Duncan & Arrow Reservoir Options Post 2024

Sounding Board - Columbia River Treaty Review

Cranbrook, B.C. July 5th, 2013

Eagle Creek confluence, Lower Arrow, Fall 2004

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45 Minute Agenda

1. Duncan Reservoir options – High Level View
   - Status Quo – no change to facility or operation
   - Decommission dam
   - Install power generation infrastructure
2. Dam decommissioning description and cost
   - Duncan and Hugh Keenleyside dams, ALGS
3. Arrow Reservoir - Stable pool benefits and issues.
4. Conclusions / Questions / Discussion

Duncan Reservoir and Dam

Photo Credit: Grant Trower

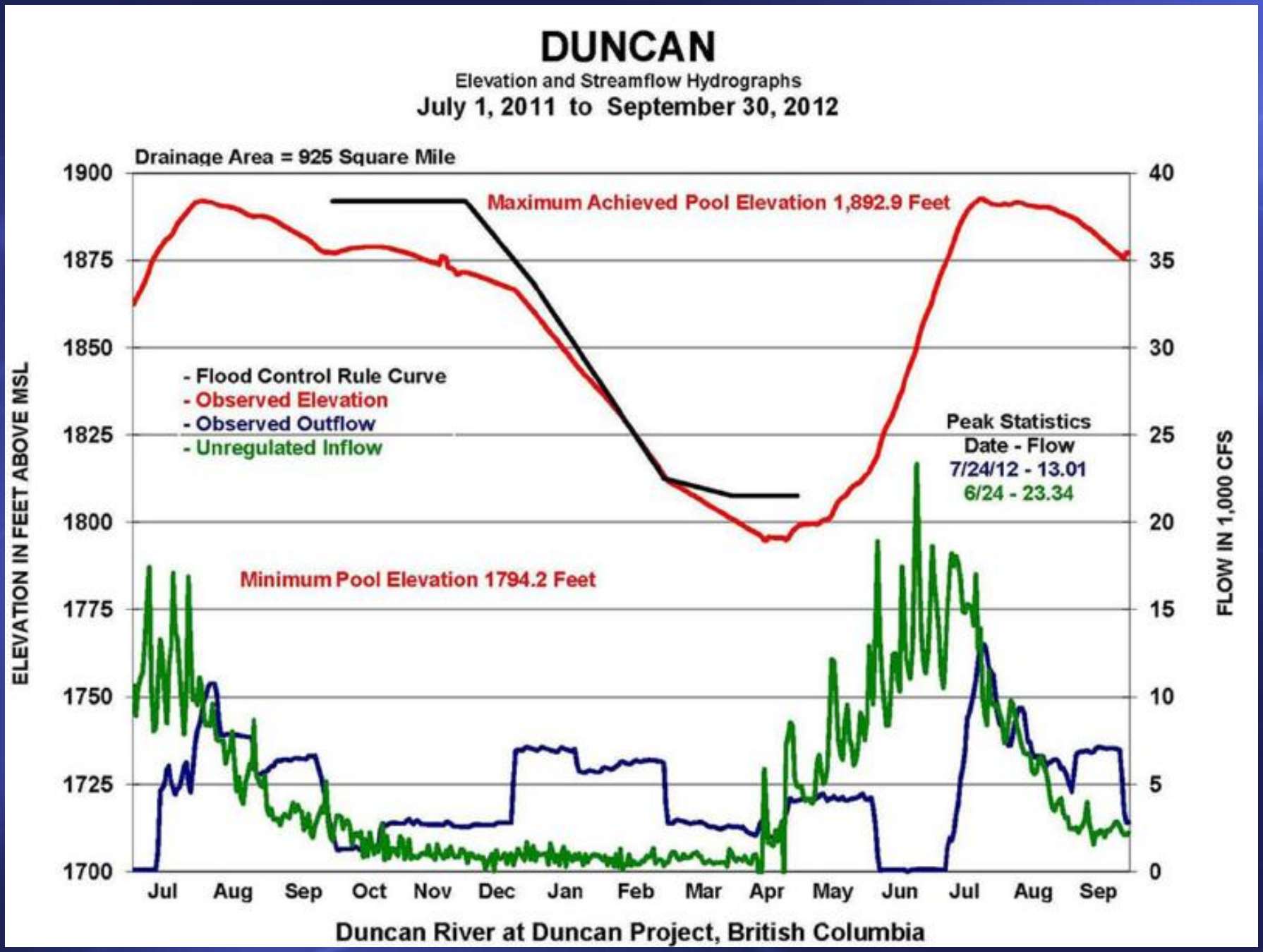
Duncan Reservoir & Dam

- Primary Purposes: increase generation revenue of downstream hydro projects; flood control benefits in Kootenay Lake, Trail, Castlegar and US (Portland).

