Arrow Reservoir 2024 Options

Columbia River Treaty Review

Fauquier, B.C. June 15, 2013

Eagle Creek confluence, Lower Arrow, Fall 2004

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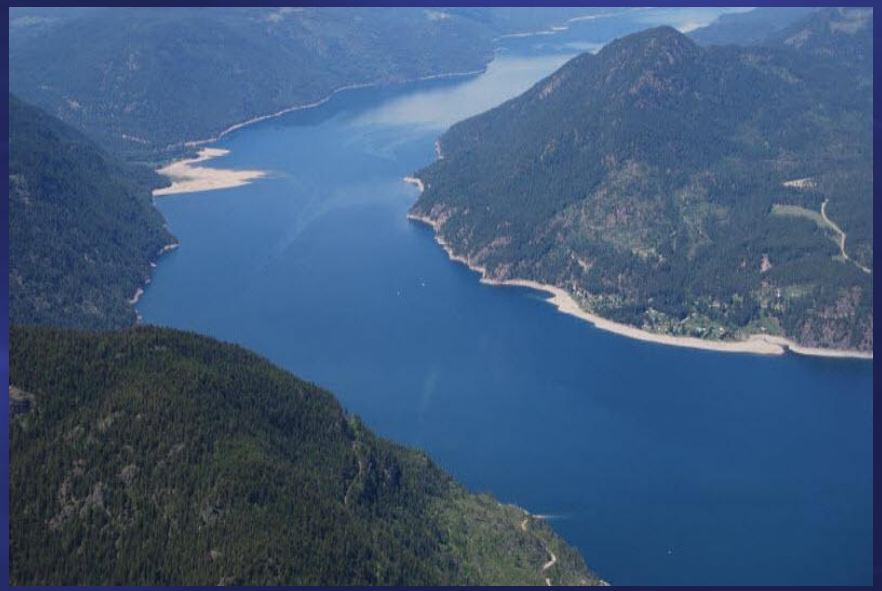
Arrow Reservoir Post 2024

- Context / Framework
- Studies / Assessments
- Reservoir options post 2024
- Questions / Discussion



