Ecofish Research Ltd.
Suite 101 - 2918 Eby Street
Terrace, B.C. V8G 2X5

Phone: 250-635-7364
info@ecofishresearch.com
www.ecofishresearch.com

MEMORANDUM

TO:	**Water Engagement Initiative (WEI)**
FROM:	**Isabelle Girard, M.Sc., R.P.Bio., Susan Johnson, Ph.D., Adam Lewis, M.Sc., R.P.Bio., and Jayson Kurtz, B.Sc., R.P.Bio., Ecofish Research Ltd.**
DATE:	**November 28, 2022**
FILE:	**1316-07**
RE:	**Kemano Intake – Desktop Assessment of Fish Entrainment**

1. INTRODUCTION

During Main Table and Technical Working Group meetings of the Nechako Water Engagement Initiative (WEI), concerns were raised regarding potential effects of Rio Tinto Alcan (RTA) operations on fish populations in the Nechako Reservoir. In particular, there was interest in understanding whether fish were being "lost" from the reservoir through the Kemano intake in West Tahtsa Lake. The process of fish moving downstream through a hydroelectric facility is termed "entrainment".

This memo provides a desktop entrainment risk assessment for the Kemano intake under current operations using the BC Hydro *Fish Entrainment Risk Screening and Evaluation Methodology* (BC Hydro 2006). The following sub-sections provide background information about the Kemano facility (including hydrological considerations) and fish habitat and community near this location, while the subsequent sections present the assessment methodology and results, as well as a discussion of the consequences of potential entrainment on relevant fish populations.

1.1. Background

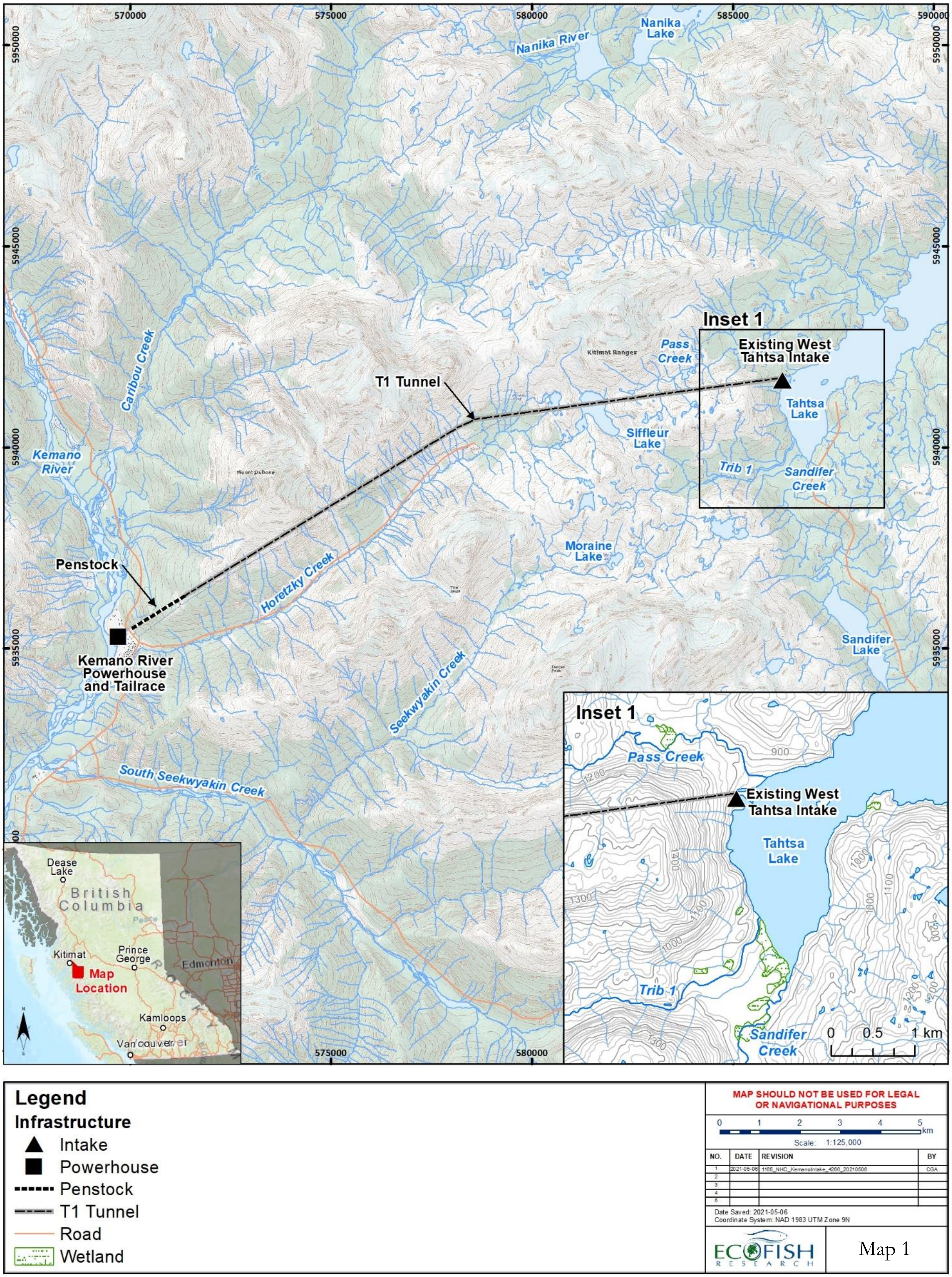
1.1.1. Kemano Hydroelectric Facility

The Nechako Reservoir is a large hydroelectric storage reservoir impounded by the Kenney Dam (which has no discharge facility) located approximately 200 km west of Prince George, British Columbia (BC) (Map 1). The reservoir is operated by RTA to produce energy for the Kitimat aluminium smelter (RTA 2011a). It has an area of ~890 km^2 and inundates a ~420 km-long chain of six major lake and river systems (Ootsa, Whitesail, Knewstubb, Tetachuck, Natalkuz, and Tahtsa). There are two reservoir outflows (KCB 2020, Girard *et al.* 2016a): the Kemano powerhouse intake portal to the west (in West Tahtsa Lake) that flows into the Kemano River watershed, and the Skins Lake Spillway to the east that flows into the Nechako River watershed (Map 1).

Existing infrastructure associated with the Kemano hydroelectric facility includes an intake in West Tahtsa Lake (Figure 1), a 16-kilometre (km) power tunnel, two penstocks, a powerhouse on the Kemano River containing eight generators with BLH Pelton turbines, a tailrace, and an 80 km transmission line to the RTA Smelter in Kitimat (RTA 2011a) (Map 1). The Kemano intake was constructed in 1953 and consists of two tunnel intake portals (T1 and T2) that deliver water into the tunnel system (Figure 2; Mercier, pers. comm. 2021). Presently, only the T1 intake portal is used to provide water to the T1 Tunnel. The intake structure has three trash rack bays in front of each intake portal for screening of debris from the water before it enters the tunnel (Girard *et al.* 2016a).

The Kemano facility operates under water licenses that prescribe a maximum diversion (discharge) of 170 m^3/s, a maximum live storage of 7,100 hm^3, and a maximum storage of 23,850 hm^3 (MOELP 2012, MOELP 1997). However, the hydraulic limitations in the T1 tunnel currently restrict the discharge to 145 m^3/s at a maximum reservoir level of 853.5 masl (Rescan 1999). Currently, the intake is pulling water in year-round, but the discharge varies annually based on power needs and sporadic maintenance or unplanned shutdowns. The average monthly discharge at the Kemano intake between January 1 and December 31, 2020, generally varied between 88.1 m/s^3 in May and 143 m^3/s in December (Figure 3, Table 1). Overall, flows were lowest in the summer, highest in the fall-winter months, and moderate in the spring (Figure 3).

Kemano Intake Location and Hydroelectric Project Overview



Path: M:\Projects-Active\1316\MXD\1165_NHC_KemanoIntake_4266_20210506.mxd

Figure 1. Intake and forebay in West Tahtsa Lake for the Kemano Hydroelectric Project.

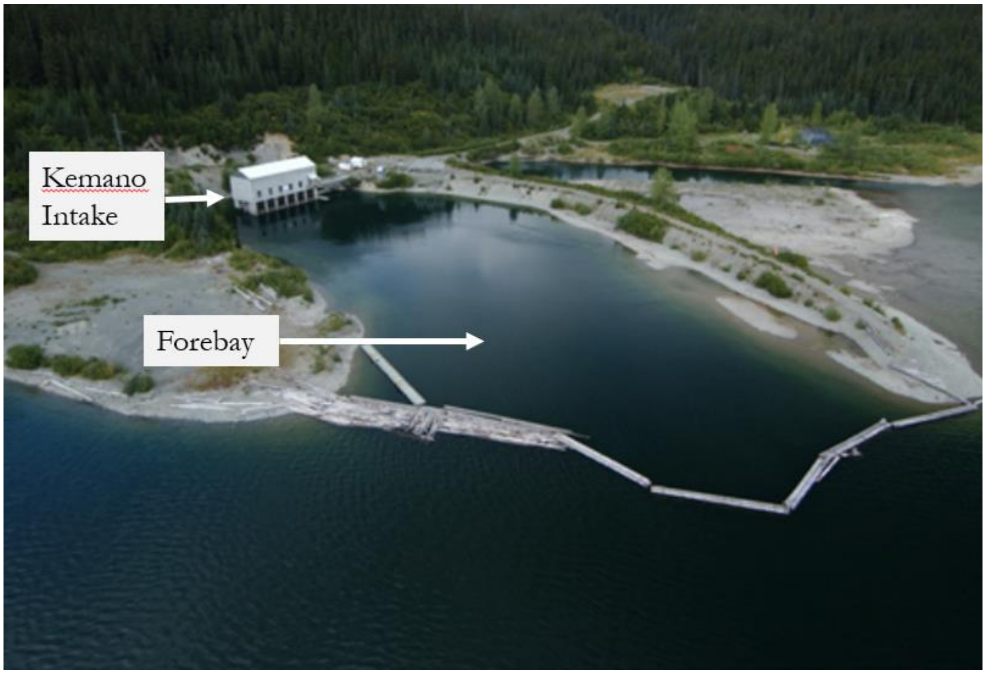


Figure 2. T1 and T2 portals of the Kemano intake.

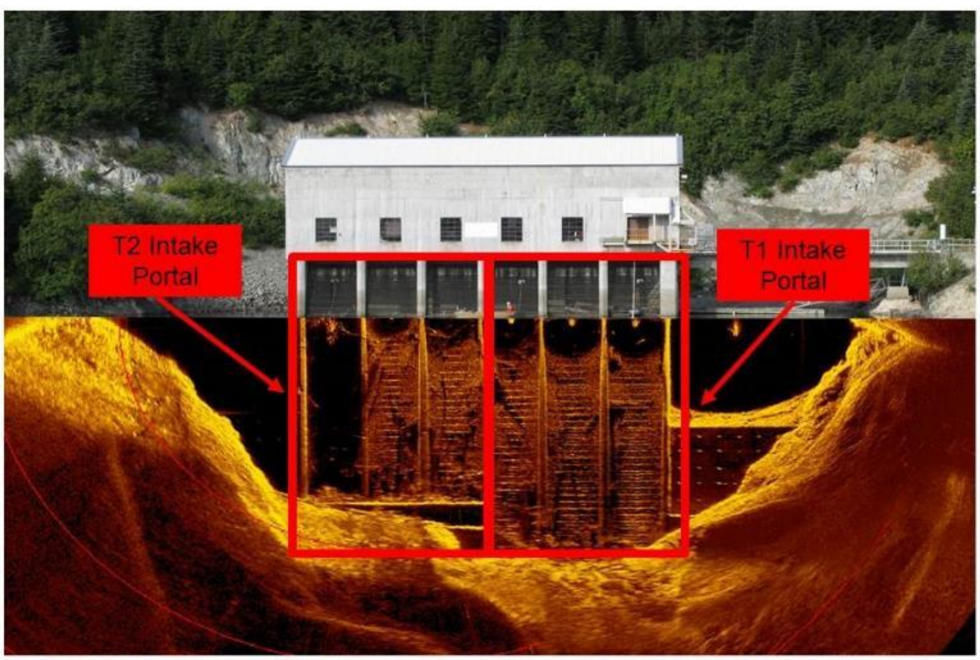
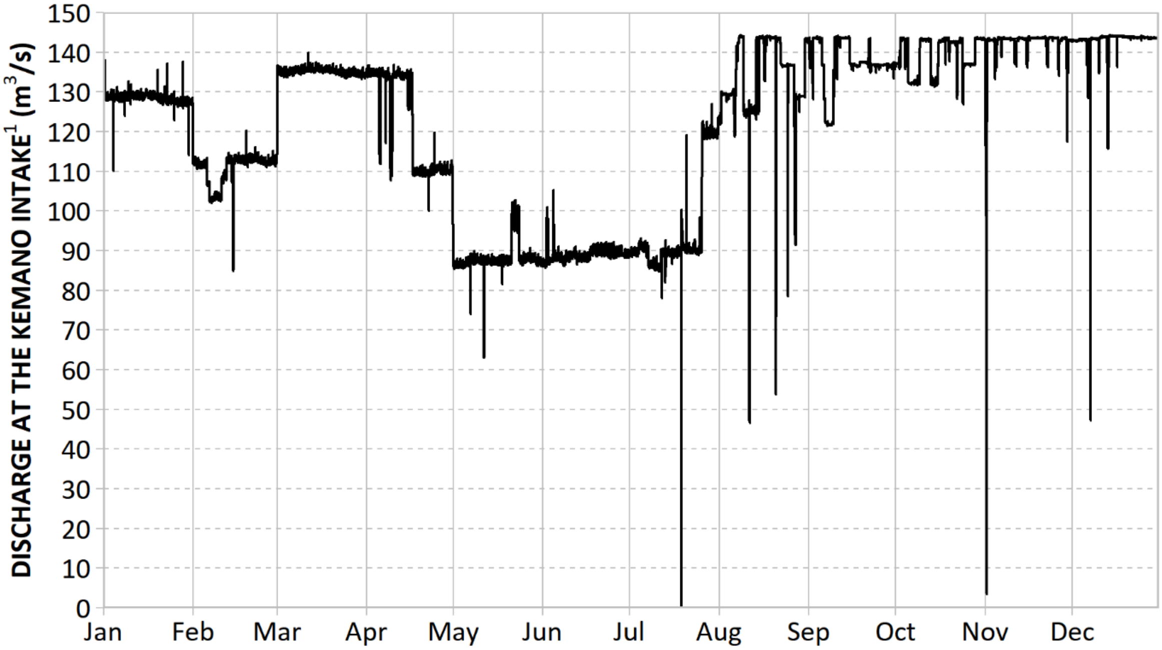


Figure 3. Discharge at the Kemano intake in 2020 (Lecuyer, pers. comm. 2020).



