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MEMORANDUM

TO: **Nechako Water Engagement Initiative**

FROM: **Casey R. Beel, Ph.D., Jayson Kurtz, B.Sc., R.P.Bio., and Adam Lewis, M.Sc., R.P.Bio., Ecofish Research Ltd.**

DATE: **December 23, 2022**

FILE: **1316-09**

RE: **Hydrology of the Nechako River Watershed – V2**

1. INTRODUCTION

For the Nechako Water Engagement Initiative (WEI), river hydrology and corresponding water levels associated with Rio Tinto's (RT) operation of Skins Lake Spillway (SLS) are the starting point for discussions at both the Main Table and Technical Working Group (TWG) meetings. The TWG has mandated Ecofish Research Ltd. (Ecofish) to provide technical memos documenting key environmental characteristics and inform the evaluation of issues under consideration by the WEI.

This memo utilizes available Water Survey of Canada (WSC) and RT data to provide an overview of the hydrology (river flows/level and water temperatures) of the Nechako River watershed. The Nechako River is in central British Columbia (BC) and is the second largest tributary (47,200 km^2) of the Fraser River (Map 1). The Nechako River originates in the Coastal Mountains of western BC and flows northeastward toward the community of Fort Fraser, where it is joined by the Nautley River. The Nechako River then flows eastward through Vanderhoof near the confluence with the Stuart River and joins with the Fraser River at Prince George.

1.1. Background

1.1.1. Nechako River Watershed Overview

The Nechako Reservoir is located approximately 200 km west of Prince George, BC (Map 1) and was created to provide water for RT's 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). The Nechako Reservoir is ~910 km^2 with a normal annual drawdown of ~3 m (10'); low and high-water level occur in late spring and late summer, respectively.

All flow from Nechako Reservoir to the Nechako River is currently via the SLS, which directs flow into 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 Nechako Reservoir provides most of the flow in the upper Nechako River (there is minimal local inflow); here, flow is reduced to ~30% of pre-dam conditions (~70% is diverted to the Kemano River) and mean flow ranges from ~40 m^3/s to 240 m^3/s (Figure 1). The Nautley River (~95 km downstream of the dam) combined with local inflows make moderate inflow contributions and mean discharge in the Nechako River at Vanderhoof (~150 km downstream of the dam) with flows ranging from ~65 m^3/s to 270 m^3/s. The Stuart River also contributes significant inflow, and by Isle Pierre (~215 km downstream of the dam) mean flows range from ~120 m^3/s to 560 m^3/s. The Nechako River flows into the Fraser River at Prince George ~275 km downstream of the dam.

1.1.2. Nechako River Hydrograph

Changes in water level/flow in the Nechako River are controlled by the discharge regime at the SLS as well as unregulated tributary inputs (e.g., Nautley River, Stuart River). River flow/level in the Nechako River trend with flows at the SLS, with increases in water level attenuating with distance downstream of the spillway. Changes in SLS water level/flow arrive at Cheslatta Lake in ≤1 hr, at Cheslatta Falls in 6-14 hrs, at Vanderhoof in 1-2 days, and at Isle Pierre in 2-3 days (Nicholl *et al.* 2021).

Prior to construction of the Kenney Dam, Nechako River water levels/flows were dominated by spring freshet (or snowmelt) with secondary peaks in the fall usually resulting from rainfall and winter flows were relatively low. Following impoundment of the Nechako Reservoir, flows have been reduced in the spring and summer with the largest flow changes in the Nechako River now occurring during the implementation of the summer temperature management program (STMP) to mitigate instream temperature for migrating Sockeye Salmon.

1.1.3. Nechako Reservoir and Skins Lake Spillway Capacity

The Nechako Reservoir has a maximum normal water elevation of 877.8 m and the corresponding maximum release flow of SLS is 1,200 m^3/s. During extreme events, both the reservoir level and SLS discharge can exceed normal capacity.

1.1.4. Annual Water Allocation and Summer Temperature Management Program

In the 1980s, Fisheries and Oceans Canada (DFO) and others expressed concern about negative effects of low SLS discharges on salmon downstream in the Nechako River. DFO raised two concerns: low spring, fall and winter flows affecting Chinook Salmon, and high river temperature (due to low flow) affecting migrating Sockeye Salmon (NFCP 2016). In 1987, a Settlement Agreement was reached between Alcan (now RT) and the provincial and federal governments requiring RT to release flows for fish in two ways: the Annual Water Allocation (AWA) and the Summer Temperature Management Program (STMP) (Anonymous 1987).

The AWA prescribes monthly minimum flow requirements (for the protection of Chinook Salmon) (Table 1). The minimum AWA annual flow is no less than 36.8 m^3/s (plus additional flows as required for cooling processes) with a normal minimum discharge of 14.2 m^3/s (Anonymous 1987).

Table 1. Annual Water Allocation Minimum Monthly Flow Releases from Skins Lake Spillway.

Month	Mean Monthly Flow (m^3/s)
January	29.2
February	29.3
March	29.4
April	54.6
May	47.2
June	40.9
July	45.6
August	50.4
September	27.6
October	28.6
November	28.8
December	29.1
Annual Mean	36.8

The STMP provides additional cooling water flows during the Sockeye Salmon spawning migration period (NFCP 2016). From July 10-August 20 (the STMP period), RT is obliged to release sufficient flow to minimize the occurrence of water temperature above 20°C (measured at Finmore, downstream of Vanderhoof) (NFCP 2016). The STMP does not directly prescribe release volume; a computer model uses water temperature and weather forecasts to predict the SLS discharge needed to meet the temperature objective (Triton 2021) and the NFCP Technical Committee instructs RT how much water to release. To meet downstream temperature requirements, flow below Cheslatta Falls is typically 170-283 m^3/s, but gate changes at SLS can vary abruptly between 14.2 and 453 m^3/s to achieve desired downstream effect as quickly as possible (NFCP 2015).

1.1.5. Operational Flow Release Targets

Beyond the AWA and STMP, operations at the SLS are governed by several flow release targets to achieve a balance between environmental and social protection, and meeting hydroelectricity production requirements (see Compass 2022 for more detail). Normal flow release targets are summarized below:

- Maximum total flow to be less than 330 m^3/s at Cheslatta Falls to avoid flooding burial sites.
- Maximum total flow to be less than 550 m^3/s at Vanderhoof to avoid flooding.
- Maximum flow 100 m^3/s at Vanderhoof during freeze-up to minimize ice jam formation.

- Maximum flow rate increases of 15 m^3/s every two weeks when the Nechako River is frozen to minimize ice jam flooding.
- Delay springtime flow increases until Cheslatta Lake shoreline is ice free to minimize effects on aquatic furbearers.

2. NECHAKO RIVER WATERSHED HYDROLOGY

2.1. Methods

WSC operates six hydrological monitoring stations within the Nechako River watershed (Table 2) that measure either water level/river flow. At three sites water temperatures are also recorded. Four monitoring sites are representative of regulated flows along the Nechako River and two sites are representative of natural unregulated tributary inputs to the Nechako River (Table 2). Here, we summarize this available data to provide an overview of hydrological conditions at each station.

Real-time (2021-2022) and historical daily data were sourced from WSC (2022). Historical daily water temperature data were supplied by RT and real-time (2021-2022) data were sourced from WSC. Note that 2021-2022 data are preliminary and are subject to change once WSC performs QA/QC. We also incorporated naturalized flows for the Nechako River at Vanderhoof (Little *et al.* 2021) to provide context of what flows would have looked like in the absence of diversion to Kemano.

Table 2. Site information for WSC hydrological monitoring stations within the Nechako River Basin.

Station Name	Station ID	Gauged Area (km)	Latitude N	Longitude W	Flow Regulation	Record Length	Available Records
Skins Lake Spillway, Nechako Reservoir	08JA013*	n/a	53°46'15"	125°58'14"	Yes	63 years (1957-2019)	Flow
Nechako River at Skins Lake Spillway	08JA023	n/a	53°46'20"	125°59'50"	Yes	14 years (1993-1995; 2012-2022)	Level
Nechako River below Cheslatta Falls	08JA017	15,500	53°41'07"	124°50'21"	Yes	42 years (1981-2022)	Flow, Level, Temperature
Nautley River near Ft. Fraser	08JB003	6,574	54°05'06"	124°36'03"	No	73 years (1950-2022)	Flow, Level
Nechako River at Vanderhoof	08JC001	25,200	54°01'36"	124°00'31"	Yes	70 years (1956-2022)	Flow, Level, Temperature
Stuart River near Ft. St. James	08JE001	14,235	54°25'00"	124°16'14"	No	80 years (1935-2022)	Flow, Level
Nechako River at Isle Pierre	08JC002	42,700	53°57'37"	123°14'05"	Yes	72 years (1951-2022)	Flow, Level, Temperature

*Real time data is not publicly available

2.2. Mean Annual Discharge

Mean annual discharge (MAD) was calculated using only years with complete records (e.g., no missing daily averages). Table 3 summarizes MAD for the entire record, minimum and maximum MAD (including the year in parenthesis), and the length of record for each site. For consistency across time and space, MAD was also calculated for a standard reference period of 1990-2020 (Table 3). We choose this 31-year period because shorter than that the data misses out on important cycles of natural variability and longer than the data start to include too much climate change signal (and historical changes to reservoir management), so the data are less representative of current hydrometeorological conditions and reservoir operations.

Table 3. Mean annual discharge (MAD) (m3/s) and minimum and maximum MAD (m^3/s) at WSC monitoring sites. Italicize values in parenthesis represent year.

