents of Łutsel K'e, compared to the more southern communities of Fort Smith and Fort Resolution (see Section 9.6). Assuming that the beaver population was small at Nonacho Lake prior to construction and operation of the original dam, the residual effects at this location from the original Project development would be considered low. Effects to beavers at Nonacho Lake for the current Project upgrades relate to changes in riparian habitat and are considered low given that the effects to riparian habitat are reversible in the medium-term.

Effects to muskrat following the original flooding of Nonacho Lake would have been low if the water level rose during the summer. However, if water levels were increased during the winter, then flooding may have resulted in mortality from an inability to access shelter and food and the potential subsequent increased predation rates. Based on traditional knowledge, the effects to furbearers along the Taltson River following the construction and operation of the original dam was high, as declines of beavers and muskrats were observed. The effects to muskrat with respect to the current Project were assessed as having a medium residual effect at Nonacho Lake (Zone 1) and Tronka Chua Lake (Zone 2).

13.10.8 Significance Determination

Effects were considered significant if they lead to changes that threatened future sustainability of the VC. As populations within Trudel Creek are not isolated from the Taltson River watershed, effects within Trudel Creek could extend to the larger population within the Taltson River watershed, and vice versa. Thus, determination of significance for wildlife VCs within the Taltson River watershed, under normal operating conditions, encompasses effects within Trudel Creek (Chapter 14).

For the overall determination of significant effects to wildlife VCs within the Taltson River watershed, the residual effects identified through the Trudel Creek effects assessment were considered together with residual effects within the overall Taltson River watershed (Table 13.10.12).

Effects classification uncertainty is presented in Table 13.10.12 and represents the level of confidence in the effect predictions at a local level. With additional data on local wildlife populations, the significance of the effects would probably not change, but the likelihood and magnitude of the effects classification would be more accurate.

13.10.8.1 36 MW OPTION

13.10.8.1.1 Furbearers

No significant adverse effect was assessed to the preservation of harvesting opportunities for muskrat within the Taltson River watershed. The residual effects at Nonacho Lake, Zone 1, and Tronka Chua Lake (Zone 2) were classified as low (Table 13.10.12). Residual effects within Trudel Creek were ranked as moderate. Together, the residual effects within the Taltson River watershed would not reduce furbearer abundance or distribution. The most severe effects are predicted to occur within the Trudel Creek area. Specifically, ramping events may cause repeated effects to furbearers. Ramping events are expected to occur every other year, but the effects are likely reversible before the next ramping event. However, the effects of ramping events are hard to predict. Water levels would increase rapidly on the Forebay and along Trudel Creek and remain elevated for a three-week period. Ramping events are scheduled to coincide with the onset of freshet, thus furbearers would expect flows to rise at this time of year, but likely not 0.8 m over a 10-hour period. Ramping may cause direct mortality through drowning, though muskrat and especially beaver would likely be able to avoid this fate. Loss of food caches and exposure to the elements and predation would likely lead to increased mortality relative to baseline where rapid changes in water levels do not occur. However, the quality habitat would still remain, providing opportunities for increased recruitment or migrants to the area.

13.10.8.1.2 Moose

There would be no significant effects to the assessment endpoint of preservation of moose within the Taltson River watershed based on the proposed 36 MW Project expansion. Because of their mobility and range, the effects of the pathways identified for this VC were considered to have low residual effects.

13.10.8.1.3 Waterfowl and Shorebirds

There would be no significant effect to the preservation of waterfowl-harvesting opportunities and populations of waterfowl and shorebirds within the Taltson River watershed based on the proposed 36 MW Project upgrade under normal operating conditions.

13.10.8.1.4 Northern Leopard Frog

The assessment endpoints of preservation of habitat and populations for northern leopard frogs would not be significantly affected by the Project. Neither residual effect for the two pathways for this VC was considered high.

Table 13.10.12 — Significance of Wildlife Effects for 36 MW Option

Valued Component	Assessment Endpoint	Pathways	Geographic Extent of Effect	Overall Residual Effect[1]	Significance	Uncertainty
Furbearers (muskrat)	Preservation of furbearer harvesting opportunities	Direct mortality leading to reduced population abundance (higher and lower water levels; includes ramping)	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Moderate/Adverse	No	Medium
		Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse		
		Riparian habitat loss/modification leading to change in population abundance.	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse		
		Stabilized water levels leading to increased abundance	Zone 3, 4 and 5 (Trudel Creek)	Moderate/Beneficial		
Moose	Preservation of moose harvesting opportunities	Riparian habitat loss/modification leading to change in population abundance	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse	No	Low
		Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse		
Waterfowl and shorebirds	Preservation of waterfowl populations and harvesting opportunities	Sublethal effect (changes to diet) leading to reduced population abundance	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse	No	Medium
Northern leopard frog	Preservation of habitat and populations	Riparian habitat loss/modification leading to change in population abundance	Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse	No	Medium

Valued Component	Assessment Endpoint	Pathways	Geographic Extent of Effect	Overall Residual Effect[1]	Significance	Uncertainty
		Direct mortality leading to reduced population abundance: drawdown of water level during winter when frogs are potentially overwintering in riparian areas	Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse		

[1] Overall Residual Effect presented is the most extreme rating for any area within the Taltson River watershed.

Table 13.10.13 — Significance of Wildlife Effects for 56 MW Option

Valued Component	Assessment Endpoint	Pathways	Geographic Extent of Effect	Overall Residual Effect[1]	Significance	Uncertainty
Furbearers (muskrat)	Preservation of furbearer harvesting opportunities	Direct mortality leading to reduced population abundance (higher and lower water levels; includes ramping)	Nonacho, Zone 2, 3 and 5 (Trudel Creek)	Moderate/Adverse	No	Medium
		Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Nonacho, Zone 2, 3 and 5 (Trudel Creek)	Low/Adverse		
		Riparian habitat loss/modification leading to change in population abundance	Nonacho, Zone 2, 3 and 5 (Trudel Creek)	Low/Adverse		
		Stabilized water levels leading to increased abundance	Zone 2, 3 and 5 (Trudel Creek)	Moderate/Beneficial		

Valued Component	Assessment Endpoint	Pathways	Geographic Extent of Effect	Overall Residual Effect1	Significance	Uncertainty
Moose	Preservation of moose harvesting opportunities	Riparian habitat loss/modification leading to change in population abundance	Nonacho, Zone 2, 3 and 5 (Trudel Creek)	Low/Adverse	No	Low
		Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Nonacho, Zone 2, 3 and 5 (Trudel Creek)	Low/Adverse		
Waterfowl and shorebirds	Preservation of waterfowl populations and harvesting opportunities	Sublethal effect (changes to diet) leading to reduced population abundance	Nonacho, Zone 2 and 5 (Trudel Creek)	Low/Adverse	No	Medium
Northern leopard frog	Preservation of habitat and populations	Riparian habitat loss/modification leading to change in population abundance	Zone 2, 3 and 5 (Trudel Creek)	Low/Adverse	No	Medium
		Direct mortality leading to reduced population abundance: drawdown of water level during winter when frogs are potentially overwintering in riparian areas	Zone 2, 3 and 5 (Trudel Creek)	Low/Adverse		

[1] Overall Residual Effect presented is the most extreme rating for any area within the Taltson River watershed.

13.10.8.2 56 MW Option

13.10.8.2.1 Furbearers

There were no assessment endpoints to which significant effects were identified during operations for the 56 MW option (Table 13.10.13). This is primarily because all effects would be short or medium-term and thus reversible. Any moderate effects that were identified would only occur within the first decade of the operations as the new hydrological regime and shoreline became established and riparian vegetation communities re-established themselves.

13.10.8.2.2 Moose

There would be no significant effects to the assessment endpoint for preservation of moose within the Taltson River watershed based on the proposed 56 MW Project upgrade. Because of their mobility and range, the effects of the two pathways identified for this VC were considered to have low residual effects.

13.10.8.2.3 Waterfowl and Shorebirds

There would be no significant effect to the preservation of waterfowl harvesting opportunities and populations of waterfowl and shorebirds within the Taltson River watershed based on the proposed 56 MW Project upgrade under normal operating conditions.

13.10.8.2.4 Northern Leopard Frog

The assessment endpoints of preservation of habitat and populations for northern leopard frogs would not be significantly affected by the Project. Neither residual effect for the two pathways for this VC was considered high.

13.10.8.3 Cumulative Effects and Significance

The effects to muskrat with respect to the current Project were assessed as having low to moderate residual effects within the Taltson River watershed. Effects to the preservation of harvesting opportunities of the multiple populations available at a regional scale were not considered significant. In addition, the distribution of muskrat, irrespective of effects from the Expansion Project, was not predicted to be significantly affected. Similarly, effects to furbearers may have had a moderate residual effect from the construction of the original dam, but, considering the multiple populations that would exist at the regional scale of the Taltson River watershed, the effect would not be significant.

13.10.9 Uncertainty

A number of factors contribute to the uncertainty of the effects assessment of the Project on wildlife, including limited wildlife baseline and wetlands data for some of the Project zones as well as a reliance on modelling for changes to hydrology and wetlands (Table 13.10.12, Table 13.10.13). With additional wildlife baseline and wetlands data, the magnitude of the effects classification could be decreased as more would be known about the VC's presence and abundance. The following section presents the key uncertainties for the VCs and summarizes how these uncertainties affected the regional determination of significance.