- Reservoir – 45 km long; 71.5 km^2 at full pool; fluctuates 30-31.4 m.; live storage 1.4M acre-ft or 1.73 km^3

- Dam – earth filled; no installed generation; 792 m long; 38.7 m high; low level outlets; spillway.

- BC Hydro owned and operated; operation dictated largely by Columbia R. Treaty.



Source: BC H presentation to RDCK Mar 22 2013

1a/ Status Quo option for Lower Duncan River

Operate for downstream power and flood control
Maintain current water release schedule and protocols

- **Fish**
  - Stranding in side channels – ramping rate protocols
  - Spawning in side channels and mainstem – flow quantity and duration.
  - Bull trout passage; mitigated through low level outlets
- **Mosquitoes**
  - Increase in quantity; reduction in quality of life for area residents
- **Total Gas Pressure, Water Temperature**
  - TGP increases in lower Duncan River with spilled water >90 m3/s.
  - Water temperature strongly correlated with releases from spill way and low level outlets ; provincial WQ guidelines exceeded at times.

1a/ Status Quo option for Lower Duncan River

Operate for downstream power and flood control
Maintain current water release schedule and protocols

- **Flooding**
  - **Lower Duncan properties can flood during August releases (up to 400 m^3/sec.)**
  - **Erosion Protection in Argenta Slough.**

- **Riparian vegetation**
  - Reduced cottonwood recruitment along river banks

1b/ Status Quo option for Duncan Reservoir

Operate for downstream power and flood control
Maintain current water release schedule and protocols

Terrestrial Wildlife

- Loss of riparian vegetation important for wildlife due to unnatural inundation

Fish stocks

- All species (Burbot, rainbow, bull and cutthroat trout, whitefish, kokanee, white sturgeon, plus non-sport fish) impacted to an unknown degree.
- Entrainment
- Loss of littoral zone
- Burbot spawning in tribs.

Recreation

- Drawdown makes navigation, access (east shore) difficult.

Cultural Resources (?)

- Bank erosion due to fluctuating reservoir levels potentially affects 2 sites.

Major Tradeoffs with Current Operations, Ongoing Costs

- Power Generation vs.
  - Flows for fish in the lower Duncan R.; fish habitat in reservoir
  - Flood management
  - Mosquito breeding in Duncan R. lowlands
  - Wildlife in lower Duncan – Cottonwood recruitment
  - Wildlife habitat in reservoir
  - Costs estimated $2.6M/yr from lost generation revenue due to operational constraints
- Recreation Quality vs. Reservoir Riparian Productivity.
  - Keep reservoir high in summer months
- Physical works costs.
  - Side channel fencing, physical works throughout (4 as of 2013 costing $2.2 M as reported in WUP Annual Report),
- Ongoing Monitoring and Assessments (17 as of 2013; cost ~$9M in 2013 WUP Annual Report).

Second Option: Decommission Dam

- Drain reservoir
- Notch dam
- Remove spillway and seal low outlet tunnel
- Build and stabilize new channel

- Rehabilitate Duncan R. and watershed to pre-dam condition (over time).

Duncan Dam

Pre Dam Construction

Post Dam Construction

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.

Cost to Decommission

- Coursier (2003): $4.6M for 0.1M m^3 of material moved, 1.27 km^2 upland restored.
- Duncan (2013): 1.1M m^3 of material moved; 21.5 km^2 of floodplain, upland restored (17x).
- **Estimate $70-$100M**; requires a full accounting cost/benefit analysis that would include:
  - lost revenue from downstream generation (Kootenay R. plants and US Columbia R. plants)
  - impact on ALGS and Arrow Reservoir (generation, flood control, etc.)
  - Ecosystem benefits, compensation/monitoring costs, etc.

