BC HYDRO
Columbia/Kootenay flood control
March 22, 2013

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Manager, System Optimization

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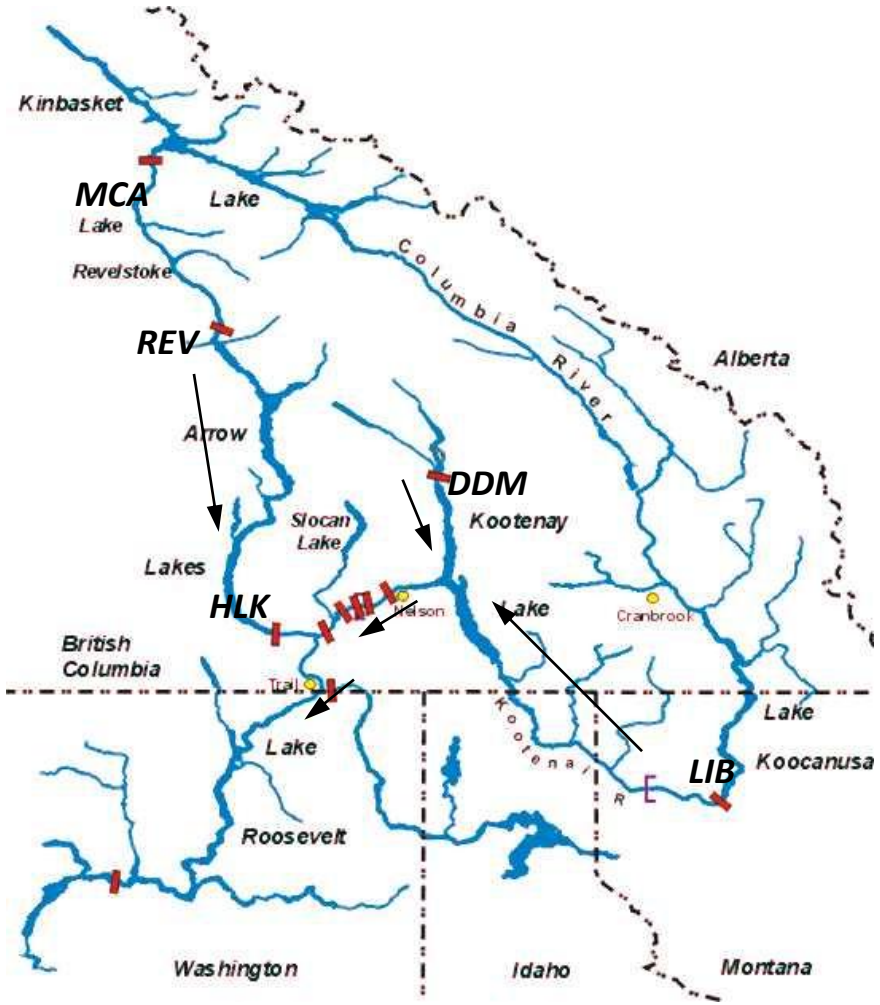
Columbia/Kootenay system



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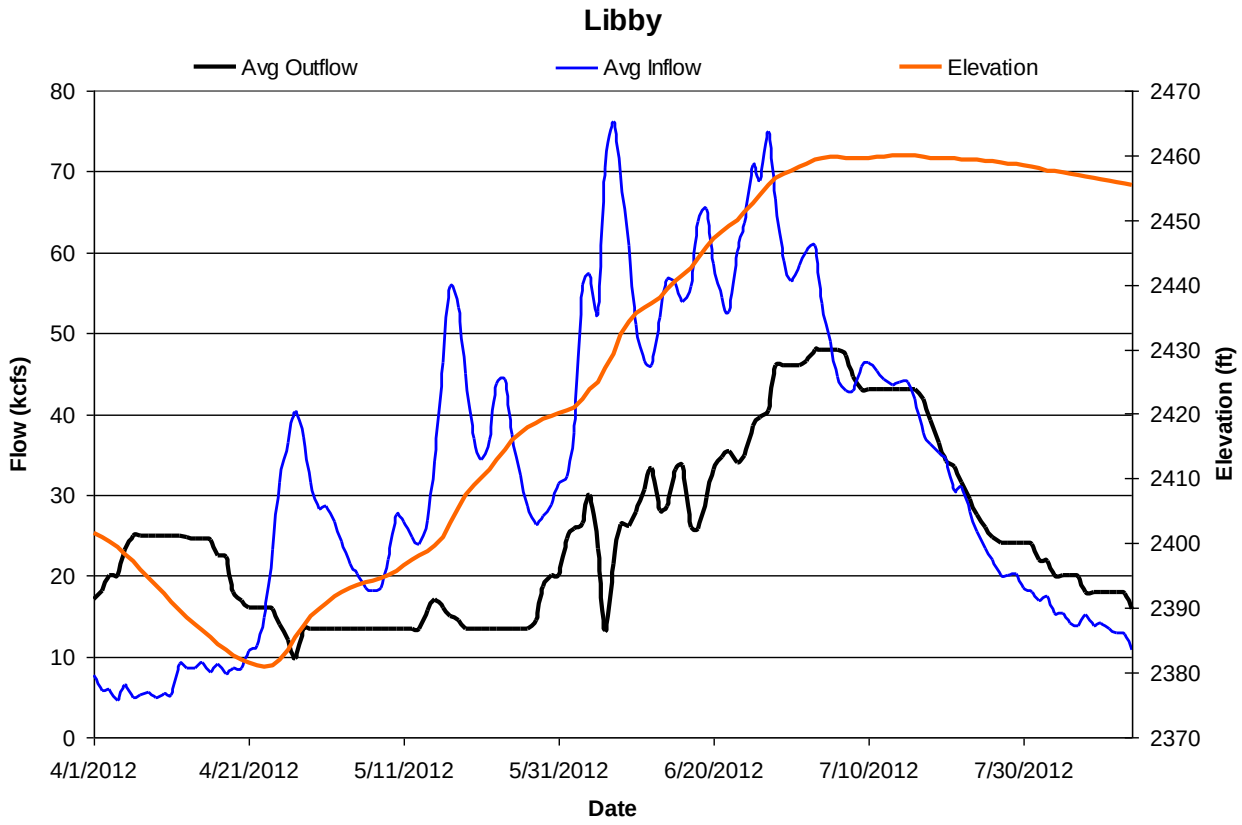
A recent high-water event: 2012