13.10.9.1 36 MW Option

13.10.9.1.1 Furbearers

Uncertainty levels are high for Zones 1, 2, and 3 because baseline data have not been collected in these Project areas. In addition, wetlands information has not been collected for Zones 2 and 3. Therefore, the amount of suitable habitat within these areas and the abundance of furbearer populations are unknown. The uncertainty level for Nonacho Lake is medium as furbearer baseline data do exist for the area and wetland modelling was possible, so there is a greater confidence in effects to the riparian habitat. If wetland habitat information was available for Zones 2 and 3, then the likelihood of the effect of riparian habitat loss leading to changes in furbearer abundance would be increased if modelling showed that an alteration to wetland extent was expected. If furbearer abundance data were available for all areas that were assessed, then the magnitude of the effects might be altered.

13.10.9.1.2 Northern Leopard Frog

Uncertainty for Zone 1 is low as baseline surveys have been conducted in this area. The magnitude of effects to this species may have been higher if baseline surveys had not indicated that the riparian areas of the Taltson River system are not being used as breeding habitat but rather are primarily summer foraging habitat. Uncertainty is medium for Zones 2 and 4 because no baseline data have been collected either for northern leopard frogs or wetlands. Northern leopard frog abundance in the northern half of Zone 2 may be very low, because this area is farther than the known northern extent of the species. The magnitude of effects might increase if additional data indicated riparian areas in Zones 2 and 4 included breeding habitat for the species. However, the significance to the assessment endpoint probably would not change.

13.10.9.2 56 MW Option

13.10.9.2.1 Furbearers

The uncertainty level for Zones 2 and 3 is high because of a lack of complete furbearer and wetland baseline data. If wetland habitat information was available for Zones 2 and 3, then the likelihood of the effect of riparian habitat loss leading to changes in furbearer abundance would be increased if modelling showed that an alteration to wetland extent was expected. If furbearer abundance data were available for all areas that were assessed then the magnitude of the effects might be altered. If furbearer populations were shown to be quite abundant then the magnitude of effects would be increased; if they were shown to be absent then the magnitude would decrease. The uncertainty level for Nonacho Lake is medium, as furbearer baseline data do exist for the area and wetland modelling was possible, so there is a greater confidence in effects to the riparian habitat. However, even with such changes to the effects classification, the regional significance to the assessment endpoint would probably not change.

13.10.9.2.2 Northern Leopard Frog

Uncertainty levels are medium for Zones 2 and 3 as no baseline data have been collected and the abundance of the species within these areas is unknown. Northern leopard frog abundance in the northern half of Zone 2 may be very low, because this area is farther than the known northern extent of the species. The magnitude of effects might increase if additional data indicated riparian areas in Zones 2 and 3 included breeding habitat for the species. However, the significance to the assessment endpoint probably would not change.

13.10.9.3 BOTH OPTIONS

13.10.9.3.1 Moose

The uncertainty level for the determination of significance for effects to the assessment endpoint for moose for both the 36 and 56 MW options is low as there is abundant suitable habitat within the Project area that is easily accessible to this VC. With additional baseline wetland data, the likelihood of the two pathways for this species might change, but the magnitude would probably remain the same.

13.10.9.3.2 Birds

The uncertainty level for waterfowl for both the 36 and 56 MW options is medium as breeding/productivity surveys have not been conducted for waterfowl in the Project zones. If breeding surveys were conducted that indicated the majority of the breeding species in the Project area was not heavily reliant on submerged vegetation as their primary food source, then the magnitude of the effect might decrease. If the abundance of waterfowl breeding in the Project area was shown to be minimal then the magnitude of the local effect might decrease. However, even with additional baseline data, the regional significance to the assessment endpoints for waterfowl and shorebirds would not change.

13.10.10 Monitoring

Monitoring of wildlife within the Taltson River watershed is recommended prior to construction and at regular intervals during the life of the Project. Any monitoring should be done ensuring consistent and transferable data so that comparisons can be made to conditions before, during, and after the Expansion Project.

TABLE OF CONTENTS

PAGE

TABLE OF TABLES

13. WATER FLUCTUATIONS IN THE TALTSON RIVER WATERSHED

13.11 SUMMARY AND CONCLUSIONS

The Expansion Project would cause a change in the hydrologic regime of the Taltson River watershed. Measurable changes in the hydrograph have the potential to cause changes in water quality, the ice regime, wetlands associated with the Taltson River, aquatic resources, fish and wildlife. The effects to these valued components are summarized below, followed by a discussion of the overall effects on the Taltson River watershed from the Expansion Project.

Effects are presented together for both the 36 MW and 56 MW expansion options where appropriate. The effects assessment summarized below relates specifically to the Taltson River watershed and the sustainability of these valued components within this geographical context. The findings of the assessment of effects on Trudel Creek (Chapter 14) were incorporated into the effects assessment for the Taltson River watershed, specifically for the determination of significant effects on fish and wildlife. Although the potential effects on Trudel Creek VCs were assessed separately as per the Terms of Reference, the Trudel Creek VCs form part of the populations within the Taltson River watershed and represent a portion of the population of the VCs that were assessed for the Taltson River watershed. Thus, the Taltson assessment used a holistic or populations approach to assessing effects, whereas the Trudel Creek assessment considered effects in isolation of the surrounding environment.

A discussion and general assessment of effects resulting from cumulative effects was presented for each VC within the Taltson River watershed and for Trudel Creek (Chapter 14); these assessments are summarized below. The assessment of cumulative effects considered the geographic boundary of the Taltson River watershed as a whole. Thus, effects were identified from pristine to baseline (historic residual effects) and baseline (current conditions) to Expansion Project within the entire Taltson River watershed for all stages of the Expansion Project (including canal construction; see Section 15.2).

13.11.1 Alterations of Water Quantity

The Expansion Project would incorporate a new generation facility at Twin Gorges of between 36 MW and 56 MW, upgrades and modifications to the control structures at the outlet of Nonacho Lake, and a bypass spillway (30 m^3/s capacity) at Twin Gorges. The primary objective of the Expansion Project would be to maximize power generation from the existing and new plants, while maintaining basin environmental constraints and conditions as required. The existing Twin Gorges 18 MW plant currently operates at between 8 and 12 MW output, with the majority of the inflow to the Twin Gorges Forebay being spilled into Trudel Creek. Moving toward full generation at either of the total capacities proposed for the Expansion Project (54 MW or 74 MW) would thus require enhanced water management within the basin, particularly with respect to the current spill into Trudel Creek. These necessary water management processes would tend to modify basin hydrological conditions from their current baseline in the basin between Nonacho Lake and Great Slave Lake. Although the total flow in the basin would not change as a result of the Expansion Project, the temporal and spatial distribution of flow from the regulated portion of the basin (i.e. Nonacho Lake) would be altered.

With the exception of Trudel Creek, alterations to the hydrologic regime of the basin would result from altered operations of Nonacho Lake. With increasing distance from Nonacho Lake, the magnitude of change would decrease as flows from unregulated portions of the basin enter the Taltson River and dampen the signature from Nonacho Lake. The greatest changes under the Expansion Project would be realized in Nonacho Lake, the Taltson River from Nonacho Lake to the Tazin River (Zone 1), from Tronka Chua Gap to Lady Grey Lake (Zone 2), and Trudel Creek (Zone 5). Alterations to the hydrologic regime would largely be a result of increased discharge from Twin Gorges through the power plants rather than over the SVS and is discussed in detail in Chapter 14.

Changes to the hydrologic regime in response to the two expansion scenarios were estimated using the Flow Model. A 13-year time series of estimated hydrologic inputs was used to run the baseline and expansion model scenarios. The Flow Model provided quantitative estimates of water levels and flows throughout the study area from Nonacho Lake to Great Slave Lake. Estimated changes in water levels and flows from baseline conditions varied between the two expansion scenarios and between the various basin zones. An overview of the general response of the basin to the two expansion scenarios can be ascertained from consideration of a few of the fundamental characteristics of the basin and the proposed plants.

The total flow at Twin Gorges is made up of two relatively independent flow sources: water from the upper Taltson River and Nonacho Lake system, and water from the Tazin River system. Current best estimates are that each source area contributes about 50% of the flow at Twin Gorges. The Taltson River at Twin Gorges has a mean annual discharge of approximately 200 m^3/s, which has ranged from about 100 m^3/s to 285 m^3/s over the available period of record. Therefore, the mean annual discharge from the unregulated Tazin system and the Nonacho Lake branch are approximately 100 m^3/s each. The release flow from Nonacho Lake therefore needs to balance on average the difference between the design flow and a mean annual available flow of about 100 m^3/s.

The design flow for the 36 MW expansion is 180.6 m^3/s, leaving an average release requirement of 80 m^3/s from Nonacho Lake, and 100 m^3/s from unregulated inflow. Therefore, in average and wetter–than-average years, the Nonacho Lake system would be expected to be successfully used for storage of freshet flows and release of water into the system later in the year. In most years, the storage of freshet runoff would shift the higher flow period from summer into winter in the river reach downstream of Nonacho Lake. In dry years, and particularly in multiple-year dry periods, the storage within Nonacho Lake would be used, and releases would be constrained.

The design flow of the 56 MW expansion is 240 m^3/s, well above the mean annual discharge at Twin Gorges over the available period of record (but below wet year annual discharges). Therefore, only in wetter-than-average years would there be excess water that could be stored in Nonacho Lake and released later in the season. In any year, the volume of water stored would be lower than for the 36 MW plant, and the associated winter releases possible would also be lower. In an average year, all water coming into Nonacho Lake would be needed for release almost immediately to maintain power plant design flows. Therefore, on average, there would not be a shift in the timing of high or low release periods from Nonacho Lake. Consequently for much of the basin, the hydrologic regime would be expected to vary less from the baseline than the 36 MW expansion scenario.