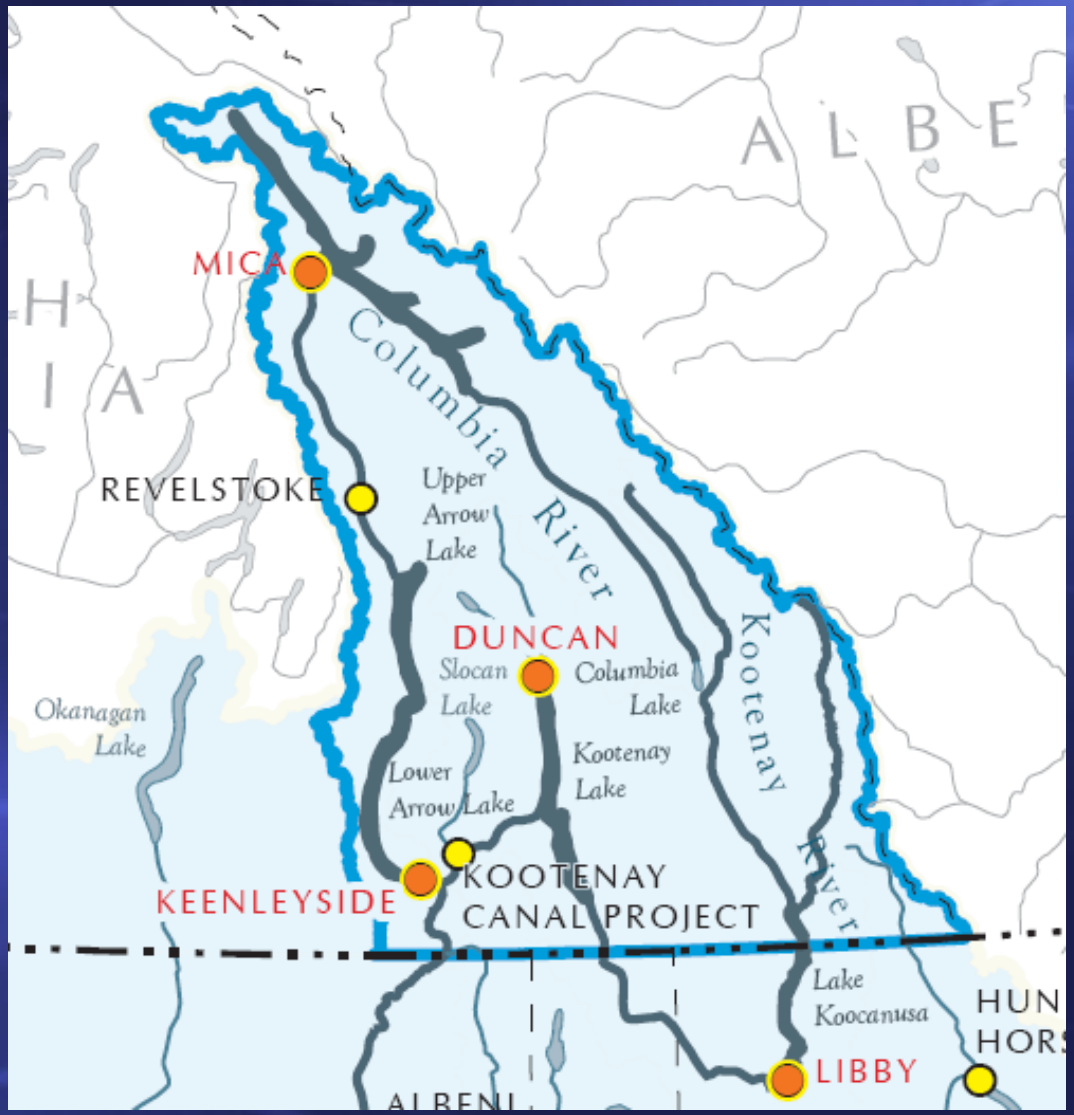
Deer Park Source: Columbia Basin Trust

Context of Discussion is *Everything*
Pieces of the Puzzle - Local and Regional Influences

- Why discuss Arrow? Can we discuss it in isolation of the CR watershed?
- Arrow inside Columbia River Treaty (CRT)
- Arrow Lake reservoir operation;
  - why it acts the way it does;
  - Arrow Lakes Generating Station, HLK dam
- Canadian Entitlement; US and Cdn perspectives
- Water Use Plan and Non Treaty Storage Agreement
- Impacts and Benefits assessments;
  - Comprehensive documentation and current studies.

Canadian side of Columbia R watershed

- 15% of Columbia watershed area
- 35% of water for entire Basin
- Up to 50% of floodwaters
- Three reservoirs total 19.1 km3 of live storage water
- 5,885 MW of installed capacity between Mica, Revelstoke and Arrow.

