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MEMORANDUM

TO: **Water Engagement Initiative (WEI)**
FROM: **Rachel Chudnow, Ph.D. and Jayson Kurtz, B.Sc., R.P.Bio., Ecofish Research Ltd.**
DATE: **July 5, 2023**
FILE: **1316-09**

RE: **Cheslatta Watershed Fish Habitat – V2**

1. INTRODUCTION

During Nechako Water Engagement initiative (WEI) Main Table and Technical Working Group meetings, concerns were raised about potential effects of Rio Tinto (Alcan; RTA) operations on fish populations in the Nechako watershed. One priority is to better understand how RTA operations affect fish habitats in the Cheslatta River watershed (CRW). The Technical Working Group (TWG) asked Ecofish Research Ltd. (Ecofish) to review literature and summarize the status of current knowledge regarding CRW fish species, with focus on how flow (and hence RT operations) affect fish habitats (i.e., issue #17), and to develop recommendations for WEI consideration. This memo provides an overview of operational impacts on CRW fish habitats and offers practicable recommendations to inform water management decisions and minimize the negative effects on these species in the CRW.

2. BACKGROUND

2.1. Nechako Hydroelectric System

The Nechako watershed is composed of three basins / drainage areas: the Nechako Reservoir, Cheslatta River watershed, and Nechako River basin (Map 1). The Nechako Reservoir is located approximately 200 km west of Prince George, British Columbia (BC) and was created to provide water for Rio Tinto Alcan's (RTA) Kemano Hydroelectric Project, which was constructed in the 1950s to provide energy to operate an aluminium smelter in Kitimat, BC. The reservoir was formed by the construction of the Kenney Dam on the Nechako River (at the east end of the reservoir), which inundated a chain of six major lake and river systems (Ootsa, Whitesail, Knewstubb, Tetachuck, Natalkuz, and Tahtsa, ~420 km total length). Dam construction also dewatered approximately 9 km of the upper Nechako River, creating an impassible barrier to fish movement from the Nechako River upstream into the reservoir. The Nechako Reservoir is ~910 km^2 with a normal annual drawdown of ~3 m (10'); low water is in late spring and high water occurs in late summer, respectively. All flow from Nechako Reservoir to the Nechako River currently occurs via Skins Lake Spillway (SLS), located on Ootsa Lake. The spillway directs flow through the Cheslatta watershed, from where water flows into the Nechako River, downstream of Cheslatta Falls approximately 9 km downstream of Kenney Dam (Map 1).

The CRW's flow regime is primarily determined by SLS releases (i.e., there is minimal tributary input). Spillway discharge varies seasonally with peak flows occurring during the growing season in summer and early fall (Figure 1). Mean annual discharge (MAD) averaged 93.6 m^3/s m^3/s for the period of record extending from 1957 to 2022 (Beel *et al.* 2022). However, discharge during individual years can vary substantially from longer-term average conditions (i.e., MAD ranged from 30 m^3/s to 259.7 m^3/s during that same period) and there are often rapid changes in discharge, especially during the growing season (Figure 1).

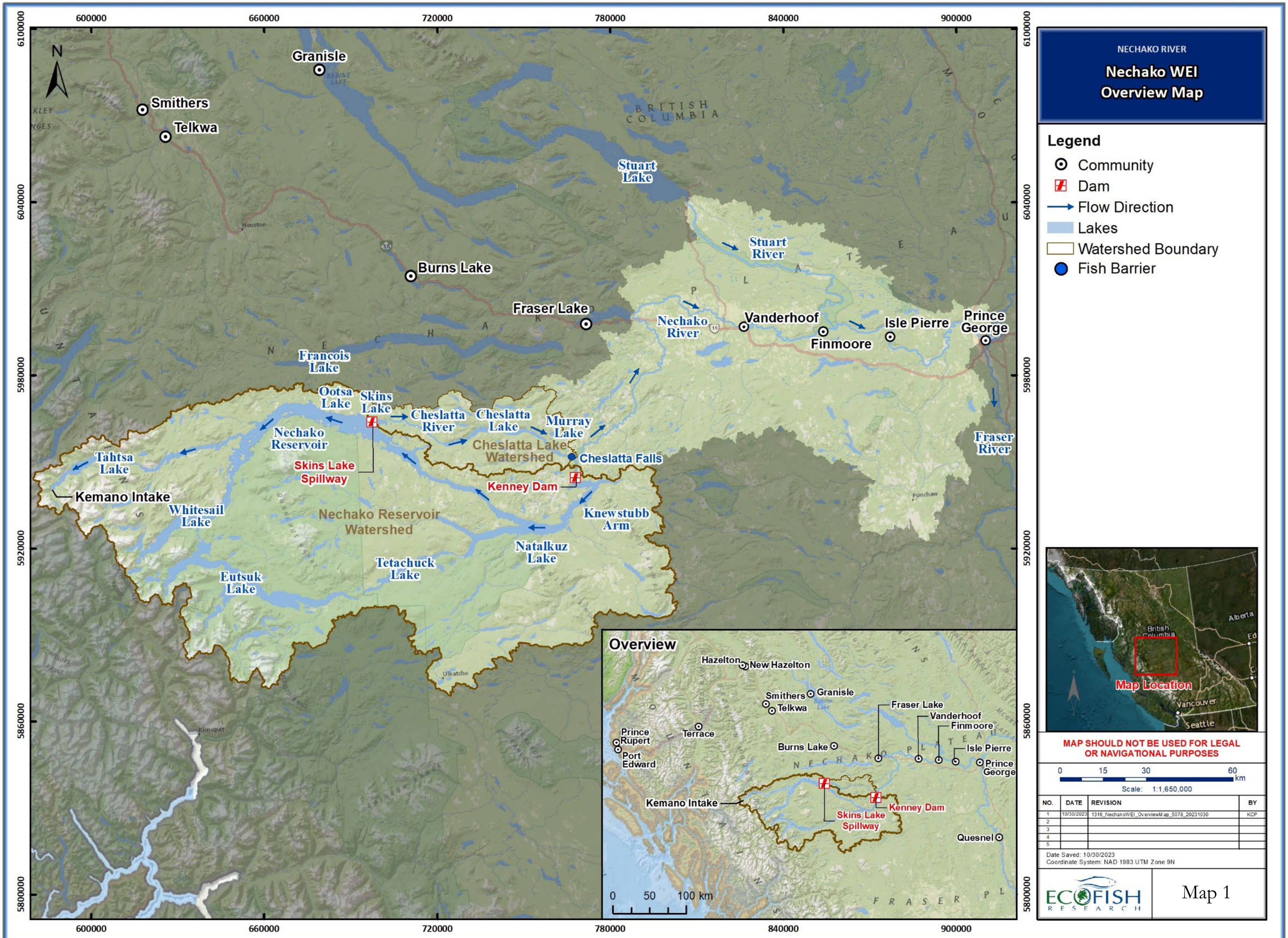
2.2. Biophysical Context

The Cheslatta watershed drains an area of approximately 1,300 m^2 extending southeast from SLS to the Cheslatta River's confluence with the Nechako River at Cheslatta Falls (Kellerhals *et al.* 1979; Hamilton and Schmidt 2005). It includes the Cheslatta River, a chain of three lakes along the Cheslatta River (i.e., Skins, Cheslatta, and Murray lakes), and approximately 25 associated tributaries (Map 2), most of which are only seasonally wetted (Table 1; Hamilton and Schmidt 2005). Generally, ephemeral tributaries are narrow (i.e., < 1 m wide), with fine-dominated substrate, and lack habitat complexity (e.g., pools, boulders, cutbanks; Triton 2000), while perennial tributaries (i.e., continuous flow throughout the year) are generally characterized as having wider channels and greater habitat complexity; BCUC 1993). Only four tributaries (Bird, Knapp, Holy Cross, and Ootsanee creeks) are thought to support fish year-round (Harder 1986; Envirocon 1993).

Prior to Nechako Reservoir infilling and creation of SLS, the Cheslatta watershed's headwaters were formed by a short (~ 2 km) section of tributary stream at the western extent of Cheslatta Lake (Lyons and Larkin 1952). The Cheslatta River's course was a small, meandering stream with a bankfull width of ~5 to 10 m through swamps, meadows, and small lakes near Ootsa Lake (Lyons and Larkin 1952; Hamilton and Schmidt 2005; Wood 2013). The natural average annual flow was approximately 0.6 m^3/s, minimum flows occurred in early spring (i.e., March) with peak flows in late spring (i.e., May) following a snowmelt driven freshet (NHC 2000).

Initiation of SLS operations in 1956 substantially affected CRW hydrology and geomorphology. Under spillway operations, water is discharged from SLS through a glacial spillway trench (forming Skins Lake) before entering the Cheslatta River. the watershed's MAD has increased approximately 12-fold. The upper Cheslatta River (i.e., upstream of Cheslatta Lake) has become a highly incised, entrenched, and confined channel with substantially larger average bankfull width (75 to 150 m width, channel downcut 10 – 20 m to bedrock; Kellerhals *et al.* 1979; Envirocon. 1993; NHC 2000; Hamilton and Schmidt 2005). Significant erosion within the upper river has increased the size of the delta at the upstream extent of Cheslatta Lake by 1 km (from 1.5 km to 2.5 km) and permanently raised the lake level by 1 – 2 m (Hamilton and Schmidt 2005). The maximum annual range of lake water levels has also increased from 1 m to 3.5 m (Hamilton and Schmidt 2005).