Under the simulated expansion scenarios, water levels in Nonacho Lake would decrease by 0.3 m and 0.7 m on average for the 36 MW and 56 MW expansions respectively, with the greatest decreases expected to in April and May. Over the 13-year model period the average annual water level varied over a 0.7 m range (i.e. from 322.87 to 323.5 masl) under baseline conditions. With the greater management of flows from Nonacho Lake, the annual variation in monthly average water levels would increase on average by approximately 80% and 30% for the 36 MW and 56 MW expansions, respectively. The timing of annual high and low water levels within Nonacho Lake would not change substantially, although with the storage of a portion of the freshet each year, water levels would remain at a relatively high level later into the year, especially under the 36 MW expansion scenario.

Average annual releases from Nonacho Lake to the Taltson River would increase under the 36 MW expansion scenario by 4%, and by 13% under the 56 MW expansion. However, releases to the Taltson River during the freshet period would decrease on average under the expansion scenarios compared to baseline. The period of decreased flows compared to baseline would extend from May through September on average under the 36 MW expansion scenario, and from June to July on average under the 56 MW expansion scenario. The peak flow period would shift on average from July under baseline conditions to August under the 56 MW expansion and to January under the 36 MW expansion. Consequently the shape of the annual inflow hydrograph to Zone 1 would be altered under the expansion scenarios and especially under the 36 MW expansion.

The increase in releases to the Taltson River and Zone 1 would be at the expense of decreased discharge from Nonacho Lake to Zone 2 at Tronka Chua Gap. Under the simulated 36 MW and 56 MW expansion scenarios, discharge at the Tronka Chua Gap to Zone 2 would decrease by 20% and 70%, respectively. Prolonged periods of zero flow would occur under both of the expansion scenarios, potentially persisting for one or more years during extended dry periods. A zero flow event that persists a full calendar year under the 36 MW scenarios was estimated to occur once out of the 13-year model simulation period. This corresponds to approximately a 1-in-25-year event based on the long-term flow records for the Taltson Basin. Under the 56 MW expansion scenario, five zero-flow years were estimated, which corresponds to approximately a 1-in-5-year event based on the long-term flow records for the Taltson Basin. During periods of zero flow over Tronka Chua Gap, Zone 2 would still receive runoff from local catchment areas.

The magnitude of alteration to water levels and flows in the lakes and river sections below Nonacho Lake would decrease with increasing distance from Nonacho Lake as flow is routed through the numerous lakes and unregulated portions of the basin contribute flow to the Taltson River. The Tazin River is the largest tributary of the Taltson River.

Below the Tazin River, the confluence of regulated flows from Nonacho Lake and the unregulated flow from the Tazin River would result in a "flattened" hydrograph which would persist to Great Slave Lake (with the exception of Trudel Creek, which is discussed in Chapter 14). In general, flows would be lower during the freshet period and higher during the winter low-flow period. Below the Tazin River, average peak monthly freshet flow would decrease from baseline conditions by approximately 20% and 6% under the 36 MW and 56 MW expansion scenarios respectively. Average minimum monthly winter flows at the same location would increase from baseline conditions by approximately 40% and 4% under the 36 MW and 56 WM expansion scenarios, respectively. Near Great Slave Lake (i.e. Taltson River below Rat River), the estimated change from baseline conditions would be approximately –7% and –4% in average monthly freshet flow and approximately +35% and +3% in minimum monthly winter flows for the 36 MW and 56 MW expansion scenarios, respectively.

13.11.1.1 Scheduled Power Outages

Outages at the Twin Gorges power facility would be scheduled on an annual basis to conduct routine maintenance. Scheduled shutdowns would occur once a year for each turbine for regular maintenance. Each turbine would be inoperative for approximately one week. Maintenance of the turbines would be completed sequentially rather than simultaneously, such that as one turbine is brought back on-line another turbine would be taken off-line. Thus, a scheduled partial shutdown of the existing 18 MW and two proposed 18 MW turbines for a 36 MW expansion, or two 28 MW turbines for a 56 MW expansion, would last approximately three consecutive weeks. The preferred timing of the annual outages would be to occur just prior to the onset of freshet, which generally occurs in April or May.

Scheduled outages would occur annually in April/May. However ramping events from the scheduled outages would only occur when turbines are operating at full generation flow (180.6 m^3/s and 240 m^3/s for the 36 MW and 56 MW expansions, respectively). Based on the Flow Model results, this was estimated to occur six times in April or May during the 13-year model simulation period for the 36 MW expansion scenario and once out of 13 years for the 56 MW expansion scenario.

During a ramping event, the level would rise in the Forebay, increasing discharge over the SVS to Trudel Creek and simultaneously decreasing flow in the Taltson River below Twin Gorges. The South Gorge Spillway would be operated and 30 m^3/s would pass to the Taltson River below Twin Gorges, reducing the initial drop of flow in the Taltson River and the increase to Trudel Creek. Flow would remain depressed in the Taltson River below Twin Gorges until the additional spill at the SVS routes through Trudel Creek and returns to the Taltson River, which would require approximately 10 to 16 hours, and returns to pre-outage flow.

Upon the re-start of the final turbine, the South Gorges Spillway would be closed and flow over the SVS would decrease. Flow and levels in the Taltson River below Twin Gorges would temporarily increase above pre-outage levels until flow through Trudel Creek has completely responded to the decrease in flow at the SVS, which would require approximately 10 hours.

Flow in the Taltson River below Twin Gorges would change by 44 m^3/s (for the existing turbine) and 23 m^3/s (new 18 MW turbines) from estimated pre-outage conditions for the 36 MW expansion and by up to 53 m^3/s (for an expansion turbine) for the 56 MW scenario, for roughly 10 to 16 hours. Based on average April and May background flow in Trudel Creek during periods of full generation flow at the power plants, the resulting changes in water level would be up to 0.34 m (decrease during initial shutdown and increase upon restart) for the 36 MW expansion and up to 0.32 m (decrease during initial shutdown and increase upon restart) for the 56 MW expansion. Water levels on the Forebay would increase for the duration of the ramping event. Water levels would increase roughly 0.1 and 0.2 m for the 36 MW and 56 MW options.

13.11.2 Alterations of Water Quality

The Expansion Project would have negligible to low magnitude effects on water quality throughout the Taltson River watershed under either expansion option. Nonacho Lake was predicted to be the main zone with the potential to experience Project-related effects. The changes in water levels in Nonacho Lake would disturb lake sediments, potentially affecting general chemistry, mercury, and sedimentation rates in the lake. Downstream transport of these substances would be experienced in the first lakes immediately downstream to the upgraded facilities (Taltson Lake and Tronka Chua Lake). Suspended substances flowing into these lakes would settle out of the water column, depositing in the lake bed. In particular, changes to suspended materials in Nonacho Lake would settle in Taltson Lake (Zone 1) and Tronka Chua Lake (Zone 2), while lakes farther downstream in Zones 1 and 2 would experience lower effects. Zones 1 and 2 are approximately 150 km in length, and suspended substances would have settled out of the water column upon flowing that distance while passing through several lakes.

The temperature and dissolved oxygen profiles would not change in most water bodies. Only Tronka Chua Lake would experience changes to water levels and volumes that would be large enough to affect temperature and dissolved oxygen. Nonacho and Taltson lakes and the Forebay would be too deep for the water level changes to have any effect.

Erosion processes would undergo negligible effects in all assessed zones because the lakes and rivers of the Taltson River watershed are generally low-gradient, low-velocity and deep-water lakes and river sections. Taltson River in Zone 1 river banks contain bank armouring from small boulders and cobblestone and provide minimal erodible materials. Zone 2 would receive lower flows; thus, lake and river levels would not reach existing levels, reducing erosion potential.

Sedimentation processes are dependent on flow and water velocity, as well as the nature of the river banks. In Nonacho Lake, increased annual variation in mean monthly water levels may change rates of sedimentation by redistributing existing sediments. In Taltson Lake, which is immediately downstream of Nonacho Lake, low level sedimentation effects may be experienced from suspended materials transported downstream. The same effects would not be experienced in Tronka Chua Lake because under the proposed scenarios, water is directed away from Zone 2 and lower volumes of water enter Tronka Chua Lake.

13.11.3 Bioaccumulation of Mercury

Overall, the baseline mercury concentrations in fish from Nonacho and Taltson lakes are similar to the reference lakes. The reference lakes have not experienced any effects from the current hydroelectric project and would not experience any effects from the proposed expansion. Currently all fish in each of the lakes are considered baseline conditions of natural pristine subarctic lakes. Fish in other remote northern water bodies in Canada have similar ranges of mercury concentrations for lake trout and lake whitefish (Stephens 1995).

Typically, new reservoirs increase water levels by several metres and flood a large terrestrial surface area compared to the proposed Expansion Project. Under the two expansion scenarios, the absolute maximum water level would not exceed the levels experienced under baseline conditions. Variation in annual water level would increase; however, there would be no flooding of new soils, only the potential for redistribution of existing mercury in lake sediments.

13.11.3.1 36 MW Summary

The modelled mercury concentrations under the 36 MW scenario would experience a low increase in the average mercury concentration for lake whitefish <350 mm, but undetectable changes for lake trout. The modelled increase for <350 mm lake trout would represent a negligible (<0.01%) increase relative to the average baseline concentration.