- 1 May snowpack in the Columbia/Kootenay region:
  - Above normal, but not extreme
- June & much of July: unprecedented rainfall in the basin
- Rainfall in June 2012:
  - 2 to 5 times the normal amounts across the upper Columbia & Kootenay basins
  - Wettest month ever at Castlegar Airport & other stations
- Inflows for Feb-July 2012:

Basin	Rank	% of Average
Mica	1st of 40 yrs	136%
Revelstoke	1st of 28 yrs	130%
Arrow	3rd of 42 yrs	127%
Duncan	1st of 40 yrs	130%
Kootenay Lake	4th of 44 yrs	142%

Libby Dam operations - 2012

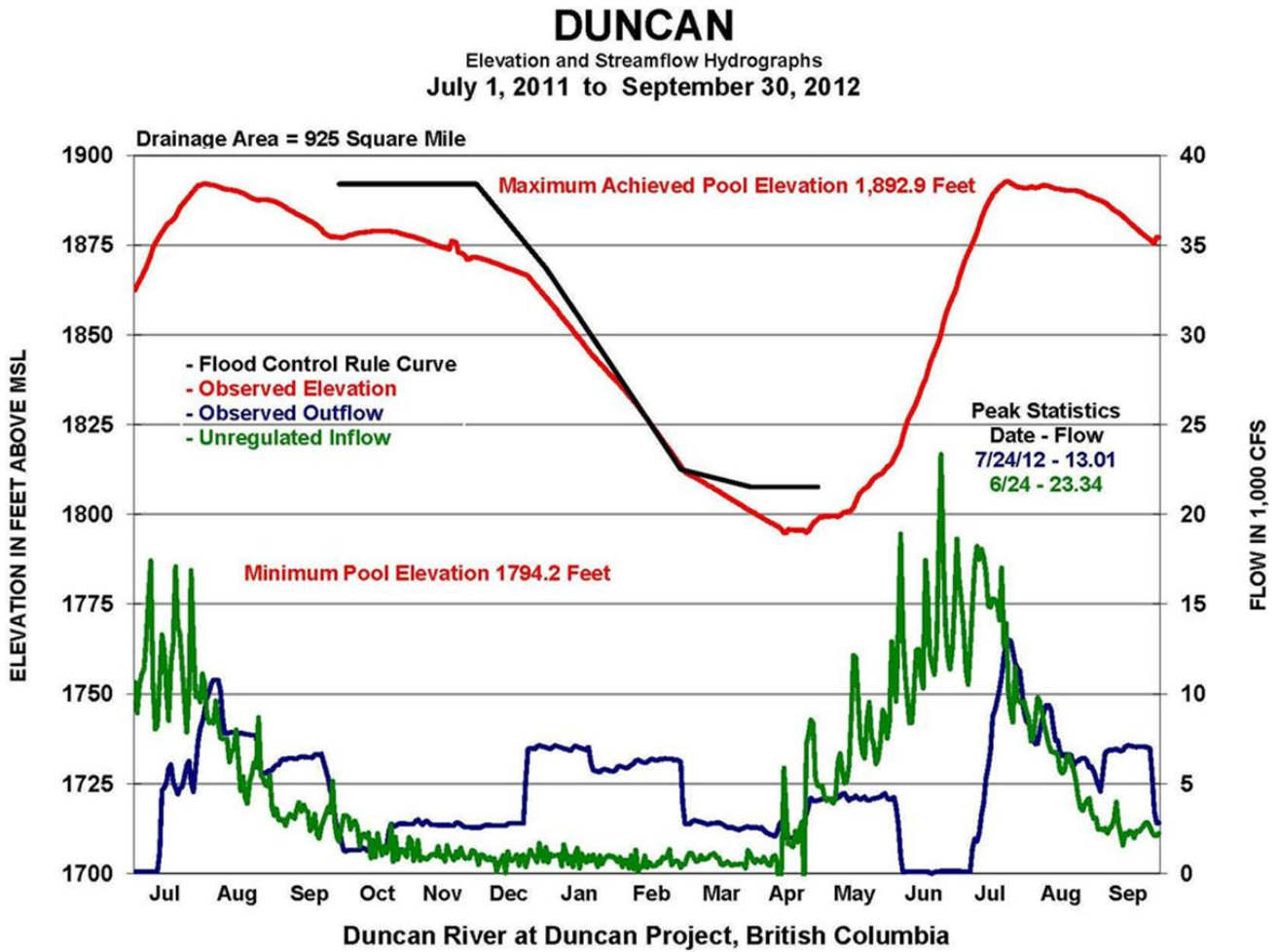
- Reservoir drawdown by late April was consistent with snowpack at the time
- Sturgeon discharge began on 28 May and spill started on 4 June
- Heavy rainfall in early June → Libby quickly transitioned to a flood risk management operation designed to manage downstream flooding in both countries
- The Corps began daily conference call updates with Canadians on 27 June and continued into July
- BC Hydro and the Corps coordinated under the Treaty to allow Koocanusa Reservoir to surcharge by up to 2 feet above its normal full pool level (first time ever)
- Support from Canadians in East and West Kootenays for this operation