Fish access in the watershed is constrained at multiple locations. A series of two naturally occurring falls (~ 28 m high) in the lower river are an impassible barrier to fish movement and prevent anadromous fish access from the Nechako River. Upstream, a series of cascades and falls throughout the upper Cheslatta River fragment fish habitat preventing movement along the full extent of the river (see Map 2; Hamilton and Schmidt 2005). In addition, SLS prevents fish access to the reservoir, although fish may be entrained from the reservoir into the CRW (Girard *et al.* 2022).



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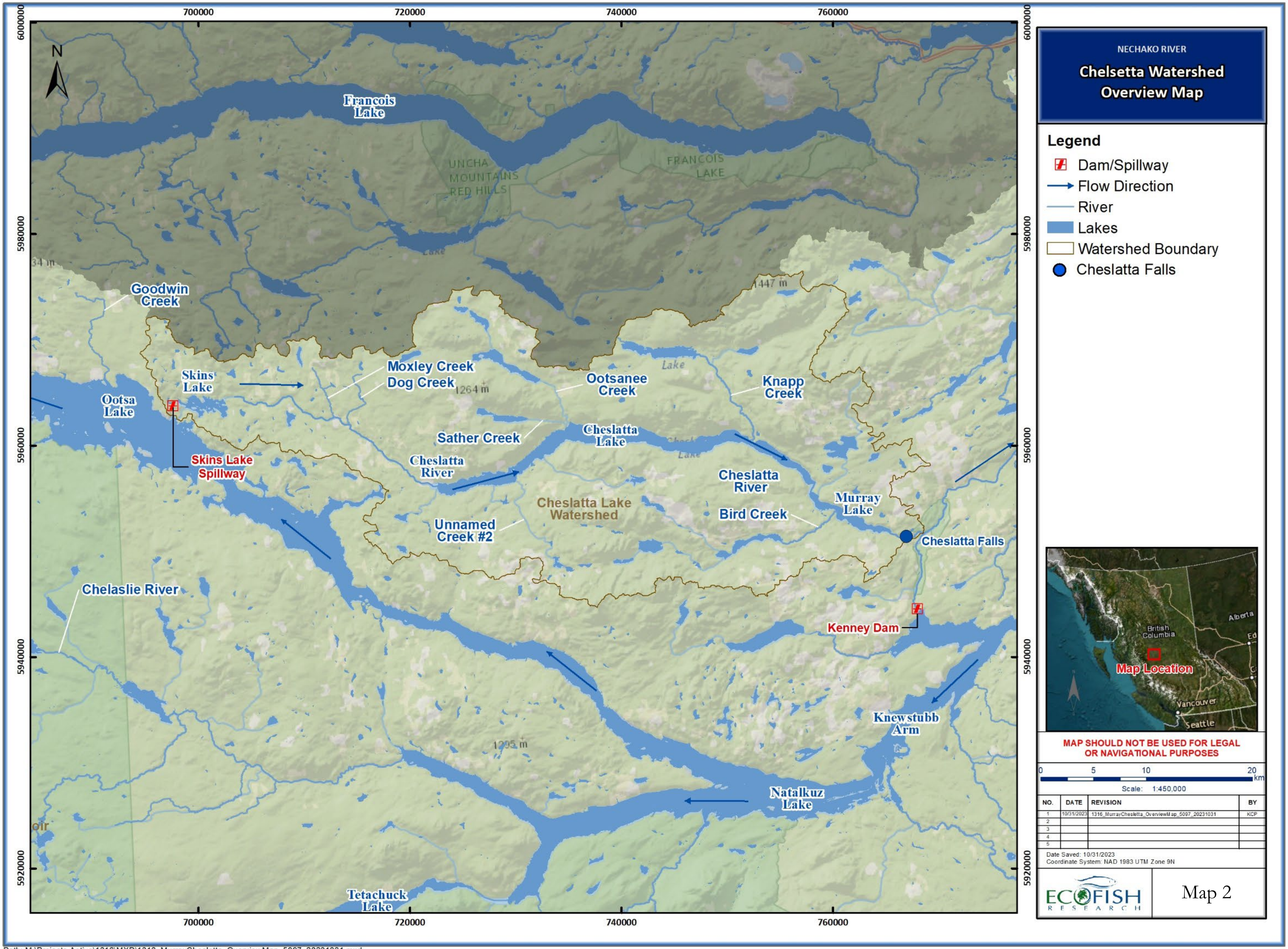

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Figure 1. Time series of the Skins Lake Spillway discharge showing variability in flows during the growing season in recent representative years.

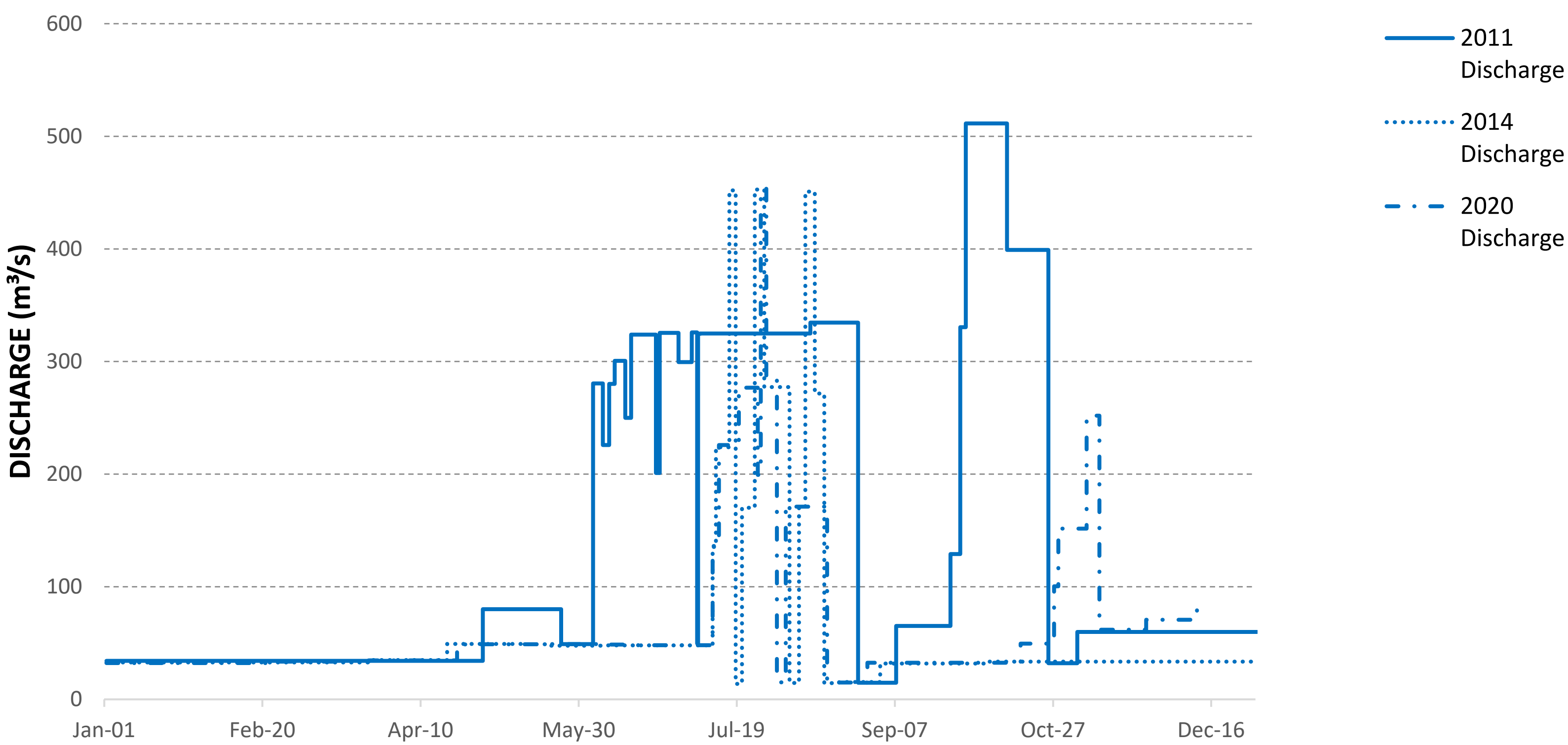

Table 1. Physical characteristics of waterbodies in the Cheslatta River watershed.

Waterbody	Length (km)*	Area (km^2)†	Maximum Depth (m)‡
Skins Lake	3.6	4.7	-
Cheslatta River	24.9	-	-
Cheslatta Lake	38.7	35.0	73
Murray Lake	8.3	5.6	26

* Linear length along the centreline, measured using Google Earth

† Skins Lake: measured using Google Earth;
Murray/Cheslatta lakes: from Lyons and Larkin (1952), cited in Hamilton and Schmidt (2005)

‡ Lyons and Larkin (1952), cited in Hamilton and Schmidt (2005). Does not account for ~1–3.5 m increase in maximum lake elevation post-reservoir construction.

