To:	**WEI Technical Working Group members**
From:	Jayson Kurtz, TWG Coordinator, Ecofish
Date:	March 9, 2021
Re:	**WEI Technical Working Group meeting: Wednesday, March 3, 2021, 9:00 am to 12:00 am**

Attendees:

- Stephen Dery (UNBC)
- Dan Sneep (DFO)
- Phillip Krauskopf (FLNRORD)
- Justice Benckhuysen (RT)
- Andy Lecuyer (RT)
- Jayson Kurtz (Ecofish)
- Jennifer Carter (Ecofish)
- Duncan McColl (FLNRORD)
- Alec Mercier (RT)
- Wayne Salewski – Nechako Environment and Water Stewardship Society

Meeting Objective: to brainstorm interests regarding reservoir fish and river fish.

Agenda:

- Review last meeting and action tracker.
- Summary of information assessments: reservoir erosion, Miworth flooding and erosion, and juvenile chinook temperature tolerance
- Summary of Nechako Roundtable AGM and UNBC workshop
- Interests, Objectives and PMs.
  - River fish (remaining interests)
  - Reservoir fish (remaining interests)

Updates from last TWG Meeting:

- Preliminary search of literature presented 6 additional WQ sites sampled for metals on the Nechako River. Sampling occurred once at all sites in 2015 by UNBC.
- Ongoing review of how to evaluate migration history when assessing temperature effects on migrating salmon.

- Ongoing task to determine at what elevation does the Nechako River cause backwatering in the Nautley River.

Information Summaries:

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

- Erosion in the Nechako Reservoir
- Erosion and flooding information at Miworth
- Temperature effects on juvenile Chinook

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

TWG Discussion

Erosion at Miworth comments and considerations:

- Most issues are land use and development issue.
- It was confirmed no resultant works have been completed at Bergman Rd. site but improvements have been made at the following sites:
  - Concrete chunks were installed at Island Park is of no further concern to the province.
  - Concrete chunks overlaid by rip rap were installed at Frankford Rd.
- Inquiry on what elevation are the above improvements functional (i.e., target maximum) – the province will provide information
- Need to evaluate the link to operations and what can be done
- PM pathway to be developed based on flow thresholds and maximum elevation where improvements are functional
- Need to understand natural inflow DS of Vanderhoof as no hydrology is available in order to model PMs

Action Item: Jenn and Jayson to follow up with Phillip regarding information on elevation at which improvements are functional

Action Item: Jayson to discuss with Alec how we can model PMs for Miworth

Temperature effects on juvenile Chinook comments and considerations:

- Need to understand where Chinook are rearing and what habitat they utilize.
  - What is the role of tributaries for cooling flow and for rearing? What is their contribution?
  - Observations that tributary-rearing Chinook are healthier and tributaries are impacted by land management and wildfires

    - Targe Creek (Copely) – historical Chinook spawning that has potentially been affected

- NFCP has completed a lot of work on Chinook; however, their target mandate was 3,100 to 4,000 fish and concluded that river conditions are suitable for that target.
- NFCP hatch and incubation studies suggested no issues with survival.
- There are no studies looking at how to maximize fish production, what is the carrying capacity, etc.
- NFCP looked at incubation (rivals best ever), health/body index (as expected), outmigration (proportional to spawners).
- Some indication of juvenile density dependance for > 4,000 spawners

<u>Summary of Nechako Roundtable AGM and UNBC workshop:</u>

UNBC sessions:

- Number of research topics relevant to what we are doing here.
- Academic presentations for first evening were recorded. Stephan to provide link.

Watershed Council general meeting:

- Presented other work of what is going on and is ongoing.
- Spring technical workshop to happen.

<u>TWG discussion on Chinook productivity:</u>

Conclusion:

There is general agreement that to establish habitat PMs we need to understand habitat usability (depth, velocity, substrate, LWD). We will be scoping work to understand this information including instream habitat for Chinook but also other issues: side channels, flooding, erosion, recreation.