- Koocanusa surcharge allowed Libby to maintain a lower discharge, providing flood reduction benefits downstream
- Reservoir level was above normal full pool, 2459 feet, from 3 to 26 July.
- Peak reservoir level was just under 2460 feet on 16 July.
- Peak Libby discharge of 48 kcfs occurred on 3-7 July.
- River level at Bonners Ferry peaked at 1766.6 ft, 2.6 feet above flood stage.

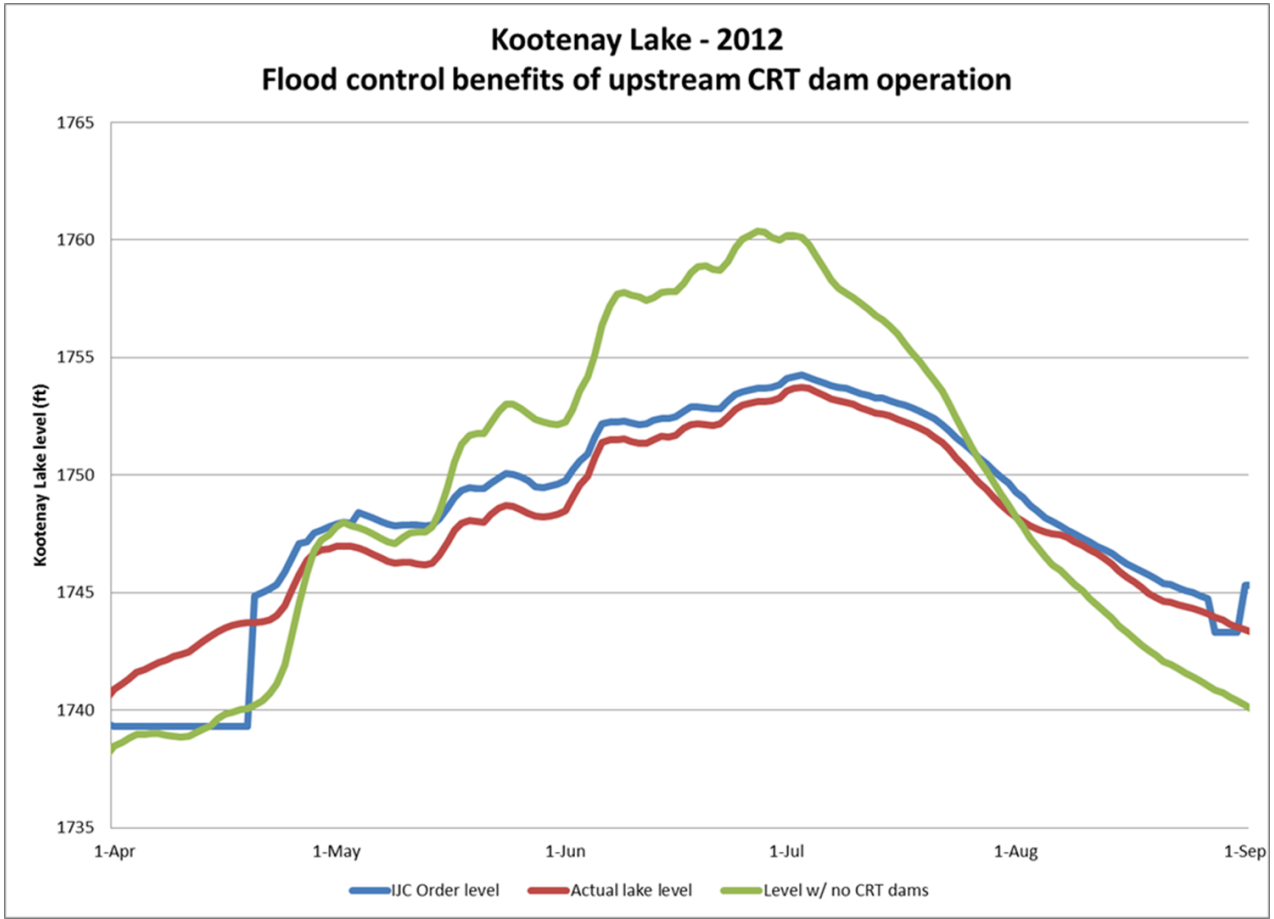
Duncan Dam operations - 2012

- Drafted to near empty in late April. Operated to manage reservoir refill in May.
- Discharge reduced to minimum possible during June & early July to reduce inflow into Kootenay Lk.
- After Kootenay Lk level had peaked, then Duncan discharge was increased to manage reservoir refill and balance upstream (reservoir) impacts vs. downstream flooding impacts (local & Kootenay Lake)
- Duncan Reservoir was surcharged by ~ 1 ft (0.3 metres) to reduce the peak discharge & downstream flooding