"-" denotes unknown values

2.3. Fish Community

The CRW provides lacustrine, riverine, and tributary fish habitat for at least 15 species including one burbot, (family: Lotidae), five minnows (Cyprinidae), six salmonids (Salmonidae), sculpins[1] (Cottidae), and two suckers (Catostomidae; Table 2). All fish present in the watershed are year-round residents, excluding potential entrainment from the Nechako Reservoir via SLS (Girard *et al.* 2022). Most fish community research in the watershed has been preliminary reconnaissance work (e.g., see Harder 1986; Hatfield Consultants 1998; Triton 2000; Sparks and Martin 2021) and individual species' distribution and habitat use in the system are relatively unknown. Most species are known from other systems to inhabit both lacustrine and riverine habitats, while others (i.e., Lake Trout, Lake Whitefish) have been identified by the literature as primarily present in lake systems (Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007). Available local knowledge shows the watershed supports both traditional and recreational salmonid harvest: Lake Trout have been captured exceeding 20lbs (Reid, pers. comm. 2022; Robertson, pers. comm. 2021), Rainbow Trout regularly exceed 2 pounds, and Mountain Whitefish appear abundant (Salewski, pers. comm. 2023). The native distributions,

[1] CRW sculpins have only been identified to the genus level (*Cottus* spp.). Given Prickly Sculpin (*C. asper*) and Slimy Sculpin (*C. cognatus*) have been identified in both the Nechako Reservoir and Nechako River, these species are likely also present in the CRW.

conservation status, population trends, life histories, and habitat use for each of these species assemblages are summarized in Appendix A and detailed in a comprehensive review of fish species in the Nechako watershed (Chudnow *et al.* 2022).

Understanding of the species contributing to the CRW fish community is complicated by conflicting information. Accounts of Bull Trout and Dolly Varden in the CRW are unreliable: extensive sampling has not detected either species in the watershed, and historical records indicating their presence are considered to be an error (Hagen and Decker 2011). In addition, local residents and others often refer to Bull Trout, Dolly Varden, and Lake Trout (confirmed in the CRW) as "char" and have even been reported as Arctic Char, perhaps further confusing the reported distribution of these species. Given best available information, in this document all char species in the CRW are considered Lake Trout; Bull Trout and Dolly Varden are assumed to be absent from the watershed.

Further, only one survey (Lyons and Larkin 1952), was identified that provides Cheslatta watershed fish community species composition information prior to construction on SLS. The spatial scope of this survey was limited to Cheslatta and Murray lakes only (i.e., Skins Lake, Cheslatta River, and Cheslatta watershed tributaries not included) and only identified presence of Lake Whitefish, Lake Trout, Rainbow Trout, sculpins, and suckers[2]. Several surveys conducted following construction of Skins Lake Spillway have since identified additional species in the watershed (see Table 2). This is likely in part due to the consideration of additional Cheslatta watershed habitats (i.e., Skins Lake, Cheslatta River, and tributaries) in combination with differences in survey methodology, sampling techniques, and sampling intensity between surveys (e.g., gillnet survey by Lyons and Larkin 1952 may not have selected small fishes such as minnows; see Lyons and Larkin 1952; Ableson 1985; Harder 1986; Hamilton and Schmidt 2005). Beyond this, it is unclear if variation in observed species composition is in part the result of fish movement into the CRW via the spillway (e.g., Brassy Minnow observations in Skins Lake; Hamilton and Schmidt 2005).

The taxonomic classification and distribution of Umam is also unclear. This fish is of high importance to the Cheslatta Carrier Nation, and although its name roughly translates to "pygmy" whitefish (Triton 2008a), it is unclear if this is a somewhat more common translation (i.e., "small" whitefish – Mountain Whitefish and Lake Whitefish are confirmed present) rather than specifically meaning the taxonomic species Pygmy Whitefish (*Prosopium coulterii*). Although the CRW is outside the known distribution of *P. coulterii* (McPhail 2007), this document will continue to discuss Pygmy Whitefish as (*Prosopium spp.*) in addition to Mountain Whitefish and Lake Whitefish. There is ongoing work by the Cheslatta Carrier Nation to better understand whitefish populations in the CRW (e.g., Sparks and Martin 2021).

[2] Lyons and Larkin 1952 only identified sculpins (*Cottus* spp.) and suckers (*Catastomus* spp.) to the genus level.

Table 2. Cheslatta River watershed fish species.

Family	Common Name	Scientific Name[1]	Known Habitat Use[2]
Burbots	Burbot	*Lota lota*	Lacustrine & Riverine
Minnows	Brassy Minnow	*Hybognathus hankinsoni*	-[3]
	Lake Chub	*Couesius plumbeus*	Lacustrine & Riverine
	Longnose Dace	*Rhinichthys cataractae*	Lacustrine & Riverine
	Northern Pikeminnow	*Ptychocheilus oregonensis*	Lacustrine & Riverine
	Peamouth Chub	*Mylocheilus caurinus*	Lacustrine & Riverine
	Redside Shiner	*Richardsonius balteatus*	Lacustrine & Riverine
Salmonids	Kokanee	*Oncorhynchus nerka*	Lacustrine & Riverine
	Lake Trout	*Salvelinus namaycush*	Lacustrine
	Lake Whitefish	*Coregonus clupeaformis*	Lacustrine
	Mountain Whitefish	*Prosopium williamsoni*	Lacustrine & Riverine
	Rainbow Trout	*Oncorhynchus mykiss*	Lacustrine & Riverine
	Umam[4]	*Prosopium* sp.	Lacustrine & Riverine
Sculpins	Sculpins[5]	*Cottus* spp.	Lacustrine & Riverine
Suckers	Largescale Sucker	*Catostomus macrocheilus*	Lacustrine & Riverine
	Longnose Sucker	*Catostomus catostomus*	Lacustrine & Riverine

[1] Presence/absence information sourced from: Ableson 1985; Envirocon 1989; Hamilton and Schmidt 2005; BC MOE 2021a, 2021b; Robertson, pers. comm. 2021; Triton 2000.

[2] Species specific habitat use derived from literature regarding known habitat use in systems across British Columbia.

[3] Observations in Skins Lake Spillway plunge pool indicate species could be entrained from Nechako Reservoir (Hamilton and Schmidt 2005).

[4] Species' taxonomic classification is unclear. This fish is important to the Cheslatta Carrier Nation, and it is unclear if the rough translation ("pygmy" whitefish; Triton 2008a) relates to a common translation (i.e., "small" whitefish) or refers to *Prosopium coulterii*. The Nation is undertaking ongoing work to better understand whitefish populations in the basin (Triton 2008a; Robertson pers. comm. 2021; Sparks and Martin 2021).

[5] Sculpins have only been identified in the Cheslatta watershed to the genus level (*Cottus* spp.). Prickly Sculpin (*C. asper*) and Slimy Sculpin (*C. cognatus*) are present in both the Nechako Reservoir and Nechako River and are likely also present in the Cheslatta watershed.

2.3.1. Current Level of Knowledge

Literature review identified two studies that occurred in the CRW prior to diversion flows from the Nechako Reservoir. First, Larkin (1951) focused on the environmental impacts of dam construction on Cheslatta Lake. While the second, Lyons and Larkin (1952), focused on assessment of upper Nechako watershed lakes (now inundated by the reservoir), CRW lakes, and the Nechako River, with limited survey of the rest of the Cheslatta River or associated tributaries. Most research since that time occurred in the 1980s to early 2000s and primarily focused in Cheslatta Lake and associated tributaries. Data collection generally surrounded identifying fish presence and assessing tributary habitat quality through reconnaissance. No directed studies investigating population structure, demographics, abundance trends, local distribution, movements, or life histories were identified in documents reviewed for any species. More recent, contemporary work has been limited to a single investigation focused on Umam (Sparks and Martin 2021).

3. METHODS

A literature review and data search were conducted to locate all known information regarding fish and fish habitat in the Cheslatta watershed, how flow (and hence operations) affects these aquatic resources. Specific efforts were undertaken to review British Columbia Utilities Commission (BCUC), Kemano Completion Project (KCP), Nechako Environmental Fund (NEEF), and Nechako Fisheries Conservation Program (NFCP) reports. Information was also collected via online searches including Google and Google Scholar, searches of provincial government databases (e.g., Fish Inventories Data Queries (FIDQ), Habitat Wizard, Ecological Reports Catalogue (EcoCat), and Forest Renewal BC (FRBC) Reports Inventory) and organizational databases (e.g., NEEF 2022; UNBC 2022), and review of scanned archival copies of government and organizational reports.

Few of these studies provided information directly pertaining to CRW fish populations. Further information regarding the impacts of flow diversion through the CRW were highly limited (i.e., Slaney *et al.* 1984; Slaney 1987; Bruce 1991; Sparks and Martin 2021). For this reason, we infer possible impacts of flow diversion based on known attributes of fish species' life histories and habitat use in other systems.

4. RESULTS

4.1. Overview of Potential Pathways of Effect

Watershed-specific habitat suitability information at different SLS discharge levels is not available. Despite this lack of information, available evidence suggests that habitat suitability in the CRW has been significantly modified by flow diversion. Here, we identify key pathways through which RTA operations could potentially effect CRW fish species as the result of flow alteration. Many potential pathways can influence habitat conditions in both lacustrine and riverine habitats (i.e., within Cheslatta River and Skins, Cheslatta, and Murray lakes), however the mechanisms through which these pathways effect fish may vary by habitat. In addition, there are several pathways that are habitat specific. Potential pathways of effect are summarized in Table 3.