For fish >350 mm, modelled increase in average mercury concentration would not be detectable for all fish in all water bodies. Lake trout that are >530 mm would continue to exceed the Health Canada guideline, which is commonly seen in larger fish due to bioaccumulation over time. Mercury concentrations in these lake trout would be similar to the surrounding reference lakes at equivalent fork length sizes. Consumption of lake trout >530 mm should be minimized by all people. Lake whitefish would be below the guideline for all fish sizes.

13.11.3.2 56 MW Summary

Under the 56 MW scenario, there would be less effect to mercury concentrations in fish compared to the 36 MW scenario. The modelled increase would be detectable in lake whitefish from Taltson Lake that were <350 mm because these fish experience in-lake and upstream lake effects. The mercury concentration would increase from 0.03744 to 0.03746 mg/kg ww. This concentration would be below the site-specific reference concentration (RC).

The concentration in lake whitefish in Nonacho Lake and lake trout in both lakes that were <350 mm had average mercury concentrations exceeding the site-specific RC at baseline levels. Under the expansion scenario, no detectable increases would occur and there would be no measurable ecological effect.

For fish sizes that were >350 mm, the modelled mercury concentration increases for lake trout and lake whitefish in both water bodies were lower than detection limit. Although baseline maximum concentrations exceeded the human health guideline for lake trout >530 mm, they would be representative of baseline conditions, and similar to reference lakes for equivalent-sized fish. Consumption of lake trout >530 mm should be minimized by all people. Lake whitefish would be below the guideline for all fish sizes.

13.11.4 Alterations of Ice Structure in Trudel Creek

Ice conditions on the Taltson River have been reviewed and assessed qualitatively on the basis of three available ice surveys. Predictions have also been made on how the development of either a 36 MW or 56 MW Expansion Project would affect the existing ice regime in this reach.

For the 36 MW development scenario, the proposed changes to the management of flows from Nonacho Lake include releasing near-to-baseline flows from October through December, suggesting that ice freeze-up would be similar to the baseline condition. Discharges from the reservoir are predicted to increase above baseline conditions from January through April. At rapids sections and in the open water leads, increasing the flow may cause staging or backwatering effects and increase the potential for localized flooding along the shoreline.

For the 56 MW development scenario, releases from Nonacho Lake into the Taltson River would be higher than baseline from October through December, but flows through the Tronka Chua Gap would be lower than baseline. For regions downstream of the Taltson/Tazin confluence, ice formation flows are expected to be similar to the baseline condition. An increase in the formation flow may slow the ice cover formation somewhat in the reach between the Taltson/Tazin confluence and the Nonacho reservoir. It is expected that an ice cover would continue to form relatively quickly on the many lakes and slow-velocity reaches in this zone in spite of the increased flow. However, the open-water leads that currently exist at the narrower channel sections and rapids would likely be a bit larger in extent. The increased open water area may lead to the development of a rougher and thicker ice cover immediately downstream of any of these open-water areas.

The changes to operations at Nonacho Lake are not expected to have an effect on the large lakes downstream of the reservoir. The increased lake depth during the freeze-up period is not expected to change the mechanism of thermal ice generation. The ice thickness should remain consistent with baseline conditions. However, on Nonacho Lake, the lake level is expected to decrease throughout the winter months, which is likely to break up the ice cover close to the shoreline. This is similar to what occurs under baseline conditions.

It is possible that during scheduled outage events at the Twin Gorges facility, the Trudel Creek ice cover may partially break up and re-jam within the channel or in the Taltson River downstream of Elsie Falls. This could lead to localized flooding at and immediately upstream of any ice-jam. Although there is potential for this to occur under baseline conditions, the probability of this occurring would increase under the proposed Expansion Project.

This qualitative assessment of potential changes in ice structure is based on three ice field studies within the Taltson River watershed and on predictive hydrologic modeling. The effect of changes in flow conditions on ice structure at critical locations would depend on the local river hydraulics and stream morphology at the individual sites. Site-specific field work and possibly modeling would be required to give a quantitative assessment of change.

13.11.5 Wetlands

Wetlands were selected as a valued component (VC) of the Taltson River watershed specifically, as they influence the hydrologic regime and provide habitat to various wildlife including furbearers, moose, waterfowl, shorebirds, and northern leopard frogs along Trudel Creek. The assessment endpoints for the wetlands VC was the preservation of wetland extent and the maintenance of wetland function. Wetland extent is the size of individual wetlands and total wetland area potentially affected by the Project. Wetland function is a process or series of processes that wetlands carry out, such as a wetland's ability to regulate the hydrology of a given area, provide habitat to wildlife, and support the ecology of its surroundings.

One pathway was identified that could affect the wetland assessment endpoints in each zone under operations: water level changes leading to a change in the flood regime, which could alter wetland extent and function.

Changing water levels would affect the current flood regime, which is the primary force in maintaining riparian wetland communities. The direction of change (increase or decrease in flows) is not as important as the magnitude and duration. Water levels substantially above or below current ecosystem community boundaries would result in species composition shift following natural succession. The extent and function of wetlands along the Taltson River are maintained by the flood regime. To determine effects to wetlands from the Project, an ecological assembly model was developed for the existing wetlands. Ecological assembly is defined as the structure and composition of an ecosystem. Structure relates to the vertical and horizontal ground cover by all species within a community, whereas composition is the abundance and distribution of individual species within a community. Vegetation structure and composition and therefore ecological assembly are influenced by the hydrologic regime, and ultimately water level fluctuations.

Within the Taltson River watershed, there exist clear transitions in vegetation from sedge to willow. This boundary corresponds to the elevation that is inundated for a given portion (< 40%) of the growing season. Given the hydrologic changes proposed under both expansion scenarios, this ecosystem boundary and thus wetland extent and function would be affected. The results of the Taltson flow model were input into the ecological assembly model to determine the effects on wetlands.

The change in the hydrologic regime would cause a change in community structure as determined by the ecological assembly model and/or inferred solely via changes in water levels. Changes in the community structure would result from a change in the flood-controlled community boundary. For wetlands in the Taltson River watershed, this is predicted to allow willow and sedge to shift downslope as the habitat "dries". Submergent vegetation is also predicted to shift down with the water level. Little net change in wetland extent is predicted, assuming both willow and sedge succession is successful over time. The overall residual effect is moderate given the length of time assumed for the wetland to stabilize: up to ten years.

As the community structure changes in response to changes in the flood regime, so too would wetland function. In terms of Taltson wetland hydrologic function, the current wetlands are not considered key factors in the rate of release of freshet volume over time (given the large storage capacity of Taltson lakes), nor are they considered instrumental in maintaining minimum flows through the winter (given that the Taltson River is relatively self-regulated by significant but few hydraulic controls from Nonacho to Twin Gorges). Thus, the overall hydrologic function of Taltson wetlands on the Taltson River hydrograph is minimal. Taltson wetlands are, however, assumed to play a significant role in terms of wildlife habitat. Under either the 36 MW or 56 MW option, the overall wetland extent is not expected to change measurably in the medium-term. In the short-term, there would be succession in species location and abundance but there would not be periods of large reductions in overall habitat. Thus, the overall residual effect on wetland function has been conservatively rated as moderate.

Rapid changes in water levels from ramping events were considered Minor pathways to effects on wetlands on the Forebay and along the Taltson River (downstream of Elsie Falls) because the small rise in water levels on the Forebay would not cause a change in the assessment endpoints, and the change in water level on the Taltson River would be of short-term duration (up to 10 hours) and thus would not cause a change in the assessment endpoints.

13.11.6 Aquatic Resources

The hydrologic changes under both the 36 MW and 56 MW expansion options that were deemed to be Valid pathways to effects on aquatic resources were decreased flow, increased flow range, decreased flow range and altered hydrograph parameters. Decreased flow pathway was Valid for all zones under the 36 MW option and Valid for Nonacho Lake, Zone 2 and Zone 3 under the 56 MW option. Increased flow range pathway was Valid for Nonacho Lake (36 MW and 56 MW options) and Zone 2 (36 MW option only). Decreased flow range pathway was Valid for Zone 1, Zone 3 and Zone 4 (36 MW option) and Valid for Zone 1, Zone 2 and Zone 4 (56 MW option). Altered hydrograph parameters pathway was Valid for Zone 2 and Zone 3 (36 MW and 56 MW options) and Zones 1 and 4 (36 MW option only). Pathway validation focused on changes in the hydrologic regime during the summer months (June to August) when the aquatic resource communities are most productive and diverse.

13.11.6.1 Nonacho Lake

Nonacho Lake was predicted to have low magnitude decreases in water levels throughout the year. In summer, these decreases could result in minor loss of habitat along the perimeter of the lake, affecting littoral vegetation (emergent and submergent) and associated littoral benthos. This would subsequently result in short-term loss of productivity while the newly-formed littoral zone becomes suitable for aquatic plants and a diverse and productive benthic community. Field surveys indicated that emergent vegetation grows to roughly 1 m depth, and submergent vegetation was generally observed from about 25 cm to 105 cm depth (CGL 2008a). Therefore, the projected decreases in water levels would affect the upper portion of littoral habitat in summer, but leave deeper emergent and some submergent plants intact. It was also noted (CGL 2008a) that vegetation may grow deeper than that observed because surveys were done earlier in the growing season. Any profundal habitat that changes to littoral habitat would represent a net loss of profundal habitat.

This loss is considered negligible based on the total profundal habitat within Nonacho Lake, which is 20 to 30 m deep.