[1]Discharge at Kemano Intake is equal to discharge at Kemano Powerhouse (Mercier, pers. comm. 2021)

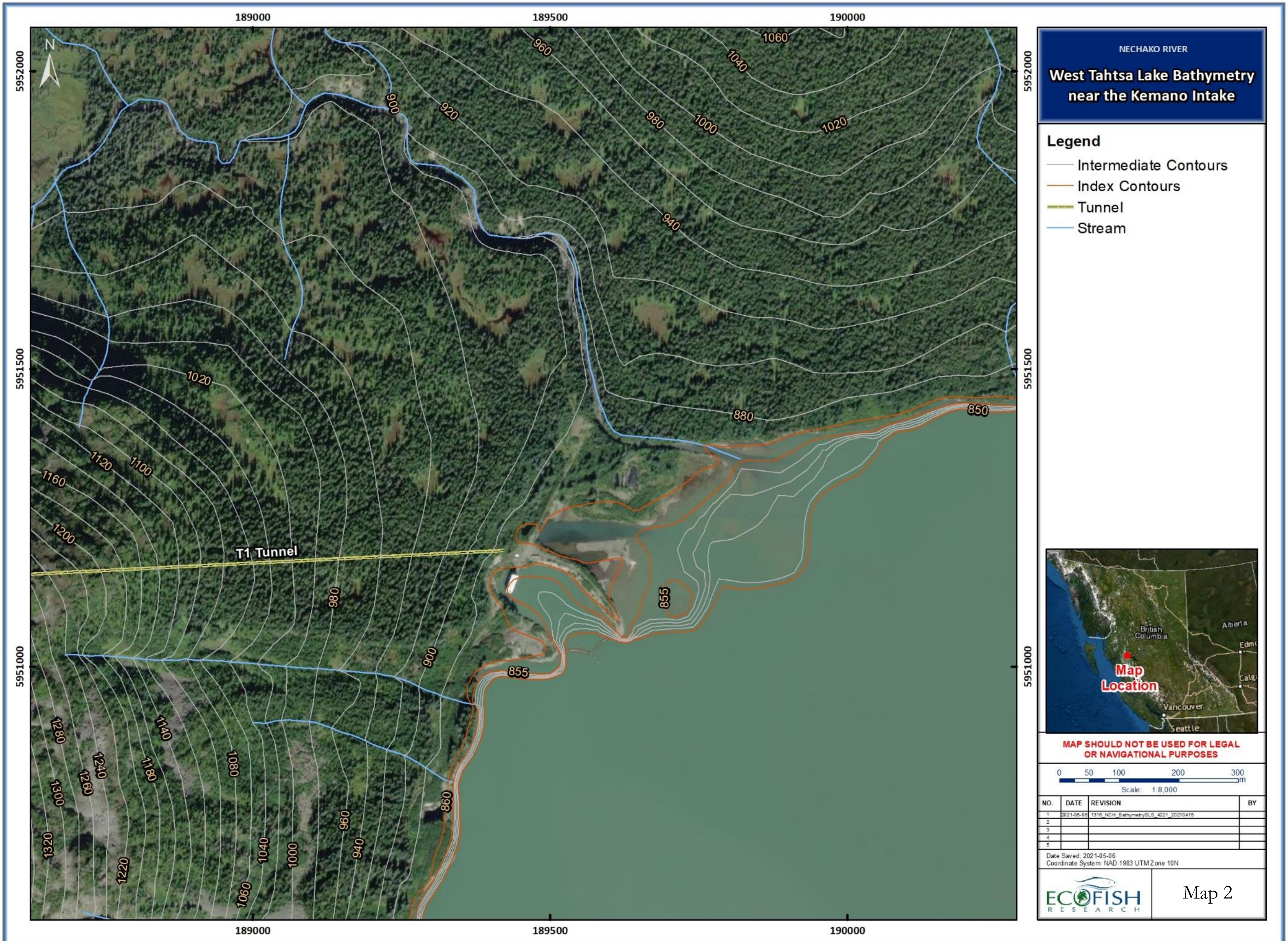
Table 1. Summary statistics by month for discharge at the Kemano intake as measured at the trash racks (Lecuyer, pers. comm. 2020).

Month	Discharge (m^3/s)		
	10th %tile	Average	90th %tile
January	127	128	129
February	103	110	113
March	134	135	136
April	109	122	135
May	86.3	88.1	88.7
June	87.4	88.9	90.2
July	86.1	94.7	119
August	124	134	144
September	128	137	144
October	132	139	144
November	137	142	144
December	143	143	144

1.1.2. Fish Habitat near the Kemano Intake

Fish habitat exists along the lake shoreline, littoral zone, and pelagic zones of West Tahtsa Lake; fish habitat conditions are typical of those in the Nechako Reservoir. In the forebay area of the intake (Figure 1), the shoreline has a gradual slope (Map 2). Based on available imagery, the substrate is expected to be dominated by fine sediment. In comparison to habitat adjacent to the Skins Lake Spillway, habitat in the Kemano forebay consists of more littoral habitat combined with deep water habitat, which may be more suitable for some fish species common to both areas. However, the habitat in the Kemano forebay contains less suitable habitat than much of the surrounding area in West Tahtsa Lake.

The minimum water level near the Kemano intake is 843.8 masl, and the bottom of trash racks is located at 830.6 masl for the T1 portal and 835.2 masl for the T2 portal (Lecuyer, pers. comm. 2021, Mercier, pers. comm. 2021). These water levels differ slightly from those in the Nechako Reservoir due to head loss across Tahtsa Narrows (Mercier, pers. comm. 2021). Based on these elevation data, it appears that the water depth in front of the T1 portal varies between 13 m and 23 m with high water levels in the summer, moderate levels in the fall and winter, and the lowest levels in the spring (Mercier, pers. comm. 2021).



Path: M:\Projects-Active\1316\MXD\1316_NCH_BathymetrySLS_4221_20210415.mxd

1.1.3. Fish Community near the Kemano Intake

At least 15 fish species have been reported in West Tahtsa Lake and its local tributaries including Bull Trout (*Salvelinus confluentus*), Burbot (*Lota lota*), Coastrange Sculpin (*Cottus aleuticus*), Dolly Varden (*Salvelinus malma*), Kokanee (*Oncorhynchus nerka*), Lake Chub (*Couesius plumbeus*), Largescale Sucker (*Catostomus macrocheilus*), Longnose Sucker (*Catostomus catostomus*), Mountain Whitefish (*Prosopium williamsoni*), Northern Pikeminnow (*Ptychocheilus oregonensis*), Peamouth Chub (*Mylocheilus caurinus*), Prickly Sculpin (*Cottus asper*), Pygmy Whitefish (*Prosopium coulterii*), Rainbow Trout (*Oncorhynchus mykiss*), and Slimy Sculpin (*Cottus cognatus*) (Table 2; Envirocon 1984, Triton 1989, RTA 2011b, RTA 2013, MOE 2021, Robertson, pers. comm. 2021).

Table 2. Fish species likely to be present in West Tahtsa Lake, as well as their provincial and federal status.

Fish Species	Scientific Name	Provincial Status[1]	Federal Status (COSEWIC)
Bull Trout	*Salvelinus confluentus*	Yellow	None
Burbot	*Lota lota*	Yellow	None
Coastrange Sculpin	*Cottus aleuticus*	Yellow	None
Dolly Varden	*Salvelinus malma*	Yellow	None
Kokanee	*Oncorhynchus nerka*	None	None
Lake Chub	*Couesius plumbeus*	Yellow	None
Largescale Sucker	*Catostomus macrocheilus*	Yellow	None
Longnose Sucker	*Catostomus catostomus*	Yellow	None
Mountain Whitefish	*Prosopium williamsoni*	Yellow	None
Northern Pikeminnow	*Ptychocheilus oregonensis*	Yellow	None
Peamouth Chub	*Mylocheilus caurinus*	Yellow	None
Prickly Sculpin	*Cottus asper*	Yellow	None
Pygmy Whitefish	*Prosopium coulterii*	Yellow	None
Rainbow Trout	*Oncorhynchus mykiss*	Yellow	None
Slimy Sculpin	*Cottus cognatus*	Yellow	None

[1]Yellow=not of concern, Blue=of concern because of characteristics that make the species particularly sensitive to human activities or natural events; Red=Endangered or Threatened under the *Wildlife Act*

2. FISH ENTRAINMENT ASSESSMENT METHODS

2.1. BC Hydro Methodology

We evaluated fish entrainment following the *Fish Entrainment Risk Screening and Evaluation Methodology*, which was developed to provide a transparent and understandable evaluation process for fish entrainment (BC Hydro 2006). This methodology has been used previously by Fisheries and Oceans Canada (DFO) to assess the significance of entrainment at hydroelectric projects, and it has also been used at other hydroelectric facilities within BC, both for BC Hydro and other utilities. The methodology consists of two stages, an Overview Risk Screening (ORS) and a Risk Assessment and Evaluation (RAE).

The ORS is a high-level desktop biological and facility screening assessment used to identify overall concerns related to fish entrainment. The assessment is based on a literature review of available fish information such as species and life stages present, habitat use and behaviour, physiology, and abundance and distribution, combined with infrastructure information such as velocity at the intake and operational regime. The result of the ORS leads to a rating of entrainment risk as low, moderate, or high.

If the rating is low, no further action is needed. If the rating is moderate, then further evaluation is needed for relevant fish species, as well as a management plan. However, the facility may not require mitigation. If the entrainment risk is rated as high, then a RAE is required, which is a more detailed quantitative analysis that includes components like a cost-benefit evaluation of risk mitigation and management (BC Hydro 2006). Field studies may also be needed to provide biological or operational data to support the RAE. A high-risk rating also requires monitoring, mitigation, and a management plan for fish entrainment (BC Hydro 2006).

This report provides a desktop assessment of entrainment and thus is limited to the screening stage of the methodology (i.e., ORS). The goals of the ORS were to establish:

- The likelihood of fish entrainment within the Project intake, as expressed by the *Entrainment Likelihood Rating*. This rating was obtained by assessing whether the fish community is predisposed to entrainment (Species-Life Stage Hazard Screening) and whether operation of the facility is likely to lead to fish entrainment (Physical Hazard Screening);
- The ecological significance of fish entrainment on the fish community, as expressed by the *Ecological Significance Rating*. This rating was obtained by assessing the value and abundance of the fish that may be entrained (Value-Abundance Rating), as well as the proportion of the population that may be impacted (Proportion of Population Impacted Rating);
- The consequences of entrainment to fish (the *Fate/Consequence Rating*), which was obtained by assessing the effects of entrainment on the fish that may be entrained; and

- The frequency of occurrence of fish entrainment (the *Frequency of Occurrence Rating*).

The results of these four rating evaluations were then used to develop a *Final Risk Screening Rating* for the Project. Further details on this methodology can be found in BC Hydro (2006).

2.2. Study Area

The study area for this assessment is similar to that of previous assessments (e.g., Kemano backup tunnel Project; Girard *et al.* 2016b, RTA 2013, RTA 2011b) and consists of West Tahtsa Lake, which represents around 6% of the total area of the reservoir (e.g., 63 km^2 out of 910 km^2; BGC 2014), and three tributaries near the Project intake (i.e., Pass Creek, Sandifer Creek and an unnamed tributary referred to as "Trib 1") (Map 1).

2.3. Literature Review

The literature that was consulted to provide this assessment consists of:

- Kemano facility data and information:
  - Kemano intake discharge and Nechako reservoir water level data from RTA (Mercier, pers. comm. 2021).
  - 2011 Environmental Impact Assessment for the Backup Tunnel Project (RTA 2011a).
  - 2011 Fish entrainment assessment for the Backup Tunnel Project (RTA 2011b).
  - 2013 Fish entrainment assessment for the Backup Tunnel Project (RTA 2013).
- West Tahtsa Lake fish community reporting:
  - Kemano completion Project environmental studies: Potential for entrainment of fishes through the proposed power plant intake in West Tahtsa Lake and water release facilities at Kenney Dam: A preliminary environmental impact assessment (Envirocon 1984).
  - Nechako Reservoir fish fauna studies 1989: West Tahtsa intake area and adjacent tributaries (Triton 1989).
  - Backup Tunnel Project – Environmental Assessment Addenda #3. Fish Entrainment Risk Screening and Evaluation Draft (RTA 2011b).
  - Backup Tunnel Project – Environmental Assessment Addenda #3. Fish Entrainment Risk Screening and Evaluation Final (RTA 2013).
  - Traditional knowledge shared by the Cheslatta Carrier Nation (Robertson, pers. comm. 2021).

- Fish species habitat use information:
  - BC fish and fish habitat use literature (e.g., McPhail 2007).
  - Other published scientific literature.
- Government resources such as the Fish Inventories Data Queries (FIDQ) and the Ecological Reports Catalogue (EcoCat).
- Scientific literature on fish entrainment (including BC Hydro entrainment assessments) and fish swimming capabilities (e.g., BC Hydro 2007).

2.4. Assessment Assumptions and Limitations

This assessment was based on available information, which was limited in some cases. For example, limited information was available on fish habitat in the Kemano forebay, creating some uncertainty in the assessment. Due to limited information availability, the following assumptions were also made:

- Fish distribution and relative abundance obtained from the 2011/2012 studies in West Tahtsa Lake (RTA 2011b, RTA 2013) were assumed to be representative of fish distribution near the Kemano intake.
- Discharge data provided by RTA for 2020 were assumed to provide an accurate representation of the current operational regime at the Kemano intake.
- The calculated areas for the T1 and T2 intakes portal and the T1 tunnel were assumed to be accurate; calculations were based on our analysis of the design drawings provided by RTA.

3. FISH ENTRAINMENT ASSESSMENT (RESULTS)

3.1. Likelihood of Fish Entrainment

The first step of the ORS was to determine the likelihood of entrainment based on habitat preferences by fish species and life-stages (Species-Life Stage Hazard Screening), the physical and operational characteristics of the intake and the predisposition of fish to become entrained through the intake (Physical Hazard Screening). These likelihoods were determined using available literature combined with operational information from RTA on the Kemano intake.