Table 3. Specific potential pathways of effect of flow on the Cheslatta watershed fish community.

Potential Pathways of Effect	Lakes	Mainstem	Tributaries
Hydrolocially suitable habitat		X	X
Turbidity	X	X	X
Flushing rate	X	X	
Habitat access	X	X	X
Inundation and dewatering	X	X	X
Ramping rate	X	X	
Riparian connectivity	X	X	X
Geomorphology and sedimentation	X	X	X
Temperature	X		
Food availability	X	X	X

Each of these potential pathways could ultimately affect overall species production and impact the relative species abundances and thus fish community composition in the CRW. In Section 4.1.1 to Section 4.1.3 below, we discuss available evidence regarding the impacts of these pathways (as relevant) by habitat type.

4.1.1. Cheslatta River

River flow (i.e., discharge) has been called the 'master variable' effecting fish communities (Poff *et al.* 1997; Bergendorf 2002). It directly affects aquatic habitats through multiple mechanisms which govern the amount of physical space available for fish (and their food) and the quality of available habitats (i.e., by determining channel width, water depth, and velocity; Raleigh *et al.* 1986). Water velocity also has secondary effects on physical and biotic habitat components (e.g., channel geomorphology, habitat connectivity, habitat complexity, productivity).

Temporal flow variation is also a critical aspect shaping fish communities in riverine systems. Fish have evolved to natural variations in flow in ways that maximize their survival (Lytle and Poff 2004). Seasonal flow variation is also a defining factor in determining fish life history event timing, physiology, behaviour, and adaptations to local conditions. For example, seasonal flow patterns directly impact reproductive strategies, feeding, and growth, and ultimately play a role in individual survival (Bergendorf 2002).

There is limited available data regarding the relationship between the current flow regime and habitat availability (i.e., quantity and connectivity) within the Cheslatta River. Available evidence suggests that Cheslatta River fish habitat availability is limited across a broad range of flows, most notably at flow extremes. At high discharge levels, large portions of the channel likely contain velocities that physically displace fish due to swimming ability or as the result of fish avoidance, reducing overall habitat quantity (Lindstrom and Hubert 2004; Katopodis and Gervais 2016). While at a range of reduced flows, wetted width and thus overall available habitat quantity also decreases.

Further, fish access to in-river and adjacent tributary habitats (see Section 4.1.3 below) may also be negatively affected across a range of flows. At high flows, cascades and falls fragment and isolate portions of the river (Hamilton and Schmidt 2005). While at low flows, barrier exposure in areas that are highly incised or have steep gradients and exposed bedrock may also limit or prevent fish passage (NHC 2000; Hamilton and Schmidt 2005). Reductions or changes to in-river habitat connectivity can affect numerous fish species, notably those that are reliant on specific portions of the river (i.e., with specific habitat characteristics) at specific times (e.g., Kokanee or Rainbow Trout spawning; Appendix A; McPhail 2007).

Information regarding the relationship between flow and fish habitat quality is also limited. Overall, fish habitat quality in the Cheslatta River appears poor across a range of flows. The river lacks many of the habitat attributes that are generally considered prevalent in highly productive, small streams. This effects numerous fish species, notably those species or life stages that are highly reliant on complex, fluvial rearing habitats for survival (e.g., Rearing juvenile Rainbow Trout; Appendix A; McPhail 2007). High flow releases via SLS are the primary factor limiting Cheslatta River habitat quality, however many of the effects of high flow remain even when flow is reduced, resulting in relatively low habitat quality across a broad range of flows. Although sustained, long-term reduced flows may result in limited habitat improvements, across most factors affecting fish habitat quality, substantial improvement is not expected with changes to the current flow regime alone (i.e., without intervention through restoration actions).

High flow periods cause geomorphological changes that significantly decrease river habitat complexity. Many of these impacts remain even when flows are relatively low (i.e., habitat complexity is not expected to substantially increase at reduced flows). For example, at present, the main river channel is disconnected from its former floodplain and is no longer connected with riparian habitats as the result of high flows and resultant erosion and scour (Envirocon 1984; Hamilton and Schmidt 2005). At low flows the stream wetted width decreases, further increasing the distance between the wetted channel, floodplain, and riparian habitats. Overall, this mechanism has reduced the presence of woody debris throughout the river and reduces the likelihood of future wood recruitment across a broad range of flows (i.e., due to the physical distance between the river margins and wetland and riparian habitats). Lack of woody debris reduces available habitat complexity (i.e., wood can serve as important fish habitat as well as a velocity barrier during periods of high flow; Hafs *et al.* 2014) and reduces the potential for terrestrial insect leaf drop decreasing food availability for the fish community.

Erosion and scour as the result of high flows also removes fine to cobble sediments from the river's substrate, depositing it in the lakes downstream (NHC 2000; Hamilton and Schmidt 2005). As a result, at present, the river appears to have low substrate complexity and is composed of primarily course cobble, boulders, and bedrock (NHC 2000). This effects fish species reliant on fine or gravel substrates for portions of their life history (e.g., sculpin rearing and Rainbow Trout spawning, respectively; McPhail 2007) and limits the growth of macrophytes and emergent vegetation. Sustained reductions in flow are expected to prevent future erosion and scour of finer sediments, however the period of time required for these sediments to accumulate to such a degree that they provide valuable fish habitat and are able to support plant communities is uncertain.

Although some of the factors contributing to Cheslatta River productivity[3] are external to flow (i.e., unproductive (oligotrophic) surface waters in Nechako Reservoir are the primary source of water to the Cheslatta River), this impact is compounded by the effects of high flow (Abell and Lewis 2022). High flows directly increase flushing rate, while erosion and scour limit the growth of periphyton, macrophytes, and emergent vegetation further reducing habitat complexity for fish and invertebrate communities (Abell and Lewis 2022). Sustained reductions in flow are expected to result in increased fish habitat quality through increases in habitat complexity and productivity (i.e., reduced flushing rate and limited future erosion and scour, increased substrate complexity and creation of potential habitat for periphyton, macrophyte, and emergent plant growth and thus invertebrate and fish communities), however the magnitude of improvement is uncertain.

Beyond the impacts of specific discharge levels on the fish community, the time scale over which SLS discharge changes also has important consequences for fish. Flow ramping can alter the locations of hydrologically suitable habitat and can change micro-habitat quality. Further, sharp changes in flow over a short period of time may result in fish stranding or isolation in habitats that are susceptible to dewatering. Nicholl *et al.* (2022) provides an assessment of stranding risks downstream of the spillway, and therefore, this potential pathway of effect is not detailed here.

4.1.2. Cheslatta and Murray Lakes

Specific data regarding how fish habitat in CRW lakes changes with spillway discharge is limited. However, available evidence suggests littoral and pelagic habitats are negatively affected over a range of flows (e.g., Larkin 1951; Lyons and Larkin 1952; Envirocon 1993; NHC 2000; Hamilton and Schmidt 2005; Stockner and Slaney 2006). Spillway operations increase the magnitude and frequency of CRW lake water level fluctuations (i.e., water level maximum range increase from ~1.0 m, historic to 3.5 m, current; Hamilton and Schmidt 2005), resulting in repeated inundation and dewatering along lake shorelines.

Nearshore habitats have low hydrological stability and overall littoral habitat quality appears low as the result of multiple processes including desiccation, freezing, and erosion (e.g., due to wave action or precipitation; Hamilton and Schmidt 2005; Stockner and Slaney 2006). At present, most of the

[3] Details regarding Cheslatta River productivity are provided in Abell and Lewis (2022).

upper littoral shoreline appears to lack vegetation (i.e., reduced primary productivity[4] of periphyton, macrophytes, emergent vegetation) and is disconnected from riparian habitats[5] (Wilcox and Meeker 1991; Zohary and Ostrovsky 2011). This reduces habitat quality for, and thus secondary productivity of associated invertebrate communities (Zohary and Ostrovsky 2011; Abell and Lewis 2022). Beyond direct impacts of decreased productivity on food availability, loss of periphyton, plants, and woody debris decreases habitat complexity in the upper littoral zone, with important implications for fish species that are reliant on nearshore habitats for portions of their life history (Appendix A).

In addition to the effects of water level variability, lake productivity has also been affected by multiple other pathways of effect as the result of flow diversion through CRW. These pathways are discussed in detail within Abell and Lewis (2022). Although data on lake productivity are generally lacking, current productivity has substantially declined[6] as the result of multiple mechanisms including:

- Influx of highly unproductive (oligotrophic) surface water from the Nechako Reservoir;
- Increased plankton flushing and reduced nutrient retention due to reduced water residence time as a consequence of increased flows; and
- Increased turbidity resulting in decreased light penetration and reductions in photic zone area.

Together, these mechanisms decrease primary productivity of periphyton, phytoplankton, macrophytes, and emergent vegetation and secondary productivity of associated invertebrate communities, thus reducing overall food availability for the fish community.

Erosion and scour throughout the Cheslatta River as the result of flow diversion has also resulted in significant sediment deposition throughout both Cheslatta and Murray lakes (Kellerhals *et al.* 1979; Ableson 1985; NHC 2000). Beyond the impacts of increased turbidity on primary production, increased sedimentation in lakebed habitats has potential direct effects on the fish community, particularly for species reliant on unembedded course substrate for spawning and incubation (e.g., Longnose Dace, Northern Pike Minnow, Peamouth Chub, Kokanee, Lake Trout, Lake Whitefish, suckers; McPhail 2007).

