BRITISH COLUMBIA

COLUMBIA RIVER TREATY REVIEW

Objectives and Performance Measures

Kootenay System Status Summaries

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Introduction

The following objectives and performance measures have been developed to support the analyses of potential impacts to stakeholders for several water management alternatives for the Kootenay River system. Summaries of modelled operating alternatives are as follows:

Scenario 1 – Current Libby operating regime - VarQ flood control regime and discharges for fish based on latest U.S. Endangered Species Act objectives for sturgeon, bull trout, and salmon

Scenario 2 – "Pre-1993" Libby operating regime – Standard flood control regime, discharges optimized for flood control and power in both countries

Scenarios 3(a)&(b) – Early refill of Koocanusa Reservoir – Current Libby operating regime, adjusted to target refill of Koocanusa by (a) 1 June and (b) 30 June

The purpose of this analysis is to respond to stakeholder requests to better understand the potential consequences of water management changes for the Kootenay system. This preliminary analysis will support discussions surrounding the Columbia Treaty Review. However, it must be emphasized that Kootenay River system water management is affected, to a large extent, by U.S. decisions on Libby operating objectives for flood control and downstream fish.

There are a range of issues that could be affected by operational changes that are not reflected to date in performance measures. These include:

- Fish impacts other than for kokanee
- Lake productivities (phosporous and mysis)
- Impacts for Duncan reservoir and river

Duncan impacts are not discussed here because Duncan operations are largely independent and have been studied at length during the Duncan Water Use Plan process (2001-07). Further measures for other fish and wildlife and productivity issues may follow at a later point.

Lake Koocanusa: Angler Days

Location	Lake Koocanusa
Objective	Recreation / Fish
Sub-Objective	Angling Effort
Performance Measure	Angler Days
Calculation Summary	Angler Days between between May 1 and Sept 15 using an empirically-derived relationship between reservoir elevation and kokanee length
Directionality	Higher is better
Source	Eric Parkinson (former Ministry of Environment Scientist)

Description

Kokanee account for 98% of the recreational harvest of Koocanusa reservoir. Parkinson (2012) has developed an empirical relationship relating angling days for kokanee in the Canadian portion of Koocanusa reservoir to kokanee length and reservoir elevation. When the elevation is high there is more fishing effort, and at very low elevations there is little reservoir area remaining in Canada for fishing. The reservoir is typically drawn down by about 100' (30 m) by the beginning of May (elevation 2360' (719.3m)). In most years, the reservoir reaches near full pool (2459' (749.5 m)) sometime in July. At full pool, the reservoir is 145 km long and extends 77 km into Canada. Anglers start fishing at about 2420'

(737.6m) but the reservoir is not fully fishable until 2435' (742.2m) at approximately June 30 because of high sediment concentrations from the slowly submerging mudflats. Kokanee move out of the reservoir in early September, resulting in a 2-month season that can support up to 25,000 angler-days/year.

Calculation Summary

Parkinson (2012) describes a rule curve for angler days vs. filling date for Koocanusa reservoir. Effort is calculated as:

Effort (Angler Days) = Days* (112.5 + 4.7*(0.824 * Len - 189)) = 328 * Days

Where Days is the number of days with elevation > 2440 ft between May 1 & Sept 15. [A kokanee length of 285 mm (avg length of kokanee caught , 1988-2007) is assumed.]

Lake Koocanusa: Preferred Elevation Days

Location	Lake Koocanusa
Objective	Recreation, private property
Sub-Objective	Aesthetics, beach access and dust prevention
Performance Measure	Preferred Elevation Days
Calculation Summary	Days in range, 2445'(745.2m)-2455'(748.3m), Victoria Day to Labour Day
Directionality	Higher is better
Source	Columbia Basin Trust (2004)

Description

CBT (2004) found that a range of recreation stakeholders generally preferred a reservoir level range of 2445' (745.2m) - 2455' (748.3m), Victoria Day – Labour Day. This preferred range incorporates several negative factors that emerge at lower elevations, including the emergence of sand bars, the potential for dust mobilization during wind storms, and unpleasant aesthetics. Negative effects from high reservoir levels begin approximately 4 feet (1.2m) below the full pool mark of 2459' (749.5m).

Boat access is considered as a separate performance measure for this analysis.

Calculation Summary

Preferred elevation days are calculated as the number of days when the reservoir level is within the range 2445' (745.2m) - 2455' (748.3m) during the 1 May to 30 September period. A higher number of days counted in this range is better.

