Columbia River Basin Hydrosystem

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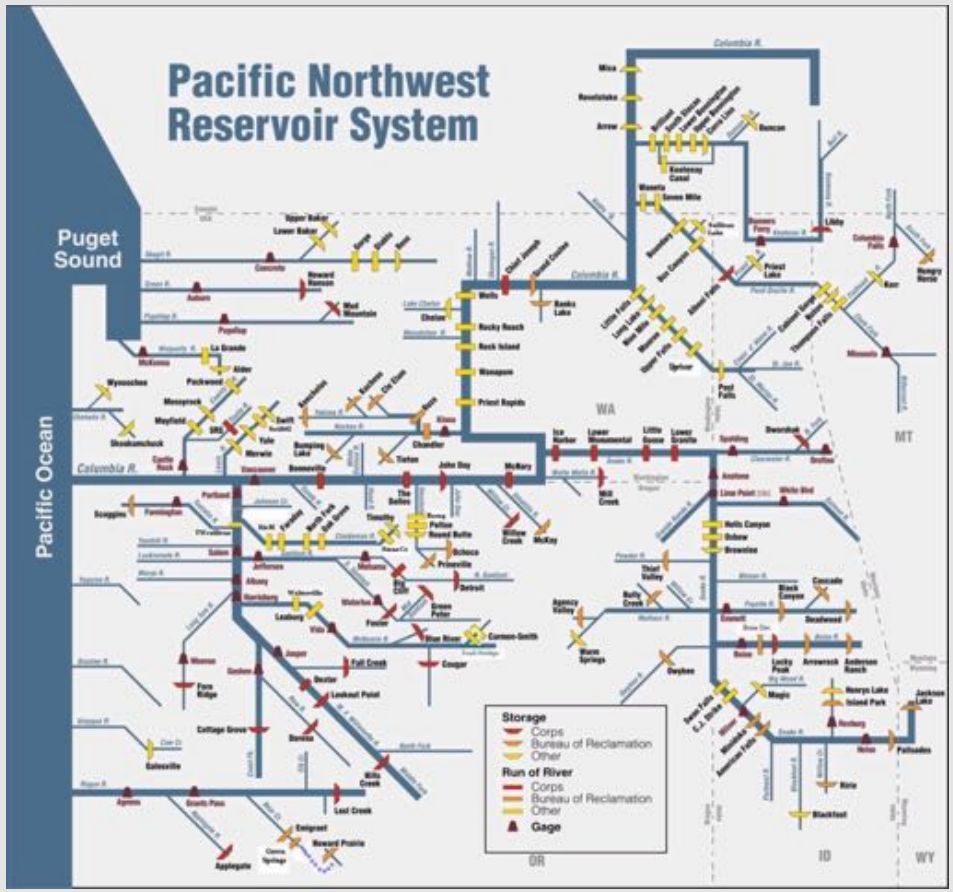
Outline:

- Overview of the Basin
- PNW Hydro & Transmission System
- Streamflow Volatility
- Columbia River Treaty Intro
- Storage Info
- Hydropower Operations
  - Constraints/Objectives
  - Seasonal Operations



The Columbia River Basin

- The Basin is ~260,000 square miles
- Average annual runoff of about 200 million acre-feet (Maf); 4th largest river in North America
- Average flow of ~275,000 cfs; varies from 36,000 to 1,240,000 cfs
- Most hydropower capacity (~34 GW) in North America
- >40% of all U.S. hydropower is generated on the Columbia and Snake
- Hydro >50% of the region's installed capacity

The Columbia River Basin

Canada has 15% of the basin area, but ~35% of average annual flow at The Dalles.

Kootenay River, with 14% of the flows at The Dalles, begins in B.C. mountains east of Columbia Lake, flows south into MT and northern ID, and then back in to B.C. at Kootenay Lake, and joining the Columbia at Castlegar (~25 miles north of border).

Pend Oreille River has 15% of the mean flow at The Dalles; also flows west and north into Canada and joins the Columbia just north of the border (<1 mi.).

Snake River is the largest tributary with 43% of the basin area, but flows at the mouth (Ice Harbor) are only about 27% of the mean flow at The Dalles.