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[4] Abell and Lewis (2022) provide a detailed discussion of CRW productivity.

[5] Aerial imagery indicates presence of an unproductive drawdown zone in Cheslatta Lake that generally lacks riparian vegetation, which is not apparent in aerial imagery of other unregulated lakes in the region.

[6] Prior to flow diversion, Cheslatta Lake was moderately productive (mesotrophic) while Murray Lake was highly productive (eutrophic) (Lyons and Larkin 1952; Hamilton and Schmidt 2005).

4.1.3. Tributaries

Tributaries are well studied relative to other Cheslatta watershed habitats, primarily through reconnaissance level assessments (Appendix B; see work by Harder 1986; Triton 2000, 2008a, 2008b; Sparks and Martin 2021). Overall, tributary fish habitat is highly limited; only four of ~25 tributaries (Bird, Knapp, Ootsanee, and Sather creeks) are thought to support fish year-round (Harder 1986; Envirocon 1993). In addition, four tributaries (i.e., Enz Creek, Holy Cross Creek, Unnamed Creek #3, Unnamed Creek #4) have been identified as potentially important / suitable spawning habitat for Rainbow Trout and possibly Umam (Lyons and Larkin 1952; Sparks and Martin 2021). Despite data available through these sources, little information exists regarding the relationship between the current flow regime and tributary habitat quantity, quality, and fish access. Understanding the relationship between flow and tributary habitat is particularly important for species that are reliant on flowing water for portions of their life history (e.g., Kokanee, Mountain Whitefish, and Umam spawning, Rainbow Trout spawning and rearing; McPhail 2007) due to the general lack of alternative high quality fluvial habitats within the watershed.

Available information suggests upper reaches of most river tributaries lack fish habitat (e.g., Kellerhals *et al.* 1979; Hamilton and Schmidt 2005), while no information is available regarding habitat suitability in the upper reaches of lake tributaries. The upstream reaches of many of the Cheslatta River's tributaries have steep gradients with increased instream water velocities and may lack low velocity margin habitat (i.e., preferred rearing habitats). Steep slopes and resultant erosion may also limit habitat availability for periphyton, macrophytes, and invertebrates, limiting food availability for rearing fish. While head scarps and deep gullies present in many tributaries can trigger landslides, increasing tributary sediment load and possibly reducing the quantity and quality of salmonid spawning habitat depending on whether gravel is delivered to the stream (Kellerhals *et al.* 1979; Hamilton and Schmidt 2005). Although the mechanism resulting in current habitat conditions in upper tributary reaches is associated with historic Cheslatta River flows[7], future changes in mainstem flows are not expected to result in significant changes to upper tributary reach habitats.

The relationship between lower tributary reach habitat and flow is similar for both lake and river tributaries. Many tributaries adjust to decreases in Cheslatta River flow or lake water elevation by downcutting through alluvial fans at tributary confluences (Hamilton and Schmidt 2005). At reduced flows, this could impact tributary connectivity to river habitats due to exposure of barriers to fish (e.g., high gradient, drops, or falls at tributary mouths (NHC 2000). Fall reconnaissance work in 2022 did not identify lake tributary access issues at any of the sites visited (Bird, Enz, Holy Cross, Knapp, Ootsanee Sather and numerous unnamed creeks; Regehr and Kurtz 2023); however, reconnaissance was not able to visit river tributaries. Several tributaries investigated, including all streams thought to

[7] Current tributary geomorphology is largely resultant to changes to the Cheslatta river's geomorphology (i.e., lower thalweg / increased gradient) following diversion (Ableson 1985; Hamilton and Schmidt 2005).

be important to fish production (i.e., Bird, Knapp, Ootsanee, and Sather creeks; Hamilton and Schmidt 2005) lack lateral connectivity with riparian habitats[8] across a range of flows reducing fish habitat quality (e.g., availability of woody debris; Harder 1986; Hamilton and Schmidt 2005). Although the spatial extent of this is limited at higher flows, at low flows this lateral connection decreases as river channel width or lake water level decreases, further reducing habitat complexity and the availability of woody debris recruitment.

5. DISCUSSION

5.1. Potential Limiting Factors, Data Gaps, and Uncertainties

As discussed above, information available to identify the effects of flow on CRW fish habitats is highly limited. Here, we identify key pathways through which RTA operations could potentially affect these habitats based on best available evidence for the fish species and habitat types under consideration (see Table 3). Negative effects of the flow regime on habitat quantity, quality, and fish access will impact all species and life stages present in the watershed but will be of particular importance for species that are reliant on highly impacted habitats for portions of their life history (i.e., Kokanee and Rainbow Trout spawning)[9]. At this time, there is limited information to evaluate the biological significance of most pathways of effect or their associated interaction with flow management (but see Abell and Lewis 2022 for a discussion of limiting factors to CRW productivity). Specific data gaps and uncertainties surround:

- ***Current hydrology***: Available information is based primarily on recent spillway release data and there is generally a lack of contemporary field data across CRW macro-habitats. Collection of current hydrological data (e.g., using in-river hydrometric gauges, lake water level monitoring) would permit more complete assessment of current conditions (e.g., through an instream flow study). This would support the development of more robust recommendations of operational flows to maximize fish production.
- ***Fish population distribution, demography, and dynamics***: Although several reconnaissance level studies have inventoried CRW fish populations, this work was largely confined to tributaries and most work occurred prior to 2008. While available local knowledge demonstrates that both Lake Trout and Rainbow Trout support traditional harvest and recreational angling in the watershed. Overall, there is a general lack of contemporary fish

[8] As the result of repeated inundation of lower tributary reaches due to changes in lake and river water levels.

[9] For example, Ableson and Slaney (1990) identified the mainstem Cheslatta river as the most important habitat for rainbow trout spawning and rearing in the system. Further, Triton (2000) identified lack of these habitat types as significant limiting factors to fish production.

distribution, demographics, and abundance data across all habitat types. In particular, Skins Lake data are sparse.

Generally, spawning and rearing habitats throughout the CRW are thought to be limited, impacting production (Triton 2000). Contemporary information on the location of spawning and rearing habitats, as well as the sum of conditions that limit their presence and quality would better clarify the impacts of the current flow regime on specific species of interest. It would also aid in identification of were remedial actions could provide production benefits (e.g., see Ableson and Slaney 1990; Stockner and Slaney 2006).

- ***Fish passage barriers***: Barriers to fish movement have been identified in the mainstem Cheslatta River and some tributaries. In the river, there is uncertainty whether mainstem flow affects fish passage (e.g., at high flow, some barriers may be passable). While in tributaries, existing barrier observations date from research occurring prior to the mid-2000s. As a result, current conditions may not reflect these observations. These data gaps could be reduced through use of an instream flow study in the Cheslatta River mainstem in conjunction with a contemporary barrier assessment within key tributaries (i.e., those thought to support fish).

5.2. Potential Performance Measures

Performance measures are metrics for evaluating how changes in flow affect a particular interest or issue. The following section(s) describe favorable flow scenarios, performance measures, and/or objectives for the key issues discussed earlier in this document. This information is provided for consideration by the WEI Technical Working Group and Main Table to support the structured decision-making process. It is important to recognize that the draft performance measures, etc. presented here might be revised, replaced, or ignored depending on the specific needs and interest of the WEI.

- ***Hydraulically Suitable Habitat*** – Available evidence suggests that SLS discharge negatively effects CRW fish habitat quantity and quality, and fish access to specific areas throughout the watershed. However, detailed information regarding the magnitude and range of impacts are uncertain. Given these uncertainties it is not possible to develop a quantified, specific PM for this pathway of effect at this time. Although it is not expected that fish habitat quantity, quality, or access will improve substantially at any one specific SLS discharge rate, increased flow stability is expected to benefit fish and fish habitats in river, lake, and tributary habitats. Given presently available information, the most appropriate PM for this potential pathway is given by:
    - PM1: *Increased SLS discharge stability (i.e., reduced range of SLS discharge levels*)
- ***Stranding Risk*** – Detailed discussion of CRW stranding risk is provided in Nicholl *et al.* (2022). Changes in SLS discharge cause changes in river wetted width and CRW

lake water levels, which can strand or isolate fish. In the lakes, these ramping rates are attenuated by lake morphology. However, in the river, presence of high-risk stranding habitats and presumed presence of multiple fish species indicates that fish stranding is likely to occur, particularly in the upper sections where attenuation is limited. Detailed discussion of CRW stranding risk is provided in Nicholl *et al.* (2022).

  - PM2: *Defer to measures proposed by Nicholl et al. (2022).*

- ***Productivity*** – Cheslatta River and CRW lake productivity is affected by SLS discharge over a range of flows as the result of multiple mechanisms. This topic, including PM development, is given specific consideration in Abell and Lewis (2022).
  - PM3 – PM5: *Defer to measures proposed by Abell and Lewis (2022).*

6. CONCLUSION/CLOSURE

This memo provides a review of the potential for changes in flow to affect CRW fish habitat between Skins Lake Spillway and Cheslatta Falls. Outcomes of the review have been used to develop preliminary performance measures for the WEI to consider, and data gaps have been identified that could be addressed with further study.