Kootenay Lake operations - 2012

- From mid-March until the end of July, FortisBC & BC Hydro discharged the maximum possible out of Kootenay Lake, limited only by the Grohman Narrows channel restriction.
- All requirements of the IJC Order (Kootenay Lake Board of Control) were met.
- Kootenay Lake level peaked at 1753.8 feet → highest level since 1974
- Without the surcharge of Libby/Koocanusa Reservoir, the peak level of Kootenay Lake would have been a further 0.3 feet higher.
- Without the operation of Libby & Duncan, the level of Kootenay Lake would have been about 6.6 feet (2 m) higher



Grohman Narrows Channel Improvement Project Current Status

BC Hydro initiated the project in Summer 2012

Project team is currently:

- Reviewing available historical information
- Identifying key issues/risks
- Planning/scoping work required to confirm project feasibility

Preliminary assessment of project benefits was completed earlier

Project cost estimates currently not available – this is the biggest uncertainty !

Current plan for field work:

- Bathymetry – Fall 2012
- Geotechnical drilling to confirm depth to bedrock – Spring 2013
- Revised costs and benefits studies – Fall 2013

Mica (Kinbasket) reservoir levels, inflows, & outflows July 2011 to Sep 2012

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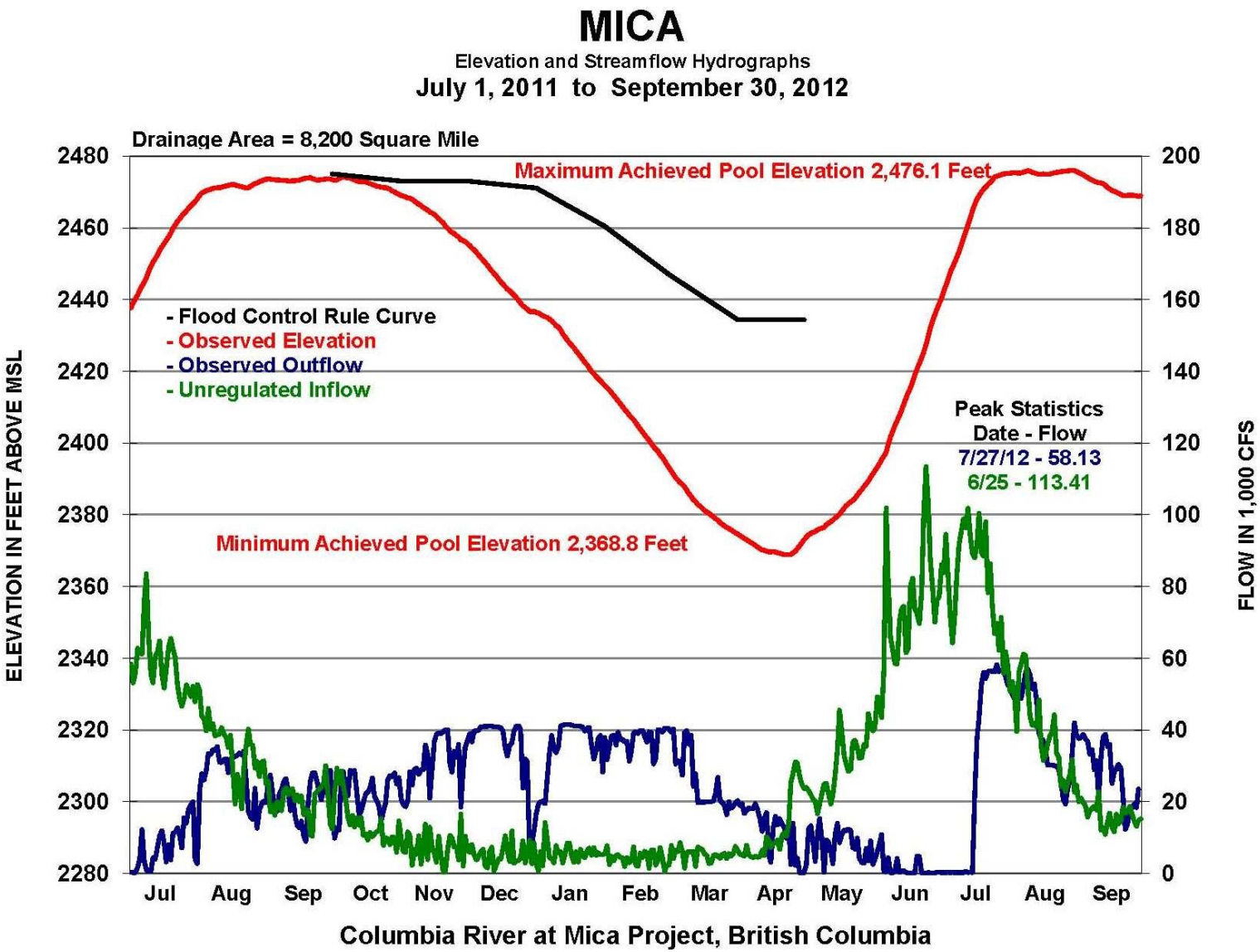