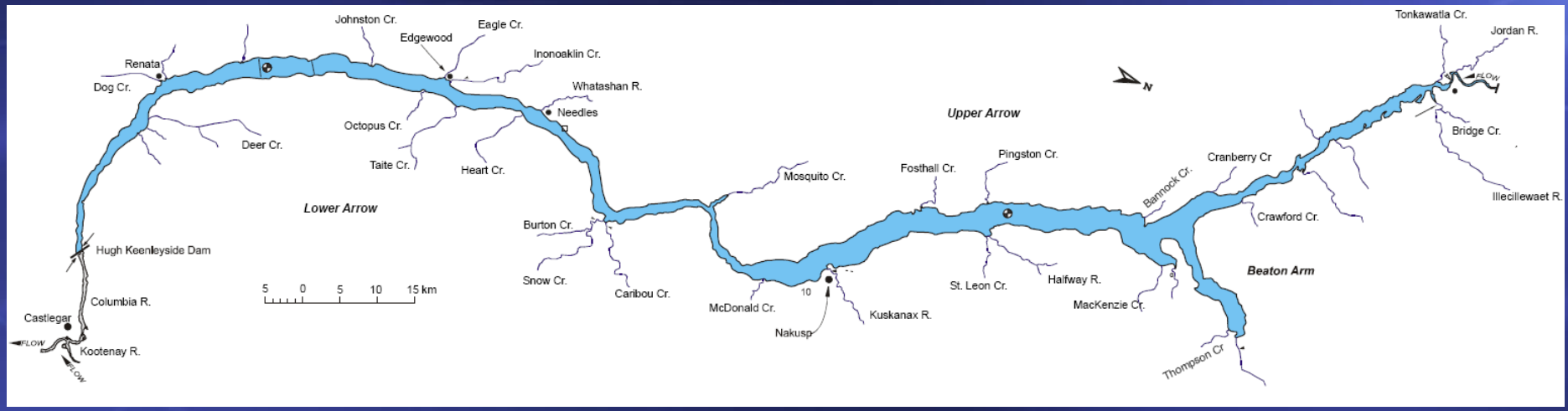


Source: Province of BC, Columbia Treaty Review website

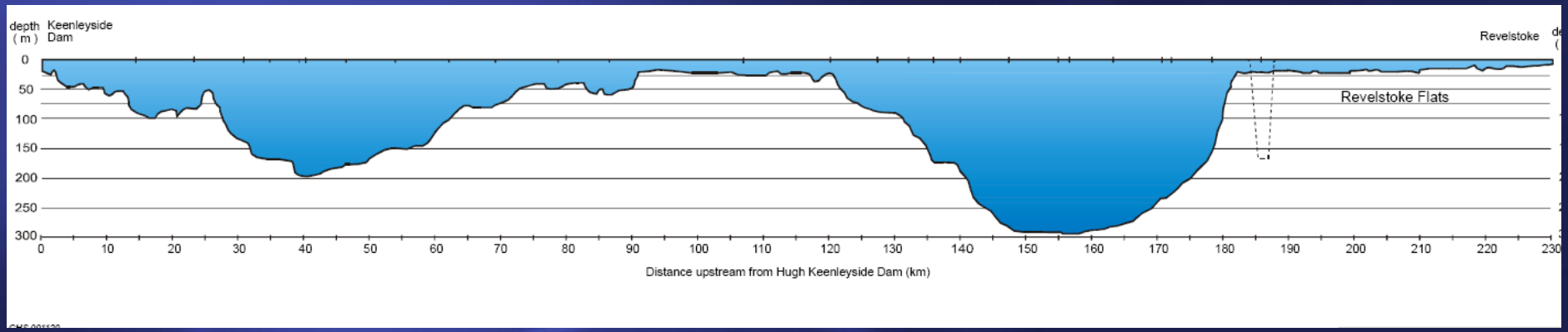
Arrow Lake Numbers

- Length: 240 km
- Area at full pool: 464 km^2
- Live storage of 7.1 M acre-feet or 8.8 km^3
- Drawdown 40-50 ft; up to 66 ft if required
- Area between high and low pool: 19 km^2

Map of Arrow Lakes/Reservoir



Depth Profile of Arrow



Source: Adapted from Schindler *et al*. 2006

Columbia River Treaty and Arrow

- Hugh Keenleyside dam built 1968 primarily for US flood control and to increase/optimize power generation potential both in Canada and US.
- Flood control for Trail and Castlegar.
- Did not foresee or account for water for “soft constraints”
  - First Nations, fish, ecosystem function, irrigation, navigation, etc.
- Handcuffed other uses of Arrow for 60 years.
- BC received various payments and annual Canadian Entitlement.

Why talk about Arrow?