3.1.1. Species-Life Stage Hazard Screening

Fish species that have a high risk of entrainment within the Kemano intake were identified based on a professional interpretation of the following attributes, which led to a hazard risk screening rating of low, moderate, or high:

- Fish species and life stages present in West Tahtsa Lake and likely to be present near the Kemano intake entrance;
- Habitat use and preference, which indicate whether a fish species and life stage uses littoral, limnetic and/or profundal zones of the reservoir, thereby providing an indication of the risk of using habitats near the Kemano intake; and
- Movement behaviour, which would indicate the propensity of a fish to migrate near and/or use the Kemano intake entrance location.

An assessment of behavioural and physiological characteristics that can affect the potential for fish entrainment such as conspecific behaviour, use of the water column and swimming ability are addressed in Section 3.1.2.2. Of note, other physiological (e.g., sensory ability of fish to detect a hazard) and environmental factors (e.g., water temperature stress that may reduce the ability of fish to react to a hazard) were not assessed because: (1) the fish species present in the reservoir (and West Tahtsa Lake) are assumed to have similar sensory abilities, and (2) the water temperature in West Tahtsa Lake is expected to fluctuate slowly compared to a stream, and thus have negligible effect on entrainment potential into the Kemano intake.

3.1.1.1. Fish Species and Life Stages Evaluated

The 15 fish species identified in Section 1.1.3 were included in the Species-Life Stage Hazard Screening. This is consistent with the new *Fisheries Act*, which now considers all fish species rather than just fish species of commercial, recreational, and aboriginal value (DFO 2021). However, because some species may be difficult to differentiate and/or use similar habitats, they were combined into Char sp. (Bull Trout and Dolly Varden), Whitefish sp. (Mountain Whitefish and Pygmy Whitefish), and Sculpin sp. (Prickly Sculpin and Slimy Sculpin), for the assessment. In addition, it was assumed that all life stages (larvae/alevin, fry, juvenile, and adult) could be present in the Kemano intake area, although some may have limited presence due to preferential use of the tributaries. Table 3 provides a summary of habitat use information for the fish species of interest along with a summary of the likelihood that the species would utilize the habitat near the Kemano intake area.

3.1.1.2. Species-Life Stage Rating

Table 4 provides the Species-Life Stage Hazard Screening results for the relevant fish species and associated life stages in each season based on a professional interpretation of: available fish habitat use information (Table 3), the depth contours in the intake area (Map 2), and the discharge into the Kemano intake (Figure 3, Table 1). This last criterion was determined by the expected water level within West Tahtsa Lake and discharge into the intake in each season (see detail in Section 3.1.2.3). In general, a low rating was given when the water level within West Tahtsa Lake was "high" with a corresponding "low" discharge into the intake (i.e., summer), while a moderate rating was generally given when the water level was "low" with a moderate discharge into the intake (i.e., spring). A high rating was more likely when the water level in West Tahtsa Lake was "moderate" with a "high" discharge into the intake (i.e., fall, winter) because the risk of entrainment increases with the volume of water diverted. As noted by Martins *et al.* (2013), many entrainment events recorded for adult Bull Trout through Mica Dam in BC occurred when the reservoir was at high pool and drafting.

3.1.1.3. Conclusion for Entrainment Assessment

Fifteen fish species were identified as potentially using West Tahtsa Lake. In the absence of evidence to the contrary, we assumed that all of these fish species could potentially be present near the Kemano intake and subject to entrainment. However, to conduct the entrainment risk assessment following the BC Hydro guidelines (BC Hydro 2006), only the species most likely to be entrained (i.e., the species with at least one life stage per season rated at high hazard for entrainment per the Species-Life Stage Hazard Screening) were retained for the remaining steps of the assessment. These species were Burbot, Kokanee, Largescale Sucker, and Rainbow Trout (Table 4).

Table 3. **Summary of habitat use information for fish species in Tahtsa Lake and likelihood of fish using the habitat near the Kemano intake.**

Fish	Spawning Period	Habitat Use			Movement Behaviour	Life Stage Potentially Present near the Kemano Intake	Likely Presence near the Kemano Intake	Potential Entrainment Hazard
		Spawning	Rearing	Adult				
Burbot	December to March	In one to ten feet of water over sand/gravel bottom or five to ten feet over gravel shoals	Limnetic and littoral zones of lakes.	Limnetic habitat. Prefers cool water, restricted to hypolimnion in summer.	May move to nearshore areas to feed at night. Spawn in shallower waters. No downstream movement propensity. They do however migrate for spawning.	All life stages	Potential for this species to use the area throughout the year due to littoral and limnetic habitat in the forebay.	Moderate for all life stages and seasons, but increased to high in fall and winter for juveniles and adults due to discharge and water level.
Char sp.	August to October	Stream spawning in the downstream end of pools	Mostly in streams, may overwinter in lakes	Mostly in streams but may use littoral zone of lakes	Seasonal movements for spawning and overwintering. Some populations can be anadromous but this is not common.	Juveniles, Adults	These species are not likely to use the intake area because they spawn and rear primarily in streams.	Minimal for all life stages and seasons.
Coastrange Sculpin	Early April to Late June	Stream spawning in rocky habitat	Mostly fluvial but in lakes associated with shallow nearshore habitat with coarse gravel and cobble beaches	Mostly fluvial but in lakes associated with coarse gravel and cobble beaches	Not much known about lake populations but move into streams for spawning. No downstream movement propensity.	Juvenile, Adult	These species are not likely to use the intake area because they spawn and rear primarily in streams.	Minimal for all life stages and seasons.
Kokanee	Mid-September to Late October	Streams and littoral zones of lakes over gravel and cobble substrate	Limnetic and littoral zones of lakes	Limnetic zones of lakes	Seasonal movements for spawning, diel feeders in presence of thermocline. Schooling behaviour, and have positive rheotactic (flow) response. Some juveniles may choose to migrate to the ocean.	Fry, Juveniles, Adult	The intake area is likely to provide only marginal habitat for spawning. Larvae are not at risk as they are not in the water column. Juvenile and adult rearing and feeding during the growing season could occur in the intake area. In the winter, this habitat may be used for foraging opportunity.	Low for fry in spring and summer and moderate for fall. Moderate for juveniles and adults spring and summer, but increased to high for juvenile and adults in fall in winter due to discharge and water level.

Table 3. Continued (2 of 4).

Fish	Spawning Period	Habitat Use			Movement Behaviour	Life Stage Potentially Present near the Kemano Intake	Likely Presence near the Kemano Intake	Potential Entrainment Hazard
		Spawning	Rearing	Adult				
Lake Chub	May to August	Flowing or standing water, substrate unimportant, shallow water and generally in streams	Close to bottom in littoral zone in spring, move closer to the shoreline in summer	Close to bottom in littoral zone in spring, move closer to the shoreline in summer	Adults move from nearshore habitat in the day to deeper habitat at night (up to 50 m). Move in schools to spawning habitats. No downstream movement propensity.	Juvenile, Adults	These species are not likely to use the intake area because they spawn primarily in streams and rear primarily in shallow waters. Adults are also expected to use shallower and shoreline habitats, which are limited in the forebay compared with other habitat in West Tahtsa Lake.	Low for all life stages and seasons.
Largescale Sucker	April to mid-July	Fine to coarse gravel lake shoals or sandy areas of tributary streams	Benthic lake habitat when reach 16 to 18 mm in length	Benthic lake habitat up to 25 m depth	Species is relatively sedentary. No downstream movement propensity. However, they do undergo diel movements (shallow shoreline habitat to deeper waters) and spawning migration.	All life stages	The intake area is likely to provide only marginal habitat for spawning. Juvenile and adult rearing and feeding during the growing season could occur in the intake area. In the winter, this habitat may be used for foraging opportunity.	Low in spring for larvae and in spring and summer for fry, and juveniles when they are expected to utilize stream or shallow lake habitat. Moderate for adults in spring and summer due to favorable deep habitat in the forebay. High for juveniles and adults in fall/winter due to discharge and water level.
Longnose Sucker	Early spring to mid-June	Streams over gravel substrate in moderate current	Limnetic and littoral zones of lakes	Limnetic and littoral zones of lakes	Adults move from nearshore habitat in the day to deeper habitat at night. Spawning migration in spring. No downstream movement propensity.	Juvenile, Adult	There is potential for some use of the intake area in the summer, fall, and winter but not for spawning and early life stages.	Low for juveniles in spring and summer and adults in summer. Moderate for adults in spring during spawning migration. Upgraded to moderate for juveniles and adults in fall/winter due to discharge and water level.

Table 3. Continued (3 of 4).

Fish	Spawning Period	Habitat Use			Movement Behaviour	Life Stage Potentially Present near the Kemano Intake	Likely Presence near the Kemano Intake	Potential Entrainment Hazard
		Spawning	Rearing	Adult				
Whitefish sp.	November to Late December	Streams and littoral zones of lakes over gravel and cobble substrate	Littoral zones of lakes in shallow water <2 m	Limnetic or littoral zones of lakes	Consistent seasonal movement for spawning and summer feeding, schooling behaviour, positive rheotactic (flow) response, no downstream movement propensity.	Fry, Juveniles, Adult	The intake area likely provides limited spawning or rearing habitat. Adults may use this habitat year-round for foraging.	Low for fry/juveniles in all seasons and moderate for adults in all seasons due to favorable limnetic habitat in forebay.
Northern Pikeminnow	Late May to early July	Gravel shallows on lake shores or short distance up tributary streams	Forage in shallower, nearshore areas of lakes in loose schools in summer	Move into deeper benthic offshore lake habitat	Adults tend not to make large migrations. No downstream movement propensity.	Juvenile, Adult	Fry and juveniles are not expected to utilize the intake area in the spring and summer. There is potential for use by juvenile in fall/winter due to presence of some shallow water habitat and adults throughout the year, although adults likely found in deeper offshore habitat in West Tahtsa Lake.	Low for juveniles in spring and summer. Moderate for juveniles in fall/winter and adults in all seasons, although most likely offshore, thus not upgraded in fall/winter due to discharge and water levels.
Peamouth Chub	Mid-May to Early June	Streams or shallow littoral zones in lakes over gravel substrate	School in littoral zones of lakes	Limnetic and littoral zones of lakes, benthic in winter	Seasonal habitat changes as adults. Use nearshore and surface in evening and offshore and deeper in the day during the summer, during the fall and winter associated with the bottom, and spawning migrations to streams in the spring. No downstream movement propensity.	Juveniles, Adults	Fry and juveniles are not expected to utilize the intake area in the spring and summer. There is potential for use by juvenile in fall/winter and adults throughout the year.	Low for juveniles in spring and summer. Moderate for juveniles in fall/winter and adults in all seasons, although not upgraded due to discharge and water levels due to limited movement in these seasons.

Table 3. Continued (4 of 4).

Fish	Spawning Period	Habitat Use			Movement Behaviour	Life Stage Potentially Present near the Kemano Intake	Likely Presence near the Kemano Intake	Potential Entrainment Hazard
		Spawning	Rearing	Adult				
Sculpin *sp.*	Mid-March to late June	Streams in rocky or littoral zones in lakes	Forage over the substrate in deep water, may school along steep, rocky shoreline	Associated with cover during the day, forage in the open at night in deep water or littoral habitat	Limited movements expected. May move into streams to spawn. No downstream movement propensity.	Juveniles, Adults	Spawning occurs primarily in streams; thus, eggs and larvae are not expected near the intake area. Juvenile and adult movements are limited.	Low for all life stages and seasons present.
Rainbow Trout[1]	Mid-April to Late June	Primarily in streams and lake outlets. Rarely in littoral zones of lakes	Streams and littoral zones of lakes	Streams and littoral or limnetic zones of lakes	Spring migration for spawning, no schooling, opportunistic feeding, and show a positive rheotactic (flow) response. No downstream movement propensity.	Juvenile, Adult	Spawning in the intake area is unlikely, but there is potential for rearing of juveniles in the fall and winter and use by adults in the summer, fall, and winter.	Low for juveniles in the spring and summer. Moderate for adults in the spring and summer, but increased to high for juveniles and adults in the fall/winter due to discharge and water level.

[1]Reference information for all species was taken from McPhail (2007), except for Northern Pikeminnow that included information from Beamesderfer (1992) and Rainbow Trout that included information from Mellina *et al*. (2005) and Winsby *et al.* (1998).

Table 4. Species–Life Stage Hazard Screening for the Kemano intake.

Season	Tahtsa Lake Water Level vs Discharge[1]	Life Stage	Burbot	Char sp.	Coastrange Sculpin	Kokanee	Lake Chub	Largescale Sucker	Longnose Sucker	Whitefish sp.	Northern Pikeminnow	Peamouth Chub	Sculpin sp.	Rainbow Trout
			Fish Species											
Spring	Minimum water level with a moderate discharge	Larvae	Moderate	n/a	n/a	n/a	Low	Low	n/a	Low	n/a	n/a	n/a	n/a
		Fry	Moderate	n/a	n/a	Low	Low	Low	n/a	Low	Low	Low	n/a	n/a
		Juvenile	Moderate	Low	Low	Moderate	Low	Low	Low	Low	Low	Low	Low	Low
		Adult	Moderate	Low	n/a	Moderate	Low	Moderate	Moderate	Moderate	Moderate	Moderate	n/a	Moderate
Summer	High water level with a low discharge	Larvae	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Fry	Moderate	n/a	n/a	Low	Low	Low	n/a	Low	Low	Low	n/a	n/a
		Juvenile	Moderate	Low	Low	Moderate	Low	Low	Low	Low	Low	Low	Low	Low
		Adult	Moderate	Low	Low	Moderate	Low	Moderate	Low	Moderate	Moderate	Moderate	Low	Moderate
Fall	Moderate water level with a high discharge	Larvae	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Fry	n/a	Low	n/a	Moderate	Low	n/a	n/a	Low	n/a	n/a	n/a	n/a
		Juvenile	High	Low	Low	High	Low	High	Moderate	Low	Moderate	Moderate	Low	High
		Adult	High	Low	Low	High	Low	High	Moderate	Moderate	Moderate	Moderate	Low	High
Winter	Moderate water level with high discharge	Larvae	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Fry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Juvenile	High	Low	Low	High	Low	High	Moderate	Low	Moderate	Moderate	Low	High
		Adult	High	Low	Low	High	Low	High	Moderate	Moderate	Moderate	Moderate	Low	High

Green=Low risk, Yellow=Moderate risk, Red=High risk

[1]Entrainment risk is based on a combination of West Tahtsa Lake water level and discharge at the Kemano Intake.

[2]n/a=non applicable because the life stage is not expected to be present.

[3]Apart from salmonids and Lake Chub, fish species are considered juveniles by the fall.

