To:	**WEI Technical Working Group members**
From:	Jayson Kurtz, TWG Coordinator, Ecofish
Date:	February 18, 2021
Re:	**WEI Technical Working Group meeting: Thursday, February 18, 2021, 1:00 pm to 3:00 pm**

Attendees:

- Stephen Dery (UNBC)
- Phillip Krauskopf (FLNRORD)
- Dan Sneep (DFO)
- Justice Benckhuysen (RT)
- Andy Lecuyer (RT)
- Jayson Kurtz (Ecofish)
- Jennifer Carter (Ecofish)
- Nikolaus Gantner (FLNRORD)
- Jason Collier (EDI)
- Zsolt Sary (FLNRORD)
- Duncan McColl (FLNRORD)
- Ian Spendlow (FLNRORD)
- Alec Mercier (RT)
- Wayne Salewski – Nechako Environment and Water Stewardship Society

Meeting Objective: Present summaries and information, and brainstorm interests regarding salmon and temperature, and river fish.

Agenda:

- Review last meeting and action tracker.
- Summary of information assessments: Nautley Weir, water quality, naturalized flow assessment, and salmon temperature tolerance
- Interests, Objectives and PMs.
    - Salmon and temperature
    - River fish

Information Summaries:

Ecofish presented information summaries of four action items assigned during the TWG and Main Table meetings:

- History of the Nautley Weir
- Available Water Quality Data/Sampling Sites
- Salmon Temperature Tolerance
- Naturalized Hydrograph

Summaries for the first three topics are provided at the end of this document and will be forwarded under separate cover when complete.

The naturalized hydrograph summary was a shared-screen presentation of a live application that displayed synthesized Nechako River hydrographs assuming there was no Kemano diversion (all water flows down the Nechako). The display included 2 plots: the hydrograph for each year (1981-2018) and the synthesized mean and 5^{th}/95^{th} percentile flows for that same period. The app also allows selection of a single year and compare the naturalized hydrograph to the actual hydrograph (with diversion).

TWG Discussion

Nautley Weir summary comments and considerations:

- If we increase flows in Nechako, will natural backwatering increase or replace the weir function?
- We still need to assess what level does Nechako backwater Nautley – ongoing action item.
- Is there ongoing erosion downstream, that might affect fish passage?
    - Collectively we are not aware of realized concern about fish passage: sockeye definitely pass and sturgeon appear to.

Naturalized hydrograph summary comments and discussion:

- Interest to explore this more, including adding temperature (actual and synthesis – UNBC working on this)
- Question regarding volume difference between actual and naturalized – does it reflect changes in Kemano generation? No, diversion is stable (110-140m^3/s), differences in flow largely due to reservoir storage (time lag).

Water temperature and salmon summary comments and considerations:

- Migration time (Fraser, Nechako) – assumed to be 3-5 days from Prince George to Stuart, add a few days to Nautley and upper Nechako. Chinook have ~12 day residence time between migrating and spawning
- There are various questions that should be considered:
    - What are the effects of current temperature on the population, survival?
    - What frequency and how many days are there 20^o exceedances?
    - How many fish are exposed to the timing and duration of exceedances of 20^o or other thresholds? How does this change for different temperature thresholds?

- How do we consider migration temperature history? Conservative approach might be prudent (but science isn't conclusive)
- How long does it take, is there adaptation to temp in Fraser stocks?
- How does exposure to previous migration conditions (i.e., temperature, flow, obstacles) affect availability of aerobic scope by the time they reach the Nechako River? Do these factors overshadow in-river scope, or the ability for operations to affect survival?

Discussion on modeling and sensitivity analysis:

- RT has a model that can be used to model flow scenarios and compare PMs for range of interests
- Approach is to model to maximize specific PMs, to impose hard constraints (e.g., never exceed a specified flow), soft constraints (e.g., never go below a certain flow unless specific conditions occur), or to optimize between PMs

Placeholder for other topics

- Study on salmon fry/par production and health/condition factor relevant to temperature and flow.