Station Name	Record Length	MAD[1] m^3/s	MAD[2] m^3/s	Min. m^3/s	Max. m^3/s
Skins Lake Spillway, Nechako Reservoir (08JA013)	1957-2022	93.6	74.6	30.0 *(1980)*	259.7 *(1958)*
Nechako River below Cheslatta Falls (08JA017)	1981-2022	76.0	78.6	50.8 *(2019)*	186.3 *(2007)*
Nautley River near Fort Fraser (08JB003)	1950-2022	32.0	32.5	14.0 *(1980)*	73.4 *(2007)*
Nechako River at Vanderhoof (08JC001)	1956-2022	138.3	125.8	32.2 *(1956)*	335.9 *(1976)*
Stuart River near Fort St. James (08JE001)	1935-2022	131.2	134.0	77.6 *(1980)*	194.1 *(1972)*
Nechako River at Isle Pierre (08JC002)	1951-2022	278.7	267.5	129.1 *(1980)*	531.6 *(1976)*

[1] Full length of record

[2] 1990-2020

Figure 1. **31-year mean annual discharge (MAD; 1990-2020) as a function of distance downstream of the SLS. Also shown is the percentage increase in MAD relative to SLS (grey shading). Distance downstream of SLS was measured as the river length using Google Earth.**

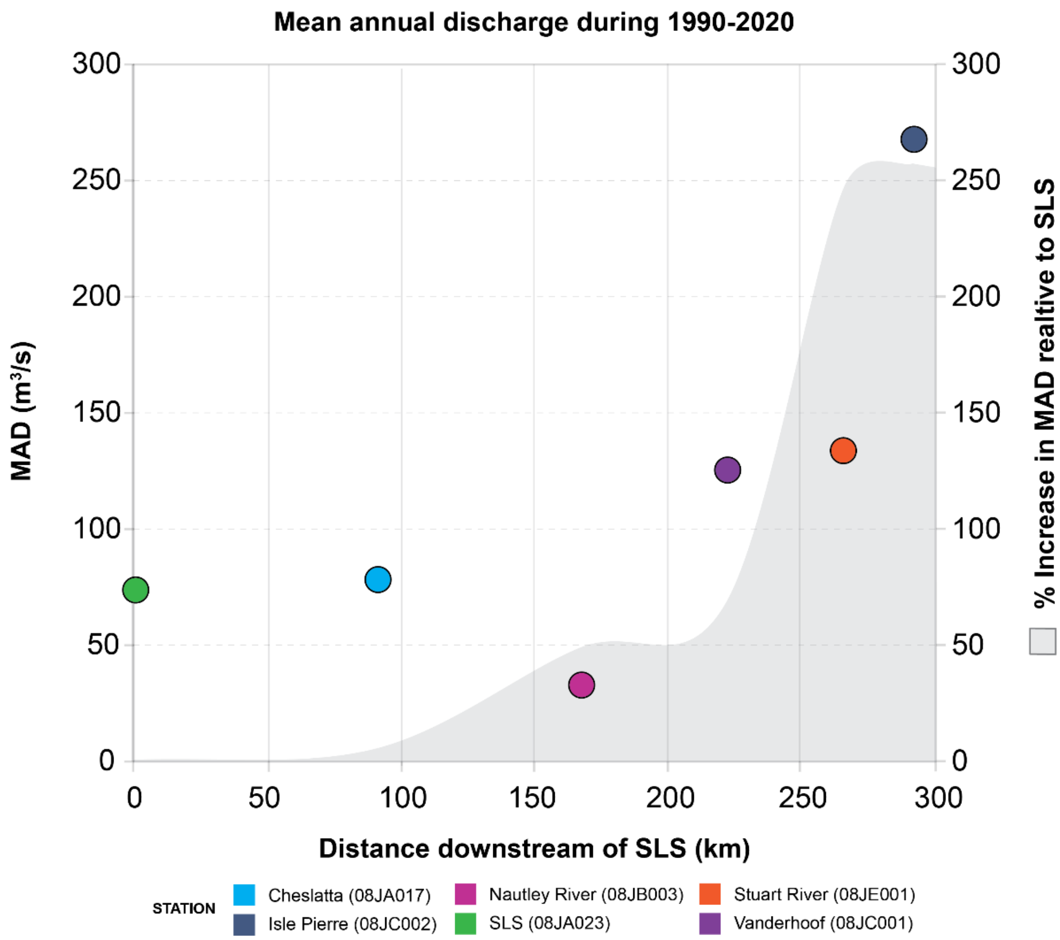
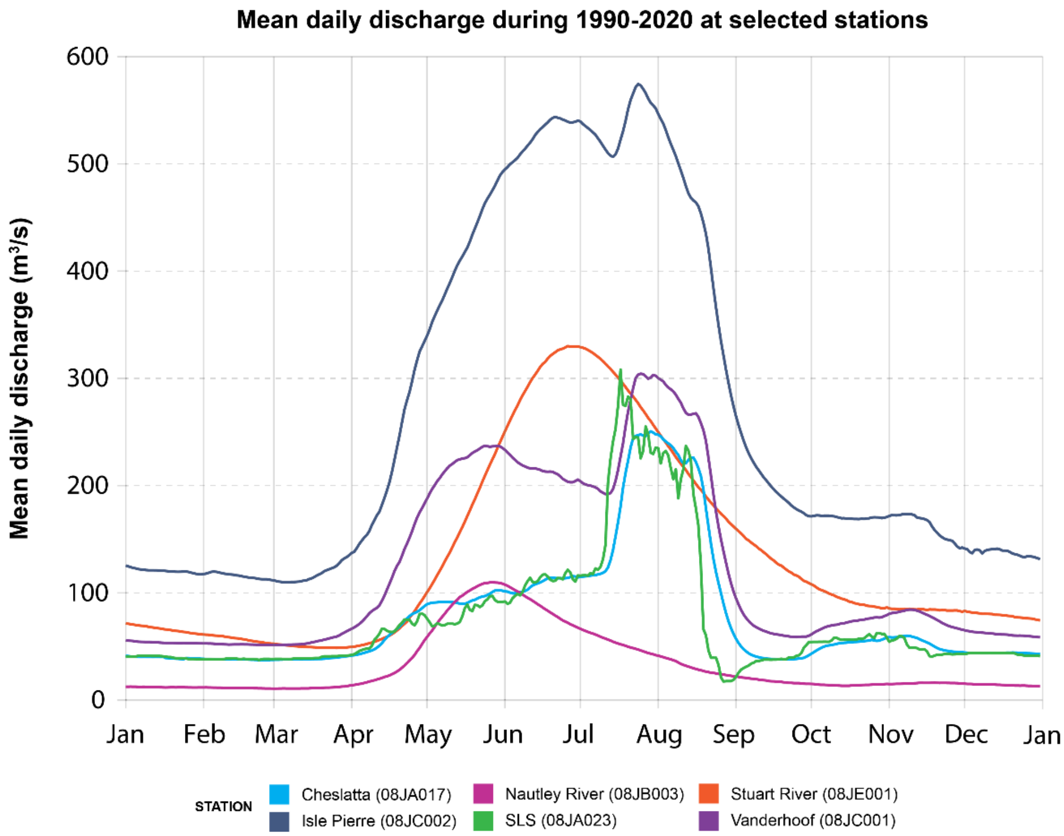


Figure 2. 31-year mean daily discharge (1990-2020) at sites in the Nechako River watershed.

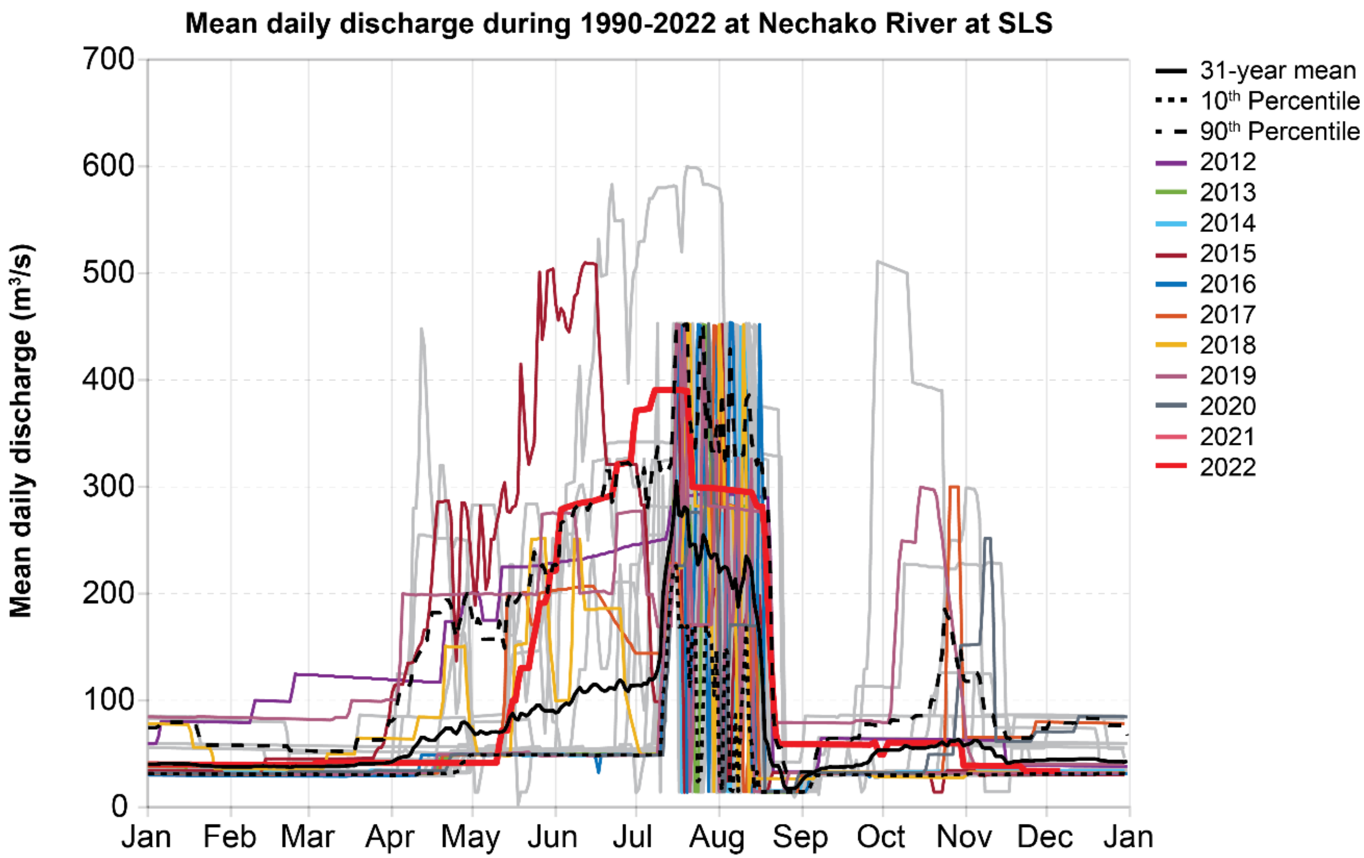


2.3. Summary Hydrographs

For each site, we provide hydrographs of mean daily discharge for the period 1990-2022 that include hydrographs of the 31-year mean and the 10th and 90th percentiles for the period 1990-2020. Hydrographs from the last ten years (2012-2022) are colourized to highlight recent hydrological conditions.