General discussion:

- Three potential issues regarding tributaries: access for juveniles or adults, temperature/productivity, and preferred rearing habitat.
- What about natural floodplain (overland flow, cottonwood community)? Other research showing importance for productivity, river function, direct habitat.
- NFCP did not assess tributaries but did assess some secondary channels near Diamond Island.
- Side channels are of interest as they provide habitat, ecological function, geomorphological function, and flood relief.
- Regarding side channels, need to consider operations context:
    - Side channels are not part of floodplain: always historically wetted.
    - Hard to reach floodplain level upstream of Nautley without significant flooding downstream.
- Nechako river is not traditionally LWD controlled leading to lack of structure in the river – primary habitat driver is water depth.

    - Monitoring data suggests that LWD enhancement structures attract fish but it is not clear whether they increased production.
- Need to consider in-river habitat:
    - depth, velocity (not necessarily proportional to discharge);
    - productivity and food;
    - channel margin;
    - secondary channels;
    - tributaries; and
    - different types of habitats based on life stage.
- PM Pathway forward:
    - Use habitat suitability to set PM targets.
    - Potential options to evaluate habitat suitability in tributaries, side channels, and river:
        - Desktop exercise using stage-discharge curve (+/- 20%?) and google earth to estimate invert elevations (less resolution).
        - Air photo analysis – distribution of meso habitats (more resolution).
        - Drones or satellite info to collect data (greatest resolution).
    - Focus on operational changes to Nechako, what changes can we make (i.e., is Nechako River level affecting fish access)?
- Coho are using area upstream and adjacent to Cheslatta falls area for holding and spawning.

Action Item: Jayson to scope work for habitat suitability assessment. Need to reach out to Andre Zimmerman NHC regarding using satellite imagery.

Interests, Objectives, and PMs:

Category	Interest	Potential Issue/pathway of effect	Pathway forward
		River	
Fish	River temperatures for fish (resident trout and char)	River temperatures can affect growth and survival	• For all interests listed, PM pathway forward: completing habitat suitability assessment will provide insight into developing PM for various fish species, see discussion on Chinook productivity above.
Fish	Chinook salmon (habitat flow timing, temperature)	issue needs to be refined	
fish	Off-channel	need to refine	
Fish	resident fish species (habitat, flows, temperature)	issue needs to be refined	
fish	Side-channels	need to refine	

Information Summaries

Nechako Reservoir Erosion:

One key issue raised during WEI discussions is the relationship between reservoir operations and shore erosion processes; landowners are concerned about disruption to infrastructure and properties as well as large wood (LW) deposits and their role in erosion processes.

Nechako Context

In the past 30 years, the average water level of the reservoir typically varies by about 2 m annually from about a low of approximately 850 m in April to high levels of about 852 m in July.

Shore Erosion

a. Shore erosion is related to a wide range of physical, chemical, and biological controls and, in many settings, it occurs naturally and is related to local shoreline configuration, underlying geological/soil conditions, wind and fetch, water currents, and longshore sediment supply.
b. Impounded reservoirs are often more susceptible to erosion due to the creation of inundated areas that were previously only subject to terrestrial processes. Erosion in reservoirs can be further accelerated by manipulation of water levels during operations.

Beach Morphology

a. A primary control on shore erosion is the composition of the beach with smaller grain sizes that are more susceptible to transport by wave action than larger grain sizes more resistant to movement.
    i. The gradient of the beach face is related to sediment size with smaller sediments more gently sloped than coarser sediments which can hold a steeper face. Sediments of different sizes can be sorted by wave action to create a sandy foreshore with a coarse-grained backshore.
    ii. These morphological differences create shorelines that are resistant to wave action by dissipating wave action in low gradient areas and reflecting wave action in high gradient areas.
    iii. Newly formed beaches may not have had time to adjust to hydraulic forces.
b. There are a variety of shoreline compositions and beach configurations along the Nechako Reservoir.
    i. Some Nechako shores are characterized by a wide, low gradient, gravel-sand beaches. There may be evidence of back-cutting at the upper limit of the waterline, however, erosion is mediated by the dissipative potential of the beach slope and the stability provided by the coarse sediment resulting in low rates of erosion.

ii. Other Nechako shores are characterized by steep bluffs along an exposed headland. Undercutting and progressive erosion is evident, and erosion is exacerbated by the limited presence of a dissipative foreshore, steep topography, and erodible sediment.