Coursier Dam, S. of Revelstoke

For reference:

- Glines Canyon dams (WA): $351M US for 2 concrete dams.
- Klamath R. watershed (OR, CA): 4 concrete dams for $460M US

Third Option for Duncan

Install Generation

- CPC: Initial pre-feasibility exploration of generation potential.
- 20-30 MW generation capacity; 80-120 GWh/yr.
- Install units in existing low level outlet area.
- $100-$130/MWh cost range.
- Operate January – June.
- Transmission to Kaslo with line upgrade.
- Waneta is CPC's current focus.

Contrast three options

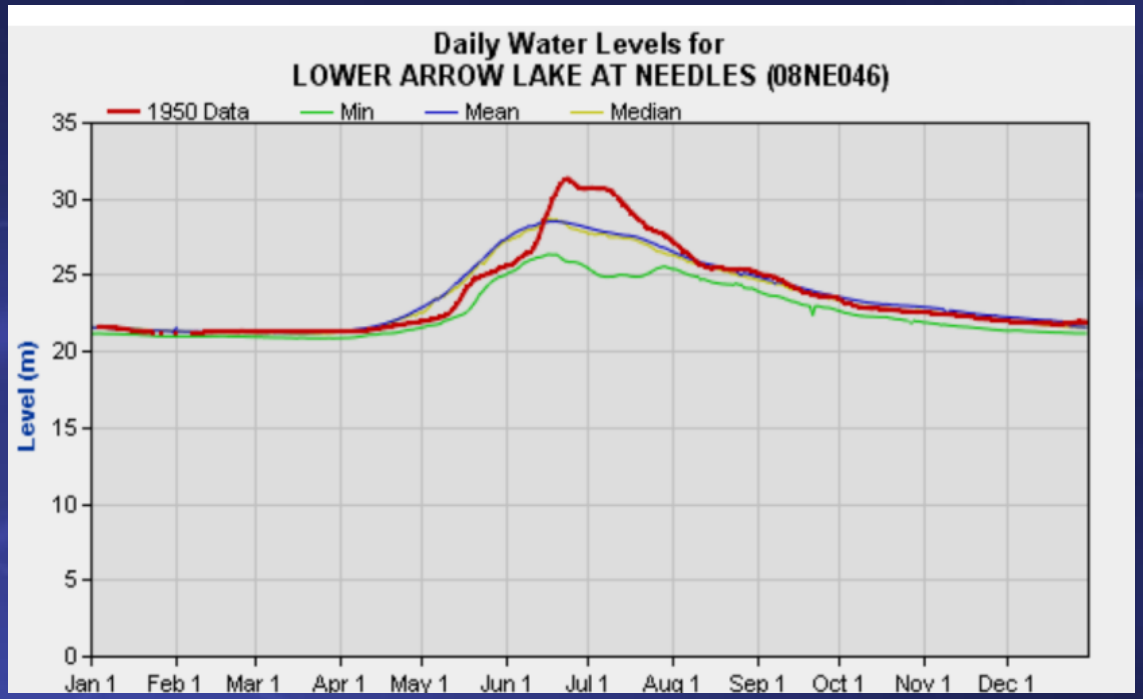
- Status Quo (#1) and Installing Power Generation (#3) are very similar in terms of continuing impact.
  - Generation: Provide alternative BT passage; CPC revenue; fund local initiatives, employment, etc.

- Dam Decommission
  - **Reservoir riparian vegetation** will re-establish; benefits wildlife, shore erosion.
  - all dam/reservoir related **fish** issues will be resolved (stranding, access to spawning/rearing habitat past dam, entrainment, etc.)
  - Mosquitos - ? – poor conditions pre-dam in LDR.
  - TGP/temperature – non-issues.
  - Kootenay Lake fertilization – reduce or eliminate.
  - Reduced generation revenue and flood management control in Kootenay Lake.