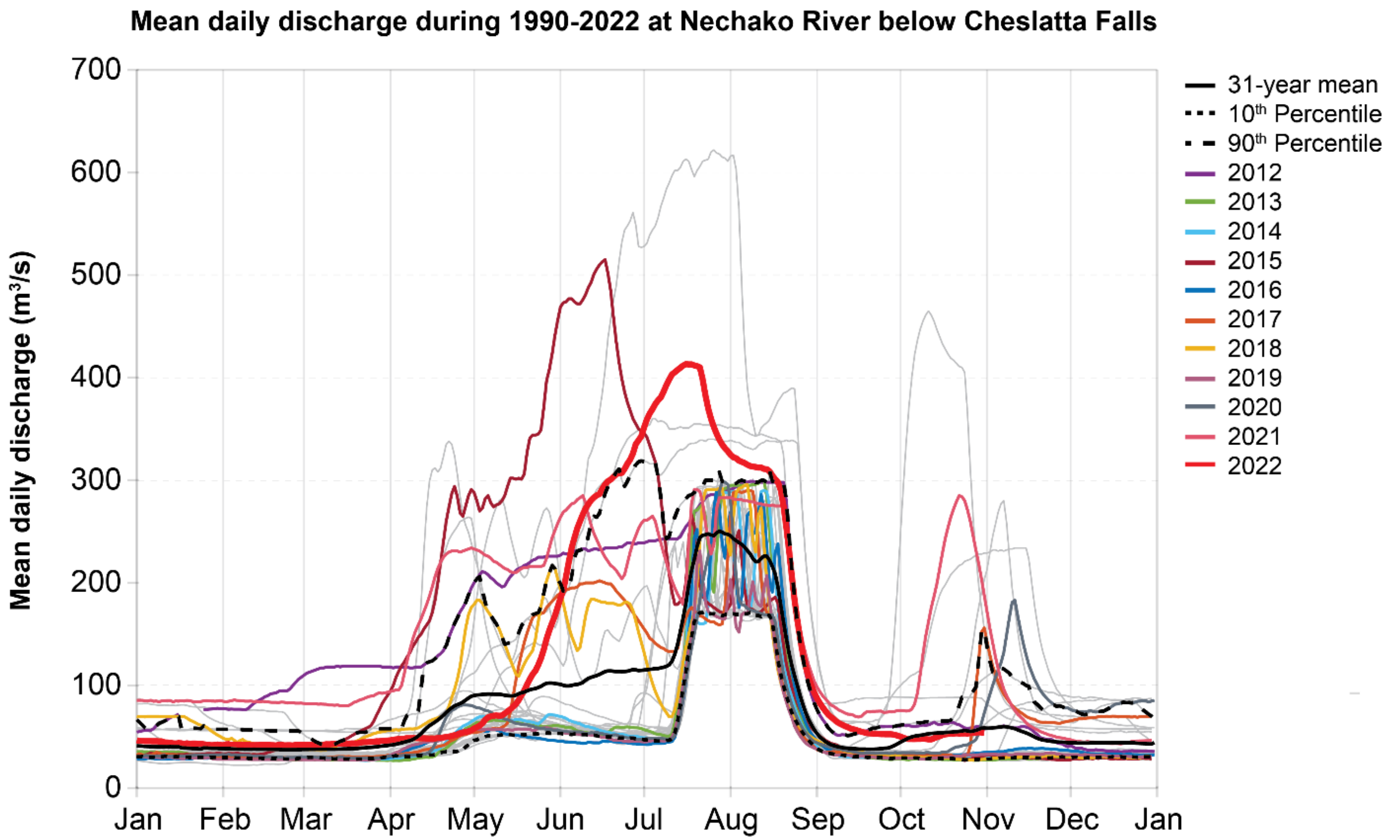
2.3.1. Nechako River at Skins Lake Spillway (08JA023)

Figure 3. Summary hydrograph of mean daily discharge during 1990-2022 for Nechako River at Skins Lake Spillway (SLS). The 10th and 90th percentiles and the 31-year mean are for 1990-2020.



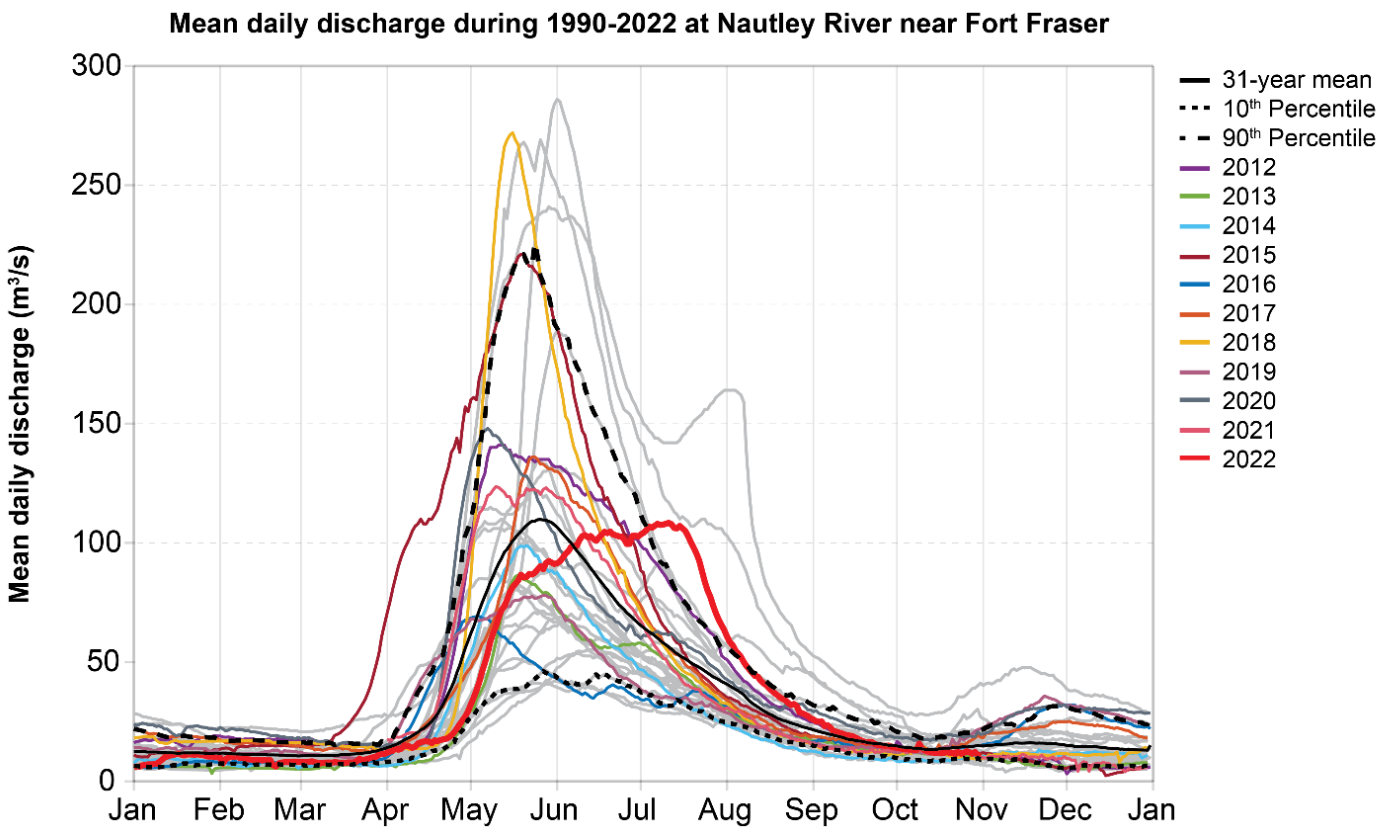
2.3.2. Nechako River below Cheslatta Falls (08JA017)

Figure 4. Summary hydrograph of mean daily discharge during 1990-2022 for Nechako River below Cheslatta Falls. The 10th and 90th percentiles and the 31-year mean are for 1990-2020.



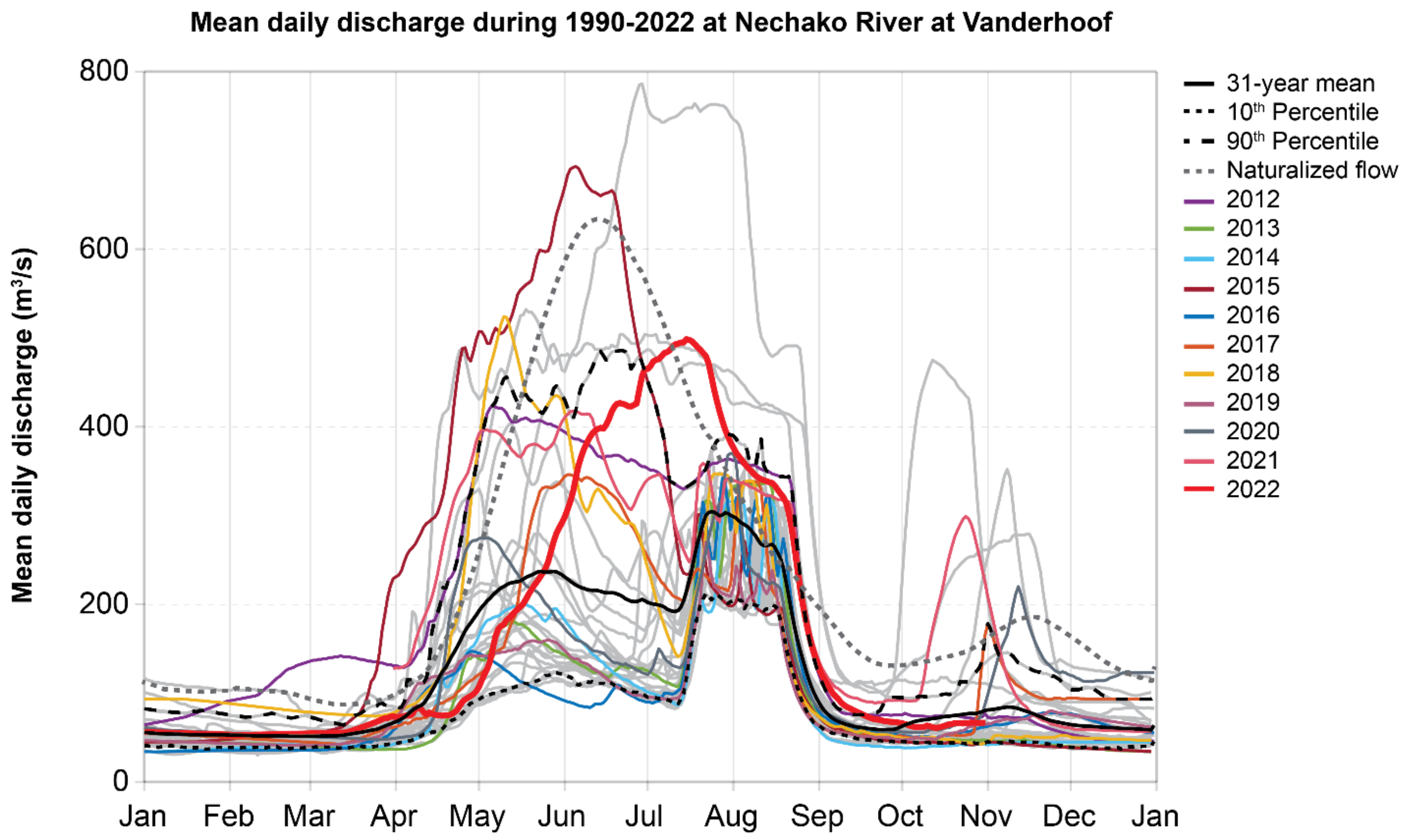
2.3.3. Nautley River near Fort Fraser (08JB003)

Figure 5. Summary hydrograph of mean daily discharge during 1990-2022 for Nautley River near Fort Fraser. The 10th and 90th percentiles and the 31-year mean are for 1990-2020.



