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northwest hydraulic consultants

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April 28, 2021

Upper Fraser Fisheries Conservation Alliance
298A Mission Road
Williams Lake, BC
V2G 5K9

Attention: **Andrea Sterling, RPBio**
Via email: Andrea@sabiology.ca

Re: **Endako River Weir**
Preliminary Dam Consequence Assessment - Rev. 1

1 Summary

Northwest Hydraulic Consultants Ltd. (NHC) has conducted a preliminary dam consequence assessment of the proposed Endako River Weir in response to the request by the Upper Fraser Fisheries Conservation Alliance (UFFCA).

Our assessment show that the consequences of a sudden failure of the proposed weir at the outlet of Burns Lake are low. This classification is based on a sunny-day failure worst-case scenario, where a full dam breach at a water level of 0.75 m above the current lake invert induces a rapid increase in outflow, estimated at 7.9 m^3/s, from Burns Lake on the Endako River.

This increase in outflow is maximal at the proposed location of the dam and translates downstream, attenuating and reducing in discharge downstream. For reference, the 2-year and 5-year estimated flood discharges at the proposed dam location are 33 m^3/s and 49 m^3/s respectively (NHC, 2021)

The increase in outflow from the worst-case scenario breach investigated in this study is unlikely cause loss-of-life or impact environmental and cultural values. The primary Infrastructure and economic losses will be limited to the weir structure and structure owners.

The remaining sections of this memo summarize the methodology used, findings and basis of the preliminary assessment.

2 Background

The Endako River discharges from Burns Lake and flows for 85 km before becoming tributary joining the Stellako River and discharging to Fraser Lake. The Endako River is highly sinuous (S = 1.8 to 2.0) with a low channel slope of approximately 0.03%. There is a relatively wide floodplain with numerous cut-offs and oxbows. The planform suggest a relatively low sediment supply and slow meander translation.

The proposed Endako River Weir is located at the outlet of Burns Lake, shown in **Figure 2.1**, immediately south of the Babine Forest Products Ltd. mill site.

Figure 2.1 Location of proposed control structure (base image Google Earth, 2021)

The Yellowhead Highway (Highway 16) runs parallel to the river on the north side from the outlet of Burns Lake to Fraser Lake and there are several highway and CN Rail crossings that span the river. The watershed is utilised for agriculture and forestry, with high licensed demand for summer irrigation, as well as industrial demand year-round (Department of Fisheries and Oceans, 1995).

Urban development is concentrated in small communities throughout the watershed and includes the Village of Burns Lake, Endako, and Fraser Lake.

A summary of the attributes of the Endako weir and Burns Lake is shown in Table 2.1 below.

Table 2.1 Endako weir and reservoir

Weir	
Location	Near Sheraton, BC, at the outlet of Burns Lake
Coordinates	54° 10' 38.3720" N, 125° 29' 16.1865" W
Purpose	Conservation: storage in Burns Lake to increase downstream Endako River flows during the summer / fall period
Status	Detailed design under review
Type of Dam	Rock-fill/earth-fill weir
Dam Failure Consequence Classification	NHC preliminary assessment: Low
Height	0.7 m above assumed lake invert elevation of 698.1 m
Crest Length	42 m, curved upstream

Crest Width	Approximately 1 m
Base Width	Approximately 6 m
Reservoir (Burns Lake)	
Surface Area	11,800,000 m^2
Total Storage Capacity[1]	8,850,000 m^3
Reservoir (Lake) Length	22
Reservoir (Lake) Perimeter	72 km

3 METHODOLOGY

NHC reviewed the methodology of the Dam Safety Program outlined in Estimating Dam Break Downstream Inundation (BC MFLNRO, 2016) and Downstream Consequence of Failure Classification Interpretation Guideline (BC MFLNRO, 2017), prepared by the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO).

Empirical formulas are used to estimate the dam breach parameters: volume of material eroded, breach width, and breach peak discharge. Hydrograph attenuation curves show the peak flow reduction for channel slopes of 5%, 2%, 0.5%, and 0.1% with reservoir storage from 10 to 2000 ac-ft (approximately 12,000 to 2,467,000 m^3).

Flood-induced failures and sunny-day failures are the recommended dam consequence scenarios to evaluate.

Because the Endako River has a very low slope and the proposed weir structure has a live storage volume greater than 2,000 ac-ft (8,850,000 m^3), the methodology outlined by MFLNRO documentation is not suitable to assess the downstream inundation from a sudden breach of the Endako River weir.