Effects of Large Wood

a. Nechako shoreline has a high load of Large Wood (LW) which can be of external origin.

b. LW is an important part of aquatic ecosystems and is used in restoration and stabilization actions where it can enhance natural processes that buildup the backshore while maintaining shoreline processes.

c. Interaction between LW and beach stability is not well studied.

    i. A study by Kramer and Wohl (2015)[1] identified and classified different types of "driftcretion" features (persistent driftwood concentrations) on Great Slave Lake. The study determined that many driftcretions features protect shorelines, form new coast morphologies, and slow shoreline retreat.

    ii. Many similar LW deposit types identified by Kramer and Wohl (2015)[1] are evident in the Nechako Reservoir and, in general, have a protective effect on the shoreline.

    iii. Other studies show that LW facilitates vegetation and limits erosion. Furthermore, shore-deposited LW has been shown to protect steep shorelines.

d. A study by Wilson (2020)[2] of designed/installed LW structures used an experimental modelling approach to demonstrate that benched LW configurations result in the most stable gravel beach and a single LW piece provides similar benefits to a benched arrangement when placed below the still water level. However, a single LW piece may be detrimental when placed on the upper beach if there are large wave heights due to the concentration of breaking wave energy in a single location. Furthermore, the study concluded that LW designs that include LW below the still water level (such as a benched configuration) are most effective at stabilization.

Shoreline Protection Actions

a. Shoreline protection includes passive, soft-engineered, and hard-engineered approaches. Selection depends on variables such as cost, site characteristics, and maintenance requirements.

b. Examples of shoreline protection actions:

    i. Passive: (1) surface and groundwater management and (2) vegetation management

    ii. Soft Engineering: (1) beach nourishment (sediment addition), (2) large wood, (3) re-slope and revegetation, and (4) retaining wall removal and restoration

[1] Kramer, N., & Wohl, E. (2015). Driftcretions: The legacy impacts of driftwood on shoreline morphology. Geophysical Research Letters, 42(14), 5855-5864.

[2] Wilson, J. (2020). The Efficacy and Design of Coastal Protection Using Large Woody Debris (Doctoral dissertation, Université d'Ottawa/University of Ottawa).

iii. Hard Engineering: (1) rock revetement and (2) vertical bulkhead

Conclusion

a. The shorelines of the Nechako reservoir are still dynamically adjusting and on-going erosion is to be expected as equilibrium beach profiles are reached.

b. Erosion processes will be greater in areas of exposed headlands or with steep existing topography. Gently sloped shorelines will more effectively dissipate wave energy.

c. In general, LW plays a stabilizing role in beach and shoreline settings and, over time, may interact with vegetation to trap sediment, contribute to beach progradation, and further stabilize shores.

d. These natural processes may be mimicked through the construction of shore protection features but careful consideration should be made before removing LW as it may destabilize high-risk areas.

Miworth Erosion and Flooding:

The Regional District of Fraser-Fort George provided the following information regarding flooding and erosion at Miworth:

1. Generally, there is awareness of bank erosion concerns in Miworth community, including, but not limited to, Bergman Road and Island Park Drive areas.

2. The Regional District submitted an application for bank armouring in 2009 to the province; however, the grant was not approved. The application with report provides a study done by the province in 1998 and history leading up to 2009. These reports are summarized below.