Arrow reservoir levels, inflows, & outflows
July 2011 to Sep 2012

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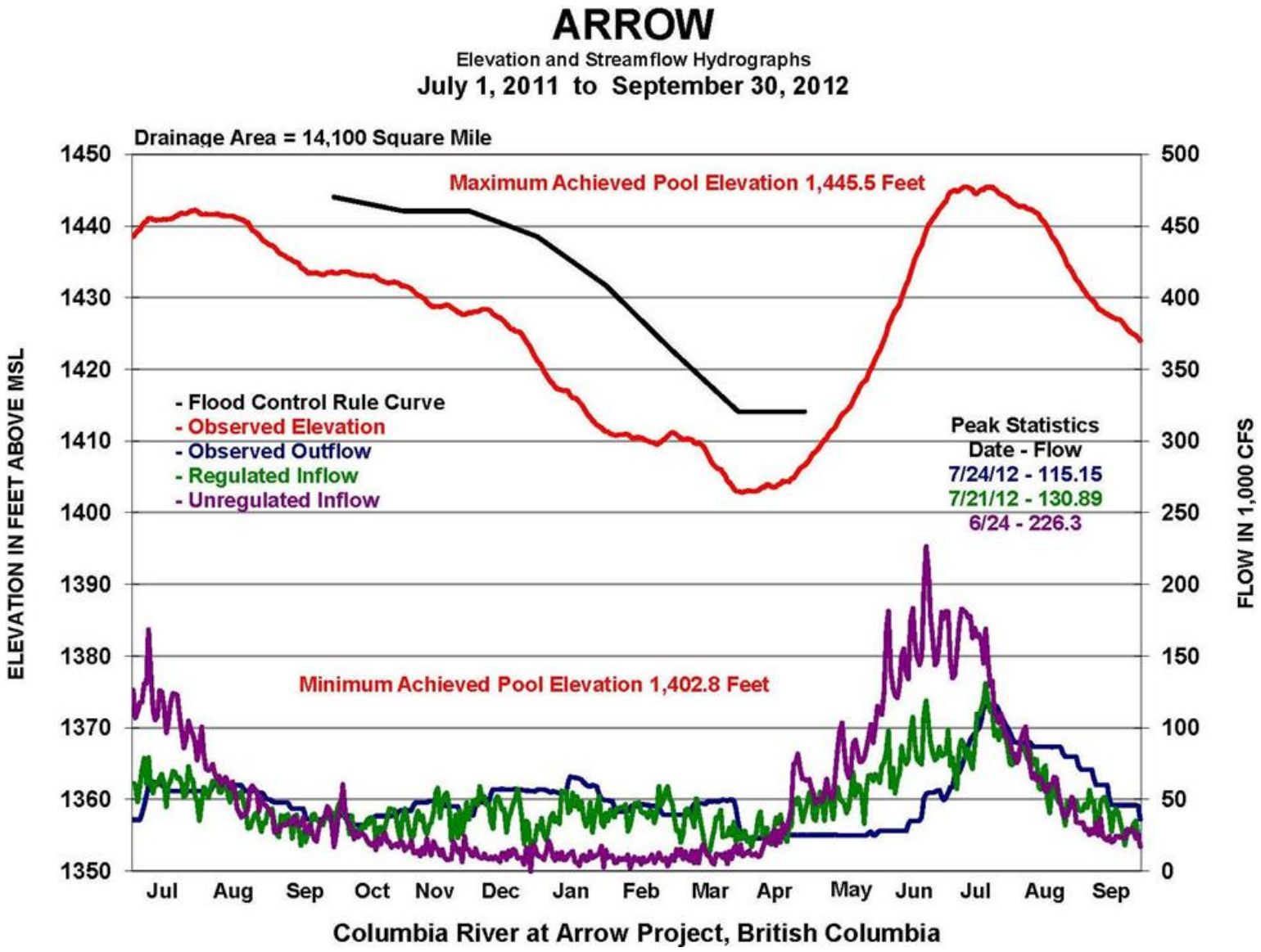