Interests, Objectives, and PMs:

Category	Interest	Discussion
Fish	River temperatures for fish (chinook salmon)	Based on current understanding of temperature effects on migrating Chinook and Sockeye, several potential approaches to establish PMs: • bookend temp targets based on aerobic scope 20-80% and consider tradeoffs with other interests? (if there isn't sensitivity with other objectives, then choose higher scope/lower temp) • Develop specific PM based the presented research – focus on data from Nechako • Factor in buffer to consider history of individual fish migration and temperature exposure.
Fish	River temperatures for fish (STMP)	• Same as above
Fish	Chinook salmon (habitat flow timing, temperature)	• Temperature effects on rearing Chinook will be presented next TWG to facilitate development of PM discussion • There is a request for data on outmigrating Chinook and request to evaluate migration challenges (i.e., flow and temp) to determine what condition fish are in once at mouth of Nechako

Next Meetings

Subsequent meetings will be 3 hours (with 15 min health break in the middle) back on our alternating Wednesday schedule.

- March 3, 9 am to 12 pm

- March 17, 9 am to 12 pm
- March 31, 9 am to 12 pm

Information Summaries

Nautley Weir History:

Two reports on the history of the Nautley Weir were summarized, one on the history of the Nautley Weir completed in 1972[1] and one a review of the structure completed in 2017[2]:

- The 1972 Nautley Weir History report[1] summarises the identification of the need for the Nautley Weir, the installation of the weir, repairs to the weir and complaints against the weir up to 1972.
    - Completion of the Kenney Dam led to the lowering of the Nechako River and a consequential erosion process of the Nautley River.
    - This erosion process was due to the formation of a set of rapids with a water level drop of 5 feet at the Nautley - Nechako confluence. The rapids and associated erosion were advancing up the Nautley River towards Fraser Lake at a rate of up to 10 feet per day. Concern was that if the erosion process were allowed to continue, it would destroy the road bridge across the Nautley River and also permanently lower the water level of Fraser Lake by up to 5 feet.
    - A rock weir was constructed in 1953 on the Nautley River at the outlet of Fraser Lake to prevent erosion of the Nautley River and prevent the lowering of water levels in Fraser Lake.
    - In 1965 an inspection of the weir was completed in response to complaints of low water levels in Fraser Lake.
        - Inspection concluded part of the weir had been washed out and the control level had dropped 2 ft.
        - The weir was repaired in 1965.
    - Multiple other complaints about the weir causing low water level in Fraser Lake between 1969-1970.
        - Inspections found no problems with the weir.
        - A physical instrument survey was completed in 1971 and 1972 found no damage to the structure.
    - The report concludes that the weir has not changed since last repaired in 1965 with any erosion or settlement being of negligible nature, and lower water levels observed since were due to natural causes (i.e., decrease in flows)
- A review of the Nautley River Hydrologic Control was completed in 2017[2].
    - A public inquiry about the water levels on Fraser Lake spurred this review of the hydrologic control structure to determine if any structural changes have occurred over time that may contribute to the change in water level of Fraser Lake.
    - Review reports cross-section survey completed in both 1993 and 2017 to show comparison over time.
    - The review concluded that the hydrologic control structure has not noticeably changed since 1993 and therefore the hydrologic control is not responsible for any water level fluctuations in Fraser

[1] Anderson, J.M. 1972. Outlet Control, Faser Lake (Reference No. 0124854). Prince George office of the Water Rights Branch.

[2] McCarthy, C. 2017. The Nautley River Hydrologic Control Review. Consultant's report prepared by Swiftwater Consulting Limited. November 2, 2017.

Lake. This conclusion was backed up by 60 years (1952 to 2013) of Water Survey of Canada records from a monitoring station at the outlet of Fraser Lake that confirms that the hydrologic control provides a stable control structure.

- The review goes on to suggest other considerations that may influence the water level fluctuations, including the declining trend in mean annual discharge from Fraser Lake. Also noted is a general decline over time in the monthly distribution of runoff in all months except April and May which show an increase, related to freshet.