Yours truly,

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APPENDICES

Appendix A. Resident Fish Periodicity, Habitat Use, and Temperature Preference Summary

Appendix B. Fish Habitat in Selected Cheslatta Watershed Tributaries

Appendix A. Resident Fish Periodicity, Habitat Use, and Temperature Preference Summary

LIST OF TABLES

Table 1. Cheslatta fish community periodicity and spatial behaviour.

Family	Species	Scientific Name	Life History Periods[1] Spawning	Fry Emergenc	Overwinterin g	Spatial Behaviour	References
Lings (Lotidae)	Burbot	*Lota lota*	Dec - Mar	Dec - Apr	None	Multiple kilometer spawning movements.	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007; Ashton *et al.* 2019
Minnows (Cyprinidae)	Brassy Minnow[2]	*Hybognathus hankinsoni*	Jun - Aug	Jun - Aug	Nov - Mar[3]	Schooling behaviour, seasonal habitat shifts to fluvial habitats.	Roberge *et al.* 2002; Scheurer *et al.* 2003; McPhail 2007; Radford and Sullivan 2014
Minnows (Cyprinidae)	Lake Chub	*Couesius plumbeus*	May - Aug	May - Aug	Nov - Mar[3]	Schooling behavior when appropriate cover unavailable. Evidence of spawning and post-spawning dispersal.	Brown *et al.* 1970; Lane *et al.* 1996; Roberge *et al.* 2002; McPhail 2007; Davis 2016
Minnows (Cyprinidae)	Longnose Dace	*Rhinichthys cataractae*	May - Jul	May - Aug	Nov - Mar[3]	Seasonal shift from riffles to slower, deeper water. Evidence of major seasonal movements.	McPhail and Lindsay 1970; Peden 1991; Roberge *et al.* 2002; McPhail 2007
Minnows (Cyprinidae)	Northern Pikeminnow	*Ptychocheilus oregonensis*	May - Jun	May - Aug	Nov - Mar[3]	Upstream spawning migration.	Jeppson and Platts 1959; Beamesderfer 1992; Roberge *et al.* 2002; McPhail 2007
Minnows (Cyprinidae)	Peamouth Chub	*Mylocheilus caurinus*	May - Jun	May - Jun	Nov - Mar[3]	Schooling behavior and seasonal migrations. Juveniles move into low-gradient tributaries (summer) and return to main river (overwinter).	Scott and Crossman 1973; Porter and Rosenfeld 1999; Roberge *et al.* 2002; McPhail 2007; Davis 2016
Minnows (Cyprinidae)	Redside Shiner	*Richardsonius balteatus*	Apr - Jul	May - Aug	Nov - Mar[3]	Some evidence of movements from lakes to small lake head tributaries.	Porter and Rosenfeld 1999; Roberge *et al.* 2002; McPhail 2007
Salmonids (Salmonidae)	Kokanee	*Oncorhynchus nerka*	Sep - Nov	Mar - May	Oct - Apr	Diel vertical migrations for prey or predator avoidance.	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007
Salmonids (Salmonidae)	Lake Trout	*Salvelinus namaycush*	Jul - Nov	Feb - Jun	None	Post spawning dispersal distances up to 160 km. Evidence of homing to spawning locations.	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007
Salmonids (Salmonidae)	Lake Whitefish	*Coregonus clupeaformis*	Sep - Nov	Early spring	None	Spawning migrations to tributary habitat with post-spawning dispersal to lakes.	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007; Gorsky *et al.* 2012
Salmonids (Salmonidae)	Mountain Whitefish	*Prosopium williamsoni*	Oct - Nov	Mar - Jun	Nov - Mar	Spawning, foraging movements and schooling behavior.	Ford *et al.* 1995; McPhail and Troffe 1998; McPhail 2007; Schmidt *et al.* 2019
Salmonids (Salmonidae)	Rainbow Trout	*Oncorhynchus mykiss*	Apr - Jun	Jun - Aug	Oct - May	Spawning migrations to tributary habitat and post-spawning dispersal.	Scott and Crossman 1973; Raleigh *et al.* 1984; Roberge *et al.* 2002; McPhail
Salmonids (Salmonidae)	Umam	*Prosopium* sp.	Oct	Spring	Unknown	Juvenile schooling.	McPhail 2007; Sparks and Martin 2021
Sculpins (Cottidae)	Prickly Sculpin[4]	*Cottus asper*	Feb - Jul	Feb - Aug	None	Coastal populations make spawning migrations to estuary environments; interior population movement patterns unknown.	Porter and Rosenfeld 1999; Roberge *et al.* 2002; EBA 2006; McPhail 2007
Sculpins (Cottidae)	Slimy Sculpin[4]	*Cottus cognatus*	Apr - May	Apr - Jun	None	Relatively stationary (i.e., movements generally < 100 m).	Roberge *et al.* 2002; McPhail 2007; Gray *et al.* 2018
Suckers (Catostomidae)	Largescale Sucker	*Catostomus macrocheilus*	Apr - Jul	May - Aug	Nov - Mar[3]	Evidence of spawning migrations, otherwise relatively sedentary. Some observed diel movements (i.e., inshore at night and off-shore during day).	McEvoy 1998; Roberge *et al.* 2002; McPhail 2007
Suckers (Catostomidae)	Longnose Sucker	*Catostomus catostomus*	Apr - Jun	Apr - Jul	Nov - Mar[3]	Evidence of complex spawning, foraging, and overwintering migrations, otherwise relatively sedentary. Diel movements (i.e., inshore (night) and off-shore (day)).	Geen *et al.* 1966; McPhail 2007; McPhail and Lindsay 1970; Scott and Crossman 1973

[1] Quantified estimates of habitat features are based on available literature. Where no quantitative estimate is available qualitative estimates (i.e., shallow, deep, low, medium, high / shallow, deep / fine, medium, large) are used.

[2] Observations at Skins Lake Spillway plunge pool indicate species could be entrained from Nechako Reservoir (Hamilton and Schmidt 2005).

[3] Species (or closely-related species) are known to overwinter, but specific months are unknown. November-March assigned based on minimum winter season in the study

[4] Sculpins in the Cheslatta River watershed have only been identified to the family level, it is likely that this species is present in the basin.

Table 2. Cheslatta fish community habitat use.

Family	Species	Scientific Name	Habitat Type	Preferred Habitat Characteristics[1]						References
				Spawning	Incubation	Juvenile Rearing		Adult Rearing	Overwintering	
						Young of Year	Juveniles			
Lings (Lotidae)	Burbot	*Lota lota*	**Lacustrine**	1.0 - 10.0 m deep, sand to gravel substrate.	Non-adhesive, demersal on substrate.	Limnetic larvae.	Benthic areas, cover (e.g., boulders).[2]	> 2 m deep.	Deep water.[2]	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007; Ashton *et al.* 2019
			Riverine	Low velocity, silt to fine gravel substrate, e.g., behind deposition bars.		Unknown, may concentrate behind deposition bars until shifting to benthic habitat.		Deep main channels, turbid water.		
Minnows (Cyprinidae)	Brassy Minnow	*Hybognathus hankinsoni*	**Lacustrine**	Shallow, vegetative cover, fine substrate.[2]	Adhesive, demersal on substrate of vegetation.	< 1.5 m deep, fine substrate, vegetative cover.[2]		< 0.5 m/s velocity, fine substrate, vegetative cover.[2]	Deep water.[2]	Roberge *et al.* 2002; Scheurer *et al.* 2003; McPhail 2007; Radford and Sullivan 2014
			Riverine							
Minnows (Cyprinidae)	Lake Chub	*Couesius plumbeus*	**Lacustrine**	Shallow, substrate unimportant.[2]	Non-adhesive, demersal eggs.	< 1 m deep margins or shorelines, vegetative cover, fine substrates.[2]	Demersal in littoral or marginal habitats, vegetative cover, fine substrates.[2]	Demersal in littoral or marginal habitats, vegetative cover, fine substrates.[2]	Deep water.[2]	Brown *et al.* 1970; Lane *et al.* 1996; Roberge *et al.* 2002; McPhail 2007; Davis 2016
			Riverine							
Minnows (Cyprinidae)	Longnose Dace	*Rhinichthys cataractae*	**Lacustrine**	Wave-swept shores or shallow offshore arears, cobble, rubble, or boulder substrate.	Adhesive, demersal in substrate nest.	Limnetic, shallow, nearshore areas, overhanging vegetation, sand to cobble substrate.	Unknown.	Gravel to boulder substrate, vegetative cover.	Deep water.[2]	Gee and Machniak 1972; Brazo *et al.* 1978; McPhail and Lindsay 1970; Peden 1991; Roberge *et al.* 2002; McPhail 2007
			Riverine	0.4 - 1.0 m/s surface velocities, coarse gravel substrate, riffles.		Shallow pools, riffles, and other low velocity areas, fine substrate.		0.4 - 0.5 m/s velocity, coarse gravel to boulder substrates, vegetative cover.		
Minnows (Cyprinidae)	Northern Pikeminnow	*Ptychocheilus oregonensis*	**Lacustrine**	Shallow, sand-free gravel/cobble substrate.	Adhesive, demersal on substrate.	Inlet streams or lakes,< 0.25 m deep, vegetative cover, fine substrate.[2]		Shallow, submerged vegetation or deep water.	Deep water.[2]	Jeppson and Platts 1959; Beamesderfer 1992; Roberge *et al.* 2002; McPhail 2007
			Riverine	< 0.4 m/s velocity, gravel or cobble substrate.				> 1 m deep, < 1 m/s velocity.		
Minnows (Cyprinidae)	Peamouth Chub	*Mylocheilus caurinus*	**Lacustrine**	Shallow nearshore areas, rubble substrate.	Adhesive, demersal on substrate.	Shallow, nearshore areas.	Deeper water.	Shallow depths.	Deep water.[2]	Scott and Crossman 1973; Porter and Rosenfeld 1999; Roberge *et al.* 2002; McPhail 2007; Davis 2016
			Riverine	Flowing water, gravel substrate.		Inlet / outlet streams / tributary mouths, shallow, low velocity water.	< 0.5 m deep, < 0.1 m/s velocity, vegetative cover, gravel substrate.	Low velocity, vegetative cover, gravel or rubble substrate.		
Minnows (Cyprinidae)	Redside Shiner	*Richardsonius balteatus*	**Lacustrine**	-	Adhesive, demersal on substrate or vegetation.	-		Littoral-profundal zone, vegetative cc	Deep water.[2]	Porter and Rosenfeld 1999; Roberge *et al.* 2002; McPhail 2007
			Riverine	Tributary streams, 0.1 m deep, gravel substrate, vegetative cover, riffles.		< 0.5 m deep, < 0.1 m/s velocity, fine to gravel substrate.		1 - 2 m deep, < 20 m/s velocity, fine substrate, vegetative or woody cover.		
Salmonids (Salmonidae)	Kokanee	*Oncorhynchus nerka*	**Lacustrine**	Inshore areas or tributaries, limnetic, littoral, near upwellings or sub-surface flow, small to medium cobble.	Demersal in substrate (i.e., in interstitial spaces).	Littoral or limnetic zone.	Offshore areas	Offshore areas	Offshore, deep water	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007
Salmonids (Salmonidae)	Lake Trout	*Salvelinus namaycush*	**Lacustrine**	5 - 50 m deep, course substrate (e.g., gravel to boulder).	Demersal in substrate (i.e., in interstitial spaces).	Shallow, immediate or delayed movement to deep water.		All depths, deep water after lake stratification.	Distributed across available habitats.	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007