Lake Koocanusa: Boat Access Days

Location	Lake Koocanusa
Objective	Recreation
Sub-Objective	Boat Access
Performance Measure	Boat Access Days
Calculation Summary	Days above 2407.15’ (733.7m)
Directionality	Higher is better
Source	BC Hydro Engineering (Technical memo)

Description

A new boat ramp, constructed in 2011 adjacent to the Kikomun Bridge, is usable for reservoir levels down to 2407.15’ (733.7m). Since the boat ramp was constructed only in 2011, there is not yet enough data to ascertain how heavily the ramp is used – feedback on this issue would be valuable.

Calculation Summary

Boat access days will be calculated as the number days above 2407.15' (733.7m) from 1 May to 30 September. A higher number of days counted in this range is better.

Lake Koocanusa: Flooding Metre-Days

Location	Lake Koocanusa
Objective	Vegetation and Wildlife
Sub-Objective	Flooded vegetation
Performance Measure	Flooding Metre-Days
Calculation Summary	Number of metre-days below full pool (2459', or 749.5m) April 15 – Oct 15
Directionality	Higher is better
Source	Technical advisory meeting, Creston 2012

Description

This area has not been studied as extensively as others in the Kootenay and Columbia systems, and so data is relatively sparse. Pre-impoundment maps (Ketcheson 2005) show a floodplain vegetation community (cottonwood and wetland) extending well below the current full pool elevation. These areas now have compromised wildlife values because they are underwater for prolonged periods. When they are exposed, the substrate is mud and sand.

Reducing the period of inundation during the growing season at the Kootenay-Koocanusa confluence (near full pool) would very likely produce a similar community to that observed in the Revelstoke Reach of the upper Arrow Reservoir. Surveys of tributary confluences in this area (Sand Ck, Elk River, Gold Ck) would provide a good picture of what could be obtained. Thus, strategies which do not fill Koocanusa to full pool, and limit flooding to 8-10 weeks at lower elevations during the growing season, will likely achieve the desired vegetation objective.

Calculation Summary

The number of metre-days below full pool from April 15 – October 15 is a coarse, draft measure. A more sophisticated measure that captures the more complex flooding-vegetation dynamic maybe desirable at a future point. The higher the number of metre-days below full pool the better.

Kootenay Lake – Creston Valley Floodplain: Preferred Operational Days

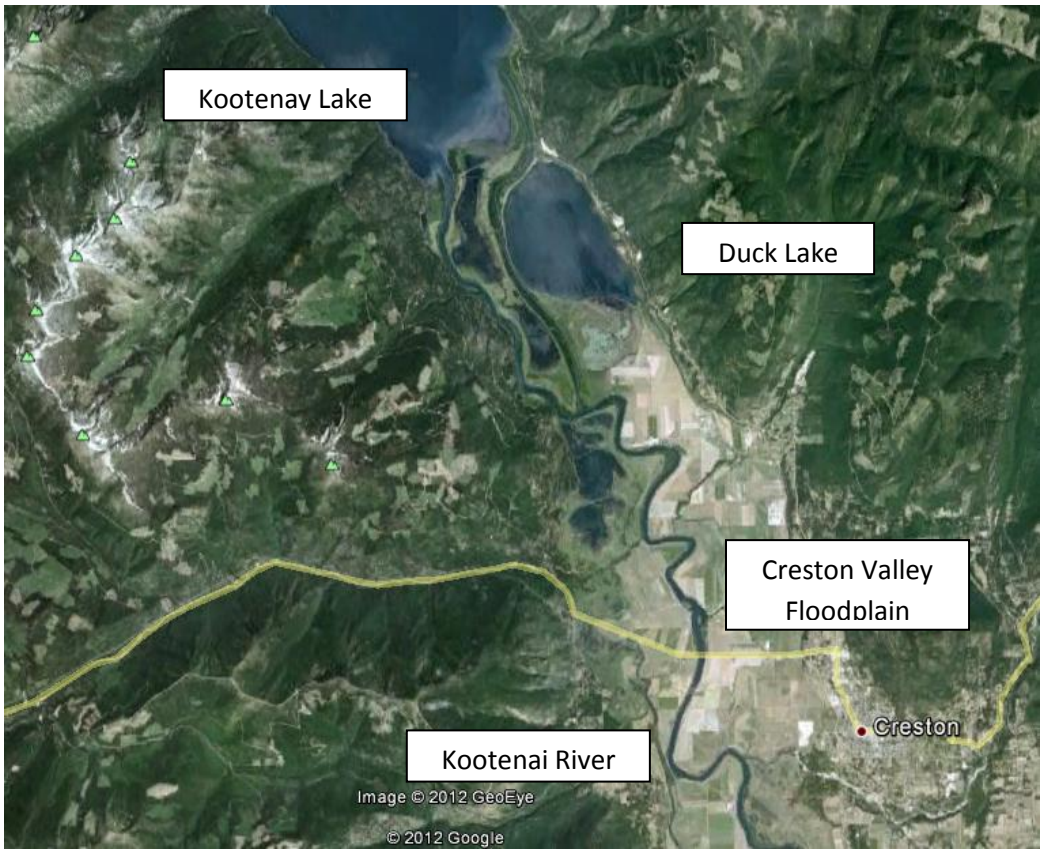
Location	Kootenay Lake - Creston Valley Floodplain
Objective	Farming and Wetland Protection
Sub-Objective	Floodplain Management Operations – Water Pumping
Performance Measure	Preferred Operational Days
Calculation Summary	Number of Days below 1750' (533.4m) 1 Jan to 15 June
Directionality	Higher is better
Source	Technical advisory meeting, Creston 2012