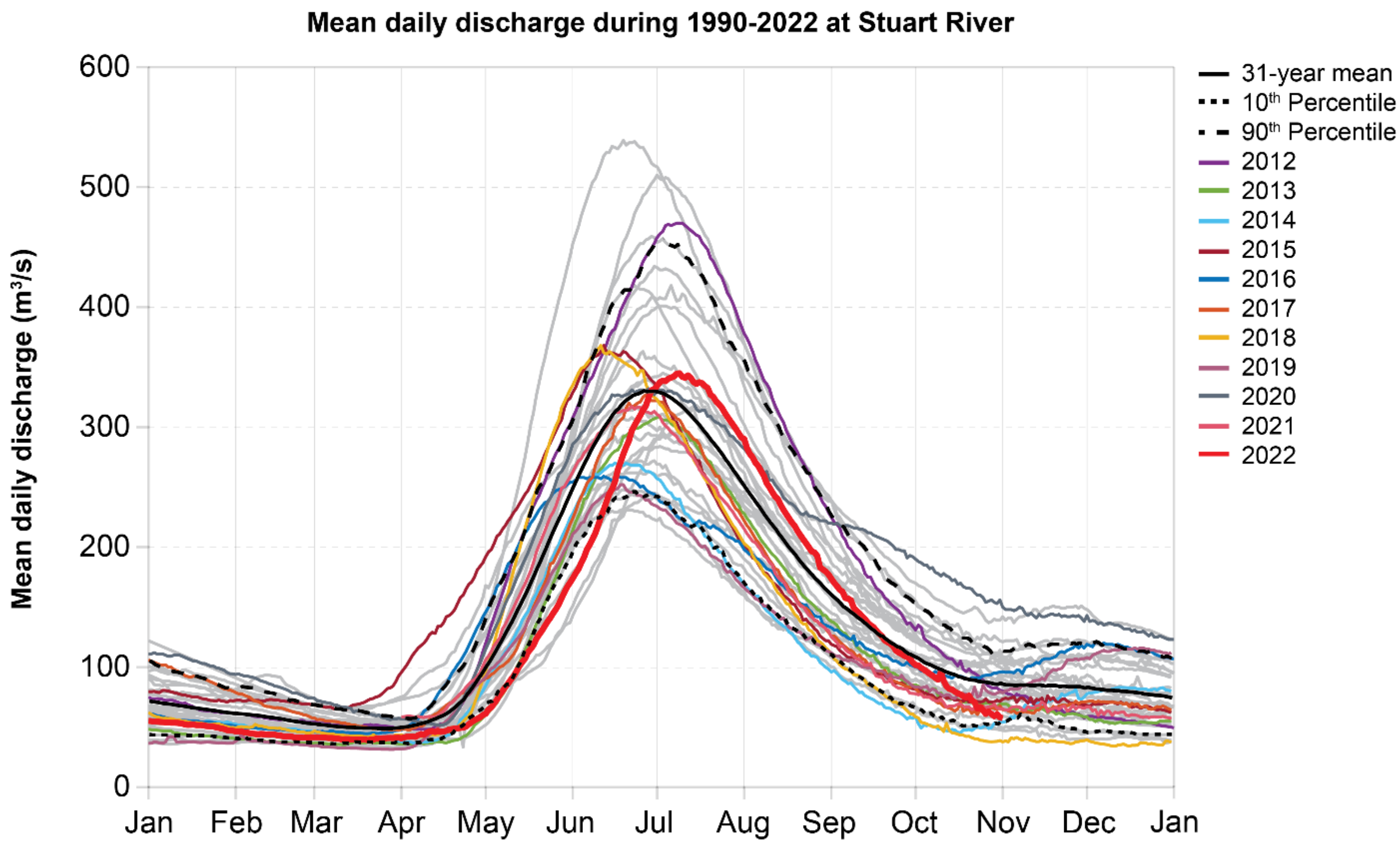
2.3.4. Nechako River near Vanderhoof (08JC001)

Figure 6. Summary hydrograph of mean daily discharge during 1990-2022 for Nechako River at Vanderhoof. The 10th and 90th percentiles and the 31-year mean are for 1990-2020.



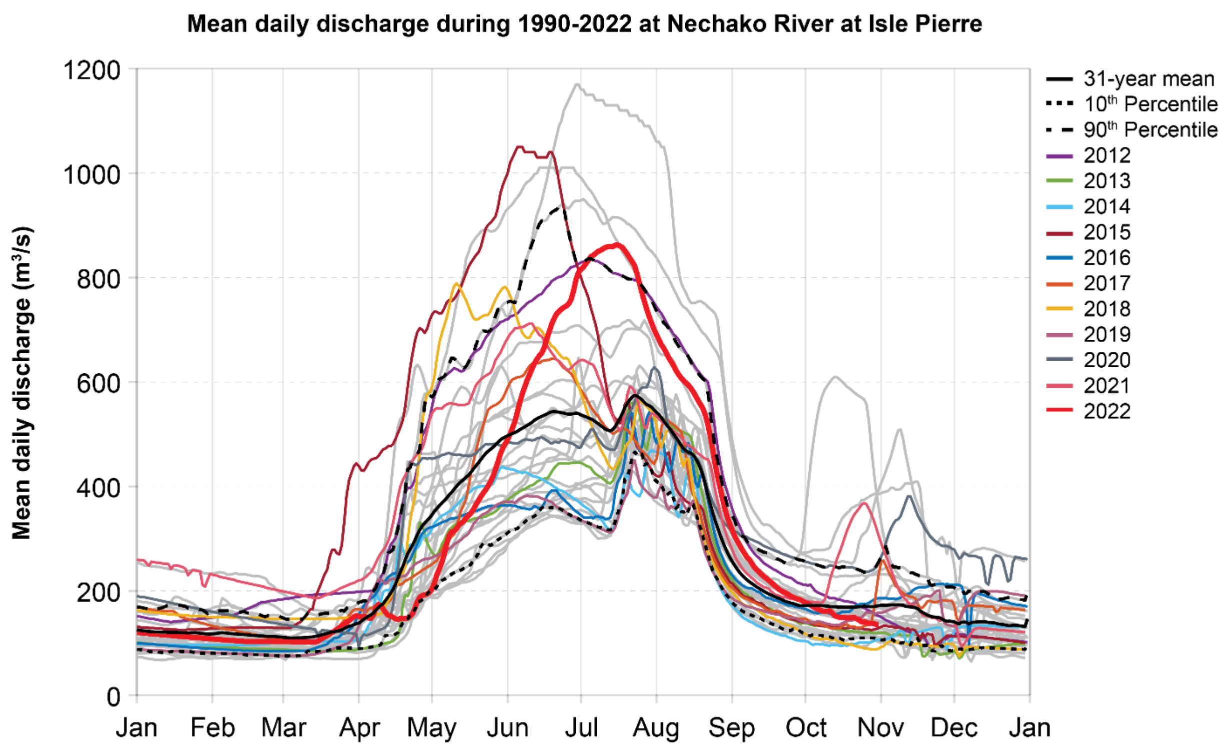
2.3.5. Stuart River near Fort St. James (08JE001)

Figure 7. Summary hydrograph of mean daily discharge during 1990-2022 for Stuart River near Fort St. James. The 10th and 90th percentiles and the 31-year mean are for 1990-2020.



2.3.6. Nechako River at Isle Pierre (08JC002)

Figure 8. Summary hydrograph of mean daily discharge during 1990-2022 at Nechako River at Isle Pierre. The 10th and 90th percentiles and the 31-year mean are for 1990-2020.



2.4. Water Level

For each site, we provide hydrographs of mean daily water level for the period 2011-2022 that include hydrographs of the 10-year mean for the period 2011-2020. We do not include percentiles in these figures due to the short length of record.

2.4.1. Nechako Reservoir

Figure 9. Nechako Reservoir levels in feet above sea level (a.s.l.) for the period 1990-2020. Data supplied by RT.