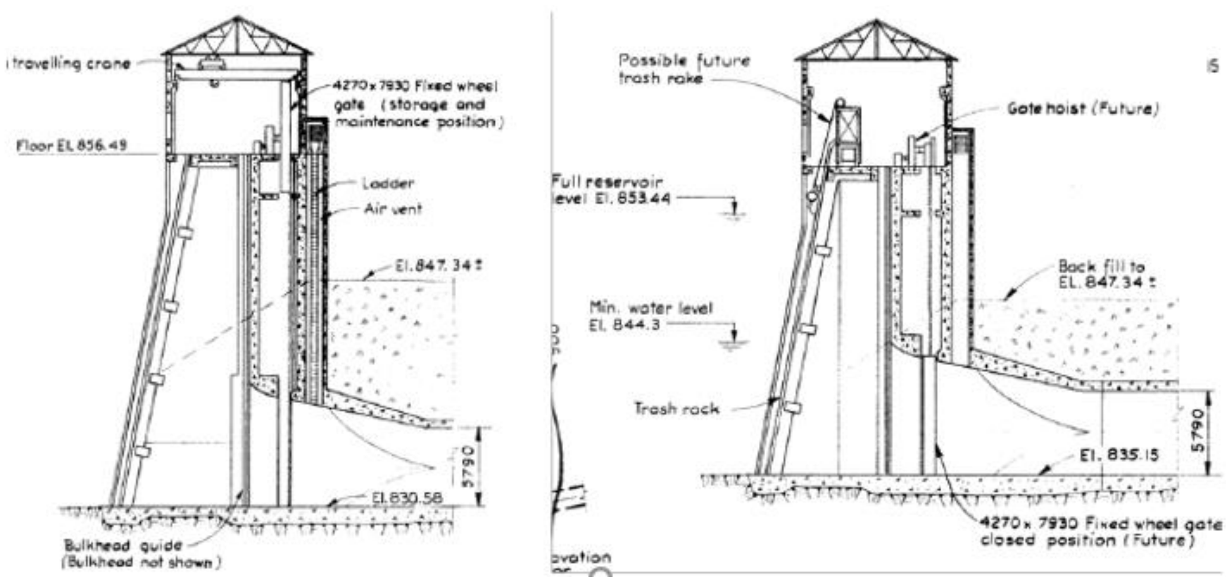
3.1.2. Physical Hazard Screening

The next step in identifying the likelihood of entrainment consisted in determining whether the type, structure, and operational characteristics of the Kemano intake pose an entrainment hazard. The predisposition of fish to be entrained through the intake is dependent on the physical characteristics of the intake (type, size, and location), the behavioural and physiological characteristics of the relevant fish species and life-stage (e.g., reaction to flow, swimming ability), and the operational characteristics of the intake. The following sub-sections provides an assessment of these factors.

3.1.2.1. Physical Characteristics of the Kemano Intake

The Kemano intake is used to transfer water into the T1 tunnel over a distance of 16 km before reaching the powerhouse located on the Kemano River (Map 1). The intake consists of two tunnel intake portals (T1 and T2) for delivery of water into the T1 tunnel system (Figure 2; Mercier, pers. comm. 2021). Presently only the T1 intake portal is used; however, water can flow into the T2 intake portal before deviating towards the T1 tunnel (Mercier, pers. comm. 2021). Each intake portal (T1 and T2) has three trash rack bays for screening debris from the waters supplied to the T1 tunnel (Girard *et al.* 2016a). A cross-sectional view of the T1 and T2 intake portals is shown in Figure 4. The T1 and T2 intake portals have heights of 26.4 m and 22.8 m, respectively, and a width of 11.9 m each. In turn, the rectangular tunnel entrance to the T1 tunnel measures 8.3 m in height and 6.0 m in width (Figure 4; Lecuyer, pers. comm. 2021).

Figure 4. Cross-sectional view of the T1 and T2 Kemano intakes (Mercier, pers. comm. 2021).



3.1.2.2. Behavioural and Physiological Characteristics of the Fish

The propensity of the focal species to be entrained is primarily dependent on their conspecific behavior (e.g., schooling behavior), propensity to be attracted to and use habitat near the Kemano intake, their use of the water column, their migratory behavior, and their ability to swim away once in the current to avoid entrainment.

Conspecific Behaviour

Conspecific behaviour such as schooling increases entrainment hazard. Of the four remaining focal species, only Kokanee are expected to school at both the juvenile and adult life stages, increasing their likelihood for entrainment. This entrainment risk was observed by Triton (1992) for Kokanee in Revelstoke Reservoir. Largescale Sucker may also school on occasion.

Attraction to Kemano Intake

Attraction to the Kemano intake is unlikely considering the size of West Tahtsa Lake and the large amount of available habitat elsewhere (including more suitable habitats such as stream outlets). However, Kokanee have been observed congregating near hydroelectric intakes in winter due to their attraction to flow and ice-free zones (Martins *et al.* 2014); therefore, they could be attracted to habitat near the Kemano intake. While Rainbow Trout are not abundant in the nearshore area of the Nechako Reservoir (Winsby *et al.* 1998), they are attracted to current and accordingly may also orient to the intake flows.

Use of the Water Column

Position of fish in the water column affects entrainment likelihood. The wheel gate that controls the Kemano tunnel discharge (Figure 4) lowers from the top of the tunnel. Thus, the entrainment hazard is expected to be highest for benthic species (i.e., Largescale Sucker) that use the lowest portion of the water column. Fish species that utilize mid-water or pelagic habitats like Kokanee, Burbot, and Rainbow Trout would be more likely to be entrained if the wheel gate is lifted more fully and draws water from higher in the water column (i.e., in the fall-winter months; Section 1.1.1).

Migratory Behaviour

Migratory behaviour increases the entrainment likelihood for all four species (i.e., Burbot, Kokanee, Largescale Sucker, Rainbow Trout). These species are typically migratory within lakes/reservoirs and connecting river systems, migrating for feeding and/or spawning (McPhail 2007). Entrainment studies at Libby Dam in Montana showed that migratory species such as Rainbow Trout, Burbot, and Largescale Sucker were entrained more often than nonmigratory fish (Skaar *et al.* 1996). However, the Kemano intake is located at the end of a trapezoidal shaped channel that is ~80 m wide, which likely minimizes the potential for migrating fish to enter the forebay and encounter the Kemano intake during their migrations (Figure 1; RTA 2011b).

Based on previous entrainment studies at hydroelectric facilities, Kokanee are the most susceptible to entrainment due to downstream movements from natal areas as juveniles (e.g., Stober *et al.* 1983, Skaar *et al.* 1996). Large numbers of Kokanee have also been entrained on an annual basis at some hydroelectric facilities (e.g., Triton 1992)[1]. In a BC Hydro entrainment study, movement behaviours of juvenile Kokanee in the Elsie Lake Reservoir led to a medium to high entrainment risk rating for this species and life stage (BC Hydro 2007).

Swimming Ability

Once fish are within the current in front of the Kemano intake, their likelihood of entrainment will depend on their swimming capabilities, which vary among fish species and life stages. Several studies have shown that the swimming ability of fish is positively correlated with their size and that smaller fish (<100 mm) are unlikely to escape entrainment within hydroelectric infrastructures (e.g., Bainbridge 1958). If adult fish, which have a higher swimming capability than other life stages, are unable to escape the currents, then all fish of these species are expected to be entrained. Investigation of juvenile swimming speeds was thus only warranted herein if adults could escape the Kemano intake velocities.

The swimming capabilities of Burbot, Kokanee, Largescale Sucker, and Rainbow Trout adults are presented in Table 5. The burst values are the swimming speeds that can be sustained for a period of 20 to 60 seconds. Generally, burst speed may only be encountered to avoid a predator, capture prey, or avoid entrainment in intakes (Katapodis and Gervais 2016). It should be noted that values in this table are based on laboratory experiments and that swimming speed is proportional to the length of a fish with larger fish generally exhibiting faster swimming capabilities.

Based on the available literature, Kokanee have the lowest range of burst speed and are expected to be the most susceptible of the four fish species to entrainment within the Kemano intake, while Rainbow Trout adults have the highest burst speed and are expected to be the least susceptible to entrainment (Table 5). These findings were compared to expected velocities at the Kemano intake (see next section) to determine the ability of fish to escape entrainment.

[1] Juvenile Kokanee can revert to an anadromous life history (Foerster 1947, Fulton and Pearson 1981, Kaeriyama *et al.* 1992, Godbout *et al.* 2011); thus, some proportion of juvenile Kokanee may choose to move downstream over the structures to try to migrate to the ocean. In the Alouette Reservoir, flows are released to allow Kokanee to migrate downstream to re-introduce anadromy to the population (Baxter and Bocking 2006, BC Hydro 2009).

Table 5. **Swimming speeds of adult fish that may be susceptible to entrainment at the Kemano intake.**

Fish Species	Burst Speed (m/s)	Average Fork Length (m)	Average Prolonged Swimming Speed (m/s)	References
Burbot	1.21	0.62	0.41	Peake 2008, Bell 1991
Kokanee	0.8 - 1.0	0.58	n/a	Katapodis 1991, Lee *et al*. 2003
Largescale Sucker	1.2 - 2.4	0.49	n/a	Peake 2008, Bell 1991, Kolok *et al*. 1993
Rainbow Trout	1.8 - 4.3	0.38	0.63	Jones *et al*. 1974, Katapodis 1991, Jain *et al.* 1997, Burgetz *et al.* 1998

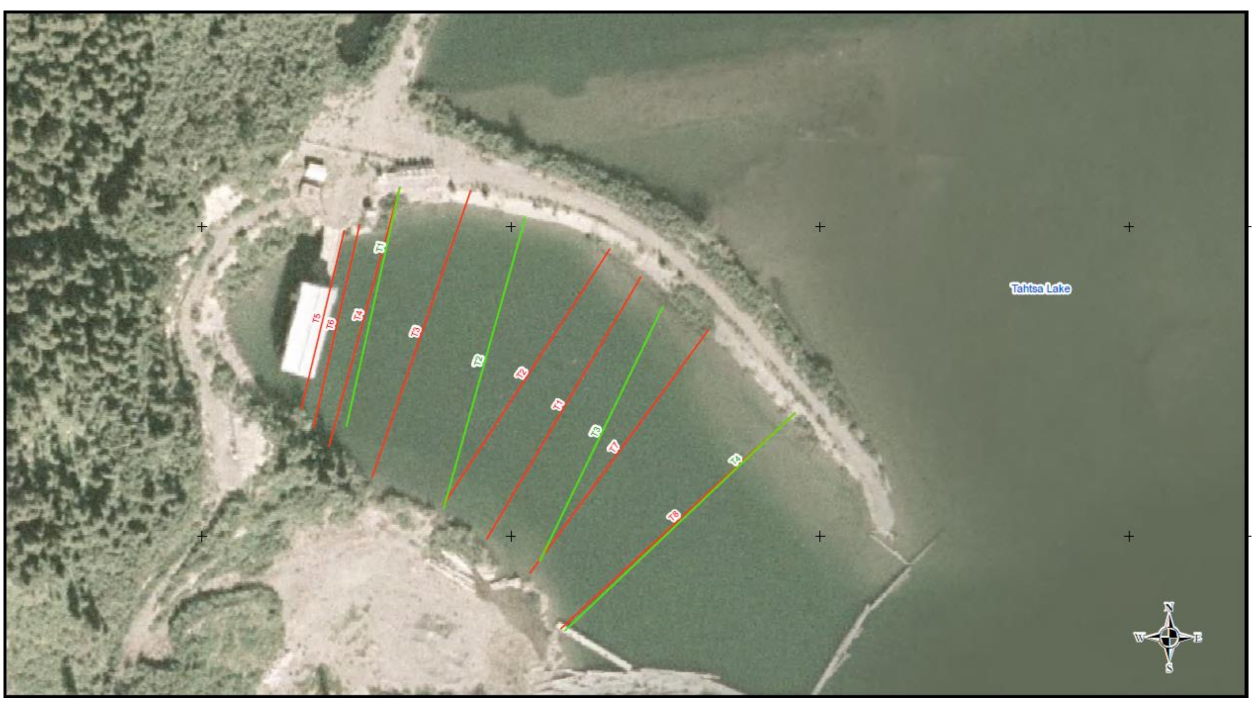
3.1.2.3. Operational Characteristics of the Intake

The flow velocities at the Kemano intake and the reservoir discharge proportion (a measure of the proportion of the reservoir volume that is diverted, as per BC Hydro methodology; BC Hydro 2006), were used as general indicators of the physical potential for fish entrainment.

Flow Velocities

Cross-sectional data was collected within the Kemano forebay using an Acoustic Doppler Current Profiler (ADCP; Figure 5) at several locations in August and October 2011 (RTA 2011b). These data are expected to be representative of both low and high discharge conditions into the intake (Figure 3). While the transect data nearest to the intake were not viable due to turbulence caused by the intake flows, transects between ~60 m and 100 m from the intake (transects T2 to T8; Figure 5) showed that the velocities in this area were generally less than 0.5 m/s with only a few instances where higher velocities were observed (0.5 m/s to 0.6 m/s; RTA 2011b). These velocities are below the burst speeds of the adults of the four focal fish species (Table 5), although slower swimmers may be exhausted if they need to stay in this current for long periods of time (e.g., Burbot and Rainbow Trout who have average prolonged speeds of 0.41 m/s and 0.63 m/s, respectively; Table 5). In turn, juveniles of all relevant species would likely be entrained.

Figure 5. ADCP transects collected within the Kemano intake forebay in 2011 (copied from RTA 2011b).



At the Kemano intake itself, scenarios of the minimum, median/intermediate, and maximum discharge and water levels within the current operational regime (Figure 3) were used in combination with trash rack and tunnel measurements to estimate the water velocities at the entrance of the trash rack portals and the T1 tunnel entrance. The following assumptions/methods were used for this purpose:

- Waters could also enter the T2 portal and deviate towards the T1 tunnel (Mercier, pers. comm. 2021). Thus, velocities were calculated for T1 alone and for T1 and T2 combined.
- Waters flow through the trash racks before deviating into the smaller-sized T1 tunnel, as shown in Figure 4.
- The height of the flow through the trash racks was obtained by subtracting the elevation at the surface of the water column (masl) from the elevation at the bottom of the trash racks (830.6 masl) (Mercier, pers. comm. 2021). This value was then multiplied by the width of the combined trash racks (T1 trash racks =11.9 m, T1 and T2 trash racks=23.8 m) to obtain the area of water flowing through the trash racks in one or two portals (T1, T2).
- The trash rack is a series of metal grids. Water can only flow through the spaces in the grid. Thus, 30% of the area of water flowing was removed to account for the metal structure of the trash racks, as recommended by KLCE (1989) to provide a net flow area.
- The area of flow into the rectangular tunnel portion of the Kemano intake was calculated using the height (8.3 m) and the width (6.0 m) of the T1 tunnel (Lecuyer, pers. comm. 2021).
- Measurements of the spaces within each grid of the trash racks were unavailable, but based on available photos, it was conservatively assumed that spaces were large enough to pass all species of adult fish under assessment (i.e., Burbot, Kokanee, Largescale Sucker, Rainbow Trout).
- The velocity in front of the trash racks and tunnel that was likely to affect any fish present near the intake was calculated by dividing the anticipated discharge by the net area of the trash racks and tunnel, respectively.