Description

Prior to dyking and impoundment, the Creston Valley was a very large wetland with a healthy and large kokanee population (Goat Creek) and other fish species (sturgeon, burbot, etc). The area is currently managed for farming (Kootenay Indian Reserve) and wildlife (Creston Valley Wildlife Area or CVWA). In farmed areas, the key is to drain fields in June so farmers can plant the hay crop. Wildlife areas in the CVWA are managed for different species (e.g. Duck Lake for waterfowl and leopard frog). Inundation of these dyked-off floodplain areas is controlled by gravity drainage when the Kootenay River level is low enough, and by pumping when the river levels are higher. River elevations adjacent to these areas are controlled by the combined backwater effect of Kootenay Lake (which depends on lake elevation) and flow in the Kootenay River. High water elevations in June and July make it more costly, difficult, or impossible to drain dyked-off areas of floodplain that are inundated by local inflows. In some years when water elevations are low these areas can be drained mostly by gravity (little cost). In years with higher river levels or greater local inflows these areas can be drained using pumps, but this increases costs and not all areas currently have the infrastructure to do this. In years with high local runoff and high water elevations it is not possible to drain all areas to meet wildlife and farming objectives given the current infrastructure. In high water years such as 2012, some dyked-off areas such as Leach Lake could not be drained due to concerns about dyke integrity (must limit the extent of head differences between the river and dyked-off areas or the dykes could fail).

Calculation Summary

CBT (2004) found that a wide range of recreational, commercial and ecological interests would be captured by the preferred elevation levels of 1744’ (531.6m) to 1746’ (532.2m) measured at Duck Lake.



Estimating elevations at Duck Lake is beyond the scope of this preliminary survey, for two reasons:

- If unregulated, Duck Lake levels are a function of both Kootenay River flows and Kootenay Lake levels. Although estimates for both of these parameters are available, a detailed hydrological model would be required to calculate elevations at Duck Lake from these inputs. It may be possible to adapt models from other processes (e.g. a recent Creston Valley Floodplain Management Plan), but this was not possible within the time available.
- Duck Lake levels are controlled by a gate between the Duck Lake outlet and Kootenay River. Predictions of Duck Lake levels would also need to assume management responses.

Following a technical meeting including floodplain operators, it was agreed that the number of days with Kootenay Lake level below 1750' (533.4m) prior to mid-June would be a coarse indicator of the implications of system water management choices on floodplain operations. Generally, whenever the Kootenay Lake level is above 1750' (533.4m), the flooplain's system of dykes, gates and pumps becomes more complex and costly to manage. More sophisticated measures may follow if required.

Kootenay Lake-Creston Valley Floodplain: Spring Dry Days

Location	Kootenay Lake - Creston Valley Floodplain
Objective	Farming and Wetland Protection
Sub-Objective	Floodplain Management Operations – Equipment Handling
Performance Measure	Spring Dry Days
Calculation Summary	Number of Days below 1739.32' (530.1m) in Kootenay Lake, March – April.
Directionality	Higher is better.
Source	BC Hydro (Kelvin Ketchum)

Description

A second operational performance measure concerns the need for relatively dry farmland during March and April in order to move farming equipment to desired locations. Although pumps may help mitigate the effects of high reservoir levels to some extent, there are costs associated with doing so.

Calculation Summary

The number of days when the Kootenay Lake level is below 1739.32' (530.1m) in March and April will be counted. A higher number of days below this threshold is better.