Water Temperature Effects on Salmon:

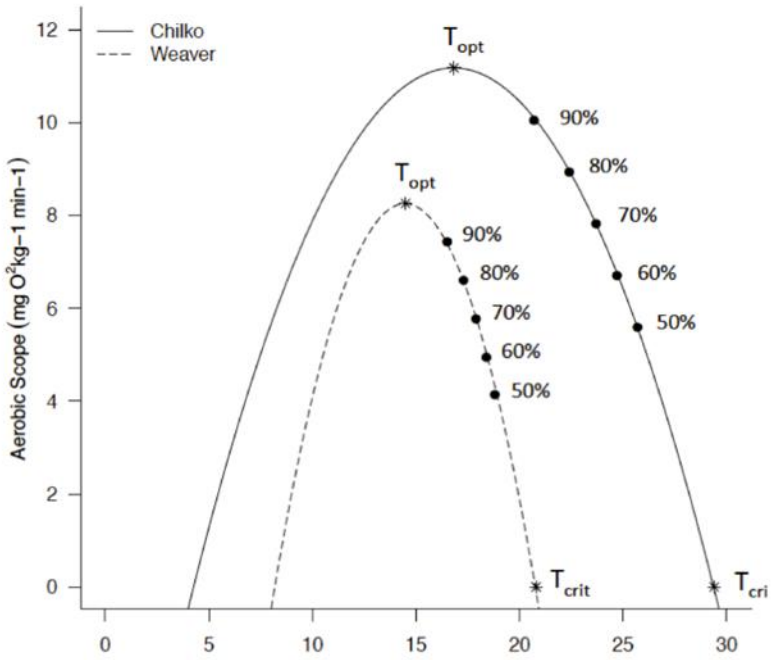
A literature review is underway to document our current understanding of temperature effects on migrating sockeye and migrating and rearing Chinook salmon to evaluate whether the STMP temperature target is appropriate. The STMP was initiated in 1980's to minimize water temperature exceedances of 20°C in the Nechako River between July 20th and August 20th for migrating sockeye salmon, which primarily include Stellako, Nadina, Early Stuart, and Francois stocks. Chinook were included in our review because they also migrate up the Nechako and can rear a year prior to out-migrating.

- There is a substantial amount of information on temperature effects on migrating salmon:
  - In general, water temperatures exceeding 17°C can increase risk of impairment of the maturation processes, susceptibility to diseases, increase stress, reduce energy use efficiency, and reduce swimming performance of migrating salmon.
  - In recent years, a large amount of research has been completed to understand population-specific temperature effects on migrating sockeye.
    - This research highlights the importance of understanding population-specific thermal limits because there are differences that have been attributed to physiological adaptations to migration challenges and historic conditions.
    - The development of thermal tolerances are based on aerobic scope, which estimates the total amount of energy available for activity, has a dome-shaped relationship to temperature that peaks at an optimum (T_{opt}) (this is where fish perform the best) and is zero at very low and very high temperatures (T_{crit}) (highest probability of mortality) (Figure 1). Research suggests between 50-80% aerobic scope is needed to successfully complete migration.
    - Thermal tolerances are associated with short-term (0 to 96 hr) exposure to temperature and have been developed for stocks of interest (Early Stuart and Nechako stocks):
      - Thermal tolerances for Early Stuart: T_{opt} 17°C, $T_{50\text{-}80\%}$ 21-24°C, T_{crit} 25.8°C; and
      - Thermal tolerances for Nechako: T_{opt} 17°C, $T_{50\text{-}80\%}$ 20-22°C, T_{crit} of 24°C.
  - Similar studies are currently underway for migrating Chinook and preliminary results for Shuswap Chinook, which are most similar to the Nechako stocks, show: a T_{opt} 15°C, $T_{50\text{-}80\%}$ 19-23°C, and T_{crit} of 25.8°C.
- In summary, a 20°C threshold makes sense for migrating Sockeye and Chinook in the Nechako River. It is above the optimal temperature range, which is naturally going to happen, but falls within the temperature threshold of 50-80% aerobic scope for both Sockeye and Chinook (19-24°C), which is suggested for migration survival.