Assuming flow only through the area of the T1 portal, the net velocity at the Kemano intake varied between 0.45 m/s and 1.31 m/s through the trash racks and 1.71 m/s and 2.90 m/s through the intake tunnel (Table 6). In turn, assuming flow through both the T1 and T2 tunnel, the net velocities were reduced to 0.25 m/s to 0.79 m/s through the trash racks (Table 7).

This variation in flows is expected to adequately represent the range of flows that fish may encounter in Kemano intake under current operating conditions. The upper velocities at the trash racks (i.e., 0.79 m/s to 1.31 m/s) are expected to exceed the burst swimming speeds of most of the adult species (in particular Burbot and Kokanee; Table 5), and thus the speeds of earlier life stages as well (i.e., larvae, fry, juveniles). However, at lower discharge (0.25 m/s to 0.45 m/s), all the adult species and likely some of the earlier life stages would be able to escape the trash rack area.

If fish are entrained past the trash racks and into the T1 tunnel, the velocities (1.71 m/s and 2.90 m/s) would exceed the burst swimming speeds of the majority of the fish (Table 5). However, it is expected that discharge decreases with distance from the Kemano intake, which would provide fish with hydraulic cues of the approaching trash racks, and thus an opportunity to avoid the intake by migrating into lower velocity areas. This same phenomenon has been shown at other facilities. For example, at the Mica Dam in BC, modeling of current in the forebay of the dam showed that beyond 15 m, the velocity profile becomes uniform and reduced, minimizing the potential for fish entrainment. Another study at this location marked Bull Trout and showed that they were holding steadily at only 23 m from the intake where flows were <0.2 m/s (Martins *et al.* 2014). Thus, under normal operating conditions the entrainment risk zone is relatively small, representing only the area immediately adjacent to the intakes (Langford *et al.* 2020).

Table 6. Predicted current velocities through the T1 trash racks and tunnel of the Kemano intake.

Flow Scenario	Tunnel Discharge (m^3/s)	Water Level Scenario	Water Level (masl)	Bottom of T1 Trash Racks Elevation (masl)	Height of Flow Through T1 Trash Racks	Flow Area (m^2)			Velocity (m/s)		
						Trash Racks (Gross)[1]	Trash Racks (Net)[2]	Tunnel[3]	Trash Racks (Gross)	Trash Racks (Net)	Tunnel
Minimum	85.3	Minimum	843.8	830.6	13.2	157	110	49.8	0.54	0.78	1.71
	85.3	Intermediate	849.2	830.6	18.6	221	155	49.8	0.39	0.55	1.71
	85.3	Maximum	853.5	830.6	22.9	272	190	49.8	0.31	0.45	1.71
Median	129.4	Minimum	843.8	830.6	13.2	157	110	49.8	0.82	1.18	2.60
	129.4	Median	849.2	830.6	18.6	221	155	49.8	0.59	0.84	2.60
	129.4	Maximum	853.5	830.6	22.9	272	190	49.8	0.48	0.68	2.60
Maximum	144.4	Minimum	843.8	830.6	13.2	157	110	49.8	0.92	1.31	2.90
	144.4	Median	849.2	830.6	18.6	221	155	49.8	0.65	0.93	2.90
	144.4	Maximum	853.5	830.6	22.9	272	190	49.8	0.53	0.76	2.90

[1]Area was calculated by multiplying the height of flow through the T1 trash racks by the combined width of the three T1 trash racks (i.e., 11.9 m)

[2]Net area was estimated by removing 30% for the trash rack steel surface, as recommended by KLCE (1989)

[3]Tunnel area was caculated using the height (8.3 m) and width (6.0 m) of the T1 tunnel

Table 7. **Predicted current velocities through the combined T1 and T2 trash racks and the T1 tunnel of the Kemano intake.**

Flow Scenario	Tunnel Discharge (m^3/s)	Water Level Scenario	Water Level (masl)	Bottom of Trash Racks Elevation		Height of Flow Through Trash Racks		Flow Area (m^2)			Velocity (m/s)		
				T1	T2	T1	T2	Trash Racks (Gross)[1]	Trash Racks (Net)[2]	Tunnel[3]	Trash Racks (Gross)	Trash Racks (Net)	Tunnel
Minimum	85.3	Minimum	843.8	830.6	835.2	13.2	8.6	260	182	49.8	0.33	0.47	1.71
	85.3	Intermediate	849.2	830.6	835.2	18.6	14.0	387	271	49.8	0.22	0.31	1.71
	85.3	Maximum	853.5	830.6	835.2	22.9	18.3	490	343	49.8	0.17	0.25	1.71
Median	129.4	Minimum	843.8	830.6	835.2	13.2	8.6	260	182	49.8	0.50	0.71	2.60
	129.4	Median	849.2	830.6	835.2	18.6	14.0	387	271	49.8	0.33	0.48	2.60
	129.4	Maximum	853.5	830.6	835.2	22.9	18.3	490	343	49.8	0.26	0.38	2.60
Maximum	144.4	Minimum	843.8	830.6	835.2	13.2	8.6	260	182	49.8	0.56	0.79	2.90
	144.4	Median	849.2	830.6	835.2	18.6	14.0	387	271	49.8	0.37	0.53	2.90
	144.4	Maximum	853.5	830.6	835.2	22.9	18.3	490	343	49.8	0.29	0.42	2.90

[1]Area was calculated by multiplying the height of flow through each set of trash racks (T1, T2) by the combined width of the T1 and T2 trash racks (i.e., 23.8 m)

[2]Net area was estimated by removing 30% for the trash rack steel surface, as recommended by KLCE (1989)

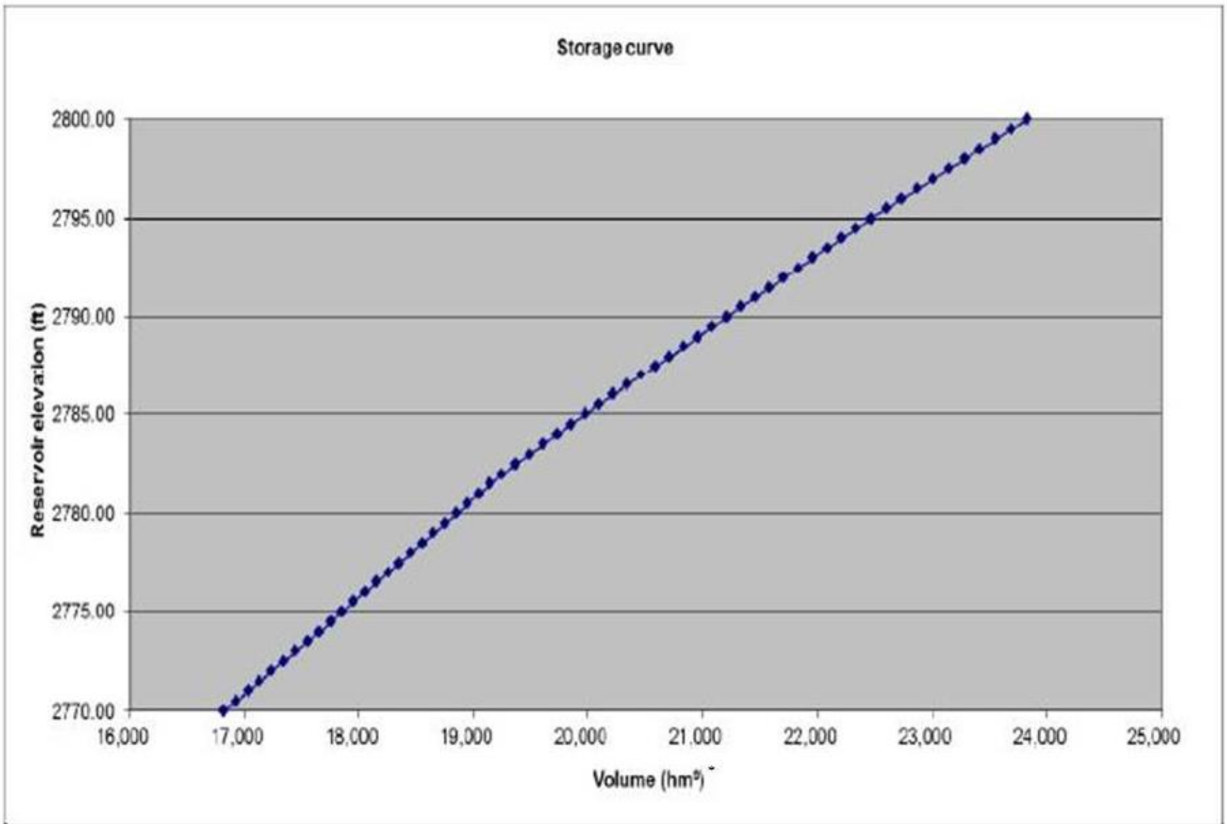
[3]Tunnel area was caculated using the height (8.3 m) and width (6.0 m) of the T1 tunnel

Discharge Proportion

The proportion of the reservoir discharged per day can act as an indicator of the propensity of fish to be drawn towards intakes and be entrained (BC Hydro 2006). Moreover, the total proportion of the reservoir discharged over a period of time (e.g., during a specific event) may be more significant than the proportion discharged each day (BC Hydro 2006). However, as the volume discharged through the Kemano intake is relatively stable for each season (Table 1), the proportion per day was used to assess the physical hazard rating.

To determine daily discharge proportion, we referred to the reservoir storage curve for elevations between 2,770 feet (844 m) and 2,800 feet (853 m) that was calculated and presented in RTA (2013) and is provided below (Figure 6). This reservoir storage curve is still accurate today (Mercier, pers. comm. 2021) and shows that the reservoir volume usually varies between ~16,900,000,000 m^3 and ~23,900,000,000 m^3. The median daily volume that passes into the Kemano intake, based on the daily discharge (Figure 3) is 11,144,113 m^3, which represents 0.07% to 0.05% daily of the minimum and maximum reservoir volumes. The discharge proportion rating was therefore low, as less than 2% of the total reservoir volume is discharged per day (per the BC Hydro methodology, percent total reservoir volume per day: <2% = low, 2%-10%= moderate, >10% =high; BC Hydro 2006).

Figure 6. Relationship between elevation and storage volume for the Nechako Reservoir (from RTA 2013).



*Volume in hectometers (hm³). 1 hectometer = 1,000,000 m³

3.1.2.4. Conclusion for Entrainment

The velocities identified in Section 3.1.2.3 (Table 6, Table 7) exceed the swimming speeds of some of the retained fish species and life stages (Table 4). However, the velocities gradually increase as one nears the intake, which is expected to lower the likelihood of entrainment by providing fish with a graduated, accelerating velocity field and vertical and horizontal velocity gradients that provide hydraulic cues of the approaching intake, thus affording an opportunity for many fish to avoid the intake by swimming away. In addition, the discharge is relatively stable within each season apart from periodical shutdown events (Table 1); thus, fish experience few notable increases in flow that could lead to entrainment. The potential for fish entrainment is also reduced by the low proportion of the reservoir waters that are being diverted through the Kemano intake (<2% total reservoir volume per day; Section 3.1.2.3).

Of the four species retained in this assessment, Kokanee is at greatest risk of entrainment based on its migratory and conspecific behaviour, swimming ability, and potential attraction to the Kemano intake area (Section 3.1.2.3). Largescale Sucker is also more sensitive to entrainment due to its conspecific behavior, migratory behavior, and use of the lower portion of the water column (Section 3.1.2.2). Thus, these species are expected to be at moderate risk of entrainment.

3.1.3. Entrainment Likelihood Rating Conclusion

The Entrainment Likelihood Rating was derived using the combination of results from the Species-Life Stage Hazard Screening (Section 3.1.1.3) and the Physical Hazard Screening (Section 3.1.2.4). The Species Life Stage Hazard Screening was summarized for each fish species and life stage by retaining the most conservative (i.e., the highest) rating for each life stage and season (Table 4). The Physical Hazard Screening rating was determined based on the conclusions of the physical hazard screening provided above (Section 3.1.2.4). The final Entrainment Likelihood Rating was then determined based on the BC Hydro methodology provided in Table 8. In this methodology, the discharge proportion rating has a stronger influence on the entrainment likelihood than the species life stage and physical hazard screenings. This evaluation led to a low Entrainment Likelihood Rating for Burbot and Rainbow Trout, and a moderate rating for Kokanee and Largescale Sucker (Table 9).

Table 8. Hydraulic entrainment likelihood rating guideline from BC Hydro (2006).

Discharge Proportion Rating	Species-Life Stage/ Habitat Hazard	Entrainment Likelihood Rating
High	High or Moderate	High
	Low	Moderate
Moderate	High or Moderate	Moderate
	Low	Low
Low	High or Moderate	Moderate
	Low	Low

Table 9. Entrainment Likelihood Rating for the Kemano intake based on the Species-Life Stage and Physical Hazard Screening ratings.

Physical Hazard Screening (Component [1]) Discharge Proportion Rating	Fish Species	Species Life Stage Hazard Screening	Physical Hazard Screening (Component Velocity vs Swimming[1]	Entrainment Likelihood Rating
Low	Burbot	High	Low	Low
	Kokanee	High	Moderate	Moderate
	Largescale Sucker	High	Moderate	Moderate
	Rainbow Trout	High	Low	Low

[1] Also considers fish behaviour and likely presence in the Kemano intake area.

3.2. Ecological Significance of Fish Entrainment on Fish Community

The second goal of the ORS was to determine the potential consequences of fish entrainment to the fish community, based on the value and relative abundance of the affected fish species and the proportion of the population likely to be affected by entrainment. The following sub-sections provide an overview of the available fish abundance and fish value information for the study area (i.e., West Tahtsa Lake), which were then used to determine the Value-Abundance Rating, the Proportion of Population Impacted Rating, and the Ecological Significance Rating.