Kootenay Lake-West Arm: Maximum Daily Elevation Change

Location	Kootenay Lake – West Arm
Objective	Fish / Recreation
Sub-Objective	Kokanee Dewatering
Performance Measure	Maximum Daily Elevation Change
Calculation Summary	Maximum daily change in lake elevation 15 Oct to end of April
Directionality	Lower is better
Source	CRTR Fish and Technical Advisory Committee

Description

Kootenay Lake elevations could influence kokanee incubation survival for shore spawners in the West Arm. Large changes (increases or decreases) in lake elevation within 48 hours are taken as a proxy indicator of the risk of adults spawning in areas that will subsequently be dewatered.

Calculation Summary

This performance measure is calculated by finding the maximum daily change in lake elevation during the period of 15 October to 30 April, averaged over each modelling year. The lower the resulting number, the better for kokanee.

Kootenay Lake: Preferred Recreation Days

Location	Kootenay Lake
Objective	Recreation
Sub-Objective	Spring Recreation
Performance Measure	Preferred Recreation Days
Calculation Summary	Days between 1744' (531.6m) and 1750' (533.4m) in Spring @ Queens Bay
Directionality	Higher is better
Source	CBT (2004)

Description

A wide variety of Spring recreational activities occur on or around Kootenay Lake, including boating, sailing, water-skiing, swimming, fishing (fly, shore, trolling), canoeing/kayaking, and beach use for multiple activities; these were identified in a Columbia Basin Trust study (CBT 2004). A broad range of preferred lake levels, 1740'(530.4m) to 1752'(534m), was identified across a broad range of stakeholder interests. BC Hydro notes that a narrower range of preferred lake levels is more consistent with recent stakeholder feedback; hence the selection of the range, 1744'(531.6m) to 1750'(533.4m), for this analysis.

Calculation Summary

The number of days when Kootenay Lake levels are between 1744' (531.6m) and 1750' (533.4m) between 20 March and 20 June will be counted. A higher number is better.

Kootenay Lake – North End: Cottonwood Restoration Days

Location	Kootenay Lake (north end): Duncan-Lardeau Valley
Objective	Vegetation and Wildlife
Sub-Objective	Cottonwood Recruitment
Performance Measure	Cottonwood Restoration Days
Calculation Summary	Days above 1748.8' (533m)
Directionality	Higher is better
Source	Technical advisory meeting, Creston 2012

Description

Prior to impoundments, this confluence area used to consist of early seral habitats which included a community made up of sedge, grasses, and low density wood shurbs at lower elevations, and a cottonwood community at higher elevations (see Ketcheson 2005 mapping report for Krebs/MoE). Impoundment resulted in reduced peak Kootenay Lake levels and reduced peak discharges from the Duncan system. This stabilized water levels in the Duncan-Lardeau Valley, which allowed the vegetation community to evolve into one dominated by very dense stands of wood shrubs and reduced

cottonwood recruitment. This latter community is considered to have much reduced values for wildlife. Dense stands of woody shrubs have limited values for waterfowl and shorebirds during their migrations (stopover and feeding use). Cottonwoods form important habitats for many bird, bat, and insect species, and current community is dominated by very old, senescent stands and there are no younger cottonwoods lower in the floodplain (as existed historically).

Increasing the seasonal pattern of flooding could help restore the vegetation community. In particular, higher Kootenay Lake levels during the freshet, followed by a naturally declining rate of freshet are required. Four to six (or more) weeks of flooding into the range, 1748.7'(533m) to 1752'(534m), would be required. There is some uncertainty about how long the inundation period would need to be to reduce the density of wood shrubs (perhaps up to 10 weeks). The timing and rate of decline in high water levels must be aligned with the timing and rate required to establish cottonwood seedlings. High water events do not need to occur every year; a one in five year schedule may be sufficient.

Calculation Summary

As a coarse measure, the number of days above elevation 1748.6 ft (533 m) will be reported. A refined measure, perhaps reporting the frequency of occasions when the lake level exceeds 1748.7' (533m) for more than 6 or 10 weeks may be preferred ultimately, since short periods of flooding may have no benefit (woody vegetation can withstand some flooding).

Kootenay Lake: High Water Alert Days

Location	Kootenay Lake
Objective	Flooding
Sub-Objective	Flooding
Performance Measure	High Water Alert Days
Calculation Summary	Days above 1751' (533.7m)
Directionality	Lower is better
Source	CBT (2004)

Description

In 1974, the level of Kootenay Lake peaked at 1754.24'(534.7 m) and resulted in significant flooding damage around the lake. In June 2012, the lake level reached 1753.8' (534.6 m), resulting in flooding damage of approximately $3 to $5 million and considerable local media coverage.