The range in flow during summer and over the year at Nonacho Lake would increase to a moderate degree. However, this increase in range would not occur every year. Its occurrence would be correlated with average to below average flow years. The effect of increased flow range is related to additional disturbance to littoral lake habitat, which could result in reduced habitat quality and reduced productivity. Some reductions in diversity and change to dominant taxa could also occur. The larger difference between summer and winter variation could result in increased ice scour and drying in winter periods. The effects relate to decreased littoral habitat productivity and diversity. Given the magnitude of the change and the frequency, the effects to productivity, biodiversity and community structure within littoral and profundal habitat would be negligible.

13.11.6.2 ZONE 1

Flows and water levels would show low magnitude decreases in summer in Taltson Lake, King Lake, Benna Thy Lake, and Lady Grey Lake. Decrease in summer water levels would result in loss of productivity as the overall wetted area would decrease and in particular the littoral community would be disturbed. A shift in community structure and loss of some diversity would also be possible, depending on the areas exposed. Field surveys in 2008 indicated that Lady Grey Lake had emergent and submergent from 0 to 150 cm depth (CGL 2008a). This suggests that only the top portions (20 to 30%) of littoral vegetation would be disturbed by the decreased water levels during summer. The overall magnitude of the change in water level is low for Zone 1.

The hydrograph was predicted to change, with higher winter flows and lower summer flows in Taltson Lake and farther downstream in Zone 1, resulting in the freshet being delayed by a month (start in late June on average). The change in the freshet timing could mean that plants and invertebrates would not receive the same levels of nutrients and organics normally transported to them at the start of the growing season (June). New seedlings and invertebrate larvae develop at set rates based on their short life cycles; therefore this alteration of their environment would disrupt their development to a certain degree. This could reduce growth and productivity of aquatic resources.

13.11.6.3 ZONE 2

Water flows and levels in Zone 2 are expected to show low magnitude decreases over summer months. This could cause drying of habitat and loss of productivity and diversity in Tronka Chua Lake and farther downstream in this zone. No field information is available regarding depth distributions for littoral vegetation in Zone 2. Effects relate to decreased littoral habitat, productivity diversity and community structure.

Increased flow ranges are predicted for Zone 2; however, within-summer monthly variation would be similar to baseline.

The hydrograph was predicted to change in Zone 2. There would be an increase in frequency from 1 in 13 to 4 in 13 years (36 MW option) and 9 in 13 years (56 MW options) where flows would be consistently low throughout the year. During low flow years, no flow would pass through Tronka Chua Gap. This would cause loss and altered quality of littoral habitat in the Tronka Chua Gap area of Zone 2. Other small local tributaries would still flow into Zone 2 although the relative amounts are small compared to baseline flow over the gap. This change, therefore, is not a new effect but a change in frequency of low flow years, which is not expected to affect biodiversity but would likely reduce overall productivity during low-flow years.

13.11.6.4 ZONE 3

Water flows and water levels would show a moderate magnitude decrease in the summer in the Taltson River downstream of the Tazin River confluence, and to a lesser extent below the power facilities. In the Twin Gorges Forebay, summer levels would show a low-moderate magnitude decrease. Lower summer levels would affect littoral productivity (plants, algae, benthos) and may affect community structure, due to exposure and alteration of littoral habitat. No field information is available regarding depth distributions for littoral vegetation in Zone 3. Profundal habitat would remain abundant, as the proportion that would transform from profundal to littoral is quite small overall.

Decreased water level ranges (36 MW option: 113 cm or 53% annually, and 22 cm or 65% over summer; 56 MW option: no changes) are predicted for the Taltson River in Zone 3. This is related to increased winter levels and decreased summer levels compared to baseline. These reductions could result in reduced nutrient and organics transport from riparian zones into the river during high flows. This would have a minor effect on productivity.

In Zone 3 above Twin Gorges Forebay, no important changes to the hydrograph were predicted for either expansion option. In the Forebay, the hydrograph would change such that 3 of 13 years (36 MW option) and 5 of 13 years (56 MW option) would become extended low-flow years. This change would not likely affect biodiversity but would likely reduce overall productivity in the three low-flow years and is considered a continuous and long-term effect as these changes would last through operations.

In the Taltson River below the Forebay, scheduled shutdowns would result in negligible to low decreases and increases in water levels (<0.3 m) over short periods (6 to 10 hours). The rate of increase may cause mortality to some invertebrates, but the overall loss of productivity would be minimal. The effect of ramping is only expected to occur 6 of 13 years (36 MW option) and 1 of 13 years (56 MW option). Many species of aquatic plants and invertebrates can withstand periods of drying over periods of days.

13.11.6.5 ZONE 4

Water flows and levels in Zone 4 would show low magnitude decreases in the summer months under the 36 MW option only. No changes are expected under the 56 MW option. The changes under the 36 MW option would result in short-term loss of some existing aquatic habitat along riverbanks, with related reduction in productivity and diversity as the littoral community is disturbed and shifts down in elevation, and profundal habitat is permanently lost. No field information is available regarding depth distributions for littoral vegetation in Zone 4. The permanent loss of profundal habitat would be negligible given the size of system in Zone 4.

13.11.6.6 OVERALL RESIDUAL EFFECTS

At various locations along the Taltson River there would be short-term loss of suitable littoral habitat as water levels drop and new littoral zones establish. The decreases in water levels are not predicted to dewater all the current suitable littoral habitat and the time required for new littoral habitat to become suitable would be short-term.

The decrease in water levels would lead to the long-term loss of profundal habitat. However, the percent loss of profundal habitat is estimated to be low and thus the residual effect would not markedly affect baseline conditions.

Increases and decrease in the range of flow would affect habitat quality. Decreases in flow range would reduce nutrient recruitment, and increases in flow range disturb sediments and dry out habitat that was previously not dewatered. However, the magnitude of change in the range is not expected to cause measurable changes in aquatic resources.

Some sections of the Taltson River would experience altered hydrographs, where the minimum flow persists for longer and/or freshet is delayed. However, these changes would be periodic and effects on aquatic resource productivity, biodiversity and community structure were not expected to lead to marked changes from baseline levels such that the sustainability and distribution of aquatic resources were in question.

13.11.7 Fisheries Resources

Within the valued component of fisheries resources, four species were selected to represent the range in habitat requirements, key ecological roles, community structure, importance to end users, and special designations by territorial and federal agencies:

- northern pike,
- lake whitefish,
- lake trout, and
- walleye (Trudel Creek only).

The diversity of preferred habitat conditions and life history characteristics of northern pike, lake trout, lake whitefish and walleye is considered to cover the interests of the fish and fish habitat conditions within the Taltson River system, including Trudel Creek.

The Department of Fisheries and Oceans Canada (DFO) has developed a Risk Assessment Framework and created Pathways of Effects (POE) for common in-stream and land-based activities. To date, DFO has identified 19 POEs, all of which were evaluated for their applicability to this Project. Those that were considered

Invalid were not considered further. Those that were considered Minor were noted, and the five considered Valid were carried forward to a full effects assessment analysis. These were:

- obstruction as it relates to entrainment;
- flow management as it relates to migration and/or access to habitats (56 MW development only);
- flow management as it relates to fish habitat structure and cover;
- flow management as it relates to food supply; and
- flow management as it relates to displacement or stranding of fish (ramping).

These are discussed below and the implications to the valued components are presented.

13.11.7.1 Obstruction as it Relates to Entrainment

This pathway results from fish being swept into either the main power plant at Twin Gorges or the mini-hydro plant at the Nonacho Lake Control structure. The likelihood of fish being swept into the turbines if they are in the conveyance canals is good; however the survivability of the turbines (vis-à-vis fish passage) is 80%. The conveyance canals are being deliberately constructed with minimal fish habitat values so as to minimize their attractiveness to fish.

This is more likely to be an issue with lake trout and lake whitefish as these are more pelagic species, whereas northern pike are fish of the lake margins, specifically in areas of riparian vegetation. Walleye are not present above Twin Gorges.

Therefore, the magnitude of the effect of this pathway is ranked as Minor.

13.11.7.2 Flow Management as it Relates to Migration and/or Access to Habitats

This pathway is only germane to the 56 MW development. It results from changes in flow over the Nonacho Lake spillway and Tronka Chua gap. Under the 56 MW water management regime, the flows over these two would be reduced, but not eliminated completely. This would reduce the potential for fish movement from Nonacho Lake to either Taltson Lake or Tronka Chua Lake. This is unlikely to have any long-term effect on the fish populations in these lakes, as these lakes are either very large in and of themselves or continuous with large systems, and the fish populations on either side of these barriers are almost certainly self-sustaining.

None of these fish species (northern pike, lake trout and lake whitefish) are migratory and there is no critical need for such movement.

Therefore, the magnitude of the effect of this pathway is ranked as Minor.

13.11.7.3 Flow Management as it Relates to Fish Habitat Structure and Cover

There are two components to this pathway. First, in the Taltson River system, the ramifications of this pathway result from altered water levels. Second, in Trudel Creek, the altered flows would be sufficient to induce changes to banks and sandbars through altered depositional patterns.

In the Taltson River, the proposed water management regime would alter the water levels in the Taltson River system, and the magnitude of these water level changes varies throughout the system. It is anticipated that in those parts of the system where the anticipated water levels fall outside the pre-existing range of variation (on a month-by-month basis) that they would incur changes to riparian vegetation, both submergent and emergent, as these plants are dependant on the edaphic conditions of the lakeshore. It is expected that the vegetation would re-establish and return to current levels of ecologic productivity within 3 years for submergent vegetation and within 10 years for emergent riparian vegetation.