3. The Miworth Community Association did some armouring work on their own. We would have to reach out to them to get background on the project. A summary letter was provided to the Regional District regarding these works. They sent a map showing the area.

4. Regional District, in its current zoning bylaw, has vertical and horizontal setbacks for any new habitable building or structure along the Nechako River. The setbacks are dependent on where along the Nechako the property is located. We can request more information if needed.

5. Through Building Inspections, if the Regional District Building Official is concerned of a natural hazard, the Building Official can request a report from a registered professional (engineer) regarding the proposed development.

6. The Regional District's Wilkins Regional Park is situated in Miworth, along the Nechako and the parks department has advised that other than the very occasional high water event which can cause the park to be shut down, they don't see any resultant works caused as a result of said high water.

7. They think there was some armouring work done at base of S. Nechako just off Frankford Road; however, this was done privately and cannot be verified.

Summary of studies provided:

BC Emergency Management - Application Form – Flood Protection Program By: Reginal District of Fraser-Fort George

An application was submitted for erosion prevention measures in the form of 185 m of riprap to be placed along the right bank of the Nechako River at Miworth, thereby linking two existing riprap areas. The location is at Island Park Drive, approximately 12.8 km upstream from the Foothills Bridge in Prince George. The application provides details of erosion studies from 1998[3], 2007[4] and 2008[5].

- In 2007, extremely high flows in the Nechako River at Island Park Drive caused extensive undermining of the gravel and silt banks. High water levels were due to exceptionally high snow pack in the Nechako basin and a late melt.
- Safety of the residences became an urgent matter. Two residences were relocated in 2007. Six residences ended up taking on stabilizing the bank at their own cost.
- High river levels in the Nechako are expected to become the norm due to changing weather patterns and the heavy loss of forest in the Nechako Basin due to Mountain Pine Beetle.

1998 Erosion Study - Miworth & Prince George: B.C Ministry of Environment, Lands and Parks[3]

- In 1998, a geotechnical assessment noted strong potential for detrimental erosion at this location and constant but minimal erosion occurred over the next decade. Residents tried several stabilization methods including concrete mats, building rubble, and tree planting.
    - Continuous toe erosion and sloughing of the 12 m high slope at Island Park Drive and Bergman Road in 1997 was caused by high flows during May and June, including 17 days when the flow exceeded 1,000 m^3/s, and a further 72 days when it exceeded 800 m^3/s. Analysis of past high flows show that the high flows of summer 1997 are not unprecedented or statistically unusual.
    - Stats show that a flow of 1,000 m^3/s has a 20 year return period, 800 m^3/s has a 5 year return period, and 600 m^3/s has a 2 year return period.
- The slope material and gravel sizes of the banks at 3 locations return different limiting velocities below which the size of the rocks will not be eroded:
    - Aspen Lane, limiting velocity = 1.2 m/s
    - Island Park Drive, limiting velocity = 0.8 m/s
    - Bergman Road, limiting velocity = 0.9 m/s
    - These velocities will be exceeded during average peak flow conditions, but significant erosion is unlikely unless the water level is above the average peak level.
- Ice jamming at Cameron St. Bridge in 1996 caused localized erosion and flooding.

2007 Erosion Study – Island Park Drive: GeoNorth Engineering Ltd.[4]

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[3] Hollingshead, G.W., D.J. McDougall. 1998. Nechako River Bank Erosion Study, Miworth and Prince George, British Columbia. Consultants report prepared for B.C. Ministry of Environment, Lands and Parks by Geonorth Engineering Ltd., June 30, 1998.

[4] McDougall, D.J. 2007. Nechako River Bank Erosion, 3185 Island Park Drive, Miworth, B.C. Memorandum to Mr. and Mrs. C. Pepplar from GeoNorth Engineering Ltd. File No. K-2364. June 28, 2007.

[5] Yaremko, E. 2008. Island Park Drive (Miworth) and Bergman Road Assessment of Bank Erosion Nechako River Near Prince George. Memorandum to G. Simmons from Northwest Hydraulic Consultants. Project No. 7190. July 24, 2008.