[1] Quantified estimates of habitat features are based on available literature. Where no quantitative estimate is available qualitative estimates (i.e., shallow, deep, low, medium, high / shallow, deep / fine, medium, large) are used.

[2] Habitat characteristics shared between lacustrine and riverine habitats.

[3] Assigned based on information available for similar species.

"-" denotes life stage does not occur in habitat type.

Table 2. Continued.

Family	Species	Scientific Name	Habitat Type	Preferred Habitat Characteristics[1]: Spawning	Incubation	Juvenile Rearing: Young of Year	Juvenile Rearing: Juveniles	Adult Rearing	Overwintering	References
Salmonids (Salmonidae)	Lake Whitefish	*Coregonus clupeaformis*	**Lacustrine**	< 30 m deep, hard/rocky substrate.	Demersal in substrate (i.e., in interstitial spaces).	Shallow, < 1 m of shore, rocky reefs, beaches w/ gravel & rubble substrate, emergent vegetative cover.	Deeper water.	All depths, shift to deeper water during summer.	Deep water.[2]	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007; Gorsky *et al.* 2012
			Riverine	Riffles or runs, shallow, gravel to cobble substrate.		Unknown.	Unknown.	Unknown.		
Salmonids (Salmonidae)	Mountain Whitefish	*Prosopium williamsoni*	**Lacustrine**	Generally inlet / outlet / tributary spawning, upwelling water.	Adhesive, demersal on substrate.	< 0.5 m deep, low velocity, sand to fine gravel substrate.[2]		Deep water.	Shallow (< 1 m), large cobble substrate.[2]	Ford *et al.* 1995; McPhail and Troffe 1998; McPhail 2007; Schmidt *et al.* 2019
			Riverine	Upwelling inflow, pool heads, riffles.				0.6 - 1.1 m deep, 30 - 80 m/s velocity, coarse gravel or cobble substrate (e.g., pools, riffles, runs).		
Salmonids (Salmonidae)	Rainbow Trout	*Oncorhynchus mykiss*	**Lacustrine**	-	Demersal in redd.	-	Inshore, cover (e.g., gravel to boulder substrate, woody debris).	Vegetative cover, woody debris. In large lakes > 50 m from shore.	Deep water.[2]	Scott and Crossman 1973; Humpesch 1985; Raleigh *et al.* 1984; Bjornn and Reiser 1991; Flebbe and Dolloff 1995; Meyer and Gregory 2000; Roberge *et al.* 2002; McPhail 2007
			Riverine	Tributary streams, inlet or outlet streams, 0.3 - 0.9 m/s velocity, fine substrate, vegetated banks, riffle, pools, pool tailouts.		Tributary steams, shallow, low velocity margins, gravel substrate.	Tributary streams, < 0.25 m deep, 0.2 -0.4 m/s velocity margins, cobble to boulder substrate.	Riffles, runs, glides, pools, cover (e.g., riparian vegetation, large woody debris, cobble to boulder substrates).	Daytime concealment (e.g., cobble-boulder substrate or woody debris).	
Salmonids (Salmonidae)	Umam	*Prosopium* sp.	**Lacustrine**	-	Demersal on or in substrate (i.e., interstitial spaces).	Unknown.	<1 m deep, margins.	Demersal in deep water, but may come to depths of ~ 2.5 m.	Deep water.[2]	McPhail 2007, Sparks and Martin 2021.
			Riverine	Inlet steams, riffles, course gravel.			Unknown.	Moderate to high velocity, gravel or cobble substrate.		
Sculpins (Cottidae)	Prickly Sculpin	*Cottus asper*	**Lacustrine**	Low velocity areas with boulders, cobble, or flat rock bottom substrate, embedded woody debris.[2]	Adhesive, under nest rock (i.e., in substrate).	Nearshore limnetic zones, vegetative cover.		Cover (e.g., cobble, boulder, woody debris).	Deep water, cover.[2]	Porter and Rosenfeld 1999; Roberge *et al.* 2002; EBA 2006; McPhail 2007; Tabor *et al.* 2007
			Riverine			Low velocity margins, cover (e.g., woody debris).		Low velocity, boulder substrate, large woody debris.		
Sculpins (Cottidae)	Slimy Sculpin	*Cottus cognatus*	**Lacustrine**	Shallow, rocky substrate.[2]	Adhesive, under nest rock (i.e., in substrate).	Nearshore limnetic zones, vegetative cover.[3]		Cover (e.g., cobble, boulder, woody debris).	Unknown	Roberge *et al.* 2002; McPhail 2007; Gray *et al.* 2018
			Riverine			Low velocity margins, seasonally flooded vegetation.	Shallow, low velocity, gravel to cobble substrate.	Moderate velocity riffles or runs, coarse gravel or cobble substrates.		
Suckers (Catostomidae)	Largescale Sucker	*Catostomus macrocheilus*	**Lacustrine**	Shoals, course gravel substrate.	Adhesive, demersal on or in substrate (i.e., interstitial spaces).	Unknown.	Benthic.	Benthic, < 25 m.	Unknown.	McEvoy 1998; Roberge *et al.* 2002; McPhail 2007
			Riverine	Riffles or deep areas (e.g., pool tailouts) near areas of slower water.		Shallow or open areas, low velocity, seasonally flooded vegetation.	0.25-0.50 m depth, low velocity, fine to cobble substrates.	Low to moderate gradient, low velocity areas, deep pools.	Deeper pools, shallow riffles.[3]	
Suckers (Catostomidae)	Longnose Sucker	*Catostomus catostomus*	**Lacustrine**	Generally tributary spawning, < 20 cm deep, shorelines.	Adhesive, demersal on or in substrate (i.e., interstitial spaces).	Shallow margins, vegetative or woody cover.	Nearshore areas.	Below thermocline during day, shallow inshore ares at night	Unknown.	Geen *et al.* 1966; McPhail 2007; McPhail and Lindsay 1970; Scott and Crossman 1973
			Riverine	0.30 - 0.45 m/s velocity riffles, gravel (0.5 - 10.0 cm) substrate.		< 0.1 m deep water, low velocity, soft substrate, submerged vegetative cover.	Shallow, low velocity areas, soft cover, (e.g., side-channels, beaver ponds).	Low to moderate gradient, low velocity, deep pools.	Deeper pools, shallow riffles.[3]	

[1] Quantified estimates of habitat features are based on available literature. Where no quantitative estimate is available qualitative estimates (i.e., shallow, deep, low, medium, high / shallow, deep / fine, medium, large) are used.

[2] Habitat characteristics shared between lacustrine and riverine habitats.

[3] Assigned based on information available for similar species.

"-" denotes life stage does not occur in habitat type.

Table 3. Cheslatta fish community temperature preferences.