- However, the aerobic scope thresholds are based on short-term exposure not a daily max, so 20°C consistent for up to 96 hrs, although laboratory tests seem to be within a 3 day exposure period.

- We are still reviewing temperature effects on rearing Chinook and will provide an update once complete.

Figure 1. Aerobic scope as a function of temperature (°C) for Weaver Creek and Chilko sockeye salmon populations. Showing temperatures associated with 50 to 90% of maximum aerobic scope as well as optimal (T_{opt}) and critical (T_{crit}) temperatures. Recreated from data was previously published in Lee et al. 2003 and Eliason et al. 2011.



Water Quality Sampling (Nechako Reservoir, Murray-Cheslatta, Nechako River):

There are 4 types of water quality sampling that have been summarized 1) WQ monitoring sites sampled by industry or permit holders under the Environmental Management Act, 2) WQ sites sampled provincially and federally, 3) Drinking water quality sampling, listed through Northern Health BC, and 4) WQ evaluation through the BC Forest & Range Evaluation Program (FREP). The first two categories are listed under BC surface water monitoring in the Environmental Monitoring System.

- Industrial water quality monitoring is associated with specific projects (i.e., Huckleberry Mine). Monitoring for these sites includes baseline and operational monitoring to assess environmental effects. There are 6 multi-year monitoring sites within the Nechako Reservoir in the Huckleberry Mine area sampled from 1998-2020 (Table 1). Nutrients, metals (including mercury), and physical parameters are assessed.
- There are 34 provincially listed sites historically sampled within the Nechako Reservoir (including head of tributaries) from 1993 to 2014. Of these sites, 8 had multi-year sampling (

- Table 2). Nutrients, metals (not including mercury), and physical parameters were assessed.
- No multi-year monitoring occurred in the Murray-Cheslatta system. There are only two sites that have one sample was collected in September 2005. Nutrients, metals (not including mercury), and physical parameters were assessed.
- There are 52 water quality sites along the Nechako River (including head of tributaries), 23 are multi-year monitoring sites, with only one long-term site sampled in Prince George from 1984-2021. Nutrients, metals, biological, and physical parameters are assessed.
- Drinking water sampling consists of both chemical (nutrients, metals (some sampled for mercury), physical parameters, and bacteriological sampling (E. coli and coliform).
    - Each site sampled is given a hazard rating of Low, Moderate or High. High hazard ratings can be given to untreated surface water sources or water with concentrations of chemicals such as arsenic. Sites with a high hazard rating are generally put on a boil advisory until the source of contamination is found or adequate water treatment facilities are installed.
- There are 4 general locations where water quality sampling has occurred in the direct area of the Nechako Reservoir and Nechako River including Ootsa Lake, Vanderhoof, Prince George, and Fort Fraser (Table 3). No drinking water sampling occurred in the area of the Murray-Cheslatta system.
    - Drinking water was tested across many sites within each general location, which included both commercial and residential well and source water.
    - There is 1 location in Nechako Reservoir in Ootsa Lake with sampling information available for the period from 2014 to 2021. Four drinking water sources were sampled for chemical and bacteriological and all sources had a low rating.
    - There are 3 locations in the Nechako River and direct tributaries with sampling information available for the period from 1994 to 2021.
        1) Fort Fraser (low hazard rating) – 2 sites with a total of 12 drinking water sources sampled – chemical and bacteriological.
        2) Prince George (2 sites moderate hazard rating, remaining low) – 101 sites with multiple drinking water sources sampled – chemical (including mercury) and bacteriological.
        3) Vanderhoof (1 site moderate hazard rating, remaining low) – 44 sites with multiple drinking water sources sampled – chemical (including mercury) and bacteriological.
- There are a number of sites within the areas of interests where WQ have been evaluated under the British Columbia Forest & Range Evaluation Program (FREP). FREP assesses the impacts of forestry and range use on 11 ‘resource values’ including wildlife, biodiversity, cultural heritage and water quality.
    - Evaluations are meant to be conducted quickly by non-specialists.
    - Use of turbidity as a primary characteristic of water quality.
    - Identifying point sources of sediment: these occur wherever artificial surface drainage from roads, harvesting or livestock disturbed terrain can reach natural streams.
    - Assessing potential surface erosion and present mass wasting: both are important in the generation of fine sediment.
- Typical sample sites within a sampling area include:

    - Road related (e.g., road-stream crossings, inter-drainage culverts, road generated slope failure);
    - Harvesting related (e.g., harvesting within/adjacent to riparian zone or harvesting generated slope failure);
    - Silviculture related; and
    - Livestock related (e.g., livestock presence within a riparian zone and stream channel).
- A standard evaluation estimates the volumes of fine sediment generated at each site and then assigns each site to different classes:
    - Site sediment generation potential class: very low, low, moderate, high, very high; and
    - General level of management: from Good (for very low) to Poor (for very high).
- The rating system provides the government with an independent assessment of how well licensees are maintaining water quality in a Results Based Management System:
    - 'Very low' or 'Low' – no action is required;
    - 'Moderate' – some concerns are noted; and
    - 'High' and 'Very high' – major water impact problems exist at the landscape level.
        - If a watershed manager has a more specific concern, more extensive evaluations of a range of variables would be required.

Table 1. Industrial water quality sites sampled across multiple years.

Source	General Location	Site	Data Records	Parameters					
				Nutrient	Biological	Metals	Mercury	Physical	Hydrocarbons
Industry	Nechako Reservoir	CREEK 4 @ TAHTSA REACH HUCKLEBERRY PE-14483	1998-2013	x		x	x	x	
Industry	Nechako Reservoir	HML-SW TAHTSA REACH	2016-2020	x		x	x	x	
Industry	Nechako Reservoir	HML-SW CREEK 8.5	2016-2020	x		x	x	x	
Industry	Nechako Reservoir	HML-SW CREEK 8-TRIB C	2016-2020	x		x	x	x	
Industry	Nechako Reservoir	HML-SW SL5-PONDA-INLET	2016-2020	x		x	x	x	
Industry	Nechako Reservoir	HML-SW SL5-PONDC-OUTLET	2016-2020	x		x	x	x	
Industry	Nechako Reservoir	HML-SW SL5-PONDD-INLET	2016-2020	x		x	x	x	

Note: all data was obtained from the Province of British Columbia's online mapping database at https://governmentofbc.maps.arcgis.com/apps/webappviewer/index.html?id=0ecd608e27ec45cd923bdcfeefba00a7

Table 2. Provincial and federal water quality sites sampled across multiple years.