This is of more concern for northern pike than it is for either lake trout or lake whitefish, as they use the shallow near-shore waters of lakes and rivers for foraging, spawning and rearing. The success of the critical life-stages of northern pike (spawning and rearing) is linked to emergent and submergent vegetation.

Therefore, the magnitude of the effects was considered to be moderate and medium-term, but reversible. In other words, the effects on fish would only last until the riparian vegetation returns to its pre-Project condition, less than 10 years.

For Trudel Creek, a 2008 assessment of erosion on Trudel Creek indicated that the altered hydrograph would result in a significantly reduced erosion rate, resulting from reduced peak monthly and daily flows. This reduction in erosion would result in an increase in water quality and a corresponding reduction in deposition. This should result in little change from existing levels of ecologic productivity. Therefore, the reduction in deposition within Trudel Creek would have a net benefit to habitat structure and cover; however, it would not result in a considerable increase in habitat values.

Walleye are a valued component in Trudel Creek only. The analysis indicates that the availability of preferred spawning habitat conditions within Trudel Creek would change; however, the present walleye population is quite small and there is abundant spawning habitat available, therefore it seems unlikely that spawning habitat (and spawning success) is the limiting factor for the existing walleye population.

The magnitude of the effects to walleye of changes to habitat structure and cover was considered moderate.

13.11.7.4 FLOW MANAGEMENT AS IT RELATES TO FOOD SUPPLY

The mechanism for this pathway is the anticipated changes in riparian vegetation and the attendant ecologic productivity of other trophic levels (i.e. insects and invertebrates) on that vegetation. As discussed above, the altered hydrograph is expected to incur changes to riparian vegetation and, furthermore, it is expected that the vegetation would return to current levels of ecologic productivity within 3 to 10 years.

The lakes for which such changes are anticipated include Nonacho (56 MW development scenario only), Taltson and Tronka Chua lakes (both development scenarios), the Twin Gorges Forebay (also both development scenarios) and Trudel Creek.

Given that northern pike use the shoreline habitats more than either lake trout or lake whitefish, they are more likely to be affected by this change. However, given the variety of shoreline available, it is considered unlikely that this would have any severe or long-term effect on the populations of any of the fish species comprising the valued components. Walleye are not found upstream of Twin Gorges, and so are outside the geographic range of this effect.

13.11.7.5 FLOW MANAGEMENT AS IT RELATES TO DISPLACEMENT OR STRANDING OF FISH (RAMPING)

Scheduled ramping events have the potential to affect the valued components northern pike, lake whitefish and walleye in four ways:

- incubating egg displacement during increased flows;
- de-watering of incubating eggs during plant start-ups;
- increased erosion and deposition, potentially smothering incubating eggs; and
- juvenile and adult displacement/stranding during plant start-ups.

Of the identified potential affects, the dewatering of incubating eggs and larval fish was found to be the only effect likely to result in a residual effect.

The proposed scheduled outages and/or maintenance period of the turbines has been planned to occur in April and/or May prior to the onset of spring freshet. This time period overlaps the timing window of spawning/egg incubation of walleye and northern pike; lake whitefish spawning and emergence typically occurs by March. Therefore, there could be a potential to dewater incubating walleye and pike eggs.

During a scheduled shutdown, the waterline elevation within Trudel Creek would increase while the water level in the Taltson River downstream of Elsie Falls would decrease. The decrease in water levels in the Taltson River is only anticipated to last 6 to 10 hours whereas the increased flows in Trudel Creek would last for the duration of the work, about three weeks.

If the shutdown event is ongoing during the initiation of northern pike or walleye spawning, then those fish could move into the newly-wetted stream margins to spawn. If that were to happen, any eggs deposited outside the pre-event wetted perimeter would be potentially left above water.

The peak spawning period for walleye and pike typically occurs in mid- to late May. Thus, if the maintenance period and subsequent plant start-up occurs prior to mid-May, the effect would be significantly less if not eliminated. Moreover, water levels would naturally increase as the ramping event would coincide with the onset of freshet. Thus, once the ramping event is complete, water levels would not retreat to levels observed at the beginning of the ramping event. This would reduce the potential for egg dewatering during a ramping event from a scheduled outage.

13.11.8 Wildlife

Within the wildlife VC, there are many species or wildlife communities that have different ecological requirements and thus respond to development differently. Table 13.11.1 lists the wildlife VCs that were identified upon review of the requirements of the TOR, community concerns raised during consultation, and federal and territorial lists of species particularly susceptible to current and future development. The assessment endpoints are also listed in Table 13.11.1 and relate to preservation of the population and preservation of harvesting opportunities. Listed together with the assessment endpoint of preservation of the population is the measurement endpoint of habitat. Habitat is listed with population as they are closely related and thus directly overlap.

Table 13.11.1 — Wildlife Valued Components and Assessment Endpoints

Key Line of Inquiry	Valued Component	Assessment Endpoint
Water fluctuations in the Taltson River watershed	Furbearers	Preservation of furbearer harvesting opportunities within the Taltson River watershed
	Moose	Preservation of moose harvesting opportunities within the Taltson River watershed
	Waterfowl and shorebirds	Preservation of waterfowl harvesting opportunities within the Taltson River watershed
		Preservation of habitat and populations within the Taltson River watershed
	Raptors that primarily consume fish	Preservation of populations within the Taltson River watershed
	Whooping crane	Preservation of habitat and populations within the Taltson River watershed
	Rusty blackbird	Preservation of habitat and populations within the Taltson River watershed
	Northern leopard frog	Preservation of habitat and populations within the Taltson River watershed

The following pathways were identified as having the potential to affect the wildlife VCs of the Taltson River watershed:

- Direct mortality from increased flows (Valid for 36 MW option: furbearers);
- Direct mortality from decreased flow (Valid for 36 MW and 56 MW option: furbearers);

- Riparian habitat loss (Valid for 36 MW and 56 MW option: furbearers, moose);
- Change in diet (Valid for 36 MW option: furbearers, moose, waterfowl; Valid for 56 MW option: furbearers, moose and waterfowl);
- Stabilized water levels; beneficial effect (Valid for 36 MW and 56 MW option: furbearers);
- Bioaccumulation of methylmercury (Invalid for all VCs; no new flooding is predicted for either the 36 MW or the 56 MW option); and
- Reduced reproductive success (Invalid for all VCs; either the VCs do not breed in the area, breed during the water level change, or the change in water level would not affect nests).

13.11.8.1 FURBEARERS

Increase in water level in Zone 1 is only predicted to occur under the 36 MW option. The magnitude of the effect was assessed as moderate for Taltson, King, and Lady Grey lakes, and low for Benny Thy Lake. In the model, the highest annual water levels occurred in the winter in the 36 MW option, thus water levels would increase from fall to winter during every average operating year. Because muskrats construct their lodges in the fall, increased water levels in the winter are of primary concern. The modelled increase in water levels between September and the highest winter water levels ranges from 19 cm to 30 cm. This range is equivalent to the height of push-ups and small lodges, and therefore it is likely that some flooding of food caches would occur. This effect would be short-term, periodic, and reversible as the population is expected to recover from the resulting effect even though the stressor would occur annually based on average conditions.

Decreased water levels are predicted under both the 36 MW and 56 MW options. The effect of lower water levels causing direct mortality through freeze-out or exposing entrances and thus increasing predation rates would occur on Nonacho Lake, Tronka Chua Lake (Zone 2), and the Twin Gorges Forebay (Zone 3). Water levels during the fall, when muskrat are preparing for winter, would decrease in the order of a half a metre more under the Expansion Project. The effects on furbearers on Nonacho and Tronka Chua lakes would be short term, periodic, and reversible as the population is expected to recover from the resulting effect even though the stressor would occur annually based on average conditions.

13.11.8.1.1 Riparian Habitat Loss/Modification

Riparian habitat (wetlands) loss or modification was assessed as highly likely for Nonacho Lake and Zone 1, and possible for Zones 2 and 3. In each of these areas, the effects were considered continuous, medium-term, and reversible as vegetation communities would re-establish themselves once the new hydrological regime occurred. Riparian plant communities can take longer than a decade to stabilize following a water level drawdown, even though plant colonization would occur sooner.

13.11.8.1.2 Sublethal Effects

The likelihood of changes to submerged vegetation communities was the same as the likelihood of the alteration of wetland extent (see Section 13.7). For furbearers, the magnitude of this effect on muskrat was classified as moderate in Nonacho Lake and Zone 1 and low in Zones 3 and 4. The effect on muskrat was classified at a lower magnitude because the alteration of wetland extent, and therefore the change to submerged aquatic food resources, would change but was not assumed to be lost. Once a new hydrological regime is established, submerged vegetation communities would re-establish and stabilize. Thus, the effect would be continuous, medium term, and reversible. While the vegetation is re-stabilizing, there would still be ample food available for furbearers.

13.11.8.1.2.1 Beneficial Pathway

The difference between yearly water level maximums and minimums would decrease by half in the Taltson River downstream of the Tazin River and downstream of Twin Gorges in Zones 3 and 4. This change was classified as beneficial for muskrat and was assessed as likely with moderate magnitude. Winter mortality from freeze-outs and increased susceptibility to predators from exposed entrances would be reduced because of the new flattened hydrological regime. This effect would be continuous and long–term. However it would be reversible following operations of the Expansion Project.