3.2.1. Relative Fish Abundance

The relative abundance of fish in the study area was estimated by two studies conducted in West Tahtsa Lake in 2011-12, which are described below. These data were collected some years ago and are limited; however, they are still expected to provide a reasonable indication of species relative abundance.

Fish sampling was conducted in West Tahtsa Lake in June, August, and October of 2011 and 2012 using gillnets, minnow trapping, and/or electrofishing (Figure 7; RTA 2011b, RTA 2013). Gillnetting results for both years indicated similar species composition and relative abundance at sampling sites closest to the Kemano forebay. Hence the data among sites was pooled and the catch per unit effort (i.e., captures per gillnet set) is presented in Table 10. Longnose Sucker, Mountain Whitefish, and Rainbow Trout comprised nearly all (93.4%) of adult fish captures. The remaining adult fish species captured (in order or relative abundance) were Northern Pikeminnow, Burbot, Kokanee, and Largescale Sucker. The composition of juveniles was slightly different with the majority (61.5%) of captures consisting of Kokanee followed by Mountain Whitefish, Longnose Sucker, Rainbow Trout, and Burbot; Northern Pikeminnow and Largescale Sucker were not observed.

Generally, the species and life stages captured in gill nets and their relative abundance was similar among sampling periods. However, some seasonal differences were observed. Kokanee was not captured in the spring (June), and nearly all Kokanee (99%) captured in the summer (August) and fall (October) were juveniles. Relative abundance of Mountain Whitefish was lower in the fall compared to spring and summer, for both adults and juveniles.

Only 11 fish were captured in minnow traps installed in West Tahtsa Lake near the Kemano forebay (Table 11). Of these captures, at least one additional species was confirmed near the intake: Coastrange Sculpin. Nearly half of the fish captured (49.1%) were sculpin sp., while the remaining fish consisted of one Longnose Sucker, one Rainbow Trout, one Burbot, and one sucker sp.

Electrofishing surveys conducted along the shoreline within Tahtsa Lake, near the Kemano forebay, in both 2011 and 2012, led to the capture of only four fish: one adult Burbot, one juvenile sucker sp., and potentially two juvenile Kokanee. Electrofishing was also conducted in the three tributaries in the study area (i.e., Sandifer Creek, Trib 1, and Pass Creek; Map 1); twenty-three fish were captured (mostly juveniles). Two Rainbow Trout, four Mountain Whitefish and one sculpin sp. were captured in Trib 1, while only Rainbow Trout were captured in both Sandifer Creek (n=8) and Pass Creek (n=8) (RTA 2013).

Figure 7. Fish sampling locations in West Tahtsa Lake near the Kemano intake in 2011 and 2012 (copied from RTA 2011b, RTA 2013).

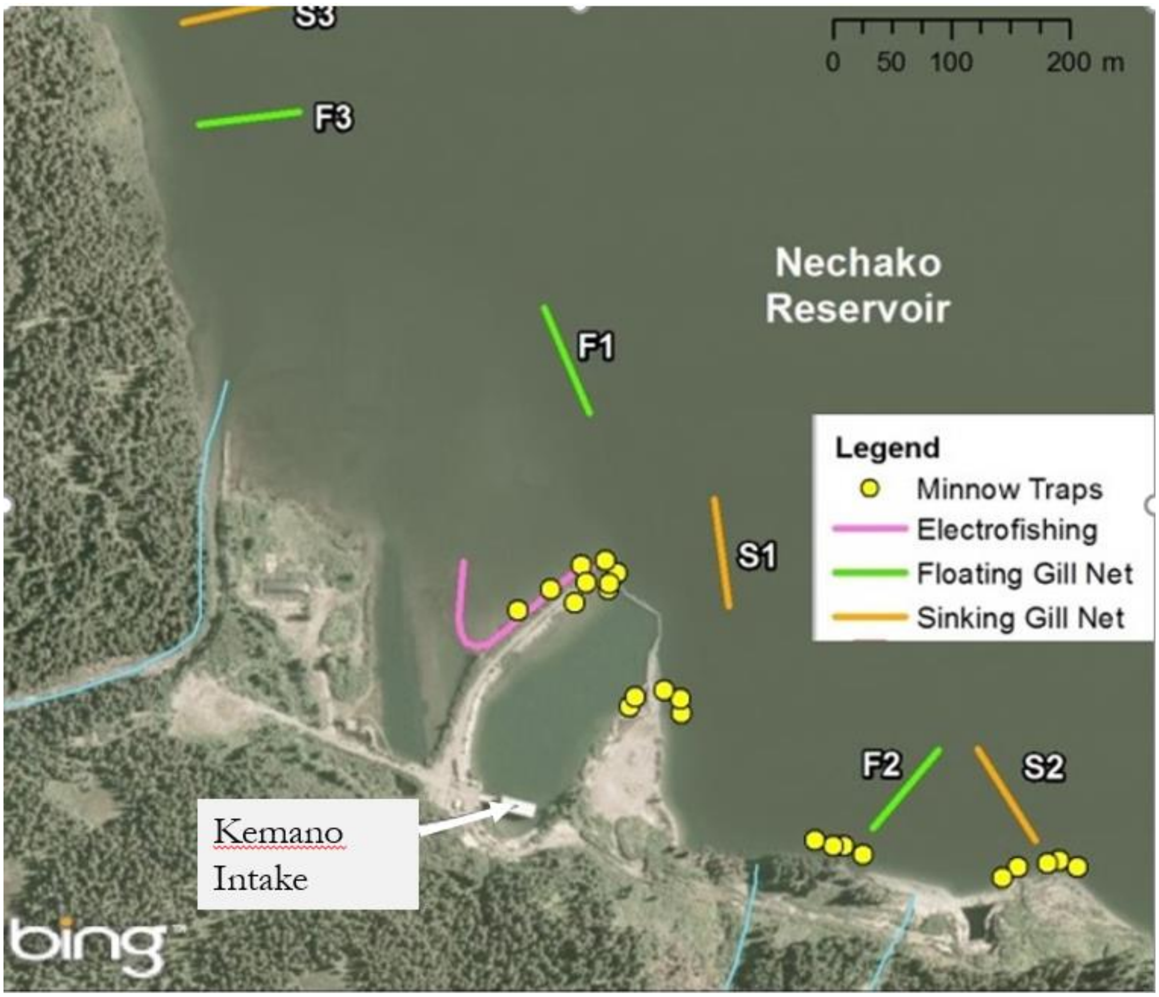


Table 10. Catch per unit effort (CPUE) for fish captured in gillnets in West Tahtsa Lake near the Kemano forebay in 2011 and 2012 (modified from RTA 2013).

Year	Sampling Period	CPUE (# of fish/net set)[1]													
		Adults (≥200 mm)							Juvenile (<200 mm)						
		Burbot	Kokanee	Largescale Sucker	Longnose Sucker	Mountain Whitefish	Northern Pikeminnow	Rainbow Trout	Burbot	Kokanee	Largescale Sucker	Longnose Sucker	Mountain Whitefish	Northern Pikeminnow	Rainbow Trout
2011	June	0.5	0.0	0.0	5.2	1.3	0.2	0.8	0.0	0.0	0.0	0.5	1.0	0.0	0.0
	August	0.0	0.0	0.2	2.2	3.7	0.2	1.0	0.5	2.8	0.0	0.0	0.5	0.0	0.0
	October	0.0	0.2	0.0	3.0	1.3	0.7	1.3	0.3	3.2	0.0	0.8	0.2	0.0	0.3
	Total	**0.5**	**0.2**	**0.2**	**10.3**	**6.3**	**1.0**	**3.2**	**0.8**	**6.0**	**0.0**	**1.3**	**1.7**	**0.0**	**0.3**
	Relative Abundance (%)	**2.3**	**0.8**	**0.8**	**47.7**	**29.2**	**4.6**	**14.6**	**8.2**	**59.0**	**0.0**	**13.1**	**16.4**	**0.0**	**3.3**
2012	June	0.0	0.0	0.0	1.8	1.8	0.0	0.5	0.2	0.0	0.0	0.2	0.7	0.0	0.0
	August	0.3	0.0	0.0	2.2	4.3	0.0	2.2	0.0	5.8	0.0	0.0	2.5	0.0	1.0
	October	0.2	0.0	0.0	0.7	0.0	0.2	2.3	0.0	4.7	0.0	0.0	0.0	0.0	0.2
	Total	**0.5**	**0.0**	**0.0**	**4.7**	**6.2**	**0.2**	**5.0**	**0.2**	**10.5**	**0.0**	**0.2**	**3.2**	**0.0**	**1.2**
	Relative Abundance (%)	**3.0**	**0.0**	**0.0**	**28.3**	**37.4**	**1.0**	**30.3**	**1.1**	**69.2**	**0.0**	**1.1**	**20.9**	**0.0**	**7.7**
Combined	June	0.5	0.0	0.0	7.0	3.2	0.2	1.3	0.2	0.0	0.0	0.7	1.7	0.0	0.0
	August	0.3	0.0	0.2	4.3	8.0	0.2	3.2	0.5	8.7	0.0	0.0	3.0	0.0	1.0
	October	0.2	0.2	0.0	3.7	1.3	0.8	3.7	0.3	7.8	0.0	0.8	0.2	0.0	0.5
	Total	**1.0**	**0.2**	**0.2**	**15.0**	**12.5**	**1.2**	**8.2**	**1.0**	**16.5**	**0.0**	**1.5**	**4.8**	**0.0**	**1.5**
	Relative Abundance (%)	**2.6**	**0.4**	**0.4**	**39.3**	**32.8**	**3.1**	**21.4**	**3.9**	**65.1**	**0.0**	**5.9**	**19.1**	**0.0**	**5.9**

[1]Assumed that each of the six gillnets had a similar effort

Table 11. **Catch per unit effort (CPUE) for fish captured in minnow traps in West Tahtsa Lake near the Kemano intake in 2011 and 2012 (modified from RTA 2013).**

Year	Sampling Period	CPUE (# of fish/trap)[1]						
		Burbot	Coastrange Sculpin	Longnose Sucker	Prickly Sculpin	Rainbow Trout	Sculpin Sp.	Sucker Sp.
2011	June	0.00	0.00	0.03	0.00	0.00	0.00	0.00
	August	0.05	0.00	0.00	0.00	0.00	0.19	0.00
	October	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.05**	**0.00**	**0.03**	**0.00**	**0.00**	**0.19**	**0.00**
	Relative Abundance (%)	**17.9**	**0.0**	**10.4**	**0.0**	**0.0**	**71.6**	**0.0**
2012	June	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	August	0.00	0.00	0.00	0.00	0.04	0.00	0.04
	October	0.00	0.03	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.03**	**0.00**	**0.01**	**0.04**	**0.00**	**0.04**
	Relative Abundance (%)	**0.0**	**28.3**	**0.0**	**8.0**	**31.9**	**0.0**	**31.9**
Combined	June	0.00	0.00	0.01	0.01	0.00	0.00	0.00
	August	0.02	0.00	0.00	0.00	0.02	0.08	0.02
	October	0.00	0.02	0.00	0.00	0.00	0.00	0.00
	Total	**0.02**	**0.02**	**0.01**	**0.01**	**0.02**	**0.08**	**0.02**
	Relative Abundance (%)	**11.3**	**13.2**	**3.8**	**3.8**	**11.3**	**45.3**	**11.3**

[1]Assumed that each trap had a similar effort

3.2.2. Fish Value

The value of fish species to recreational and aboriginal (Indigenous) fisheries was considered. Sportfishing is an important activity in the Nechako region (Ableson and Slaney 1990). Furthermore, Indigenous Groups, including the Cheslatta Carrier Nation, rely on fisheries resources in the Nechako Reservoir and broader watershed. In particular, Burbot, Kokanee, Mountain Whitefish, and Rainbow Trout are important in Indigenous and recreational fisheries (Envirocon 1989).

In recent years, Tahtsa locals have expressed concern that there are fewer Kokanee and Rainbow Trout in not only Tahtsa Lake, but also the reservoir in general (Kurtz 2021). However, none of the four retained fish species (i.e., Burbot, Kokanee, Largescale Sucker, and Rainbow Trout) have status of concern in the province (Table 1), nor are they subject to commercial fishing.

3.2.3. Value-Abundance Rating

A Value-Abundance rating was determined for each relevant fish species based on their value, abundance, and conservation status, as per the BC Hydro methodology (BC Hydro 2006). Based on the ratings definitions provided in the BC Hydro methodology (Table 12), Burbot, Kokanee, and Rainbow Trout fall into the second species category (Native species; aboriginal fishery, commercial fishery or sport fish fishery) while Largescale Sucker falls into the third species category (Native species; non-sport fish). Furthermore, the relative abundance was higher for Rainbow Trout and Kokanee (Table 10) than the other two species, and Rainbow Trout and Kokanee were of high value to Indigenous Groups (Section 3.2.2). Thus, these two species were given a high rating while Burbot was given a moderate rating and Largescale Sucker was given a low rating (Table 13).

Table 12. **Value-Abundance Categories and ratings methodology, as per BC Hydro (2006).**

Species Category	Abundance	Value
Endangered, threatened, or species of special concern	Listed species in federal or provincial registry at any level, including threatened populations.	High
Native species; Aboriginal Fishery, Commercial Fishery or Sport fish species	High to moderate use/abundance. Or low abundance and considered moderate to high value.	High
	Low use/ abundance.	Moderate
Native species; non-sport fish, or aboriginal fishery of low traditional use and value, or commercial fishery of low to	High abundance or deemed an important forage fish species for other fish.	High
	Moderate abundance or deemed a moderately important forage fish species for other fish.	Moderate
	Low abundance or not known to be significant forage species for other fish.	Low
Exotic and Introduced species	Non-native species (anthropocentrically introduced) species considered very highly by sport fishermen, commercial fishery, or by regulatory agencies.	High
	Introduced sport or commercial fish of high to moderate social importance.	Moderate
	Non-native exotic that is either a nuisance species or has moderate or negligible social, ecological or economic value.	Low

Table 13. **Value-Abundance Rating for the Kemano intake.**

Fish Species	Value-Abundance Rating	Rating Rationale
Burbot	Moderate	Native species part of aboriginal and sport fishery that is in moderate abundance
Kokanee	High	Native species part of aboriginal and sport fishery that is in higher abundance than the others
Largescale Sucker	Low	Native non-sport fish species in low abundance
Rainbow Trout	High	Native species part of aboriginal and sport fishery that is in higher abundance than the others

3.2.4. Proportion of the Population Impacted Rating

The Proportion of the Population Impacted Rating is relevant to the assessment of the overall ecological effect within the reservoir and was informed by the following:

- *Likelihood of entrainment* - rated as moderate for Kokanee and Largescale Sucker and low for Burbot and Rainbow Trout based on fish habitat use, swimming abilities, and behaviour (Section 3.1.2.4).
- *Proportion of the population expected to be entrained* - low based on low discharge proportion rating, as less than 2% of the total reservoir volume is discharged per day (Section 3.1.2.3).