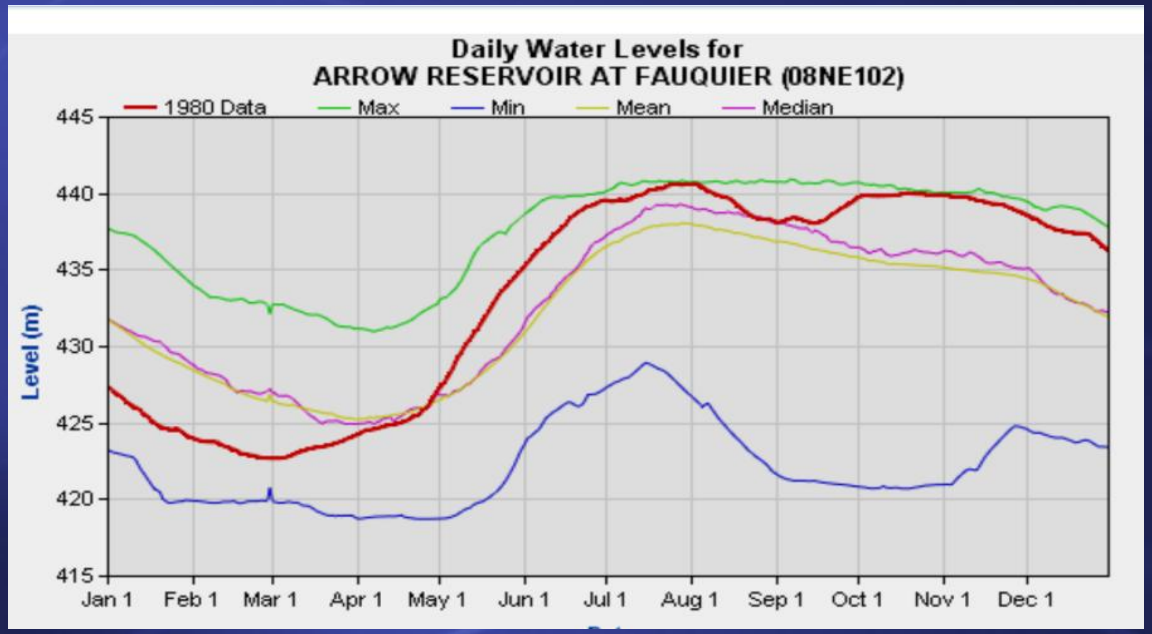
Arrow Lake Numbers

- 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

Arrow Reservoir Water Levels



1930-1968 – before HLK dam commissioned.
Red line: 1950

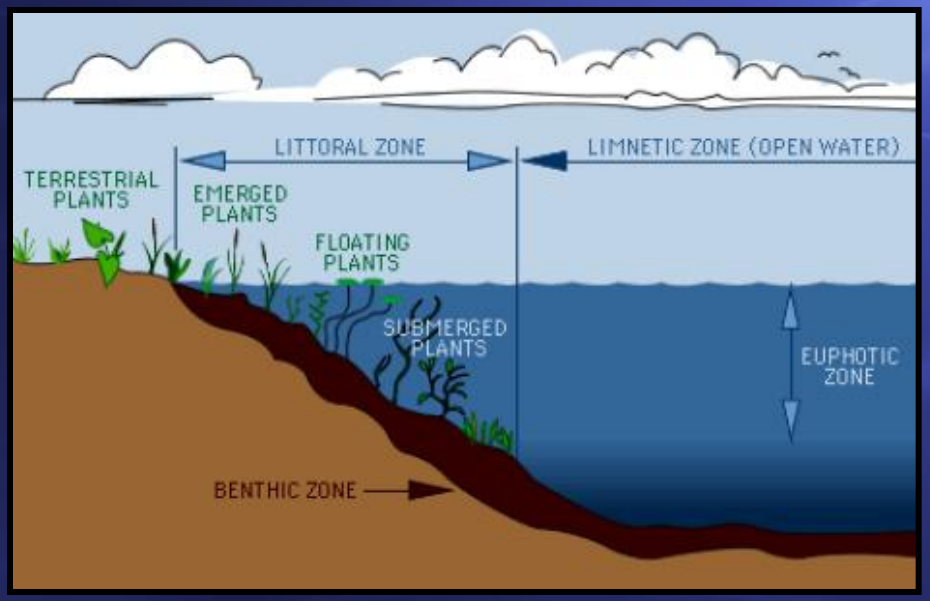


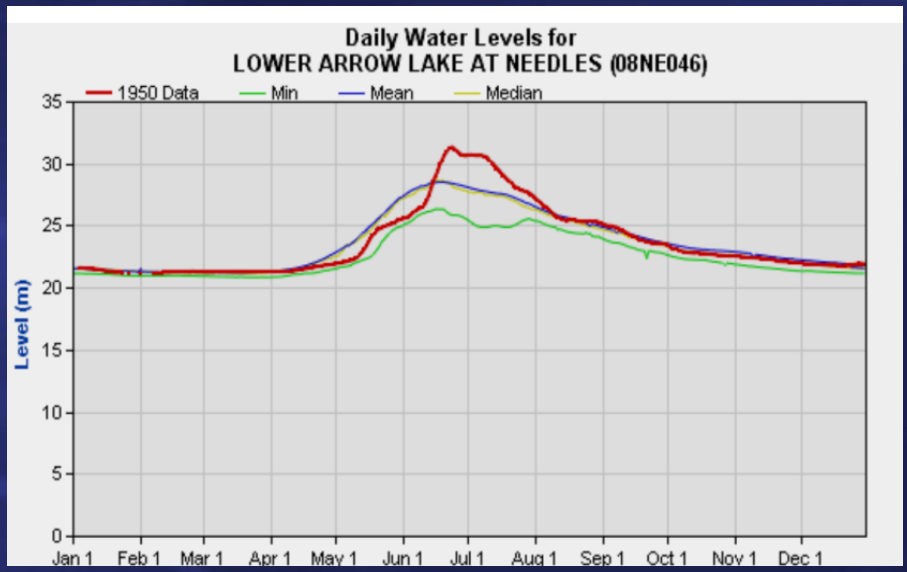
1969-2011 – after HLK dam commissioned.
Red line: 1980

Source: Water Survey of Canada

Known Impacts

- 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.
  - Propose reservoir operation to mimic natural lake hydrograph - constant elevation with short duration spike during freshet.

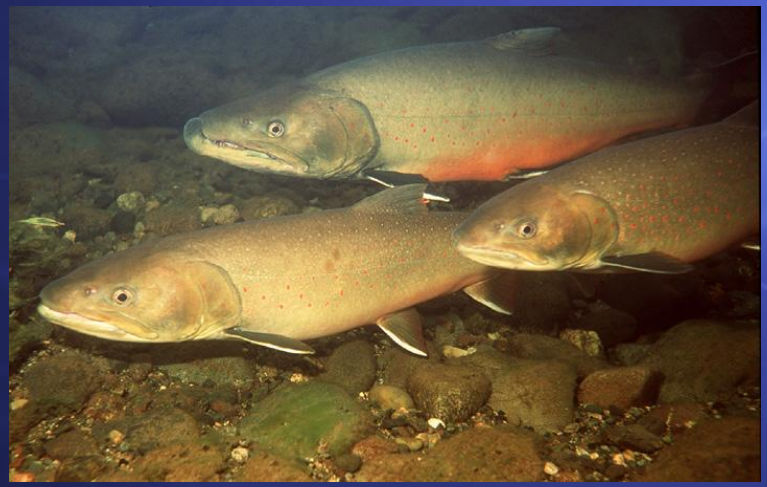




Current Arrow Reservoir Issues and Mid Elevation Constant Pool Effect

- Fluctuating levels impact recreation, tourism and forestry
  - Shore and boat recreation/tourism; beaches disappear.
  - *CP: shore access greatly improved; beaches in late summer*.

- Fisheries
  - Access to spawning tributaries compromised at low level; channel degradation due to fluctuating res. levels
  - *CP: Fish access greatly improved; increased stable spawning habitat exposed in fall for KO.*
  - Productivity may be limited by low spring reservoir levels.
  - *CP: Development of littoral zone will increase biological productivity*.
  - Compensation programs somewhat ineffective (creel surveys indicate decreasing BT and KO populations).
  - *CP: scale back many compensation programs.*



- Wildlife
  - Rising spring levels displace nesting waterfowl and shorebirds; fall levels impact migratory bird habitat availability; reduced fish populations impact raptors; riparian areas lost; acute problems in Mid-Columbia reach downstream of Revelstoke.
  - *CP: Water still rises in spring but to lesser degree and shorter duration.*