Columbia River at Castlegar/Trail 2012 high water event

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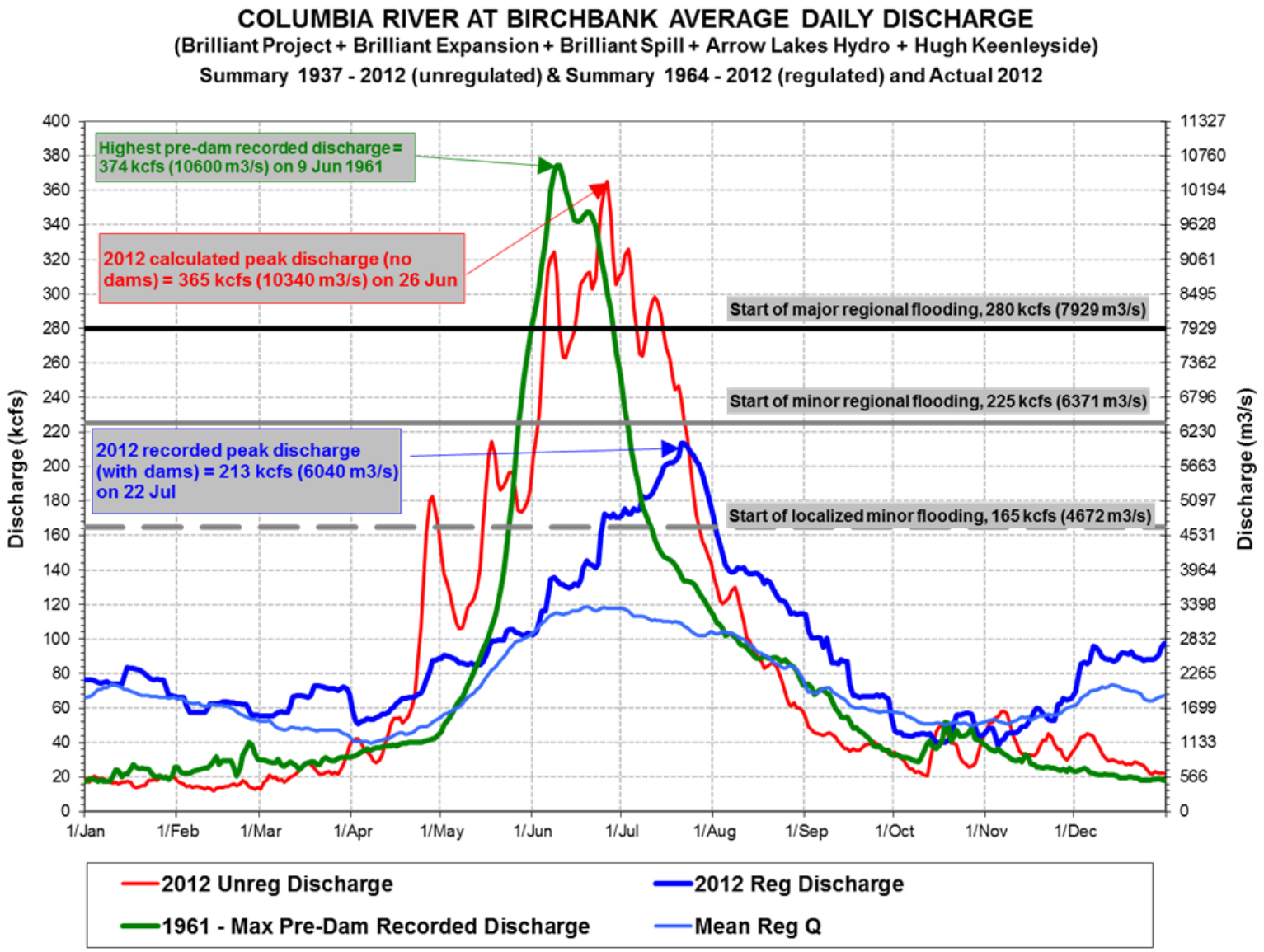

Columbia River at Castlegar/Trail

- The Columbia River flows in 2012 were well below the peak flows recorded prior to construction of the Columbia River Treaty dams:
  - 1961 & 1948: highest recorded flow of 374 kcfs resulted in major flooding damage at Trail, Castlegar, and in the U.S.
  - In 2012, without the upstream dams, the Columbia River flow at Trail would have peaked at approximately 365 kcfs.

- Even with the upstream reservoirs operated with flood control as top priority, peak flows at Trail can be much higher than those observed in 2012.

- When a reservoir is full, then inflows must be passed in order to ensure dam safety. Approximate flood-frequencies for the regulated Columbia River system, i.e. with upstream dams in place:

Return Period (approx.)	Peak flow: Columbia R. near Trail
30 years	225 kcfs
200 years	280 kcfs
Probable Max. Flood	460 kcfs

2012 Operations Summary

- Mica, Arrow, Duncan, Libby – reservoirs were refilled above their normal full pool levels (by up to 1.3 ft) to help manage downstream flood impacts.
  - reservoir surcharge: trade-off between downstream flood impacts & upstream reservoir impacts.
- Mica, Duncan, Libby – highest-ever reservoir levels.
- Arrow – highest reservoir level since 1990.
- Kootenay Lake – highest lake level since 1974.
- Mica, Revelstoke – spilled water for the first time since 1997.
- Columbia River at Revelstoke – highest flow since 1991.
- Columbia River at Trail – highest flow since 1972 (pre Mica dam).

2012 Operations Summary (cont.)

- BC Hydro, the Corps of Engineers, & FortisBC operated the reservoir system with flood management as the highest priority.
- All of these reservoirs have multiple purposes, including flood control, fisheries, recreation, energy, etc.
  These purposes must be balanced subject to domestic laws and requirements under the Columbia River Treaty and other agreements.

- Reservoir operations in 2012 significantly reduced downstream flood peak flows & levels through management of reservoir storage and surcharging.
- Without the Treaty dams in place, damage to property would have been much greater and more widespread:
  - Peak Kootenay Lake level would have been 6.6 ft higher.
  - Peak Columbia River flow at Castlegar/Trail would have been about 70% higher, similar to the level of flood flows in 1948 & 1961.

General principles of CRT primary flood control

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Flood control curves enforce an “upper bound” on reservoir operations in order to manage future flooding risk.