- Importance
  - Operations perspective:
    - Close to the US border; travel time of water between Arrow and US is minimized; within run-off forecasting timeframe
    - Provides a buffer between Mica/Revelstoke and US border; allows for optimizing power generation;
    - Has the greatest potential to change operations post 2024
    - US sees Arrow as key for flood control and providing flexibility in their own system; high value; modeled- full pool
  - Local perspective:
    - Residual discontent with Arrow operation
    - Persistent environmental, socio-economic concerns/costs

CRT: Layers of an Onion

Columbia River Treaty

Assured Operating Plan

Detailed Operating Plan

Treaty Storage Regulation

Weekly Treaty Flow Agreement

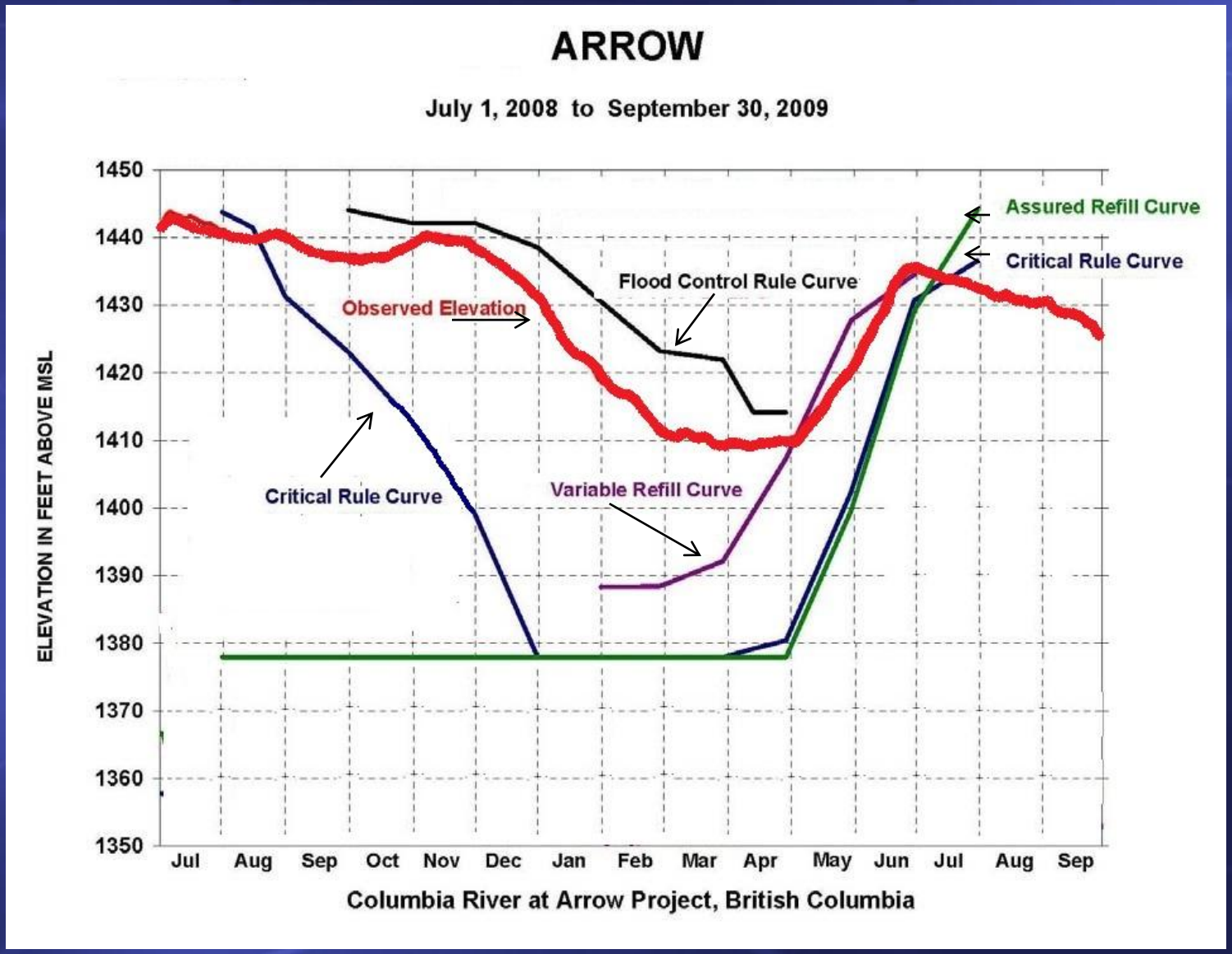
Supplemental Op. Agreements

-NTSA

-Libby Coord. Agreement

= Flow released from Treaty Dams

Treaty directs Arrow Operation



Source: Adapted from Annual Report of the CRT CDN and US Entities for 2008-09

Arrow Lakes Generating Station

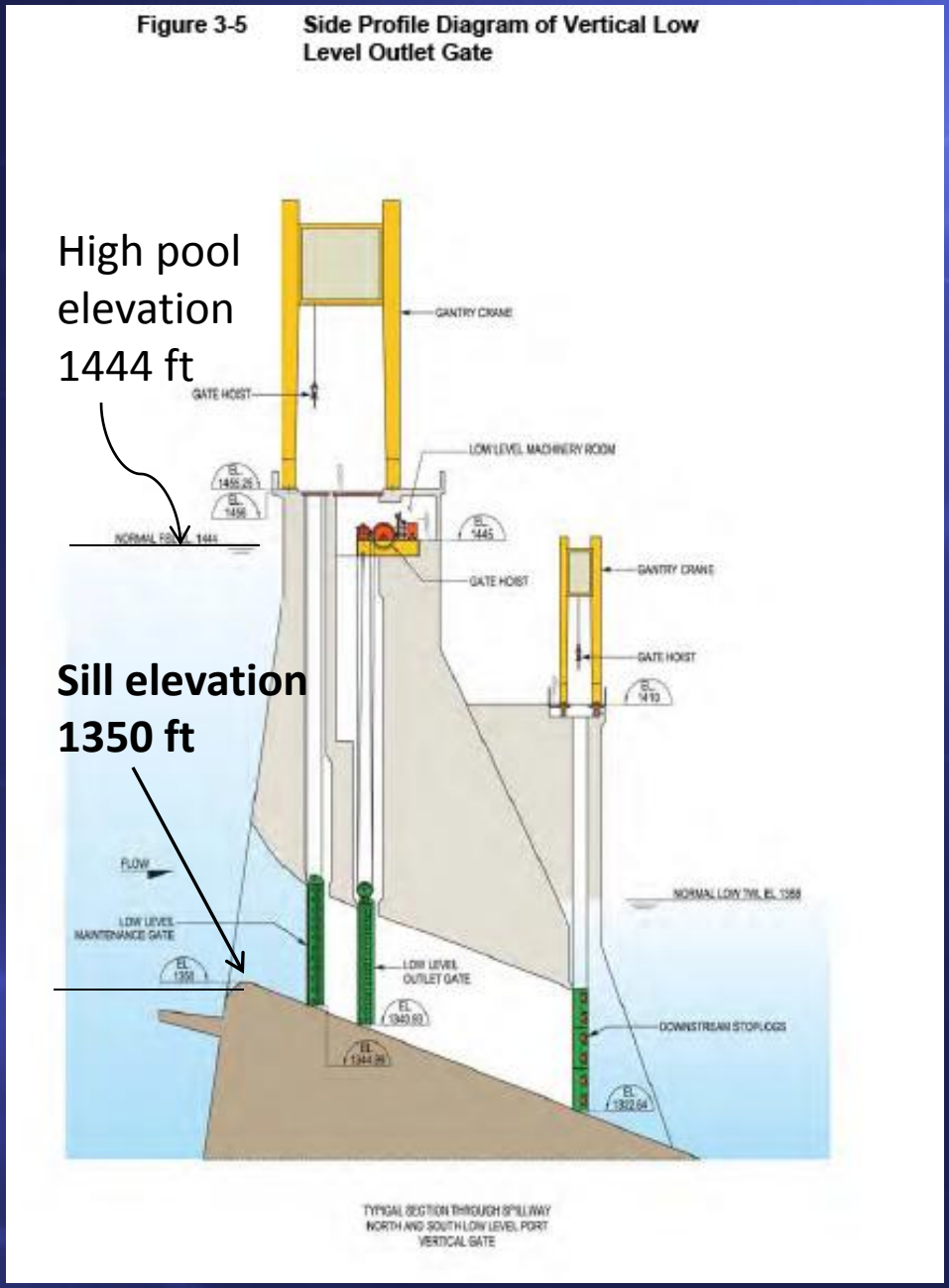
- Commenced generation in 2002
- Cost $270M; 1000 person-years of employment
- Up to 185MW capacity;
- Jointly owned by CPC/CBT, managed by BC Hydro; operated by Fortis.