NHC proposes to use the existing hydraulic analysis developed specific to the proposed structure to provide a more accurate assessment of the breach hydraulics than those provided by the guidance documentation.

The proposed methodology uses the historic and new rating curves (i.e., before and after the weir structure is in place) developed in the 1D HEC-RAS model to evaluate the greatest difference in lake elevations and resulting outflows from Burns Lake as a basis for determining the worst-case dam breach scenario.

Discharge greater than 20 m^3/s from Burns Lake are largely unaffected by the weir because it is designed to increase low flows in summer / fall and have little impact on maximum surface water elevations on the Burns Lake. At higher flows, the weir becomes submerged, and the lake control moves further downstream.

Inspection of the historic and new rating curves (**Figure 3.1**) clearly shows that at high flows, a dam failure will have little change in the lake water surface elevation and discharge.

[1] The total storage capacity is based on the sunny-day failure water level of 0.75 m above the existing lake invert of Burns Lake.

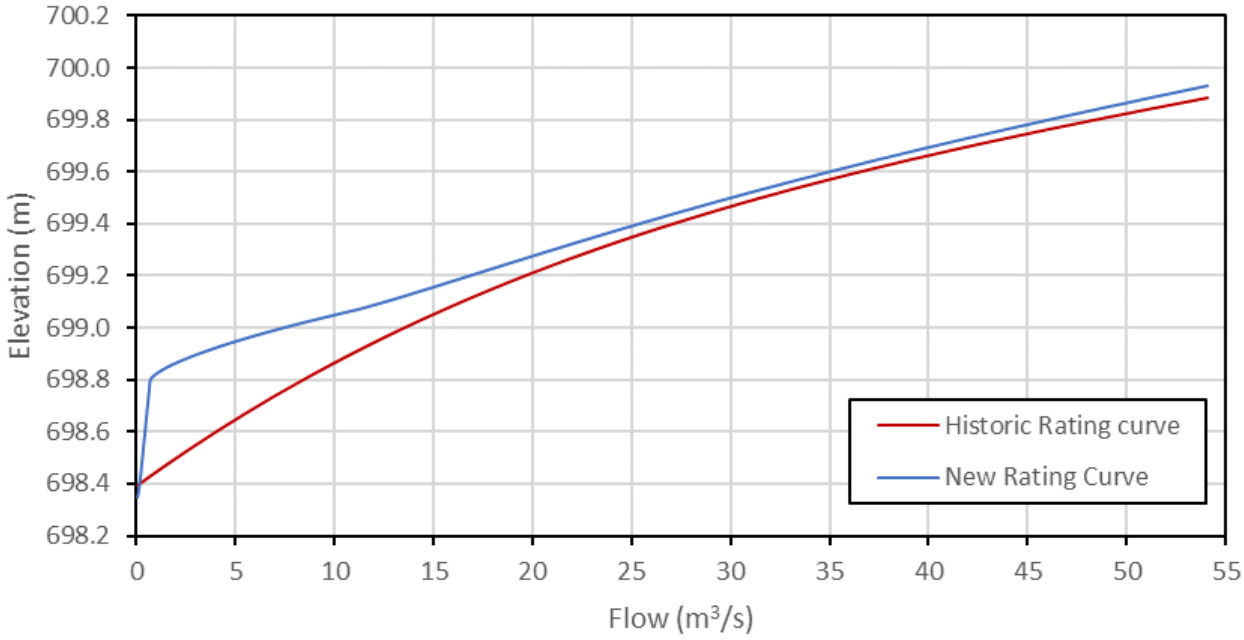


Figure 3.1 Historic and new rating curve at the location of the Endako weir and fishway at the outlet of Burns Lake

A sunny-day failure, where the weir breaches during normal operations and lower flows, will have the greatest impact on the system and is the scenario that is investigated in this study. This approach assumes that in an instant, the Endako weir is fully breached and eroded, in which case lake outflows revert to historic outflows observed in the existing river channel and the historic rating curve.

4 Sunny-Day Failure

4.1 Water Level

In comparing the new rating curve of the weir and fishway to the historic rating curve from the observed period of record (Water Survey Canada gauge 08JB012), the greatest difference in lake outflow occurs at a lake elevation of 698.85 m, or 0.75 m above the existing lake invert. At this lake level, the discharge through the weir and fishway is 1.57 m^3/s (Base Flow) and the historic discharge is 9.45 m^3/s (Breach Flow).