- Erosion
  - Shoreline erosion caused by fluctuating levels; biologically productive littoral zone non-existent.
  - *CP: shoreline riparian vegetation will resist erosion; littoral zone will return.*

- Navigation safety
  - Accidents due to changing water levels and boating hazards exposed at lower levels.
  - *CP: both addressed.*

- Highway damage
  - Road sinking and sluffing following very high reservoir levels.
  - *CP: addressed*
- Cultural sites
  - Erosion at several cultural sites due to fluctuating reservoir levels
  - *CP: erosion will subside but overall effect unknown due to lack of public info.*
- Social and community health and well being.
  - *CP: would address some of the residual social impacts and the hurt, anger and mistrust felt by Arrow Valley residents.*

Farm in drawdown zone before and after HLK dam

- Dust generation during drawdown
  - *CP: greatly reduced dust generation.*
- Expenses
  - Compensation programs reduced.
- Economic loss
  - Agricultural loss, access to forestry operations, Log booming limited at low levels; marinas impacted at high levels; many others.
  - *CP: limited agriculture could take place in some locations; productivity would increase over time. Log booming and marinas both benefit.*

Arrow Lakes Generating Station

- Cost $270M; 1,000 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

Mid elevation constant pool

Not modeled by BPA, BC Hydro (high constant pool was).

Pro

- Arrow Lk Gen Station: at elevation 1425 ft. output average 2002-present: 2,800 MWhrs per day; 63% capacity.
- Current average over all years: 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.

Con

- Loss of some Mid –Columbia ecological values.
- Terrestrial and aquatic rehabilitation costs; socio-economic adjustment costs; others

Tradeoff

- Generation at ALGS vs. ecological values in Mid Columbia reach.

Arrow Decommissioning Issues & Cost

- Unprecedented in scope.
- ALGS removed ($270M+ facility), intake channel filled; HLK earthen and concrete dam removed, locks deactivated, dam area completely restored.
- Reservoir infrastructure costs (roads relocated, ferry infrastructure, recreational facilities, municipal infrastructure, …etc.)
- Rehabilitation/restoration costs for 108.4 km^2 of pre-dam wetlands, floodplain and uplands areas.
- >$250 M

Arrow Performance Measures – Are They Sufficient?

Existing PM

All associated with weekly or seasonal reservoir elevation changes i.e. – *inside the reservoir footprint*.

All associated with the WUP as developed *inside the constraints* of the CRT.

- Mid Columbia and Arrow Reservoir PMs
  - Navigation, Recreation, Heritage and Culture, Dust, Wildlife, Fish, Vegetation, Erosion.

Additional PM or…

Suggest examine issues using full cost accounting principles that are *external* to reservoir footprint to examine operating alternatives. Not necessarily Performance Measures.

- e.g.- Agricultural production, economic and regional development, tourism potential, social health, etc.

Next Steps

- Duncan
  - Report out Duncan operation and costs/benefits with/without Treaty;
  - Consider impacts on revenue, flood control, environmental benefits/costs.

- Arrow
  - Model mid pool constant elevations in 1415-1430 ft range; impact on Mica to lower Columbia.
  - Update Performance Measures used to evaluate various Arrow constant pool scenarios.
  - Evaluate ALGS under various constant pool scenarios.

Duncan Conclusions

- Impact of Duncan operations very similar under Status Quo and Generation options
- Dam Decommissioning would resolve most if not all environmental issues but comes at a lost revenue cost; unprecedented in scale but not impossible
- Difficult to fully assess Duncan options when relatively little is known about reservoir biological values; ongoing monitoring studies remain inconclusive.
- Other options for Duncan operation may exist other than those presented.

Arrow Conclusions

- Arrow low-mid 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 low-mid constant pool scenarios is unprecedented but possible given adequate resources.

Arrow Conclusions

- ALGS generation is likely profitable under a variety of constant mid pool scenarios.

- Decommissioning HLK dam *expensive* and not required to achieve multiple benefits associated with low-mid constant pool option.

Thank you. Questions...

Kokanee Spawning Channel

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