The hazard rating for this component was estimated using the BC Hydro guidelines (BC Hydro 2006), where the Proportion of the Population Impacted Rating was defined as:

- *Low* – Effect not measurable with standard assessment methods, possibly <5% of the total species population in the reservoir;
- *Moderate* – Effect potentially detectable with standard methods but not necessarily significant, possibly 5% to 25% total species population in the reservoir; or
- *High* – Effect measurable and "significant" portion of annual mortality rate, possibly >25% total species population in the reservoir.

Using this information, we rated the Proportion of Population Impacted hazard as low for all four species at the Kemano intake, given the large size and complex habitat within the Nechako Reservoir that can be utilized by the different fish species (Table 14). Although it is likely that some fish are being entrained through the intake, it is unlikely that more than 5% of the population of any species is being entrained. Rationale for each species is further detailed below:

- *Burbot* – This species is at a low risk of entrainment (Section 3.1.2.4) and is found in low abundance near the Kemano forebay (based on current data; Section 3.2.1). It is unknown if Burbot are using habitat near the intake (i.e., in 13 m to 23 m of water; Section 1.1.2); however, they would need to be directly adjacent to the intake to experience water velocities that could cause entrainment (Section 3.1.2.3). While Burbot migrate and spawn in the fall-winter period when discharge at the Kemano intake is highest (Section 1.1.1), they usually feed in the water column where flow velocities are lower than near the bottom (and the tunnel entrance is located at the bottom of the water column). Considering these factors and the low percentage of total reservoir volume discharged per day, it is unlikely that more than 5% of the Burbot population in the Nechako Reservoir is being entrained through the Kemano intake.
- *Kokanee* – This species is at a moderate risk of entrainment (Section 3.1.2.4) and is found in higher abundance near the Kemano forebay (based on current data; Section 3.2.1). It is unknown if Kokanee are using habitat near the intake (i.e., in 13 m to 23 m of water;

Section 1.1.2); however, they would need to be directly adjacent to the intake to experience water velocities that could cause entrainment (Section 3.1.2.3). While Kokanee migrate and spawn in the fall period when discharge at the Kemano intake is highest (Section 1.1.1), they usually feed near the surface of the water column where velocities are lowest (and the tunnel entrance is located at the bottom of the water column). Considering these factors and the low percentage of total reservoir volume discharged per day, it is unlikely that more than 5% of the Kokanee population in the Nechako Reservoir is being entrained through the Kemano intake.

- *Largescale Sucker* – This species is at a moderate risk of entrainment (Section 3.1.2.4) and is found in low abundance near the Kemano forebay (based on current data; Section 3.2.1). It is unknown if Largescale Sucker are using habitat near the intake (i.e., in 13 m to 23 m of water; Section 1.1.2); however, they would need to be directly adjacent to the intake to experience water velocities that could cause entrainment (Section 3.1.2.3). Furthermore, Largescale Sucker migrate and spawn in the spring period when discharge at the Kemano intake is lower than the fall-winter period (reducing entrainment potential, Section 1.1.1). However, they do feed at the bottom of the water column where velocities are highest (and the tunnel entrance is located at the bottom of the water column). Overall, considering these factors and the low percentage of total reservoir volume discharged per day, it is unlikely that more than 5% of the Largescale Sucker population in the Nechako Reservoir is being entrained through the Kemano intake.
- *Rainbow Trout* – This species is at a low risk of entrainment (Section 3.1.2.4) and is found in higher abundance near the Kemano forebay (based on current data; Section 3.2.1). It is unknown if Rainbow Trout are using habitat near the intake (i.e., in 13 m to 23 m of water; Section 1.1.2); however, they would need to be directly adjacent to the intake to experience water velocities that could cause entrainment (Section 3.1.2.3). Furthermore, Rainbow Trout migrate and spawn in the spring period when discharge at the Kemano intake is lower than the fall-winter period (reducing entrainment potential, Section 1.1.1). They also feed in the water column where velocities are lower than near the bottom (and the tunnel entrance is located at the bottom of the water column). Considering these factors and the low percentage of total reservoir volume discharged per day, it is unlikely that more than 5% of the Rainbow Trout population in the Nechako Reservoir is being entrained through the Kemano intake.

Table 14. Proportion of Population Impacted Rating for the Kemano intake.

Fish Species	Proportion of Population Impacted Rating	Rating Rationale
Burbot	Low	Low risk of entrainment and low relative abundance in West Tahtsa Lake. While they migrate and spawn in the fall-winter period when discharge at the Kemano intake is highest, they usually feed in the water column where velocities are lower. Entrainment not likely to be resulting in a population decline that exceeds 5%.
Kokanee	Low	Moderate risk of entrainment and higher relative abundance in West Tahtsa Lake. While they migrate and spawn in the fall period when discharge at the Kemano intake is highest, they usually feed near the surface where velocities are lower. Entrainment not likely to be resulting in a population decline that exceeds 5%.
Largescale Sucker	Low	Moderate risk of entrainment and low relative abundance in West Tahtsa Lake. While they migrate and spawn in the spring period when discharge at the Kemano intake is lower, they usually feed near the bottom where velocities are higher. Entrainment not likely to be resulting in a population decline that exceeds 5%.
Rainbow Trout	Low	Low risk of entrainment and higher relative abundance in West Tahtsa Lake. Furthermore, they migrate and spawn in the spring period when discharge at the Kemano intake is lower and they usually feed in the water column where velocities are lower. Entrainment not likely to be resulting in a population decline that exceeds 5%.

3.2.5. Ecological Significance Rating

The Ecological Significance Rating combines the Value-Abundance Rating with the Proportion of the Population Impacted Rating. Based on the ratings definitions provided in the BC Hydro methodology (Table 15), Burbot, Kokanee and Rainbow Trout fall into Category 2 (Native species: sport fish or aboriginal value), whereas Largescale Sucker falls into Category 3 (Native species, non-sport fish). Using this methodology, the Ecological Significance Rating was determined to be moderate for Burbot, Kokanee and Rainbow Trout, and low for Largescale Sucker (Table 16).

Table 15. Ecological Significance Rating classifications, as per the BC Hydro Methodology (BC Hydro 2006).

Category	Value-Abundance Rating	Proportion of Population Impacted Rating	Ecological Significance Rating
1 "Listed"	High	Any	High
2 Native Species: Sport Fish or Significant Aboriginal Traditional Use or Value	Low	Low	Low
		Moderate	Moderate
		High	High
	Moderate	Low or Moderate	Moderate
		High	High
	High	Low	Moderate
		Moderate or High	High
3 Native Species: Non-Sport Fish or Moderate Aboriginal Traditional Use or Value	Low	Low or Moderate	Low
		High	Moderate
	Moderate	Low	Low
		Moderate or High	Moderate
	High	Low	Low
		Moderate	Moderate
		High	High
4 "Exotics" and Introduced Species or Low Aboriginal Fisheries Use or Value	Low	Any	Low
	Moderate	Low or Moderate	Low
		High	Moderate
	High	Low	Low
		Moderate	Moderate
		High	High

Table 16. **Ecological Significance Ratings for the Kemano intake.**

Fish Species	Value-Abundance Rating	Proportion of Population Impacted	Ecological Significance Rating
Burbot	Moderate	Low	Moderate
Kokanee	High	Low	Moderate
Largescale Sucker	Low	Low	Low
Rainbow Trout	High	Low	Moderate

3.3. Consequences of Entrainment to Fish

The third goal of the ORS is to determine the potential consequences of fish entrainment for those fish entrained in the Kemano intake. These consequences were assessed using available literature, Ecofish experience with other hydroelectric projects, and professional judgement.

Known mechanisms of injury and/or mortality to fish passing through hydroelectric projects consist of (Čada 2001):

- Strike, where fish collide with structures such as turbine runner blades, stay vanes, wicket gates, and draft tube piers, which can cause blunt trauma;
- Supersaturation of dissolved oxygen, which can cause gas bubble disease;
- Rapid, large pressure changes, which can cause barotrauma;
- Hydraulic shear, which can injure fish;
- Turbulence, which can cause a loss of orientation in fish and negatively affect their survival (e.g., leading to further injury or predation);
- Grinding, where fish are squeezed through narrow gaps between fixed and moving structures; and
- Cavitation, which can occur during turbine passage when bubbles collapse onto and injure fish.

Although fish passing through the Kemano intake and tunnel may experience most of these mechanisms of injury/mortality, blunt trauma by striking the Pelton turbines in the powerhouse is expected to cause complete mortality of entrained fish. Thus, the other mechanisms of injury/mortality are not discussed herein even though they are expected to compound the negative impacts to entrained fish.

3.3.1. Blunt Trauma

The Kemano T1 intake consists of three trash racks that lead into a 16 km long by 7.6 m wide tunnel and two 3.35 m-wide penstocks (Figure 4; DGHP 2018). The water drops over a head height of ~800 m before entering the powerhouse on the Kemano River and flowing through eight generators composed of BLH Pelton Impulse turbines that turn at 327.5 rpm (DGHP 2018).

If fish that entrained into the Kemano intake survive passage through 16 km of tunnel with high flows, they are unlikely to survive passage through the Pelton turbines where they are likely to strike the turbine runners and suffer severe mechanical-related injuries. Mortality of fish passing this specific infrastructure has previously been assessed as 100% (RTA 2013), which is further supported by literature (e.g., PCWA 2011, Čada 2001). For example, Peltier (2003) indicated that small Pelton-type turbines, designed for high-head installations, most likely cause complete fish mortality due to their basic design.

3.3.2. Fate/Consequence Rating

The Fate/Consequence Rating is based on 1) the likelihood of fish mortality when passing through the hydroelectric infrastructure and 2) an evaluation of the impacts of displacement of fish (Table 17; BC Hydro 2006). The likelihood of mortality was determined by the consequences assessment described in the previous sections (Sections 3.3 and 3.3.1) and is high for all relevant species. Displacement can be considered of neutral consequence if: (1) fish are passing to an equally suitable habitat, (2) their loss to the upstream population is not detrimental, and (3) their effect on the downstream population is neutral or positive (BC Hydro 2006). In the case of the Kemano intake, the fate of fish displaced is expected to be negative because:

- Burbot, Kokanee, Largescale Sucker and Rainbow Trout are passing to highly unsuitable habitat. The fish leaving West Tahtsa Lake will never reach the Kemano River because of high mortality through the Pelton turbines.
- Their loss to the upstream population is not detrimental. The loss of low numbers of fish from West Tahtsa Lake is not expected to have detrimental effects on the Nechako Reservoir population, as shown in Section 3.2.4 (<5%).
- Their effect on the downstream population is neutral. Due to high mortality through the powerhouse, very few fish are expected to make it into the Kemano River. Thus, the entrainment of low numbers of new individuals is not expected to negatively affect the downstream fish populations.

Based on this assessment, the overall Fate/Consequence Rating is high for all four species (Table 18).

Table 17. Fate/Consequence Rating as per the BC Hydro Methodology (BC Hydro 2006).

Displacement Impact	Individual Mortality	Fate/Consequence Rating
Neutral or Little Impact	Low Rate (0 - 10%)	Low
Moderately Negative	Moderate Rate (10 - 50%)	Moderate
Significantly Negative	High Rate (>50%)	High

Table 18. Fate/Consequence Rating for the Kemano intake.

Fish Species	Infrastructure	Fate/Consequence Rating	Rating Rationale
Burbot	Kemano T1 Intake leads into a 16 km-long tunnel (~800 m drop in elevation) and eight generators composed of BLH Pelton Impulse turbines which turn at 327.5 rpm	High	Fish going through the Pelton turbines will most certainly strike the turbine runners and suffer severe mechanical-related injuries (up to 100% mortality)
Kokanee		High	
Largescale Sucker		High	
Rainbow Trout		High	

3.4. <u>Frequency of Occurrence of Fish Entrainment</u>

The Frequency of Occurrence Rating estimates how often fish may be subjected to fish entrainment and depends primarily on the planned (or unplanned) operational conditions during sensitive periods (e.g., potential aggregation of fish in front of the intake for spawning), as well as seasonal changes in operation that may alter the potential for entrainment. If entrainment occurs infrequently, the impact on the overall health of the ecosystem and the population may be low, even if the entrainment effects are expected to be moderate. Depending on the number of individuals of a fish species that become entrained, some population level effects may be observed (BC Hydro 2006).

The frequency of fish entrainment events was classified as follows:

- Frequent – Fish entrainment occurs continuously (i.e., daily or weekly);
- Occasional – Fish entrainment occurs seasonally or annually; or
- Rare – Fish entrainment occurs rarely (i.e., less than annually).

At the Kemano intake, operations are continuous with an average monthly discharge that varies between 88.1 m/s^3 in May and 143 m^3/s in December (Figure 3, Table 1). However, there are occasional shutdowns for maintenance and repairs of infrastructure. Accordingly, some low level of entrainment may be occurring year-round (frequently), but the bulk of entrainment would occur seasonally (occasionally), coincident with fish presence at the Kemano intake.

3.5. Final Risk Screening Rating

The Final Risk Screening Rating was estimated based on a professional judgement of the combination of:

- Ecological Significance Rating;
- Fate/Consequence Rating;
- Entrainment Likelihood Rating; and
- Frequency of Occurrence Rating.

The combination of these ratings resulted in a Final Risk Screening Rating for each species, determined according to the BC Hydro Methodology (Table 19; BC Hydro 2006). The Final Risk Screening Rating was moderate for Burbot, Kokanee, and Rainbow Trout and low for Largescale Sucker (Table 20).

Table 19. **Final Risk Screening as per the BC Hydro (2006) Methodology.**

Ecological Significance Rating	Fate/Consequence Rating	Entrainment Likelihood Rating	Frequency of Occurrence Rating	Final Risk Screening Rating
High	High or Moderate	High or Moderate	Frequent or Occasional	High
			Rare	Moderate
		Low	Any	Moderate
	Low	High	Any	Moderate
		Moderate	Frequent or Occasional	Moderate
			Rare	Low
		Low	Any	Low
Moderate	High	High	Frequent or Occasional	High
			Rare	Moderate
		Moderate	Any	Moderate
		Low	Frequent	Moderate
			Occasional or Rare	Low
	Moderate	High	Frequent or Occasional	Moderate
			Rare	Moderate
		Moderate	Frequent or Occasional	Moderate
			Rare	Low
		Low	Any	Low
	Low	Any	Any	Low
Low	High	High	Frequent	Moderate
			Occasional or Rare	Low
		Low or Moderate	Any	Low
	Moderate	High	Frequent	Moderate
		Moderate or Low	Any	Low
	Low	Any	Any	Low

Table 20. Final Risk Screening Rating for the Kemano intake.