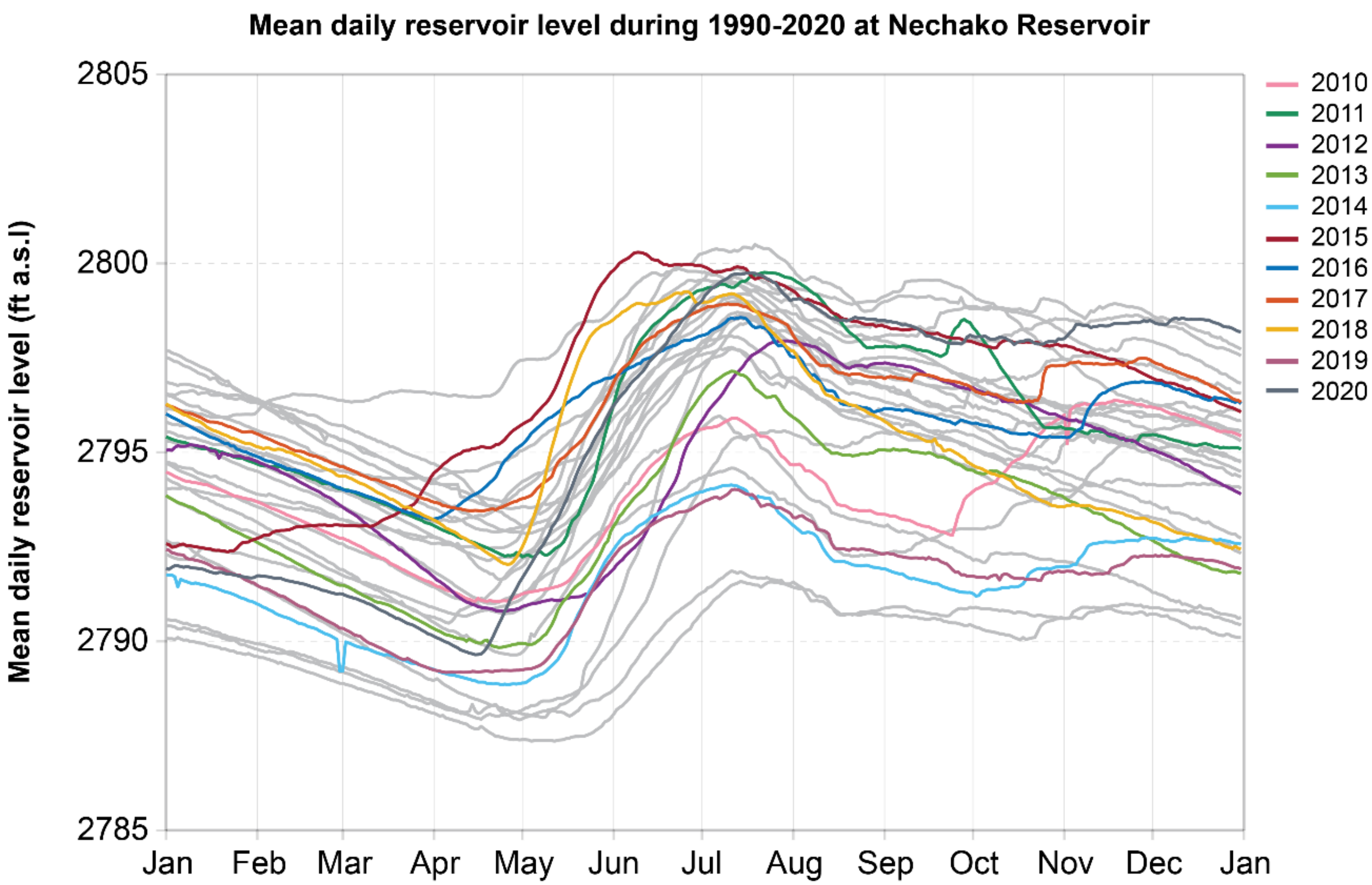
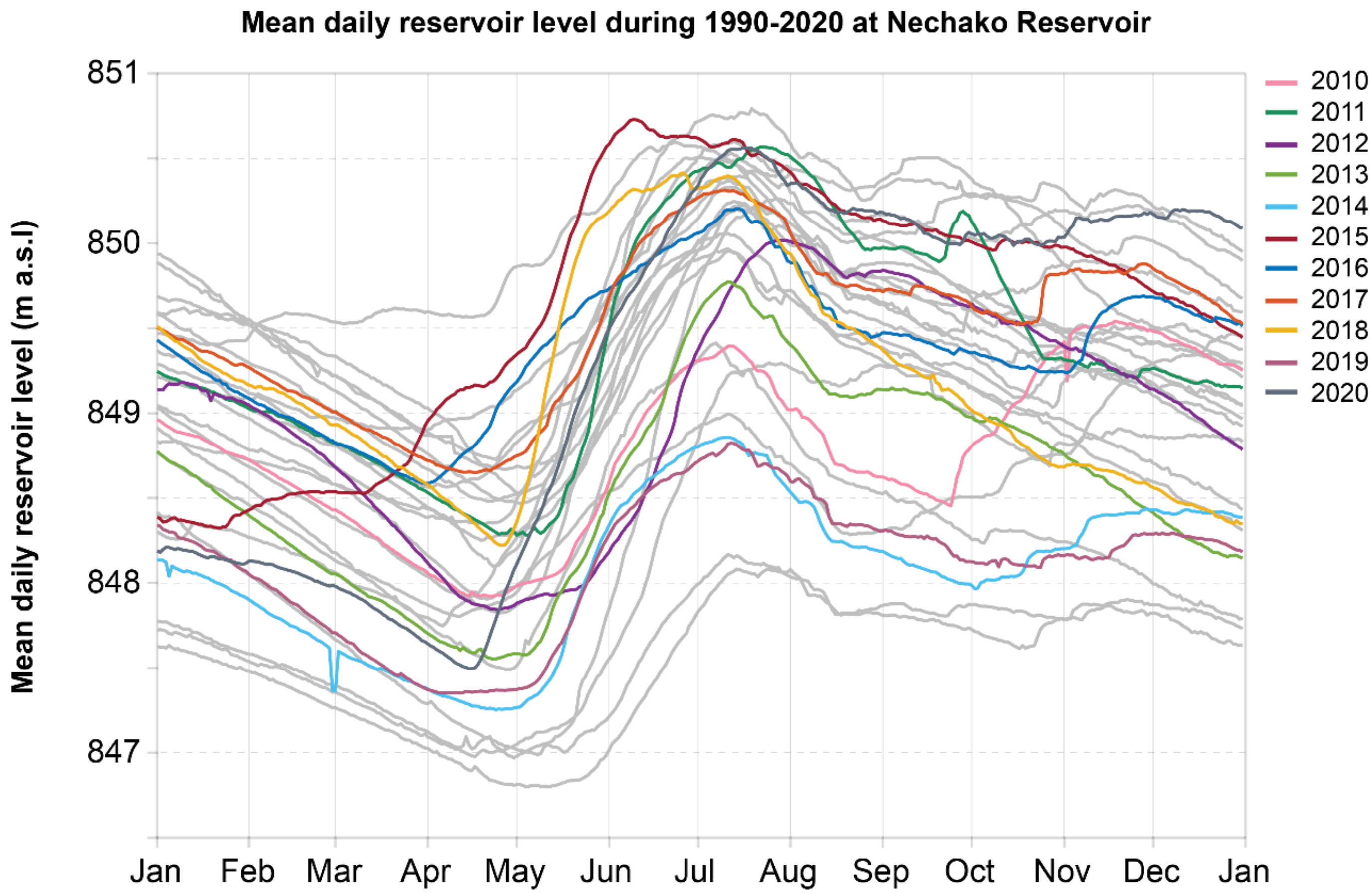
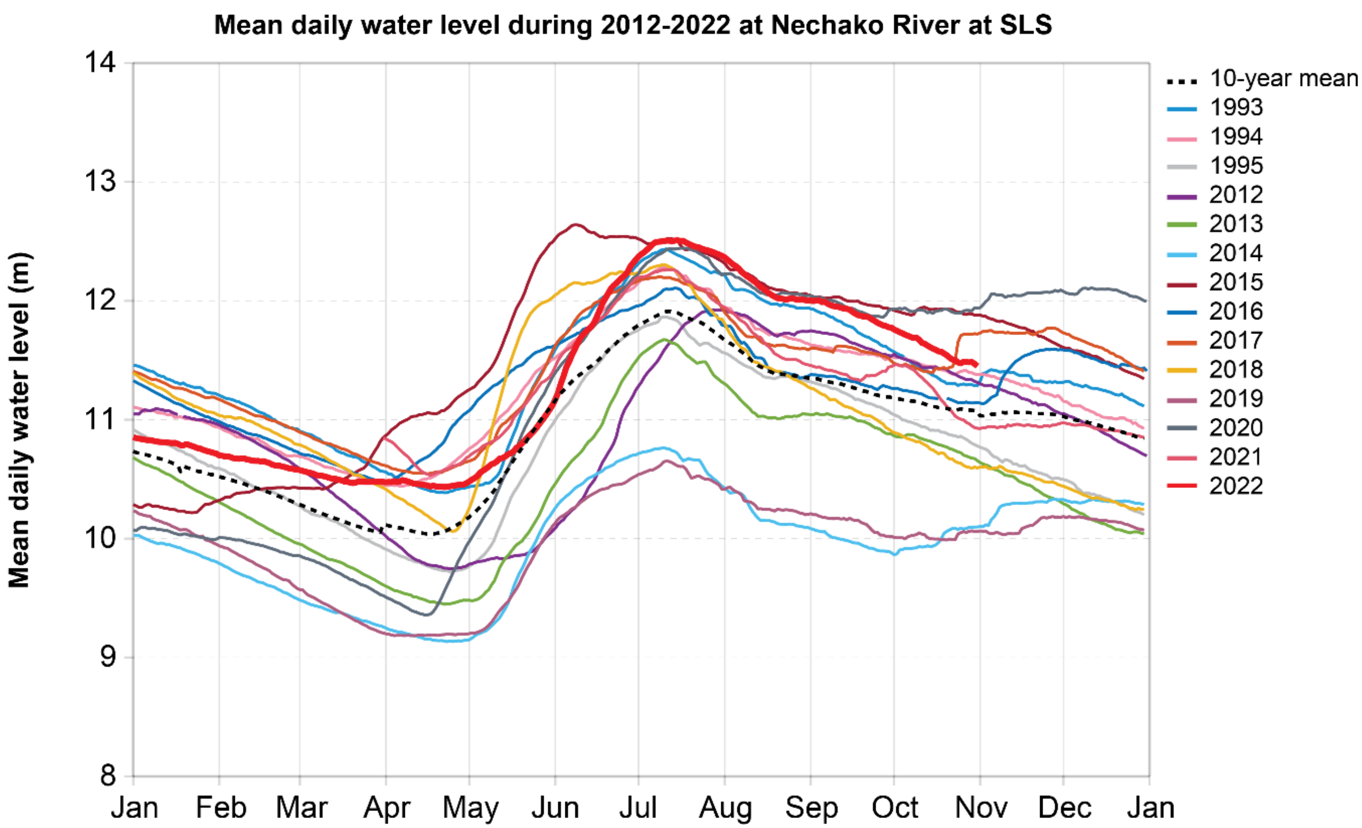


Figure 10. **Nechako Reservoir levels in meters above sea level (a.s.l.) for the period 1990-2020. Data supplied by RT.**



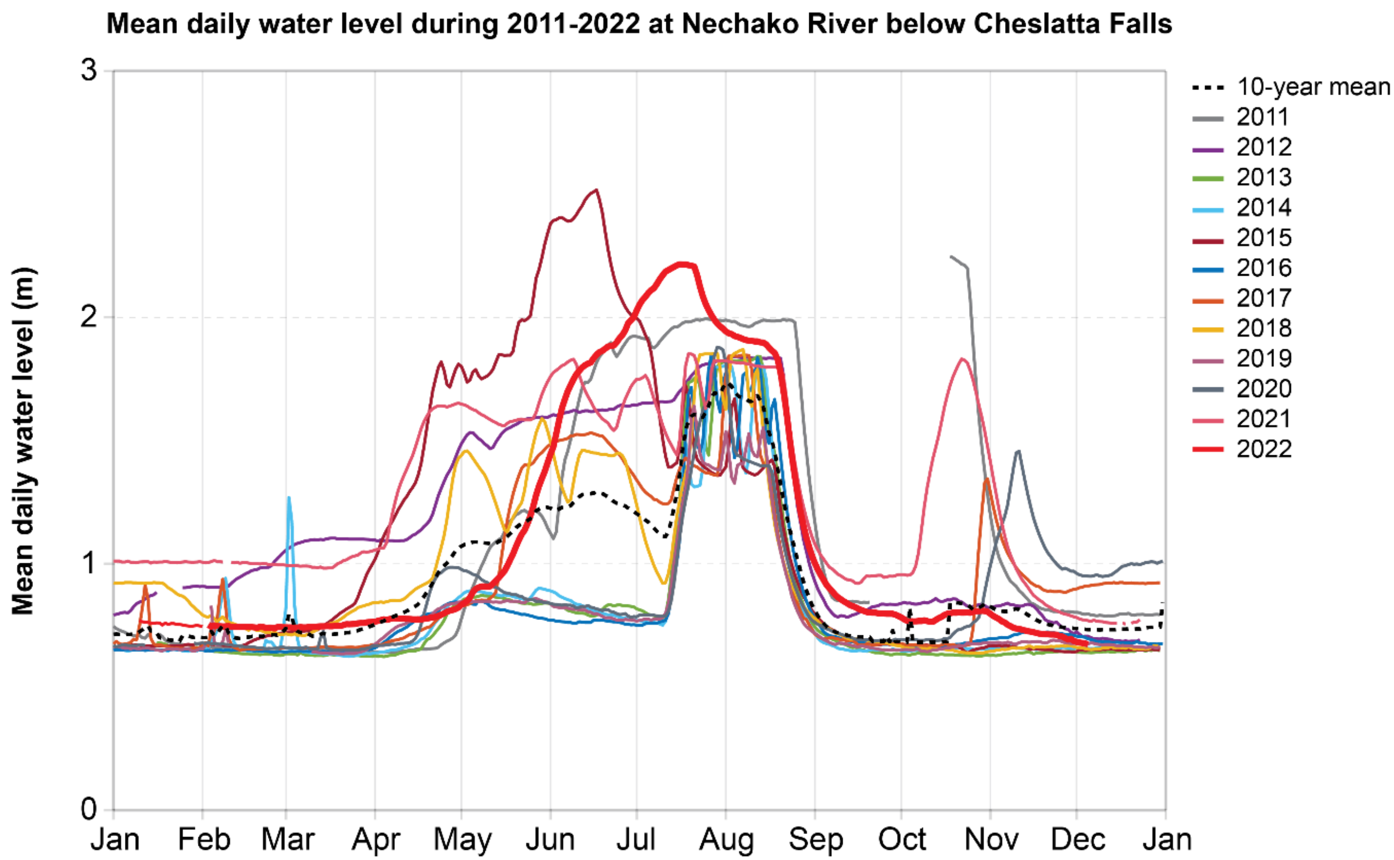
2.4.2. Nechako River at Skins Lake Spillway (08JA023)

Figure 11. Summary hydrograph of mean daily water level during 2011-2022 for Nechako River at Skins Lake Spillway. The 10-year mean is for 2012-2021.