- e.g. At times it may be best for power, recreation, fisheries, or other reasons, to store additional water in Arrow Reservoir;
- however, the Arrow flood control curve prevents this … in order to preserve enough empty reservoir space to manage future flooding risks for downstream points.

The flood control storage at each reservoir provides flood protection for local areas and for the larger Columbia River system.

e.g.:

- Duncan Dam provides local flood protection for Meadow Creek and Kootenay Lake … and downstream
- all CRT dams provide flood protection for Castlegar & Trail,BC, Tri-Cities,WA, and Portland,OR

For this reason, flood control curves are specific to individual reservoirs.

- Flood control storage cannot be “traded off” between reservoirs (except under special circumstances).

General principles of CRT primary flood control (2)

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Normally, the CRT power operation drafts the reservoir below its flood control curve … so the flood control curve doesn't constrain operations for power, recreation, fisheries, etc.

> This is almost always true for Mica and Duncan.

> At Arrow and Libby, the flood control curve affects operations more frequently.

CRT flood control curves have a fixed segment from Oct to Dec and then a variable segment from Jan to July.

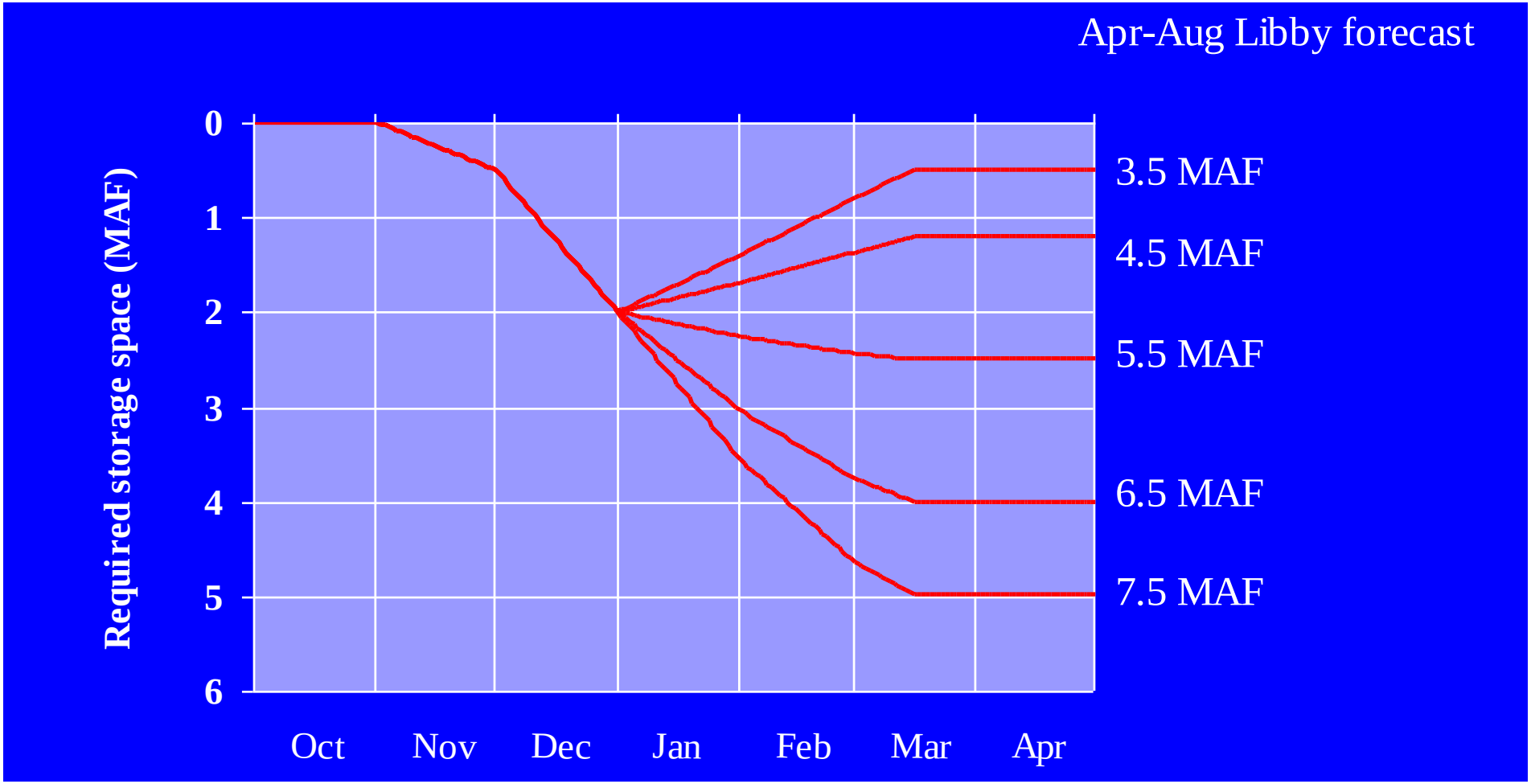
> Runoff forecasts are not reliable prior to January, so the flood control curve prior to January must "prepare the reservoir" in case of a large runoff year.

After 1 Jan, runoff forecasts become steadily more reliable, and the flood control curve depends on the runoff forecast.

> If the forecast for spring runoff is high, then the flood control curve for Jan-April is low in order to preserve more empty space in the reservoir for spring/summer flood control needs.