Fish Species	Ecological Significance Rating	Fate/Consequence Rating	Entrainment Likelihood Rating	Frequency of Occurrence Rating	Final Risk Screening Rating
Burbot	Moderate	High	Low	Frequently	Moderate
Kokanee	Moderate	High	Moderate	Frequently	Moderate
Largescale Sucker	Low	High	Moderate	Frequently	Low
Rainbow Trout	Moderate	High	Low	Frequently	Moderate

4. CONCLUSION

A fish entrainment risk assessment methodology developed by BC Hydro (BC Hydro 2006) was used to conduct a desktop-based Overview Risk Screening (ORS) for the Kemano intake in the Nechako Reservoir. The results of this assessment led to a final risk rating of moderate for Burbot, Kokanee and Rainbow Trout and low for Largescale Sucker (these species were considered most susceptible to entrainment at this location). However, there is uncertainty in this assessment due to a lack of recent information on the forebay habitat, fish distribution, and relative abundance near the Kemano intake, and the current and foreseeable operational regime.

The results of this assessment will be shared with the WEI Technical Advisory Group for discussions to address Indigenous Groups' concerns about entrainment of fish at the Kemano intake and to determine next steps. According to the ORS methodology in BC Hydro (2006), an overall risk rating of low does not require further action while a rating of moderate requires further evaluation for the relevant fish species, as well as a management plan (although the facility may not require mitigation).

Yours truly,

Ecofish Research Ltd.

<u>Prepared by:</u>

Isabelle Girard, M.Sc., R.P.Bio., P.Biol.

Senior Fisheries Biologist

Susan Johnson, Ph.D.

Fisheries Biologist

<u>Reviewed by:</u>

Adam Lewis, M.Sc., R.P.Bio., P.Biol.

President, Senior Fisheries Scientist

REFERENCES

Ableson, D. and P. Slaney. 1990. Revised Sport Fisheries Management Plan for the Nechako River and the Murray/Cheslatta System. BC Ministry of Environment. 62 p.

Bainbridge, R. 1958. The Speed of Swimming of Fish as Related to Size and to the Frequency and Amplitude of the Tail Beat. Journal of Experimental Biology, vol. 35(1): 109-133.

Baxter, B.E. and R.C. Bocking. 2006. Field trials to assess coho smolt migration success through the Alouette Reservoir, 2005. Bridge Coastal Fish and Wildlife Restoration Program.

BGC (BGC Engineering Inc.) 2014. Huckleberry Mines Ltd. TMF-3 DAM- Dam Breech and Inundation Study. 52 p.

BC Hydro. 2006. Fish Entrainment Risk Screening and Evaluation Methodology. Report No. E478. Prepared for Generation, Environment and Social Issues. July 2006.

BC Hydro. 2007. Ash River Elsie Lake Reservoir Entrainment Risk Screening. Report No. E541. March 2007.

BC Hydro. 2009. Alouette Project Water use Plan (April 15, 2009). Available online at: https://www.bchydro.com/toolbar/about/sustainability/conservation/water_use_planning/lower_mainland/alouette.html. Accessed on April 22, 2021.

Beamesderfer, R.C. 1992. Reproduction and early life history of northern squawfish *Ptychocheilus oregonensis,* in Idaho's St. Joe River. Environ. Biol. Fishes 35:231-241.

Bell, M.C. 1991. Fisheries Handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, North Pacific Division. Fish Passage Development and Evaluation Program. Third Edition.

Burgetz, I.J., A. Rojas-Vargas, S.G. Hinch, and D.J. Randall. 1998. Initial recruitment of anaerobic metabolism during sub-optimal swimming in rainbow trout (*Oncorhynchus mykiss*). Journal of experimental Biology 201: 2711 – 2721.

Čada, G.F. 2001. Development of advanced hydroelectric turbines to improve fish passage survival. Fisheries 26: 14-23.

DFO (Fisheries and Oceans Canada). 2021. Introducing Canada's modernized *Fisheries Act*. Available online at: https://www.dfo-mpo.gc.ca/campaign-campagne/fisheries-act-loi-sur-les-peches/introduction-eng.html. Accessed on April 22, 2021.

DGHP (Doug Gents History Pages). 2018. Kemano – Powerhouse. Available online at: https://www.gent.name/bc:towns:kemano:powerhouse. Accessed on May 5, 2021.

Envirocon (Envirocon Limited). 1984. Environmental studies associated with the proposed Kemano completion hydroelectric development. Volume 6: Fish Resources of the Kemano River system - Baseline information. Consultant's report prepared for Aluminum company of Canada Ltd. 95 p. + Appendices.

Envirocon (Envirocon Limited). 1989. Kemano completion Project environmental studies: Potential for entrainment of fishes through the proposed power plant intake in West Tahtsa Lake and water release facilities at Kenney Dam: A preliminary environmental impact assessment. Prepared for Aluminium Company of Canada, Ltd. Vancouver, BC.

Foerster, R.E. 1947. Experiment to develop sea-run from land-locked sockeye salmon (*Oncorhynchus nerka*). J. Fish. Res. Board Can. 6(3):267-280.

Fulton, L.A. and R.E. Pearson. 1981. Transplantation and homing experiments on salmon, *Oncorhynchus spp*., and steelhead trout, *Salmo gairdneri*, in the Columbia River system: fish of the 1939-1944 broods. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC 12, 97 p.

Girard, I., S. Cullen, and A. Lewis. 2016a. Kemano Backup Tunnel- DFO Request for Review: Assessment of Serious Harm. Consultant's report prepared for Rio Tinto Projects, Technology & Innovation by Ecofish Research Ltd., August 5, 2016.

Girard, I., S. Cullen, and A. Lewis. 2016b. Kemano Backup Tunnel – Desktop Assessment of Fish Entrainment. Draft V1. Consultant's report prepared for Rio Tinto Projects, Technology & Innovation by Ecofish Research Ltd., April 6, 2016.

Godbout, L., C.C. Wood, R.E. Withler, S. Latham, R.J. Nelson, L. Wetzel, R. Barnett-Johnson, M.J. Grove, A.K. Schmitt, and K.D. McKeegan. 2011. Sockeye salmon (*Oncorhynchus nerka*) return after an absence of nearly 90 years: a case of reversion to anadromy. Can. J. Fish. Aquat. Sci. 68(9): 1590-1602.

Jain, K.E., J.C. Hamilton, and A.P. Farrell. 1997. Use of a ramp velocity test to measure critical swimming speed in rainbow Trout (*Oncorhynchus mykiss*). Comparative Biochemistry and Physiology 117A: 411 - 444.

Jones, D.R., J.W. Kiceniuk, and O.S. Bamford. 1974. Evaluation of the swimming performance of several fish species from the McKenzie River. Journal of the Fisheries research Board of Canada 31: 1641 -1647.

Kaeriyama, M.S., S. Urawa, and T. Suzuki. 1992. Anadromous sockeye salmon (*Oncorhynchus nerka*) derived from nonanadromous kokanees: Life history in Lake Toro. Sci. rep. Hokkaido salmon hatchery 46: 157- 174.

Katapodis, C. 1991. Advancing the art of engineering fishways for upstream migrants. Proceedings of the International Symposium on Fishways "90 in Gifu, October 8-10, 1990. Publications Committee of the International Symposium on Fishways '90 in Gifu, Japan, p. 19-28.

Katapodis, C. and R. Gervais. 2016. Fish swimming performance database and analyses. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/002 vi + 550p.

KCB (Klohn Crippen Berger). 2020. Skins Lake Spillway CFD Model - Hydrotechnical Report – Rev 0. 58 p.

KLCE (Klohn Leonoff Consulting Engineers). 1989. Kemano Completion Project, West Tahtsa Intake - Design Report, PB5060 1804/KLK 1291. Report prepared for Alcan Smelters and Chemicals Ltd. December 15, 1989.

Kolok, A.S., R.M. Spooner, and A.P. Ferrell. 1993. The effect of exercise on the cardiac output and blood flow distribution of the largescale sucker *Catostomus macrocheilus*. Journal of Experimental Biology. 183: 301 - 321.

Kurtz, J. 2021. Nechako Reservoir Tour. Memorandum presented to the Main Table of the Water Engagement Initiative. October 27, 2021. 17 p.

Langford, M., D. Zhu, A. Leake and S. Cooke. 2020. Hydropower Intake-induced Fish Entrainment Risk Zone Analysis. Canadian Journal of Civil Engineering. 35 p. Available online at: cjce-2019-0466.pdf (utoronto.ca). Accessed on December 7, 2021.

Lee, C.G., A.P. Ferrell, A. Lotto, M.J. MacNutt, S.G. Hinch, M.C. Healey 2003. The effect of temperature on swimming performance in adult sockeye (*Oncorhynchus nerka*) and coho (*O. kisutch*) salmon stocks. Journal of Experimental Biology 206: 3239 – 3251.

Martins, E.G., L.F. Gutowsky, P.M. Harrison, D.A. Patterson, M. Power, D.Z. Zhu, and S. J. Cooke. 2013. Forebay use and entertainment rates of resident adult fish in a large hydropower reservoir. Aquatic Biology, vol. 19(3): 253-263.

Martins, E.G., L.F.G. Gutowsky, P.M. Harrison, J.E. Mills Flemming, I.D. Jonsen, D.Z. Zhu, A. Leake, D.A. Patterson, M. Power, and S.J. Cooke. 2014. Behavioural attributes of turbine entrainment risk for adult resident fish revealed by acoustic telemetry and state-space modelling. Animal Biotelemetry 2: 1-13.

McPhail, J.D. 2007. The Freshwater Fishes of British Columbia. The University of Alberta Press. Edmonton, Alberta.

Mellina, E., S. Hinch, K. MacKenzie, and G. Pearson. 2005. Seasonal Movement Patterns of Stream-Dwelling Rainbow Trout in North-Central British Columbia, Canada. Transactions of the American Fisheries Society, Vol. 134: 1021–1037.

MOE (Ministry of Environment). 2021. FIDQ Fish Inventories Data Queries. Available online at: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/fish/fish-and-fish-habitat-data-information/search-fish-fish-habitat-data-information/fisheries-inventory-data-queries. Accessed on April 6, 2021.

MOELP (Ministry of Environment, Lands and Parks). 1997. Water License F102324 – File No. 76940/70. 3 pp.

MOELP (Ministry of Environment, Lands and Parks). 2012. 2012 Amendment to the 1950 Agreement. 11 pp.

PCWA (Placer County Water Agency). 2011. Placer County Water Agency Middle Fork American River Project (FERC No. 2079) Final AQ 7 – Entrainment Technical Study Report – 2011. 279 p. Available online at: https://relicensing.pcwa.net/var/www/html/public_html/documents/Application//04_Vol%203%20-%20Exhibit%20E%20-%20Environmental%20Exhibit,%20Appendices,%20and%20Supporting%20Docs%20A,%20B%20&%20C/SDB_TSRs_Intro_and_AQ/09_AQ7_EntrainmentTSR/01_AQ7_EntrainmentTSR_2011.pdf. Accessed on May 3, 2021.

Peake, S.J. 2008. Swimming performance and behaviour of fish species endemic to Newfoundland and Labrador: A literature review for the purpose of establishing design and water velocity for fishways and culverts.

Peltier, R. 2003. Fish-friendly Hydro Turbines move Center Stage. Environmental Power Plant. Available online at: https://powergen.wordpress.com/2008/06/24/fish-friendly-hydro-turbines-move-center-stage-2/. Accessed on May 6, 2021.

Rescan. 1999. Nechako River - Summary of Existing Data. Report for the Nechako Environmental Enhancement Fund. 70 p.

RTA (Rio Tinto Alcan). 2011a. Kemano Backup Tunnel Project – Environmental Impact Assessment. 189 p. + Appendices.

RTA (Rio Tinto Alcan). 2011b. Backup Tunnel Project – Environmental Assessment Addenda #3. Fish Entrainment Risk Screening and Evaluation. 62 p.

RTA (Rio Tinto Alcan). 2013. Backup Tunnel Project – Environmental Assessment Addenda #3. Fish Entrainment Risk Screening and Evaluation. 64 p.

Skaar, D., J. DeShazer, L. Garrow, T. Ostrowski, and B. Thornburg. 1996. Quantification of Libby Reservoir levels needed to maintain or enhance reservoir fisheries - investigations of fish entrainment through Libby Dam, 1990-1994. U.S. Department of Energy Bonneville Power Administration Project No. 83-467. 110 p.

Stober, Q.J., R.W. Tyler, and C.E. Petrosky. 1983. Barrier net to reduce entrainment losses of adult kokanee from Banks Lake, Washington. North American Journal of Fisheries Management 3: 331-354.

Triton (Triton Environmental Consultants Ltd.). 1989. Nechako Reservoir fish fauna studies: Tahtsa Narrows and adjacent tributaries. Prepared for Alcan Smelters and Chemicals Ltd. Kemano Completion Project. 29 p.

Triton (Triton Environmental Consultants Ltd.). 1992. Revelstoke aquatic monitoring program: an assessment of Revelstoke reservoir ecology and recommendations for future monitoring. Draft report. Prepared for B.C. Hydro, Environmental Resources. 41 p + 3 appendices.

Winsby, M.B., G.C. Taylor, and D.R. Munday. 1998. Nechako Reservoir impacts of timber salvage on fish and fish habitat. 1997 studies. Hatfield consultant report prepared for the Ministry of Environment, Lands and Parks, Skeena Region. Smithers B.C. March 1998. 70p.

Personal Communications

Lecuyer, A. Environmental Senior Advisor. Emails with Ecofish on October 19, 2020, March 4, 2021, and in May 2021.

Mercier, A. Water Resources Engineering Analyst, Operational Excellence & Integrated Operations, Rio Tinto. Conference call with Isabelle Girard, Matt Sparling and Jennifer Carter on April 1, 2021 and subsequent emails with Isabelle Girard in April 2021.

Robertson, M. Senior Policy Advisor at Cheslatta Carrier Nation. Call with Jayson Kurtz in the spring of 2021.