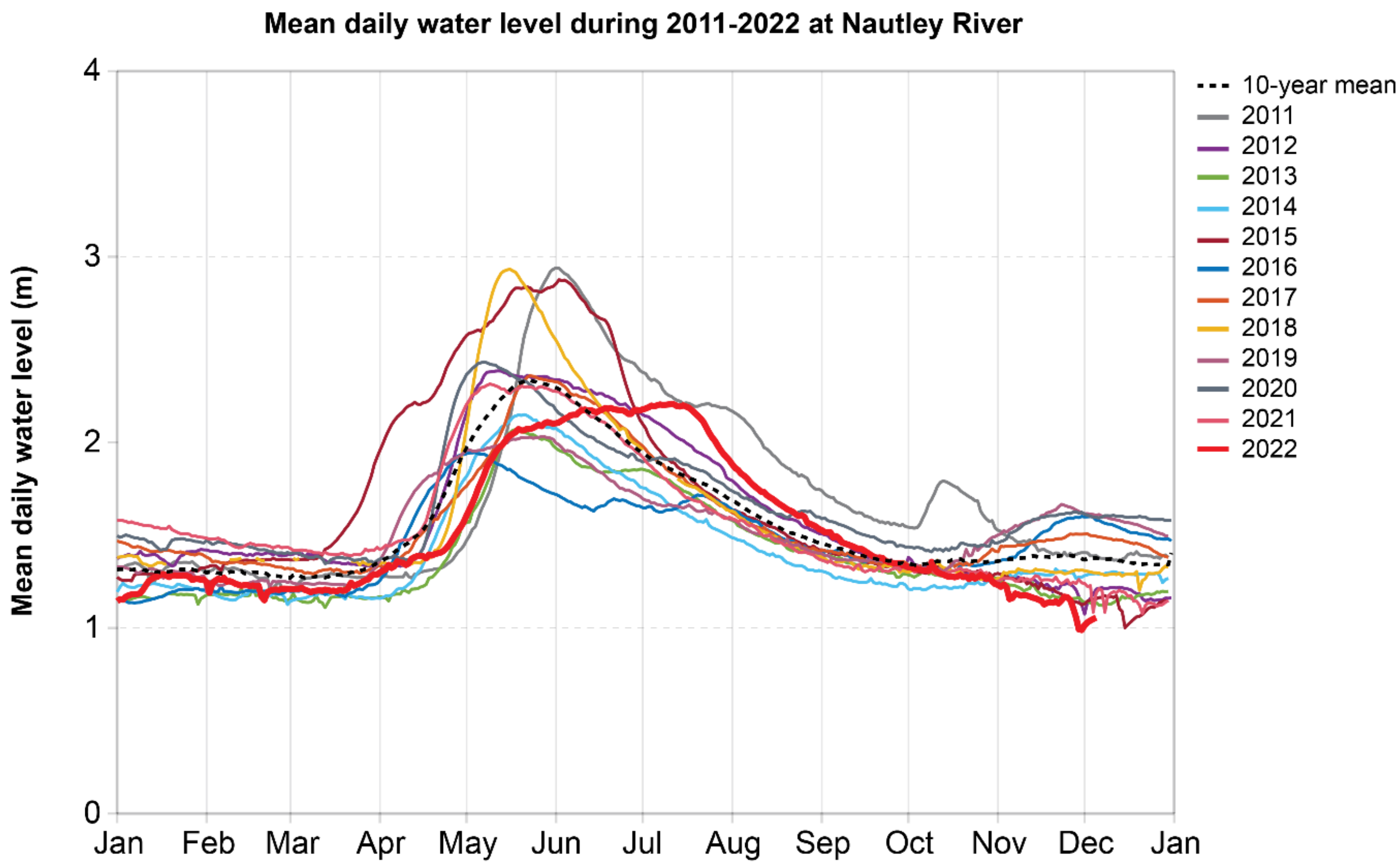
2.4.3. Nechako River below Cheslatta Falls (08JA017)

Figure 12. Summary hydrograph of mean daily water level during 2011-2022 for Nechako River below Cheslatta Falls. The 10-year mean is for 2011-2020.



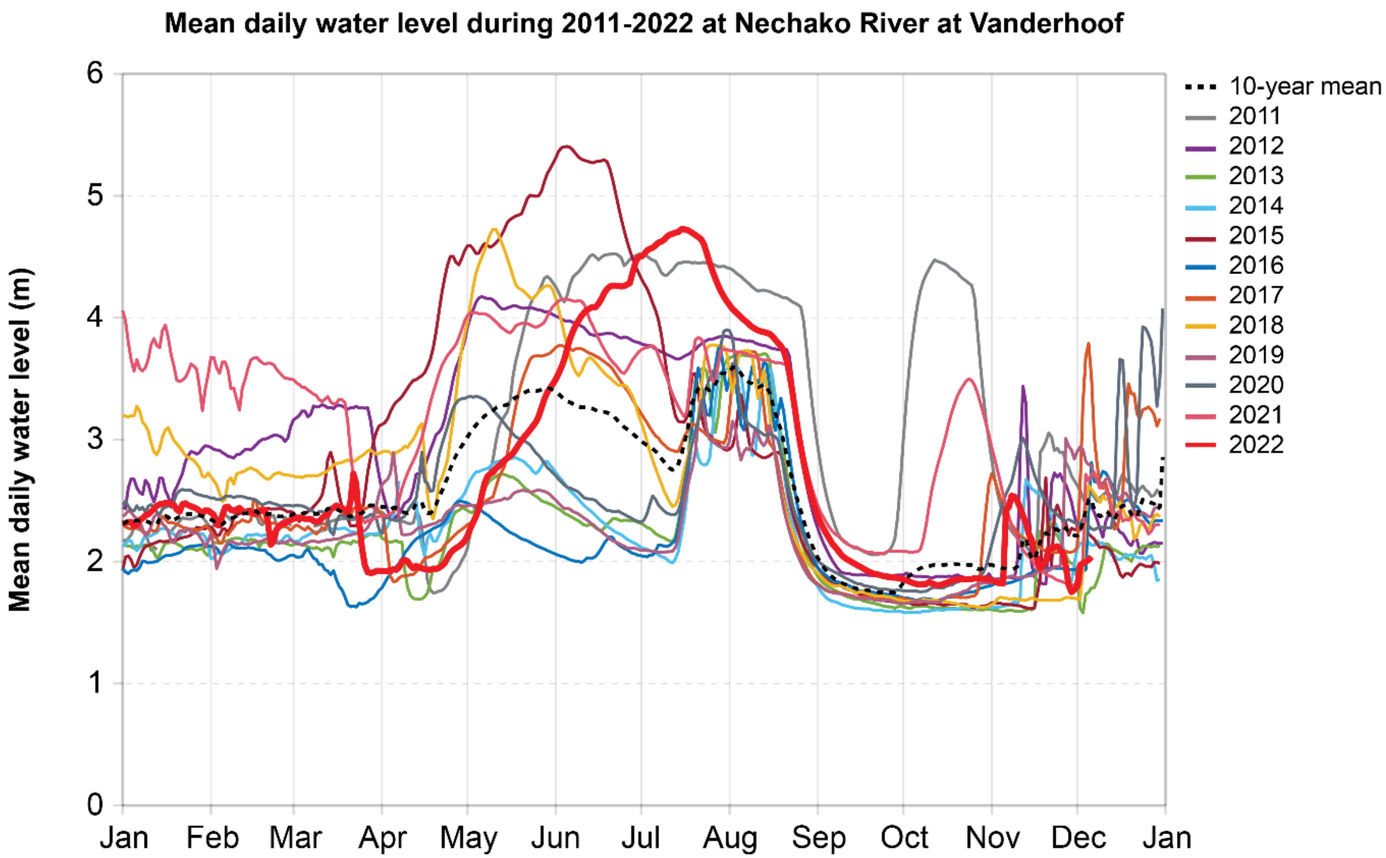
2.4.4. Nautley River near Fort Fraser (08JB003)

Figure 13. Summary hydrograph of mean daily water level during 2011-2022 for Nautley River near Fort Fraser. The 10-year mean is for 2011-2020.



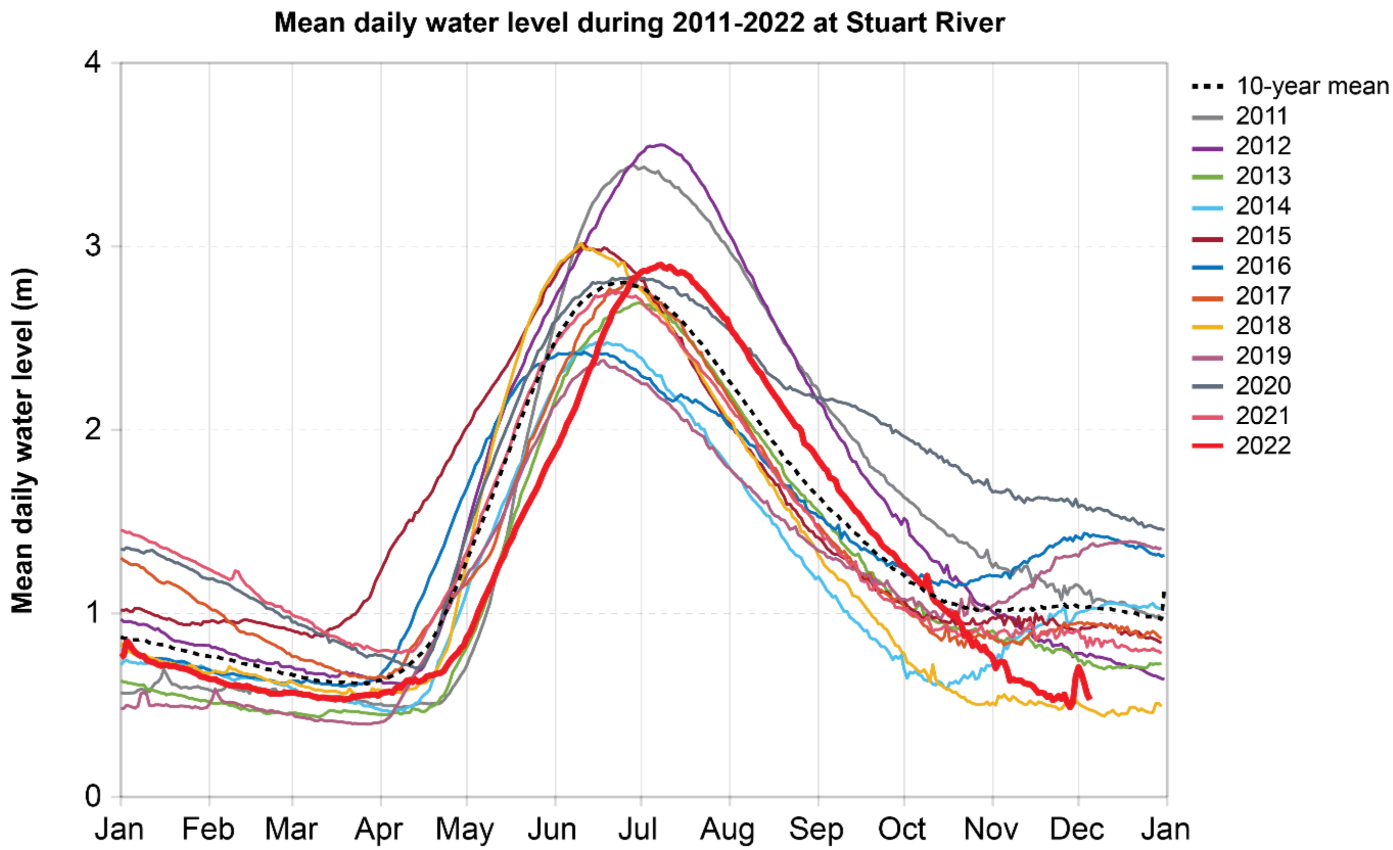
2.4.5. Nechako River near Vanderhoof (08JC001)