- Generates power when reservoir between ele. 1395 to 1446 ft.; greater output at higher reservoir elevations.
- Net annual income ~ $14M-$16M excluding Waneta financing costs; EPA with BC Hydro recently signed to 2045.

HLK dam
Low outlet gates

- Minimum drawdown elevation 1350 ft
- Normal max. pool ele. 1444 ft.
- Surcharge to 1446 ft.

- Capable of discharging up to 4,000 m^3/second



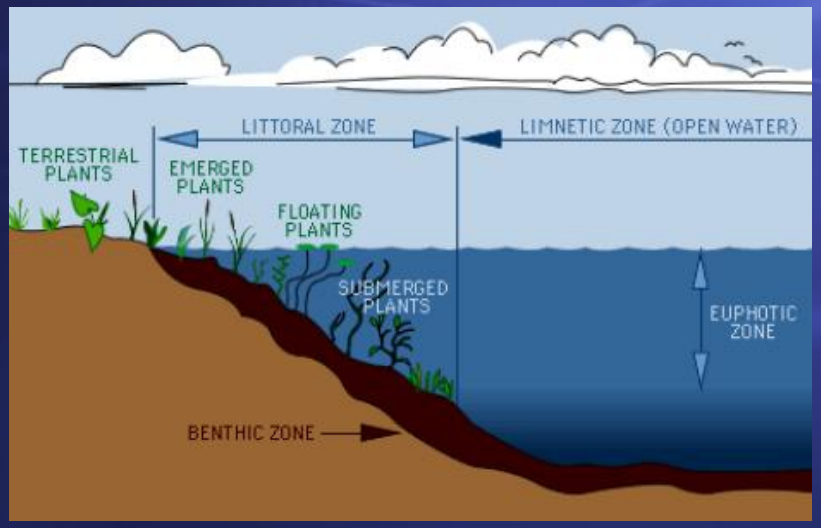
Source: Hugh Keenleyside Spillway Gates Project report July 2010

Impacts and Benefits

- Considerable and persistent impacts. Well documented, studied, understanding somewhat clear, on going monitoring/adjusting; quantitative and qualitative impact assessments.
  - Link most Arrow impacts (environmental and others) back to *fluctuating* water levels, and unnatural drawdown and flood duration/timing.
- Benefits are monetized, quantified.
  - Linked to power generation, employment and Cdn Entitlement.

Impacts – fluctuating water levels

- Aquatic productivity, macrophytes,littoral zone; fish access to spawning streams;
- Recreational Access
- Vegetation loss – Dust
- Cultural sites
- Wildlife; nesting birds
- Aesthetics



Canadian Entitlement

April 2013
United States Entity

U.S. ARMY CORPS OF ENGINEERS • BONNEVILLE POWER ADMINISTRATION

Columbia River Treaty 2014/2024 Review

Canadian Entitlement

What is the Canadian Entitlement and how did it come to be?

Before the Columbia River Treaty, high springtime flows on the Columbia River frequently overwhelmed the ability of the United States' downstream infrastructure to generate power and manage flood risk. The four dams built under the terms of the 1964 Columbia River Treaty (three in Canada and a fourth in Montana) approximately doubled the water

to Canada, has more than repaid the cost to Canada of the three dams over the Treaty's expected minimum life of approximately 60 years (beginning after the last of these dams was completed in 1973).