> With a low runoff forecast, less flood control space is needed, so the flood control curve is higher.

Example of Flood Control Curves for Columbia River Treaty projects



CRT “on-call” flood control storage (to 2024)

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- The U.S. can request that Canada operate any additional storage (beyond the primary FC storage) to help prevent a flood of > 600 kcfs at The Dalles, Oregon (just upstream of Portland)
- “On-call” storage could include additional storage in Treaty reservoirs plus Kootenay Lake, Revelstoke Reservoir, etc.
- The U.S. must pay Canada $1.875 million per call (for the first 4 calls) plus any Canadian operating losses.
- The Treaty does not specify details of how “On Call” flood control storage would be implemented. The Treaty Flood Control Operating Plan includes some documentation … but many details of implementation have not been worked out.
- The U.S. has not yet exercised this option (even in the large flood years when they had the right to). Therefore, the mechanics and practical details of “On Call” operations have never been tested.

Treaty Flood Control Provisions after 2024

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After 2024, the primary flood control protection expires and only the “Called Upon” flood control protection remains:

- The U.S. “can call upon Canada to operate storage to prevent flood in the U.S. that cannot be adequately controlled by all related storage facilities in the U.S.”
  [concept of “effective use”]
- The U.S. must pay the operating costs incurred plus any economic losses that result from the revised Canadian operation.

Treaty does not specify details on how Called Upon will be implemented

Extra slides

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Columbia River Treaty – why ?

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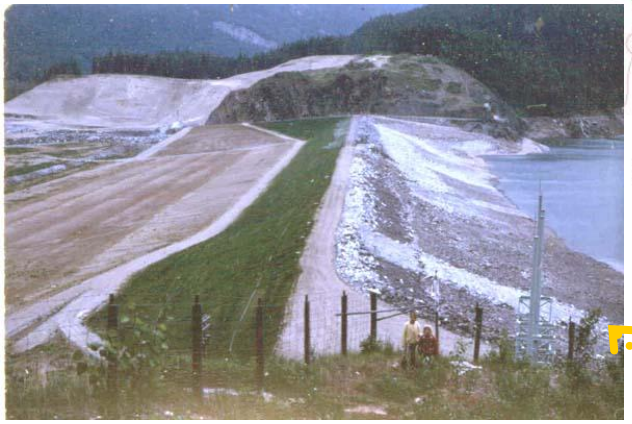
Columbia River – 4th largest in N. America

U.S.– has flood control needs and large hydroelectric plants

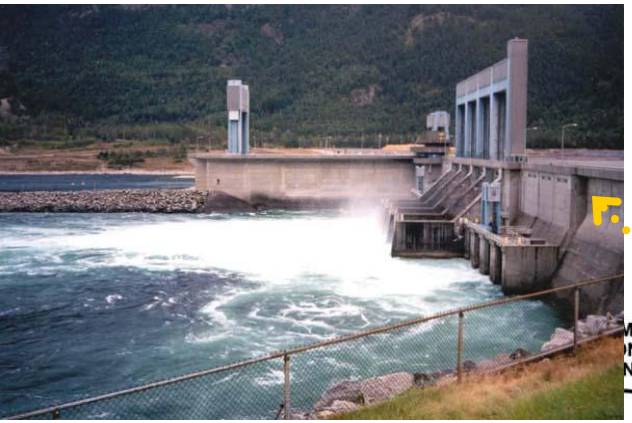
Canada – has good storage dam sites (and flood control & hydro needs)

- Canada has 15% of the basin area
- Canadian basin is mountainous, with much snow … produces 30-35% of the runoff for the entire basin
- During flood times, this can be 50%
- most hydropower production, and need for flood control, is in the U.S.



Duncan (1968)

Created the Duncan Reservoir



Keenleyside (1969)

Created the Arrow Reservoir

Mica (1973)

Created the Kinbasket Reservoir

What does the Treaty Do?

- **<u>The Treaty required Canada to</u>:**
  - construct the Mica, Arrow, & Duncan reservoirs
  - operate these reservoirs for optimum power & flood control in both countries

- ***Canada did not turn over control of its reservoirs*** **to the U.S.**
  Rather, the Treaty requires specific operations under specific conditions.

- **<u>The Treaty required the U.S. to</u>:**
  - pay Canada 50% of the value of future flood control benefits in the U.S.
  - deliver to Canada 50% of the increased power capability at downstream U.S. plants
- **<u>The Treaty permitted the U.S. to</u>:**
  - construct and operate the Libby project on the Kootenai River … flooding some Canadian land, but also providing power & flood control benefits for Canada

Treaty priorities for water usage

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1. Domestic & consumptive uses (e.g. drinking water)
2. Flood control
3. Energy production - firm
4. Reservoir refill
5. Energy production – non-firm

Other values (e.g. fisheries, recreation) are not mentioned in the Treaty and are managed by each country

Treaty benefits and term

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- Both countries realize significant flood control and power benefits from the Treaty.
- Canada received lump sum payments for its share of the U.S. flood control benefits (to 2024) and for the first 30 years of U.S. power benefits (to 2003)
- Canada will continue to receive its 50% share of electricity benefits until at least 2024

- Treaty has a minimum term of 60 years … can be terminated in 2024 by either country with 10 years notice
- Canada must continue to provide some flood protection (“Called Upon”) for the U.S. as long as the dams exist