In a sunny-day failure at this water level, the discharge from the lake would increase by 7.88 m^3/s. The change in flow is shown in **Figure 4.1** as the dam breach would cause the stage discharge relationship to change from the new rating curve to the historic rating curve.

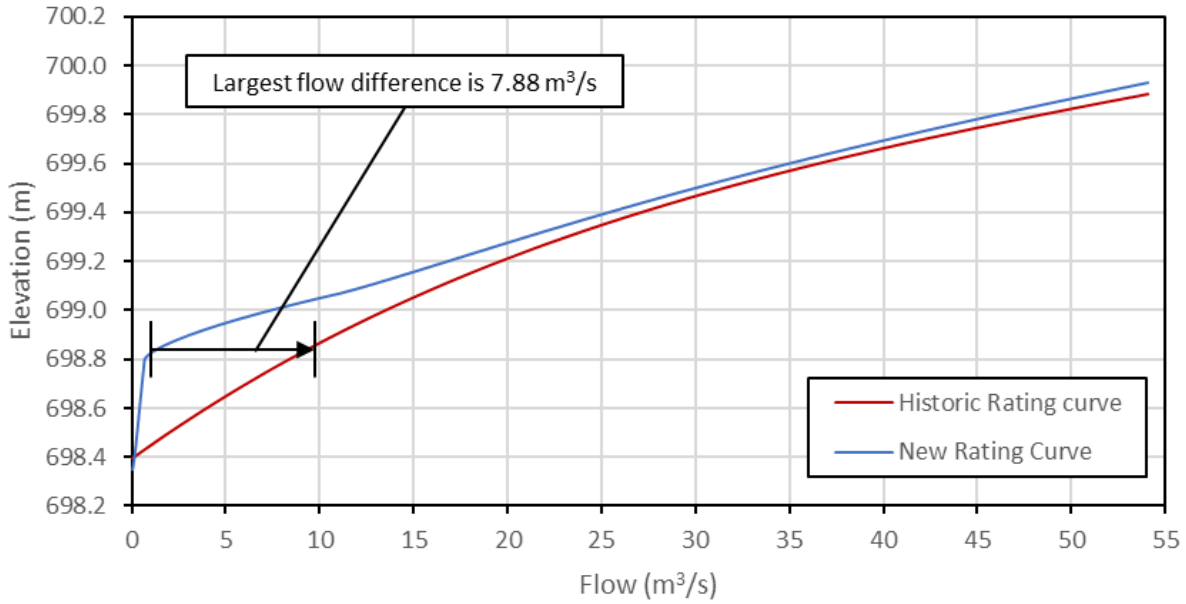


Figure 4.1 The new rating curve of the weir and fishway, and the historic rating curve of the existing channel

4.2 Breach Hydrograph

With a lake surface area of 1,180 ha, the volume of reservoir storage during the dam failure would be approximate live storage in Burns Lake: 8,850,000 m^3. Assuming no inflows to the system, at a discharge of 9.45 m^3/s, outflows would take approximately 264 hours (11 days) to return to base flow, as shown in the breach hydrograph in **Figure 4.2**. The mild slope of the river reduces hydraulic head and travel time, which results in a relatively slow attenuation of the breach flow downstream.

It is important to note that the Endako River also has significant channel storage. At an estimated length of 85 km, average width of 20 m, and average depth of 1.5 m, storage in the Endako River is approximately 2,550,000 m^3. As the Breach Flow meanders downstream, water is stored in the river and the magnitude of the breach is dissipated.