13.11.8.2 MOOSE

13.11.8.2.1 Riparian Habitat Loss/Modification

Riparian habitat loss or modification was assessed as highly likely for Nonacho Lake and Zone 1 and possible for Zones 2 and 3 based on the likelihood of change in wetland extent from Section 13.7. Because of the abundance of wetland habitat within the Taltson River watershed and the capability of moose to travel farther than furbearers to access other available habitat, the magnitude of the effect was assessed as low. Once a new hydrological regime is established, vegetation communities would re-establish.

13.11.8.2.2 Sublethal Effects

Sublethal effects from a change in the riparian vegetation communities was assessed as highly likely for Nonacho Lake and Zone 1, and possible for Zones 2 and 3, based on the likelihood of change in wetland extent as discussed in Section 13.7. Given the same rationale as above, the magnitude was classified as low.

13.11.8.3 WATERFOWL AND SHOREBIRDS

13.11.8.3.1 Sublethal Effects

Sublethal effects from a change in the riparian vegetation communities were assessed for dabbling ducks and other waterfowl that feed on aquatic vegetation as highly likely for Nonacho Lake and Zone 1, and possible for Zones 2 and 3, based on the likelihood of change in wetland extent. The magnitude was classified as moderate because of high uncertainty levels regarding breeding waterfowl populations. Overall, the effect of changes in riparian vegetation would be low.

13.11.8.4 NORTHERN LEOPARD FROG

13.11.8.4.1 Riparian Habitat Loss/Modification

Riparian habitat loss or modification was assessed as possible for Thekulthili Lake (Zone 2) and Zone 3 and highly likely for Zone 1. The magnitude for Zones 1 and 3 was classified as low because the amphibians primarily use riparian habitat for foraging during the summer. The effect would have been classified as more severe if the riparian habitat also provided breeding habitat, but baseline surveys did not document extensive breeding habitat within the riparian zone. The effect would be continuous, medium-term, and reversible.

13.11.9 Significance of the Taltson River Watershed Effects

Significance determination of Project effects on the Taltson River watershed are presented for fisheries resources and wildlife. The effects on these two VCs represent the summation of physical and biological effects from the Project within the entire watershed. This includes the residual effects identified in the Trudel Creek effects assessment. As populations within Trudel Creek are not isolated from the Taltson River watershed, effects within Trudel Creek could extend to the larger population within the Taltson River watershed, and vice versa. Thus, the pathways that led to effects on fish and wildlife VCs within Trudel Creek were included in the process to determine the overall significance of effect from the Expansion Project within the Taltson River watershed.

The Taltson River watershed effects assessment considered both a 36 MW and 56 MW expansion at Twin Gorges. For the determination of significant effects to fish and wildlife, both expansion options were assessed together by presenting the more extreme overall residual effect for a given pathway.

13.11.9.1 SIGNIFICANCE DETERMINATION – FISHERIES RESOURCES

Table 13.11.2 presents the determination of significance for the fisheries resources Valued Components of the Taltson River system, including Trudel Creek.

Table 13.11.2 — Determination of Significance of Effects to the Fisheries Resources Valued Components

Valued Component	Assessment Endpoint	Pathway	Overall Residual Effect	Overall Significance	Uncertainty
Northern pike	Fish mortality	Obstruction as it relates to entrainment	Low	Not significant	Medium
	Changes in fish access over Tronka Chua Gap and the Nonacho Lake spillway	Flow Management as it relates to migration and/or access to habitats	Low		
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate		
	Changes in food supply	Flow management as it relates to food supply	Low		
	Displacement or stranding of fish	Flow management as it relates to displacement or stranding of fish (ramping)	Low		
	Changes to depositional zones	Flow management as it relates to fish habitat structure and cover (Trudel Creek)	Low		
Lake trout	Fish mortality	Obstruction as it relates to entrainment	Low	Not significant	Medium
	Changes in fish access over Tronka Chua Gap and the Nonacho Lake spillway	Flow Management as it relates to migration and/or access to habitats	Low		
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Low		
	Changes in food supply	Flow management as it relates to food supply	Low		
Lake whitefish	Fish mortality	Obstruction as it relates to entrainment	Low	Not significant	Medium
	Changes in fish access over Tronka Chua gap and the Nonacho Lake spillway	Flow Management as it relates to migration and/or access to habitats	Low		
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate		
	Changes in food supply	Flow management as it relates to food supply	Low		

Valued Component	Assessment Endpoint	Pathway	Overall Residual Effect	Overall Significance	Uncertainty
	Changes to depositional zones	Flow management as it relates to fish habitat structure and cover (Trudel Creek)	Low		
	Displacement or stranding of fish	Flow management as it relates to displacement or stranding of fish (ramping) (Trudel Creek)	Low		
Walleye (Trudel Creek)	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate	Not significant	Medium
	Changes to depositional zones	Flow management as it relates to fish habitat structure and cover	Low		
	Displacement or stranding of fish	Flow management as it relates to displacement or stranding of fish (ramping)	Low		

The Project is presented with two development scenarios: 36 MW and 56 MW. It is not anticipated to have a significant overall effect on fish populations in the Taltson River system under either scenario.

The differences between the two arise from changes to the water management regime in Nonacho Lake and the resulting effects on the water levels in Nonacho Lake and flows out of Nonacho Lake. The water management under the 56 MW development is anticipated to induce changes to riparian habitats in Nonacho Lake, while limited changes are anticipated under the 36 MW regime. Additionally, the 56 MW Project would not result in changes to riparian habitats in Taltson and Tronka Chua lakes, which are anticipated under the 36 MW Project.

All of the effects of the two development scenarios would be short- to medium-term in duration, as they relate to anticipated changes in riparian vegetation. The vegetation is expected to return to a state analogous to its current condition (i.e. ecologic productivity) within 3 to 10 years.

The findings of the above effects assessment and significance determination relies on the assumption that riparian communities would adjust to the new hydrologic regime within a short enough time period to avoid severe effects on fish. This assumption is supported by current conditions within the Taltson River watershed. This system has been subject to perturbations of a similar type, and of equal or greater magnitude, twice before. The first and greatest change happened with the original development of the Twin Gorges power facility (in the mid-1960s), and the second happened when the Pine Point Mine closed in the mid-1980s. Thus, the system that exists today is one that has responded and recovered from events similar to those proposed, and there is no obvious reason to anticipate that it would not recover again.

13.11.9.2 SIGNIFICANCE DETERMINATION – WILDLIFE

The determination of significance of the Project effects on furbearers, moose, waterfowl and shorebirds, and northern leopard frog is presented in Table 13.11.3.

Uncertainty of the effects classification represents the level of confidence in the effect predictions that were classified at a local level. With additional data on local wildlife populations, the significance of the effects would probably not change but the likelihood and magnitude of the effects classification would be more accurate.

Table 13.11.3 — Significance of Wildlife Effects within the Taltson River Watershed

Valued Component	Assessment Endpoint	Pathways	Geographic Extent of Effect	Overall Residual Effect[1]	Significance	Uncertainty
Furbearers (muskrat)	Preservation of furbearer harvesting opportunities.	Direct mortality leading to reduced population abundance (higher and lower water levels; includes ramping)	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Moderate/ Adverse	No	Medium
		Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance.	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse		
		Riparian habitat loss/modification leading to change in population abundance.	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse		
		Stabilized water levels leading to increased abundance.	Zone 2, 3, 4 and 5 (Trudel Creek)	Moderate/ Beneficial		
Moose	Preservation of moose harvesting opportunities.	Riparian habitat loss/modification leading to change in population abundance.	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse	No	Low
		Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse		

Valued Component	Assessment Endpoint	Pathways	Geographic Extent of Effect	Overall Residual Effect[1]	Significance	Uncertainty
		population abundance.				
Waterfowl and shorebirds	Preservation of waterfowl populations and harvesting opportunities.	Sublethal effect (changes to diet) leading to reduced population abundance.	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse	No	Medium
Northern Leopard Frog	Preservation of habitat and populations.	Riparian habitat loss/modification leading to change in population abundance.	Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse	No	Medium
		Direct mortality leading to reduced population abundance: drawdown of water level during winter when frogs are potentially overwintering in riparian areas.	Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse		

[1] Overall Residual Effect presented is the most extreme rating for any area within the Taltson River watershed

13.11.9.2.1 Furbearers

No significant adverse effect was assessed to the preservation of harvesting opportunities for muskrat within the Taltson River watershed. The overall residual effects at Nonacho Lake, Zone 1, and Tronka Chua Lake (Zone 2) were classified as low. Residual effects within Trudel Creek were ranked as moderate. Together, the residual effects within the Taltson River watershed would not reduce furbearer abundance or distribution. The most severe effects are predicted to occur within the Trudel Creek area. Specifically, ramping events may cause repeated effects to furbearers. Ramping events are expected to occur every other year, but the effects are likely reversible before the next ramping event. However, the effects of ramping events are hard to predict. Water levels would increase rapidly on the Forebay and along Trudel Creek and remain elevated for a three-week period. Ramping events are scheduled to coincide with the onset of freshet, thus furbearers would expect flows to rise at this time of year, but likely not 0.8 m over a 10-hour period. Ramping may cause direct mortality through drowning, though muskrat and especially beaver would likely be able to avoid this fate. Loss of food caches and exposure to the elements and predation would likely lead to increased mortality relative to baseline where rapid changes in water levels do not occur. However, the quality habitat would still remain, providing opportunities for increased recruitment or migrants to the area.