Figure 14. Summary hydrograph of mean daily water level during 2011-2022 for Nechako River near Vanderhoof. The 10-year mean is for 2011-2020.



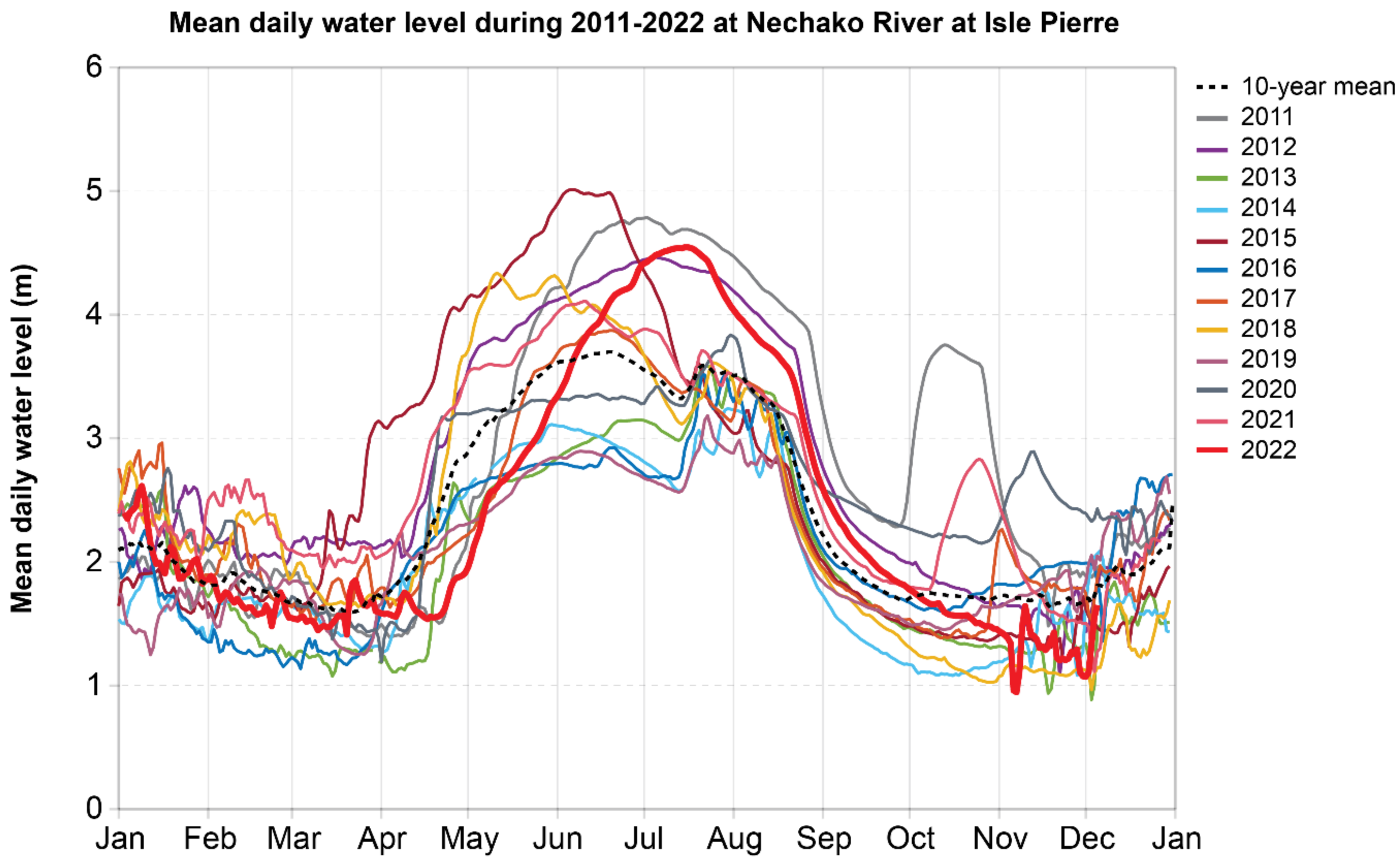
2.4.6. Stuart River near Fort St. James (08JE001)

Figure 15. Summary hydrograph of mean daily water level during 2011-2022 for Stuart River near Fort St. James. The 10-year mean is for 2011-2020.



2.4.7. Nechako River at Isle Pierre (08JC002)

Figure 16. Summary hydrograph of mean daily water level during 2011-2022 for Nechako River at Isle Pierre. The 10-year mean is for 2011-2020.

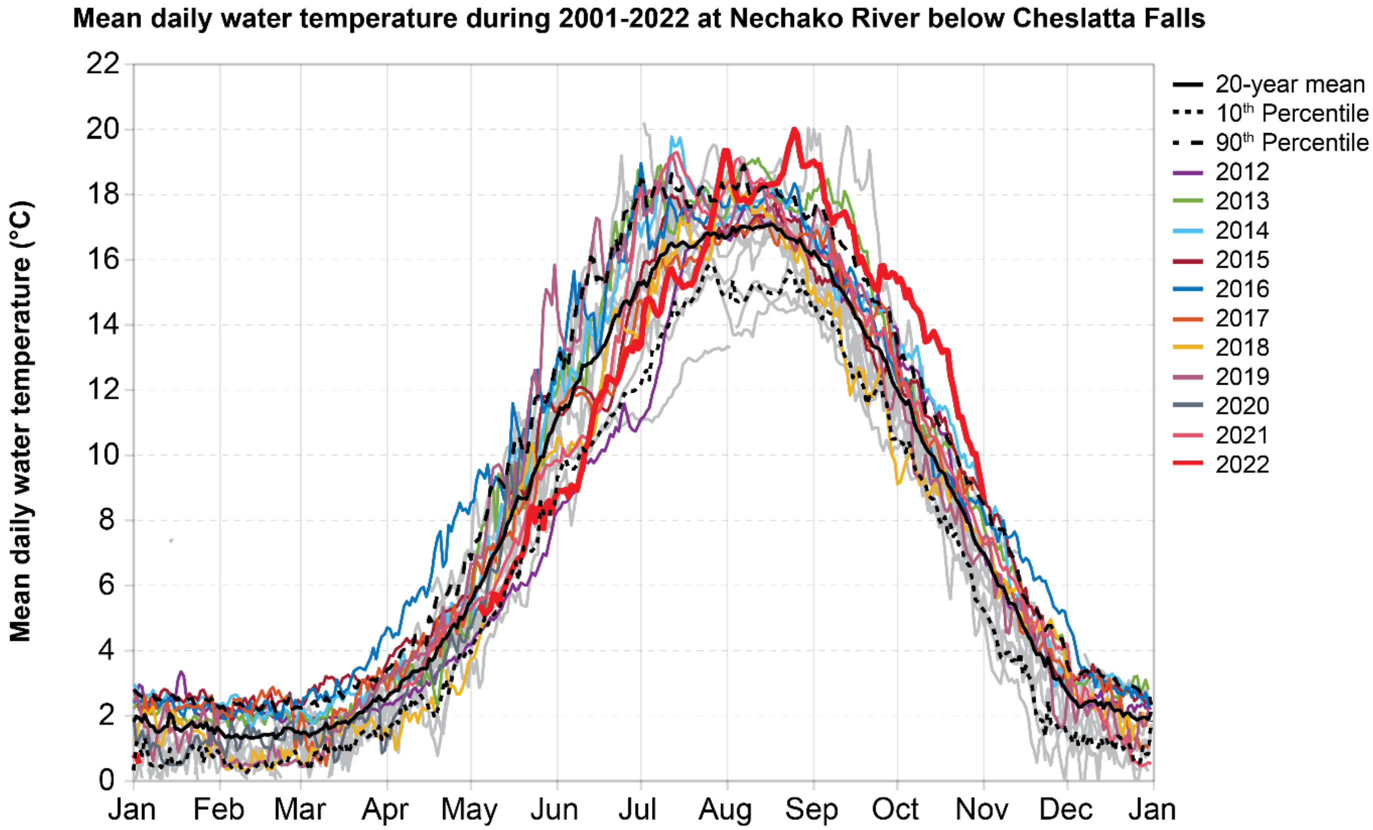


2.5. Water Temperature

Mean daily water temperature data are available at three sites within the Nechako River watershed (Table 2) and summarized below.