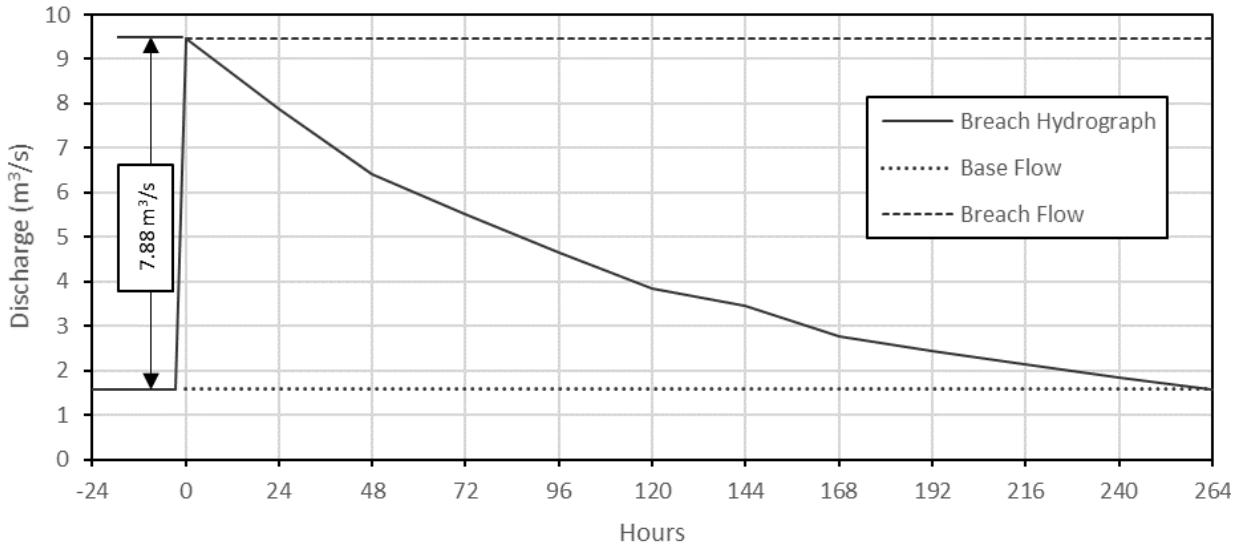


Figure 4.2 Breach hydrograph

4.3 Downstream Inundation

Cross sections of the Endako River at 185 m and 218 m downstream of Burns Lake were used to estimate the change in depth during the dam breach. Depths at the downstream cross sections rose by 0.27 m and 0.37 m, respectively (**Table 4.1**). For a more conservative evaluation, a factor of safety (FOS) of 2 was applied to the increase in flow. For the estimated breach flow with an FOS, depths at the downstream cross sections rose by 0.49 m and 0.65 m, respectively.

Table 4.1 Change in depth at the downstream cross sections during the worst-case scenario dam breach

Approximate Distance of Downstream Cross Section	Breach Type	Breach Flow Water Level	Base Flow Water Level	Change in Depth
m		m	m	m
185	Breach Flow	698.04	697.77	0.27
	Breach Flow with FOS	698.26		0.49
218	Breach Flow	697.87	697.50	0.37
	Breach Flow with FOS	698.16		0.65

As a final check, the change in lake discharge and river depths downstream during the estimated 200-year flood were evaluated. If the weir were to fully breach during a 200-year flood, depths at the cross sections 185 m and 218 m downstream would rise by 0.08 m and 0.07 m respectively.

5 Consequence Classification

5.1 Consequences of Failure

Downstream inundation from the sunny-day failure is minimal. The changes to the river hydraulics are not significant with a full dam breach of the Endako weir. Even though the potential for loss of life depends on many factors, the consequence of breaching and eroding the entirety of the 0.7 m high weir is unlikely to cause Loss of Life (LOL) or put any Population at Risk (PAR). People that could be at risk are temporary populations that may be directly downstream of the weir for some unknown reason at the time of the breach. Permanent populations are unlikely to be at risk.

Environmental and cultural values are also unlikely to be affected by a Breach Flow. For perspective, a Breach Flow of 9.45 m^3/s is less than 1/3 the magnitude of a 2-year flood event. Every year the Endako River experiences flows greater than 9.45 m^3/s.

The hazard to roads and railways is also trivial. Highway 16 is classified as a National Highway System (NHS) (Province of British Columbia, 2014). Most high valued highways and railway lines, such as Highway 16 and CN Rail, are designed to withstand a 200-year flood event. The flows expected in the sunny-day failure would be far less than what Highway 16 and the CN Rail are designed to withstand. Infrastructure and economic losses would be limited to the weir structure and owner, respectively.

6 Conclusion

The Endako River weir and fishway structure falls outside the bounds outlined in the MFLNRO Dam Safety Program documents, Estimating Dam Break Downstream Inundation (2016) and Downstream Consequence of Failure Classification Interpretation Guideline (2017). Because the river slope is very mild and the storage volume is very large, the peak discharge methodology and hydrograph attenuation curves are not suitable for estimating the effects of a breach of the Endako weir.

The approach taken by NHC to estimate downstream inundation is specific to the proposed Endako River Weir at the outlet of Burns Lake. The findings show that the worst-case scenario, with a FOS, would be a 0.65 m rise in water depth 218 m downstream on the Endako River.