13.11.9.2.2 Moose

There would be no significant effects to the assessment endpoint of preservation of moose within the Taltson River watershed based on the proposed Expansion Project. Because of their mobility and range, the effects of the pathways identified for this VC were considered to have low residual effects.

13.11.9.2.3 Waterfowl and Shorebirds

There would be no significant effect to the preservation of waterfowl-harvesting opportunities and populations of waterfowl and shorebirds within the Taltson River watershed based on the proposed Expansion Project under normal operating conditions.

13.11.9.2.4 Northern Leopard Frog

The assessment endpoints of preservation of habitat and populations for northern leopard frogs would not be significantly affected by the Project. Neither residual effect for the two pathways for this VC was considered high.

13.11.10 Cumulative Effects Summary

Prior to development of the Twin Gorges facility in 1964, the Taltson River was a non-regulated system. There was no in-stream development or flow management in the Taltson River according to the NWT license database. The hydro-electric development on the Tazin River occurred in 1929, pre-Twin Gorges, and resulted in a diversion of flows from the Tazin River and subsequently a diversion of flows from the Taltson River. The change to the biophysical components in the Taltson River watershed associated with the Tazin River development are not known; however, any changes to the biophysical components most likely stabilized over the 45 year period between the diversion of flows (1929) and the Twin Gorges development (1964). Therefore, the pre-1964 condition of the Taltson River was considered “pristine” for the cumulative effects assessment. Further, there are no reasonably foreseeable projects that would affect the Taltson River, in addition to the Expansion Project.

Limited data is available to determine pre-development or pristine conditions, as no descriptions, drawings or ground level photographs of the Taltson River were attainable. Historical flow data (in combination with modelled data), Traditional Knowledge and a review of available air photos from pre-Twin Gorges were used to describe the pristine Taltson River watershed characteristics as best as possible (summarized in Section 13.1).

In the cumulative effects assessment, incremental effects from the Expansion Project on each Valued Component (wetlands, aquatics, fish and wildlife) together with known residual effects on the Taltson River watershed from previous developments were assessed. This assessment included the identified incremental effects from the Expansion Project associated with Trudel Creek (Chapter 14) and turbine and conveyance canal operation of the North Gorge and Nonacho control structure (Chapter 15.3). These components were included to obtain a complete assessment of all cumulative effects occurring within the Taltson River watershed.

The known development that has historically affected the Taltson River watershed includes the construction (1965) and operation (1986-present) of the Twin Gorges facility. The regulated flows of the Tazin River into the Taltson River have been considered in the current Taltson hydrologic model and no further cumulative effects would occur. Initial development of the Twin Gorges facilities included damming the Taltson River at Nonacho Lake and the Twin Gorges Forebay, installing a penstock pipeline, powerhouse and tailrace at Twin Gorges, and installing a concrete apron and a spillway at the SVS. Construction and operation of the Twin Gorges facility greatly altered water levels in Nonacho Lake and the Twin Gorges Forebay. Flow rates and levels were also changed in Zones 1, 2, 3, and 4. The increased water management in the Taltson River resulted in increased winter flows and decreased summer flows. Flow began to run through Tronka Chua Gap into Zone 2 where no such flows existed previously, owing to higher water levels in the Nonacho Lake reservoir, which spilled over the gap and into Tronka Chua Lake.

The following sections first discuss the identified cumulative effects, by Valued Component, associated with the Water Fluctuations within the Taltson River. A summary discussion is then provided from the cumulative effects assessment for the Ecological Changes in Trudel Creek (Chapter 14) and Turbine and Conveyance Canal Operation Subject of Note (Chapter 15.3).

13.11.10.1 CUMULATIVE EFFECTS FROM WATER FLUCTUATIONS IN THE TALTSON RIVER

There are no data on wetland communities occupying the region during pristine environment conditions; however, such a major hydrological change would have inundated emergent vegetation and further covered submergent vegetation, changing ecosystem structure, distribution and function. There is a high degree of uncertainty as to how the wetland communities have changed in terms of extent, structure, and function, from pristine times to baseline (current), and exactly how future periods would compare. The proposed expansion options present incremental adverse effects including medium-term reduced wetland extent and altered wetland function; at least until mature wetland communities would be assumed to develop (3-10 years following expansion). The proposed development presents change to the Taltson River and Nonacho Lake wetlands that have likely stabilized since the initial development and would be expected to re-stabilize in approximately 10 years following proposed expansion of Twin Gorges and the Nonacho Lake control structure (based on rates of vegetative succession in emergent communities).

There are no data on primary and secondary producer communities from this pre-development period. Residual cumulative effects from the initial hydroelectric project development include changes in habitat structure, loss of primary and secondary productivity during inundations from large rise of water levels, potentially reduced biodiversity, and mortality of existing aquatic communities. It is not possible to quantitatively assess losses from initial development due to lack of bathymetric and biological data. There is a high degree of uncertainty as to how the biological communities have changed in terms of density and diversity of primary and secondary producers, from pristine times to current baseline (post 1986) periods, and exactly how future periods would compare with respect to these parameters. The proposed development presents further change to the aquatic resources of the Taltson River. The aquatic resources would be expected to re-stabilize in approximately 10 years following the expansion of Twin Gorges (based on rates of vegetative succession in emergent communities).

The proposed expansion options present incremental adverse effects to fish populations, primarily associated with lowered water levels. For residual effects relating to lowered water levels (Zones 1 & 2), the incremental effects are not predicted to affect long term fish populations within the watershed. Effects are predicted but would be reversible in the medium-term (less than 10 years) as vegetation establishes within the new water level regime. In terms of cumulative effects, it is difficult to determine if ongoing residual effects are present. The populations of fish within the Taltson River watershed have likely stabilized following past disturbances; however, it is not known if past disturbances created a beneficial or adverse residual effect in terms of population size, distribution, health, etc. It can be inferred that the past disturbance caused a beneficial effect given that habitat extent increased and a direct link to Tronka Chua was made.

Based on Traditional Knowledge and on reference site comparisons, construction of the original Nonacho Lake control structure resulted in riparian habitat loss for furbearers and waterfowl; however, the flooding would have been an isolated event that may have been compensated by the creation of marsh habitat. Depending on the time of year when the flooding occurred, various effects may have been experienced by local wildlife. Evidence suggests that beaver populations in the area surrounding Nonacho Lake may not be very abundant, perhaps because of its high latitude. Assuming that the beaver population was small at Nonacho Lake prior to construction and operation of the original dam, the residual effects at this location from the original project development would be considered low. Effects to beavers at Nonacho Lake for the current Project upgrades relate to changes in riparian habitat and are considered low given that the effects to riparian habitat are reversible in the medium-term. Effects to muskrat following the original flooding of Nonacho Lake would have been low if the water level rose during the summer; however, if water levels were increased during the winter, flooding may have resulted in mortality from an inability to access shelter and food and increased predation rates. Based on Traditional Knowledge, the effects to furbearers along the Taltson River following the construction and operation of the original dam was high as declines of beavers and muskrats were observed. The effects to muskrat with respect to the current Project were assessed as having a moderate residual effect at Nonacho Lake, Zone 1, and Tronka Chua Lake (Zone 2).

13.11.10.2 Ecological Changes in Trudel Creek

The cumulative effects assessment for Trudel Creek indicates that, in comparison to pristine conditions, historical activities and developments resulted in changes to wetland extent and function, aquatic productivity, availability of the preferred fish habitat structure and cover conditions, and furbearers and waterfowl. These components are anticipated to experience further changes as a result of the Expansion Project; however, it is expected that wetland extent/function and aquatic productivity would re-stabilize within 3 to 10 years. Once the habitat conditions within Trudel Creek re-stabilize, the cumulative effects to fish resources within Trudel Creek would be of low magnitude. The effects to furbearers and waterfowl would also be expected to have stabilized and re-established in response to the environmental changes.

13.11.10.3 TURBINE AND CONVEYANCE CANAL OPERATION

The cumulative effects assessment for Turbine and Conveyance Canal Operation indicates that, the Nonacho control structure micro-hydro plant and the North Gorge canal and turbines, coupled with the existing turbine at Twin Gorges, would increase the potential for the entrainment of juvenile fish, namely lake trout. The precise increase can not be determined; however, the likelihood of the juveniles using a canal or penstock leading to a turbine is low and the survivability rates if fish pass through a turbine are high. In addition, entrainment would be limited to fish spawned at or near the canal/penstock facilities and not on the entire population found throughout the Twin Gorges Forebay or Nonacho Lake.

13.11.10.4 OVERALL CUMULATIVE EFFECTS SUMMARY

Overall, the cumulative effects assessment of the entire Taltson River watershed indicates that, in comparison to pristine conditions, historical activities and developments resulted in changes to wetland extent and function, aquatic productivity, the availability of preferred fish habitat structure and cover, and to furbearers/waterfowl harvesting opportunities. These components are anticipated to experience further changes as a result of the Expansion Project; however, it is expected that wetland extent/function and aquatic productivity would re-stabilize within 3 to 10 years. Once the habitat conditions within the Taltson River re-stabilize, the cumulative effects to fish resources would be of low magnitude. The effects to furbearers and waterfowl would also be expected to have stabilized and re-established in response to the environmental changes.

Considerable uncertainty exists in regard to the pristine conditions of the Taltson River watershed, including habitat value and species populations. Further, uncertainty exists in regard to the long-term effects of past developments, considering the apparent stability of the current environmental conditions. The uncertainty associated with pristine conditions and past development effects lead to considerable uncertainty in predicting the cumulative effects as compared to pristine conditions.