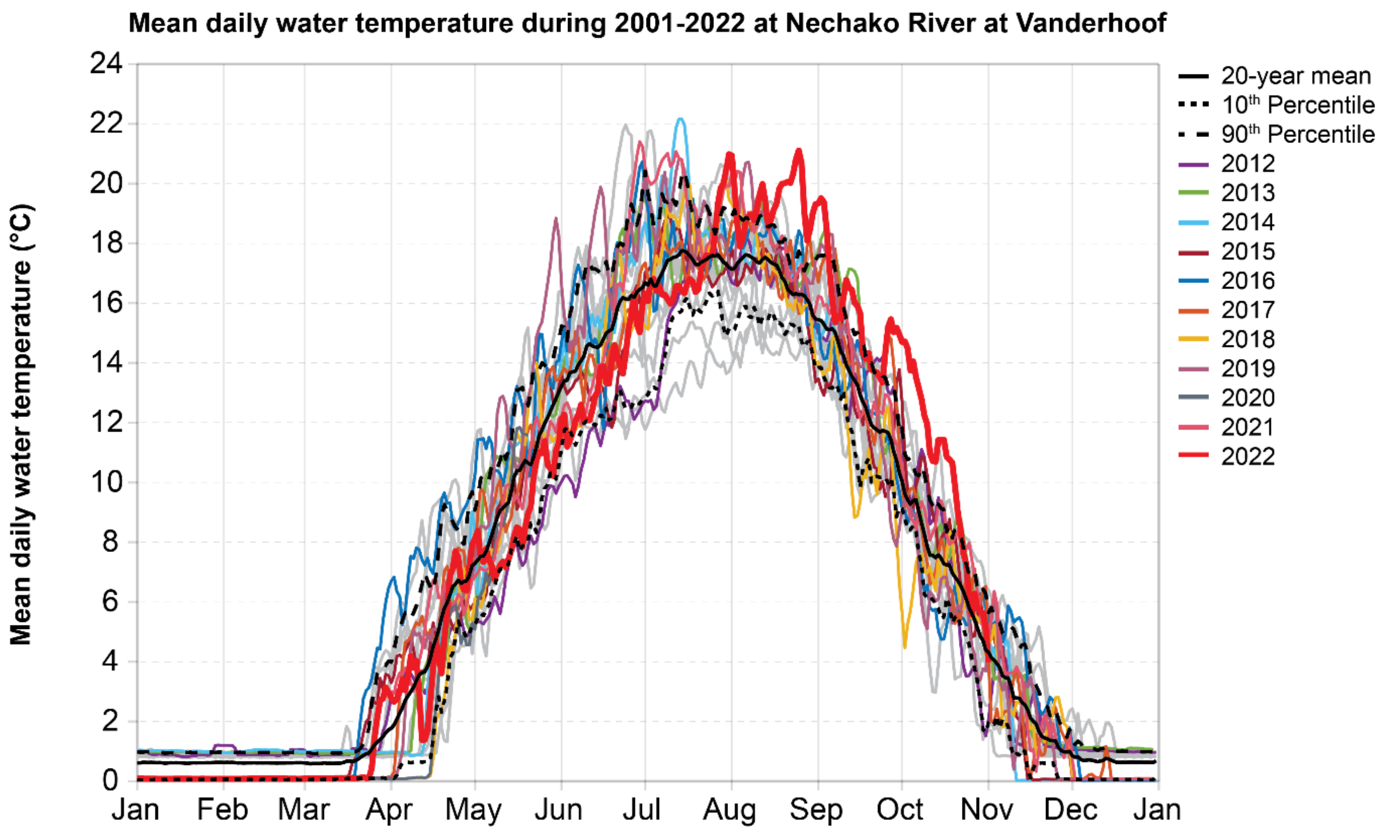
2.5.1. Nechako River below Cheslatta Falls (08JA017)

Figure 17. Summary of water temperatures (2001-2022) for Nechako River below Cheslatta Falls. The 10th and 90th percentiles and 20-year mean are for 2001-2020.



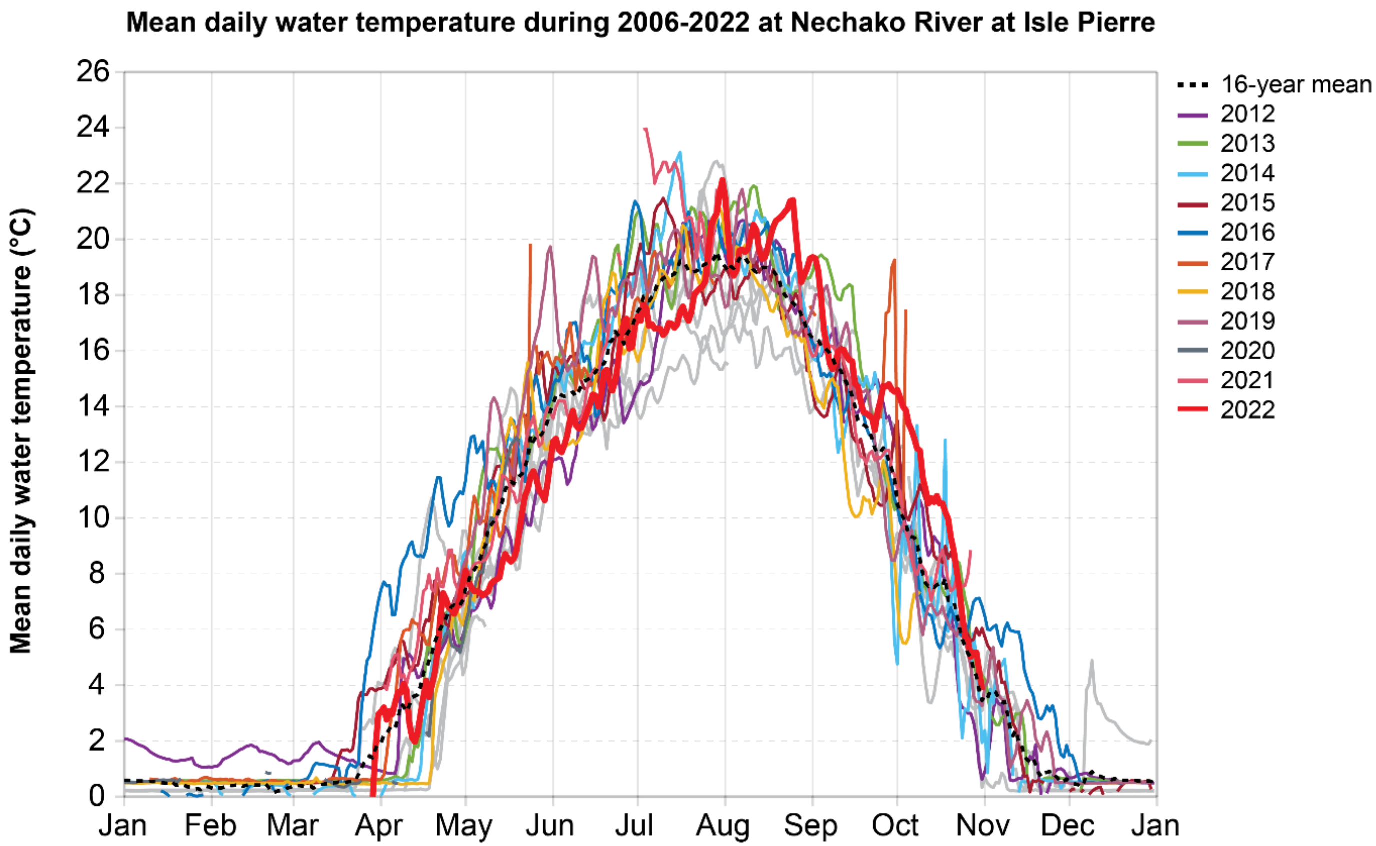
2.5.2. Nechako River near Vanderhoof (08JC001)

Figure 18. Summary of water temperatures (2001-2022) for Nechako River at Vanderhoof The 10th and 90th percentiles and 20-year mean are for 2001-2020.



2.5.3. Nechako River at Isle Pierre (08JC002)

Figure 19. Summary of mean daily water temperatures (2006-2022) for Nechako River at Isle Pierre. The 16-year mean is for 2006-2021. Percentiles are not shown on this figure due to the record being less than 20-years.



3. CONCLUSIONS

This memo utilizes available Water Survey of Canada and Rio Tinto data to provide an overview of the hydrology (river flows/level and water temperatures) of the Nechako River Basin. We provide three summary tables and 19 figures for the period 1990-2022. This period is considered representative of current hydrometeorological conditions and reservoir operations.

Yours truly,

Ecofish Research Ltd.

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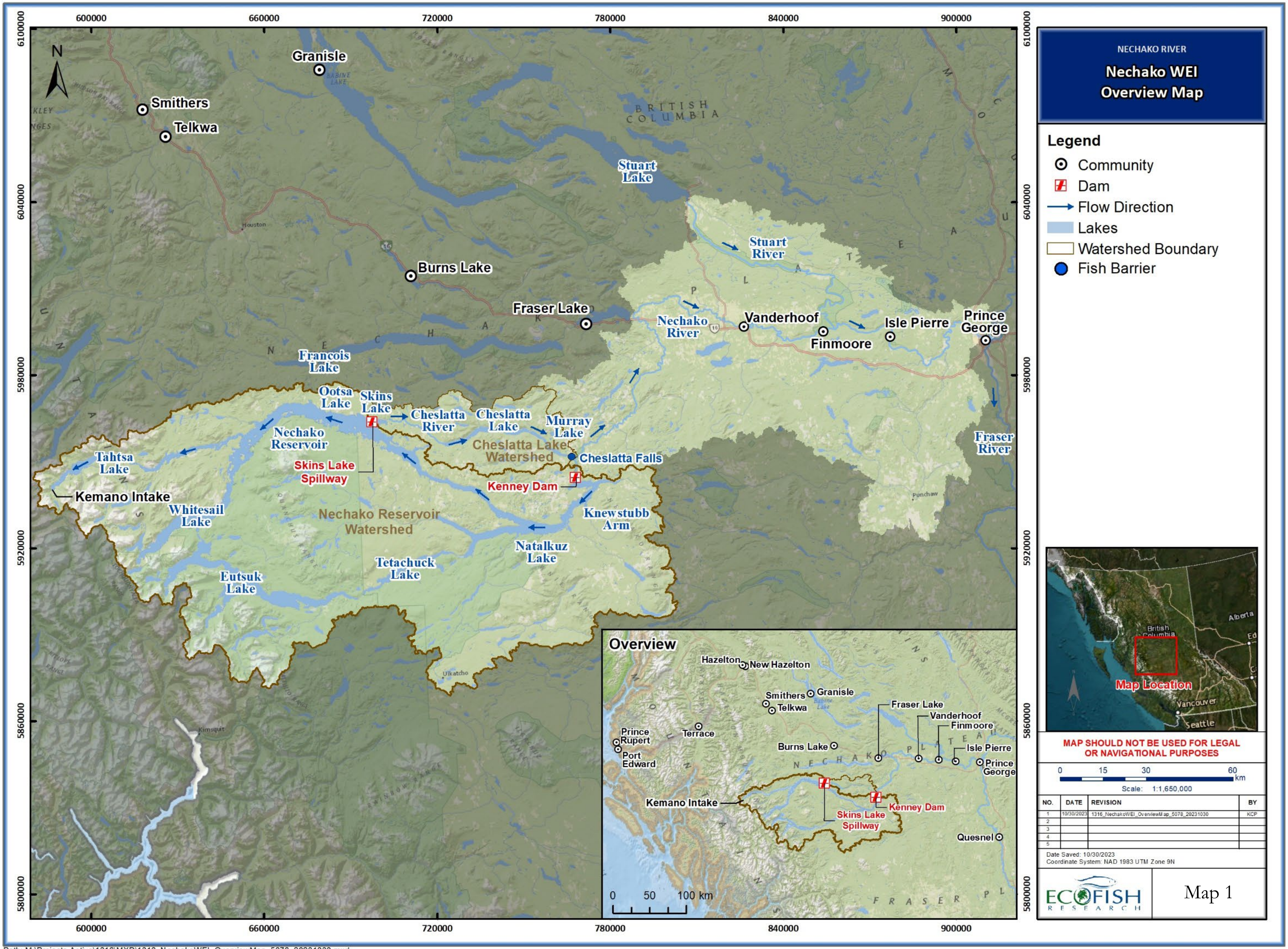
PROJECT MAP



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