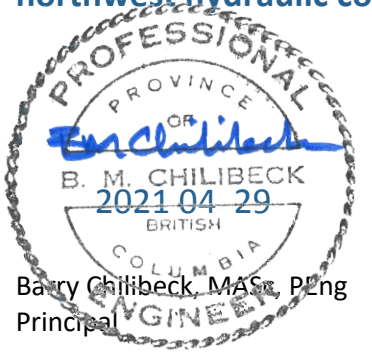
Considering that a breach flow from the weir would have negligible impact to downstream habitat, cultural values, and infrastructure and the unlikely possibility of loss-of-life other than through unforeseen misadventure, NHC would appropriately classify the Endako River weir as having low consequence downstream. This classification is based on the Provincial Dam Safety Regulation classification system under the *Water Sustainability Act* (2016) and the criteria for the various consequence categories are enclosed.

7 Closure

If you have any questions regarding this preliminary dam consequence classification for the proposed Endako River Weir, please do not hesitate to contact us at (604) 980-6011.

Sincerely,

northwest hydraulic consultants



Barry Chilibeck, MASc, PEng
Principal

NOTIFICATION

This report has been prepared by **Northwest Hydraulic Consultants Ltd.** for the benefit **Upper Fraser Fisheries Conservation Alliance** for specific application to the **Endako River Weir Preliminary Dam Consequence Assessment**. The information and data contained herein represent **Northwest Hydraulic Consultants Ltd.** best professional judgment in light of the knowledge and information available to **Northwest Hydraulic Consultants Ltd.** at the time of preparation and was prepared in accordance with generally accepted engineering practices. Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by **Upper Fraser Fisheries Conservation Alliance**, its officers and employees**. Northwest Hydraulic Consultants Ltd.** denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents.

8 References

BC MFLNRO (2016). *Estimating Dam Break Downstream Inundation*.

BC MFLNRO (2017). *Downstream Consequence of Failure Classification Interpretation Guideline*.

Department of Fisheries and Oceans (1995). *Salmon Watershed Planning Profiles for the Fraser Basin withing the Vanderhoof Land and Resource Management Plan*. 82 pp.

NHC. 2021. Endako River Weir Detailed Design Report. Prepared for Upper Fraser Fisheries Conservation Alliance. April 16, 2021. 31 pp.

Province of British Columbia (2014). *Overview of B.C. Highway Functional Classification*.

Error! Reference source not found. Downstream Consequence Classification Schedule 1 (BC MFLNRO, 2017)

Dam Failure Consequences Classification[A]	Population at Risk	Consequences of Failure[B]		
		Loss of Life	Environment and Cultural Values	Infrastructure and Economics
Low	None [1]	There is no possibility of loss of life other than through unforeseeable misadventure.	Minimal short-term loss or deterioration and no long-term loss or deterioration of: (a) fisheries habitat or wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance.	Minimal economic losses mostly limited to the dam owner's property, with virtually no pre-existing potential for development within the dam inundation zone.
Significant	Temporary only [2]	Low potential for multiple loss of life.	No Significant loss or deterioration of: (a) important fisheries habitat or important wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance, and restoration or compensation in kind is highly possible.	Low economic losses affecting limited infrastructure and residential buildings, public transportation or services or commercial facilities, or some destruction of or damage to locations used occasionally and irregularly for temporary purposes.
High	Permanent [3]	10 or fewer	Significant loss or deterioration of: (a) important fisheries habitat or important wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance, and restoration or compensation in kind is highly possible.	High economic losses affecting infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to scattered residential buildings.
Very high	Permanent [3]	100 or fewer	Significant loss or deterioration of: (a) critical fisheries habitat or critical wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance, and restoration or compensation in kind is possible but impractical.	Very high economic losses affecting important infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to residential areas.
Extreme	Permanent [3]	More than 100	Major loss or deterioration of: (a) critical fisheries habitat or critical wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance, and restoration or compensation in kind is impossible.	Extremely high economic losses affecting critical infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to residential areas.

Dam Failure Consequences Classification[A]	Population at Risk	Consequences of Failure[B]		
		Loss of Life	Environment and Cultural Values	Infrastructure and Economics

[A] Under the provincial Dam Regulation, "consequence of failure" is defined as losses or damages that are caused by a failure of a dam

[B] Under the provincial Dam Regulation, "failure" in relation to a dam means an uncontrolled release of all or part of the water impounded by the dam, whether or not caused by a collapse of the dam

1 There is no identifiable population at risk.

2 People are only occasionally and irregularly in the dam-breach inundation zone, for example stopping temporarily, passing through on transportation routes or participating in recreational activities.

3 The population at risk is ordinarily or regularly located in the dam-breach inundation zone, whether to live, work or recreate.