Family	Species	Scientific Name	Temperature Preference / Tolerance[1]				References
			Spawning	Incubation	Rearing	Adult	
Lings (Lotidae)	Burbot	*Lota lota*	**Opt**: 0.6 - 1.7 °C **SOpt**: > 4 °C	**Opt**: 2 - 6 °C **SOpt**: > 6 °C	Unknown	**Opt**: 15.6 - 18.3 °C **Lethal**: > 23.3 °C	Scott and Crossman 1973; Taylor 2001; McPhail 2007
Minnows (Cyprinidae)	Brassy Minnow	*Hybognathus hankinsoni*	**Opt**: 16 - 17 °C	**Opt**: 18 °C	**Opt**: 15.7 - 23.5 °C	**SOpt**: > 35.5 °C	Coker *et al.* 2001; Roberge *et al.* 2002; Scheurer *et al.* 2003; McPhail 2007; Radford and Sullivan 2014
Minnows (Cyprinidae)	Lake Chub	*Couesius plumbeus*	**Opt**: 10 - 19 °C	**Opt**: 8 - 19 °C	Unknown	**SOpt**: 25 - 30 °C	Brown *et al.* 1970; Coker *et al.* 2001; Roberge *et al.* 2002; McPhail 2007; Darveau *et al.* 2012
Minnows (Cyprinidae)	Longnose Dace	*Rhinichthys cataractae*	**Opt**: 11.7 °C	**Opt**: 15.6 °C	Unknown	**Opt**: 15 - 20.5 °C **SOpt**: 28 - 31.4 °C	Black 1953; Coker *et al.* 2001; Roberge *et al.* 2002; Hasnain *et al.* 2010
Minnows (Cyprinidae)	Northern Pikeminnow	*Ptychocheilus oregonensis*	**Opt**: 12 - 18 °C	**Opt**: > 18 °C	**Opt**: 20 - 23 °C	**Opt**: 21.4 - 29°C	Black 1953; Roberge *et al.* 2002; FERC 2011
Minnows (Cyprinidae)	Peamouth Chub	*Mylocheilus caurinus*	**Opt**: 10 - 15 °C	**Opt**: < 12 °C	**Opt**: < 21.3 °C	**SOpt**: < 27 °C	Schultz 1935; Black 1953; Porter and Rosenfeld 1999; Coker *et al.* 2001; Roberge *et al.* 2002; FERC 2011
Minnows (Cyprinidae)	Redside Shiner	*Richardsonius balteatus*	**Opt**: 14.5 - 18 °C	**Opt**: 21 - 23 °C	**Opt**: 12.5 - 20 °C **SOpt**: 24 °C	**SOpt**: > 25 °C	Black 1953; Porter and Rosenfeld 1999; Coker *et al.* 2001; Roberge *et al.* 2002; FERC 2011
Salmonids (Salmonidae)	Kokanee	*Oncorhynchus nerka*	**Opt**: 5 - 14 °C	Unknown	**Opt**: 10 °C **Lethal**: > 22 °C	**Opt**: 10 - 15 °C **Lethal**: > 24.4 °C	Scott and Crossman 1973; Roberge *et al.* 2002; FERC 2011
Salmonids (Salmonidae)	Lake Trout	*Salvelinus namaycush*	**Opt**: 10 - 12.8 °C	**Opt**: 0.3 - 1.0 °C	**Opt**: 10 °C	**Opt**: 15 - 17 °C **Lethal**: > 23.5 °C	Gibson and Fry 1954; Scott and Crossman 1973; Edsall and Cleland 2000; Roberge *et al.* 2002; McPhail 2007; FERC 2011
Salmonids (Salmonidae)	Lake Whitefish	*Coregonus clupeaformis*	**Opt**: < 10 °C	**Opt**: 0.5 - 6.1 °C	**Opt**: 15.5 - 19.5 °C	**Opt**: 16.8 °C	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007; Gorsky *et al.* 2012
Salmonids (Salmonidae)	Mountain Whitefish	*Prosopium williamsoni*	**Opt**: 4.5 - 7 °C	**Opt**: 6 - 8.8 °C **SOpt**: > 9 °C	**Opt**: 8.8 - 12 °C **SOpt**: 18.8 - 21.6 °C	**Opt**: 9.6 - 17.4 °C **SOpt**: > 22 °C	Rajagopal 1979; Ford *et al.* 1995; McPhail and Troffe 1998; Coker *et al.* 2001; Brinkman *et al.* 2013; FERC 2011; Schmidt *et al.* 2019
Salmonids (Salmonidae)	Rainbow Trout	*Oncorhynchus mykiss*	**Opt**: 10 - 15.5 °C	**Opt**: 10 - 12 °C **SOpt**: > 18 °C	**Opt**: 10 - 18 °C **SOpt**: > 22 °C	**Opt**: 12 - 18 °C **SOpt**: > 18 °C	Scott and Crossman, 1973; Humpesch 1985; Ford *et al.* 1995; Coker *et al*. 2001; Bear *et al.* 2007; FERC 2011
Salmonids (Salmonidae)	Umam	*Prosopium* sp.*	**Opt**: < 5 °C	Unknown	Unknown	**Opt**: < 10 °C	McPhail 2007
Sculpins (Cottidae)	Prickly Sculpin	*Cottus asper*	**Opt**: 8 - 13 °C	Unknown	**Opt**: 13 - 18 °C **SOpt**: > 21 °C	**SOpt**: > 24 °C	Black 1953; EBA 2006; Porter and Rosenfeld 1999; Coker *et al.* 2001; Roberge *et al.* 2002; McPhail 2007; Tabor *et al.* 2007; FERC 2011
Sculpins (Cottidae)	Slimy Sculpin	*Cottus cognatus*	**Opt**: 8 - 10°C	**Opt**: 7.7 °C	**Opt**: 13 - 18 °C **SOpt**: < 21 °C	**Opt**: 13 - 15 °C **SOpt**: 23 - 25 °C	Symons *et al.* 1975; Coker *et al.* 2001; Roberge *et al.* 2002; McPhail 2007; FERC 2011; Gray *et al.* 2018
Suckers (Catostomidae)	Largescale Sucker	*Catostomus macrocheilus*	**Opt**: 7.5 - 15 °C	Unknown	**SOpt**: > 29 °C	**Opt**: 21.4 - 29 °C	Black 1953; Coker *et al.* 2001; Roberge *et al.* 2002; FERC 2011
Suckers (Catostomidae)	Longnose Sucker	*Catostomus catostomus*	**Opt**: 5 - 10 °C	**Opt**: 8 - 17 °C	**SOpt**: > 27 °C	**SOpt**: > 27 °C	Black 1953; Coker *et al.* 2001; Roberge *et al.* 2002; FERC 2011; Hasnain *et al.* 2010
Suckers (Catostomidae)	White Sucker	*Catostomus commersonii*	**Opt**: 10 - 12 °C	**Opt**: 10 - 16 °C	**Opt**: 19 - 26 °C	**Opt**: 23.4 - 25.5 °C **SOpt**: 27.8 - 31.6 °C	Koenst and Smith 1982; Corbett and Powles 1983; Coker *et al.* 2001; Roberge *et al.* 2002; Hasnain *et al.* 2010

[1] Opt = Optimum, SOpt = Sub - optimal. Temperature thresholds that are unknown are excluded.

* Temperature preference assigned based on that of similar species.

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Appendix B. Fish Habitat in Selected Cheslatta Watershed Tributaries

LIST OF TABLES

Table 1. Fish habitat in selected Cheslatta River watershed tributaries.

Tributary[1]	Confluence	Fish Barriers	Tributary	Habitat	Substrate	Spawning Potential	Rearing	Overwintering	Fish Present[2]
Bird Creek	Murray Lake	Beaver dams located ~300-650 m upstream of confluence	Ephemeral, 1.0-1.9 m average width, 5%-6.5% gradient	n/a	n/a	Moderate to good	Good	n/a	CC, DV, LNC, RB, RSC
Knapp Creek	Cheslatta Lake	Beaver dam and accumulated debris over an area of 800 m^2, ~240-500 m from confluence	Perrenial, 7.5 m average wetted width, 2.2% gradient	Pools, side-channels, cover, CWD	Gravel & cobble dominated	Low to good	Good	Good, particularly near beaver dam	CAS, CC, CSU, KO, LKC, LNC, MW, NSC, RB, RSC
Ootsanee Creek	Cheslatta Lake	Beaver dam and falls impassible to fish >500 m from confluence	Perrenial, 4.3 m average wetted width, ≤2% gradient	Pools	Gravel dominated	Low to good	Moderate, limited pools & cover, no CWD	Poor, lack of pools	CAS, CC, DV, LKC, LNC, KO, MW, NSC, RB, RSC, SU
Sather Creek	Cheslatta Lake	n/a	Perrenial, 3.8 m average wetted width, 1-2% gradient	Boulders, undercut banks, CWD	Gravel & cobble dominated	Low to moderate	Moderate to good, some boulders & undercut banks	Poor, lack of pools	CAS, RB

[1] BCUC 1993; Hamilton and Schmidt 2005; MoE 2021a,b; Sparks and Martin 2021, Triton 1998, 2000, 2008a,b.

[2]CWD=Coarse woody debris, CAS=Prickly Sculpin, CC=Sculpin spp., CSU=Largescale Sucker, DV=Dolly Varden, KO=Kokanee, LKC=Lake Chub, LNC=Longnose Dace, MW=Mountain Whitefish, NSC=Northern Pikeminnow, RB=Rainbow Trout, RSC=Redside Shiner, SU=Sucker spp.

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