Calculation Summary

The high lake alert elevation is 1751' (533.7m). This performance measure will count the days Kootenay Lake is expected to exceed this threshold. The lower the number, the better.

Kootenay River: Wetland Habitat Loss

Location	Kootenay River
Objective	Multiple Environmental Objectives
Sub-Objective	Riverbird Creek Wetland Habitat
Performance Measure	Wetland habitat lost (ha)
Calculation Summary	Area calculated as a function of Corra Linn dam spills
Directionality	Lower is better
Source	BC Hydro (James Bruce)

Description

A high value wetland habitat exists immediately downstream of Corra Linn Dam on the Kootenay River. This wetland is comprised of a variety of habitat types that are used by a broad variety of obligate and facultative aquatic animals. The flood-affected wetland and pond habitats total 7.92 ha with maximum generation at Corra Linn Dam. During periods of spill at Corra Linn, this wetland area is at risk of inundation. As spills approach 63,500 cfs (1800 m3/s), the wetland habitat becomes fully inundated and no further impact occurs (other than the potential for erosion). Animals at greatest risk when the wetland is inundated are nesting birds, which either lose potential nesting sites or have their nests flooded out (potentially losing their chicks).

Calculation Summary

From a series of habitat surveys carried out in the summer of 2012, wetland habitat inundation can be approximated using the following linear equation:

Wetland habitat lost (ha)	= 7.92* Q_SpillCorraLinn/1800	if Q_SpillCorraLinn < 1800 m3/s
	= 7.92	if Q_SpillCorraLinn ≥ 1800 m3/s

It is assumed that the greater the magnitude, duration and frequency of wetland habitat inundation, the greater the impact on wetland vegetation and wildlife. For the purposes of this performance measure, it is also assumed that wetland vegetation and wildlife risk is highest from April 1 to Oct 30.

It is assumed that, as the number of ha·days of inundated habitat increases, so does the risk to wildlife populations, including changes in wetland habitat structure. Therefore, the metric chosen to evaluate relative differences in wetland inundation risk between flow alternatives is the average number of ha·days of inundated wetland habitat (1 April to 30 Oct) per year.

Kootenay River: Percentage of Saturation Days

Location	Kootenay River
Objective	Fish
Sub-Objective	Total Dissolved Gas
Performance Measure	Percentage of Saturation Days
Calculation Summary	Function that relates TDG to spills at Corra Linn dam
Directionality	Lower is better
Source	BC Hydro

Description

Air supersaturation in water can lead to gas bubble trauma in fish if exposed to gas pressures above 115% saturation. This trauma is the result of bubble formation in tissues that can impair body function (swimming ability, respiration, vision, etc.) and, hence, foraging success or predator avoidance. In vital tissues such as the brain and heart, high gas levels can lead to direct mortality.

The duration of exposure, as well as the frequency of episodic exposure events, has also been shown to be a critical factor governing the degree and extent of gas bubble trauma in fish.

Total gas pressure measurements taken downstream of Slocan Dam have shown that spill discharges at the upper four Kootenay River plants (Corra Linn spill is used as the proxy) can create air supersaturation conditions that exceed the 115% threshold.

Calculation Summary

The relationship between spill and gas supersaturation is linear and is characterised by the following regression equation (assuming full generation at the 4 Kootenay River plants and the Kootenay Canal plant):

% Saturation = 112.4 + 0.01 * Q_SpillCorraLinn (in m3/s) (Max Q_SpillCorra Linn = 2000 m3/s)

The metric to evaluate relative differences in gas bubble trauma risk between flow alternatives is:

- average number of %Sat·Days per year when total dissolved gas exceeds 115% Saturation

(It is assumed that as the number of %Sat·Days increases, so does the risk of gas bubble trauma.)

The %Sat·Days variable was averaged across all years of simulation; other summary statistics are possible.

References

Columbia Basin Trust (2004) *A Stakeholders Summary of Preferred and Potential Negative Reservoir Levels and River Stages on the Kootenay River System in Canada* - Interest Group Response Summary to proposed VarQ Alternative Flood Control Operation.

Parkinson E. (2012) *Reservoir Elevation and Angling Effort on the Canadian Portion of Lake Koocanusa*. Prepared for BC Hydro.