Source	General Location	Site	Data Records	Parameters					
				Nutrient	Biological	Metals	Mercury	Physical	Hydrocarbons
Provincial	Nechako Reservoir	EUTSUK LAKE AT JOHN BUCHAN ISLAND (CONTROL STATION)	1996-1997	x		x		x	
Provincial	Nechako Reservoir	OOTSA LAKE ACROSS FROM KNOX ISLAND	1993-1996	x		x		x	
Provincial	Nechako Reservoir	OOTSA LAKE ACROSS FROM KNOX ISLAND	1993-1996	x		x		x	
Provincial	Nechako Reservoir	WELLS CREEK	2005-2011	x				x	
Provincial	Nechako Reservoir	MCIVOR CREEK	2005-2011	x		x		x	
Provincial	Nechako Reservoir	WHITESAIL TRIB	2007-2014	x		x		x	
Provincial	Nechako Reservoir	ST. THOMAS CREEK	2007-2014	x		x		x	
Provincial	Nechako Reservoir	BRYAN ARM TRIB	2006-2011	x		x		x	
Provincial	Nechako River	NECHAKO R 200 M U/S FORT FRASER DISCHARGE	1976-2009	x	x			x	
Provincial	Nechako River	NECHAKO R 50 M D/S FORT FRASER DISCHARGE	1976-1997					x	
Provincial	Nechako River	NECHAKO R 200 M D/S FORT FRASER DISCHARGE	1976-2009	x	x			x	
Provincial	Nechako River	NECHAKO R U/S OF VANDERHOOF DISCHARGE	1974-2009	x	x			x	
Provincial	Nechako River	NECHAKO R 100 M D/S VANDERHOOF DISCHARGE. IDZ	1974-2009	x	x			x	
Provincial	Nechako River	NECHAKO R AT VANDERHOOF U/S HWY 27 BRIDGE	1972-1985	x		x		x	
Provincial	Nechako River	NECHAKO R 0.5 KM D/S OF VANDERHOOF DISCHARGE	1987-2008	x	x			x	
Provincial	Nechako River	NECHAKO R 2 KM D/S OF VANDERHOOF DISCHARGE	1987-2008	x	x			x	
Provincial	Nechako River	MURRAY CREEK APPROXIMATELY 30M U/S OF RD CROSSING; 100M U/S	2003-2007	x	x	x		x	
Provincial	Nechako River	NECHAKO R U/S OF VANDERHOOF DISCHARGE	1974-2009	x	x			x	
Provincial	Nechako River	NECHAKO R 100 M D/S VANDERHOOF DISCHARGE. IDZ	1974-2009	x	x			x	
Provincial	Nechako River	NECHAKO R AT VANDERHOOF U/S HWY 27 BRIDGE	1972-1985	x		x		x	
Provincial	Nechako River	NECHAKO R 0.5 KM D/S OF VANDERHOOF DISCHARGE	1987-2008	x	x			x	
Provincial	Nechako River	NECHAKO R 2 KM D/S OF VANDERHOOF DISCHARGE	1987-2008	x	x			x	
Provincial	Nechako River	MURRAY CREEK APPROXIMATELY 30M U/S OF RD CROSSING; 100M U/S	2003-2007	x	x	x		x	
Provincial	Nechako River	NECHAKO R AT ISLE PIERRE FERRY SOUTH BANK	1972-1975	x		x	x	x	
Provincial	Nechako River	NECHAKO R AT P.G.ONE LANE BRIDGE MIDSTR.	1974-1986	x	x	x		x	
Provincial	Nechako River	NECHAKO RIVER AT ISLE PIERRE	196601974	x		x		x	
Provincial	Nechako River	MCMILLAN CREEK UPSTREAM OF ROAD BY CAMERON BRIDGE	2004-2006	x		x		x	
Provincial	Nechako River	UNNAMED STREAM B; ENTERING NECHAKO RIVER.	2003-2007	x	x	x		x	
Provincial	Nechako River	NECHAKO R AT P.G.ONE LANE BRIDGE MIDSTR.	1974-1986	x	x	x		x	
Provincial	Nechako River	MCMILLAN CREEK UPSTREAM OF ROAD BY CAMERON BRIDGE	2004-2006	x		x		x	
Federal	Nechako River	Nechako River at Prince George	1984-2021	x	x	x		x	

Note: all data was obtained from the Province of British Columbia's online mapping database at https://governmentofbc.maps.arcgis.com/apps/webappviewer/index.html?id=0ecd608e27ec45cd923bdcfeefba00a7

Table 3. Drinking water sites sampled across multiple years.

Source	General Location	Site	Data Records	Parameters					
				Nutrient	Biological	Metals	Mercury	Physical	Hydrocarbons
Health	Nechako Reservoir	Ootsa Lake, 1 site	2014-2021		x				
Health	Nechako River	Fort Fraser, 12 sites	2003-2021	x	x	x		x	
Health	Nechako River	Prince George, 101 sites	2002-2021	x	x	x	x	x	
Health	Nechako River	Vanderhoof, 44 sites	2003-2021	x	x	x	x	x	

Note: all data was obtained from Northern Health at https://www.northernhealth.ca/services/environmental-health/drinking-water/water-sampling-and-results