In other words, the U.S. Entity's view is the Canadian Entitlement and the flood risk management payment were designed to produce a value that reflected an appropriate total payment to Canada for the cost of Treaty dams by the time the Treaty could be terminated in 2024. While the

- BC receives $150-$350 M year;
- US indicates that post 2024 Canadian Entitlement $25-$30 M per year… stay tuned.

" The value of the Entitlement is estimated to be $250-$350 million annually, while the value of the actual benefit realized by U.S. hydro generators is estimated to be $50-70 million. The Power Group is concerned these payments will continue even though the power benefits have significantly decreased."

BC Planning Processes

- Water Use Planning - WUP
  - 2000-2004; flexibility to address “soft constraints” from NTSA and moving water between Kinbasket, Arrow, Duncan and Revelstoke. Must meet total discharge and flood control CRT commitments;
  - WUP › 62 monitoring programs, 25 physical works, $120M over 12 yrs.
  - Revisit in 2020
- Non Treaty Storage Agreement – NTSA – expires 2014

WUP Soft Constraints

Table 2 Soft Constraints on Arrow Lake Reservoir[8]

Interest	Summary of soft constraint
Vegetation	If vegetation showing signs of stress (May-June) target lower reservoir levels in the fall. Preserve vegetation at/above 434 m (1424 ft).
Wildlife	Make sure reservoir levels inundating bird habitat in the early summer is no worse than 1984-1999 statistics. Bird habitat for the fall should be as good or better than 1984-1999 statistics. Draft reservoir quickly after full pool reached - target 438m (1437 ft) (or lower) by 7 Aug.
Fish	Keep levels high enough in fall for tributary access for kokanee spawning (August-November). Levels below 434 m (1424 ft) could cause problems for tributary access.
Recreation	Target reservoir levels between437.4-438.9 m (1435-1440 ft) from 24 May to 30 Sep.
Culture &Heritage	Maintain reservoir levels below 436 m (1430 ft) for all but 2.5 months.
Shoreline Erosion	Minimize duration of full pool events - water levels of 439 m (1440 ft) are ideal. Avoid sudden draw down after full pool.

Post 2024 Arrow Options

- Treaty Continue (TC) – options are constrained
  - Similar to current reservoir operation. Minor operational changes possible that require bilateral agreement.
- Treaty Terminate (TT) – much greater flexibility (view of BC Hydro, BPA)
- Long term view; sustainable (perpetuates itself). 50 year experiment , lots of data, experience. We know enough.

Arrow Post 2024 – Four Options (and variations)

1. Status quo – minor adjustments to operational regime; or smaller reservoir fluctuation › slight variation of status quo.
2. Return to pre-dam condition

   Dam removal › free flowing river + 2 lake system.
3. High el. stable pool (i.e. elevation ~1440-1444 ft)
4. Mid el. stable pool (i.e. elevation ~1425 ft)

Option 1 – Status Quo *or* Smaller but still significant pool fluctuations

McDonald Creek. Source: Columbia Basin Trust

- Sufficient data available to evaluate this option fully.
- Use full cost accounting to assess.

Option 2: Revert to pre-dam conditions 2 Lake system + Revelstoke reach

- Very challenging; unprecedented in scope.
- Reservoir/dam decommissioning is increasingly common in US; typically in run-of river smaller watersheds.
- Drain reservoir; notch HLK dam;
  - BC Hydro Coursier Dam; Revelstoke.
  - Elwha River, Olympic National Park, WA. Largest dam removal project in US.
  - Klamath River CA, OR. 4 dams, 20 months, $450M; salmon stocks expected to rebound; US gov't approval received April 2013.

Glines Canyon Dam, Elwha River, WA. Removal 2012.

210 feet high. Reservoir: 250 hectares

$351 M final cost for removal of 2 dams

Source: National Parks Service

Coursier Dam Decommissioning 2003.

- 19 m high, 685 m long
- Storage of 11,000 acre ft
- Dam safety issue

Figure 5 – Natural revegation of former reservoir above

El 1274 since 1998

Source: Seyers. 2004.