- On 19th June 2007 stream flow at the Isle Pierre gauge exceeded 1,000 m^3/s, reaching 1,150 m^3/s on 27th June 2007.
- Between 21st June 2007 and 27th June 2007, the bank at Island Park Drive had eroded back between 8 and 10 m at the river level and 1.5 m at the crest of the bank.
- This steepened the banks from 32-35 degrees as surveyed in 1998, to 45-65 degrees.

2008 Study: Northwest Hydraulic Consultants[5]

- Suggest the large and severe loss of bank in 2007 was a result of relatively slower rate of toe erosion between 1997-2007 when the max flood peak at Isle Pierre was only 720 m^3/s and the average only 572 m^3/s.
- They speculate that the slope has progressively over steepened in response to toe erosion and the 2007 peak flows caused major bank sloughs in response to over-steepened banks.

Water Temperature Effects on Juvenile Chinook:

- Population-specific thermal tolerances associated with aerobic scope are not yet available for juvenile Chinook but are currently being developed; however, thermal limits for growth and smoltification have been well studied across salmon species.
- Higher than optimal water temperature requires more energy to maintain physiological functions.
- Elevated water temperatures can hinder or reverse the smoltification process, delay outward migration, and decrease survival in the marine environment by affecting behaviour, salinity tolerance, body moisture and lipid content, growth, and condition factor. High temperatures can block the gill ATPase osmoregulatory enzyme (crucial for seawater osmoregulation) that affects migratory behaviour. ATPase is also stimulated by growth hormones, which are reduced at high temperatures. Insufficient body size and ATPase activity can lower survival during smolt.
- Growth rates increase up to an optimal temperature and then decline as food conversion efficiency or food availability is reduced.
    - Optimal growth, which affects smolitification, has been reported as 14.8°C for juvenile Chinook in the Nechako River and 15.6°C as a standard for spring Chinook.
    - A study on juvenile Chinook in the Nechako River was conducted in 1982 using both lab and field studies to assess effects of temperature.
        - Field studies assessed fish captured from 10 km downstream of Cheslatta Falls from March to September. River temperatures were recorded at Irvine's Lodge. Assessed natural growing rates through the growing season.
        - Lab studies captured juveniles in early May grown until end of July and then experiments started at assigned temperatures for 28 days. Temperatures tested were 16°C and 19-24°C in 1°C increments.
        - Brett 1982 deduced that the optimal growth of juvenile Chinook in the Nechako River would occur at 14.8°C in nature (60% of maximum daily intake), a 20% reduction in growth would occur at 18-19°C, and no growth would occur at 21.4°C. Lab studies showed optimum at 19°C on maximum daily ration.

- Generally, studies have suggested that smolitification in Chinook salmon can be impaired when reared at temperatures above the range of 12-17°C. Of note, the higher range of 17°C was reported for a southernly distributed stock in the Sacramento River in California.
- For salmonids in general, temperatures above 11-13°C can reduce ATPase levels and temperatures above 14-15°C can cease out-migration. One study reported a significant decrease in ATPase activity when Chinook were reared in temperatures above 20°C (again, a southern stock).
- NFCP outmigration study last done in 2010 compared results to historic data (1991-2004) and found 0+ fish captured in 2010 in April were larger than the historic mean but smaller in May, June and July. Condition indices in 2010 were higher than the historical minimum but slightly lower than the historical mean.
    - In 2010, mean daily water temperatures below Cheslatta Falls from January to mid-March were 0 - 3°C, around 17°C from July to August, and then declined to 7°C by November.
    - In 2010, mean daily water temperatures below the Cheslatta Falls from mid- to late April were near or above the maximum observed historically (1987-2004) but returned to around historic mean value by mid-June to mid-August. Temperatures continued to drop below the historic mean until September. By the end of September temperatures increased to around historic maximum and remained there until mid-November