Option 2-Decommissioning issues

- ALGS cease operation ($270M facility); HLK dam, locks deactivated, navigation affected.
- Rehabilitate flooded and drawdown terrestrial and aquatic habitats.
- Infrastructure impacts (roads, ferry, recreational facilities, municipal infrastructure, …etc.)
- Pre-dam 16,277 ha of aquatic and terrestrial areas (minus lakes); total area impacted >51,000 ha
- Productive use (i.e.-agricultural) of reclaimed area very limited in short term (soils are on the lake bottom); reclamation (dredging) possible.
- In the long term similar outcome as Options 3 & 4.

Option 3: Stable High Pool ~1440 ft

- Modeled by BC Hydro, BPA.
- Constant high pool elevation ~1440 ft; moderate drawdown (2-4 ft) in spring to reduce spill (TGP); coordinate discharge with Mica.
- ALGS; operate like a run-of-river; constant generation (possible upgrades to optimize?);
- BC Hydro model Ref TT, Alt 4TT, Alt 5TT

Option 3: Constant high pool; 1440 ft +/-

Pro (in the mid-long term):

- Most “soft constraints” addressed: Full boat access; stable riparian/foreshore vegetation, no dust;
- full kokanee/rainbow trout access to tributaries;
- Economic: Increased electrical generation; more flexibility to run Mica/Revelstoke/Arrow; assured navigation; tourism
- Cultural/Heritage?

Option 3: Constant high pool; 1440 ft +/-

Con:

- Mid Columbia reach: significantly reduce terrestrial habitat, riverine fish habitat; all bird habitat.
- Forfeit Canadian Entitlement; Treaty Terminate
- US downstream benefits (fish, navigation, irrigation, generation, flood control, First Nations interests, etc.) all compromised (?).

Option 4: Mid elevation constant pool el. ~1425 +/- ft.

- Not modeled by BPA, BC Hydro.

Pro

- Arrow Lk Gen Station: At 1425 ft. output avg. 2002-present: 2,800 MWhrs per day; 63% capacity.
- Current average: 2,200 MWhrs per day.
- Revenue?; power value varies seasonally.
- All socio-economic attributes associated with stable pool.
- Mid Columbia; greater terrestrial, bird habitat exposed; more riverine habitat.
- Kokanee access constant, greater low gradient spawning habitat, more valley bottom terrestrial habitat.

Option 4: Mid elevation constant pool el. ~1425 +/- ft.

- Con
  - Reduced gen. revenue from ALGS over full pool scenario
  - Loss of some Mid –Columbia ecological values.
  - Terrestrial and aquatic rehabilitation costs; socio-economic adjustment costs; others

Other options… variations on constant pool or minor pool fluctuation

- Mid elevation mean pool with minor fluctuations to optimize Mica/ALGS.
- Various constant pool elevations – *trade off between ALGS and ecological values in Mid Columbia reach.*

Next Steps

- Model mid pool constant elevations in 1415-1430 ft range for Mica to lower Columbia.
- Update Performance Measures used to evaluate various Arrow constant pool scenarios.
- Evaluate ALGS under various constant pool scenarios.
- Use a range of Canadian Entitlement values in power generation analysis.

Conclusions…

- CRT review: Clear opportunity to fully confront and address BC/Canadian concerns with CRT and Arrow operation.

- Arrow focus; presented concepts affect both upstream (Revelstoke, Mica) and downstream (lower Columbia fish, US interests, etc.)

…Conclusions

- Constant pool elevation scenario mitigates many current socio-economic and environmental impacts;
- Reservoir modeling and public consultation required to determine optimal elevation.
- Reservoir rehabilitation under lower constant pool scenarios is unprecedented but certainly possible given adequate resources.
- ALGS generation is possible (and likely profitable) under a variety of mid pool constant pool scenarios.

Thank you. Questions...

Spawning Kokanee, Kokanee Spawning Channel

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