PNW Hydropower System

Partnership - COE, BOR, BPA, State/Public/Private Utilities, Tribes, BC Hydro

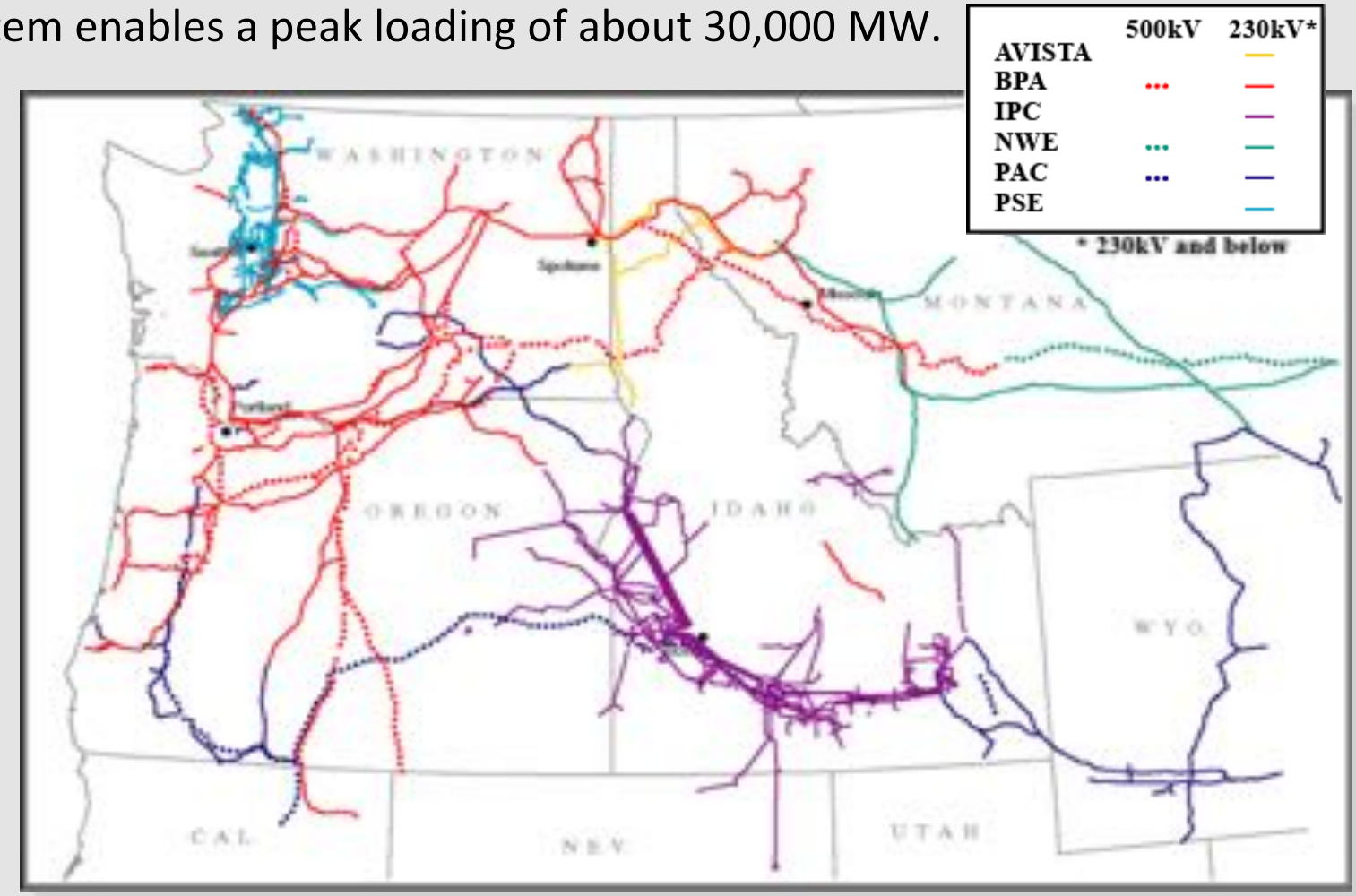
- Early development: Rock Island (1932), Bonneville (1937), & Grand Coulee (1941)
- Heavy development in the 1950's and '60s, ending in the '70s.
- Power Act: Mandate to provide low cost, reliable power & effective resource stewardship

The FCRPS :

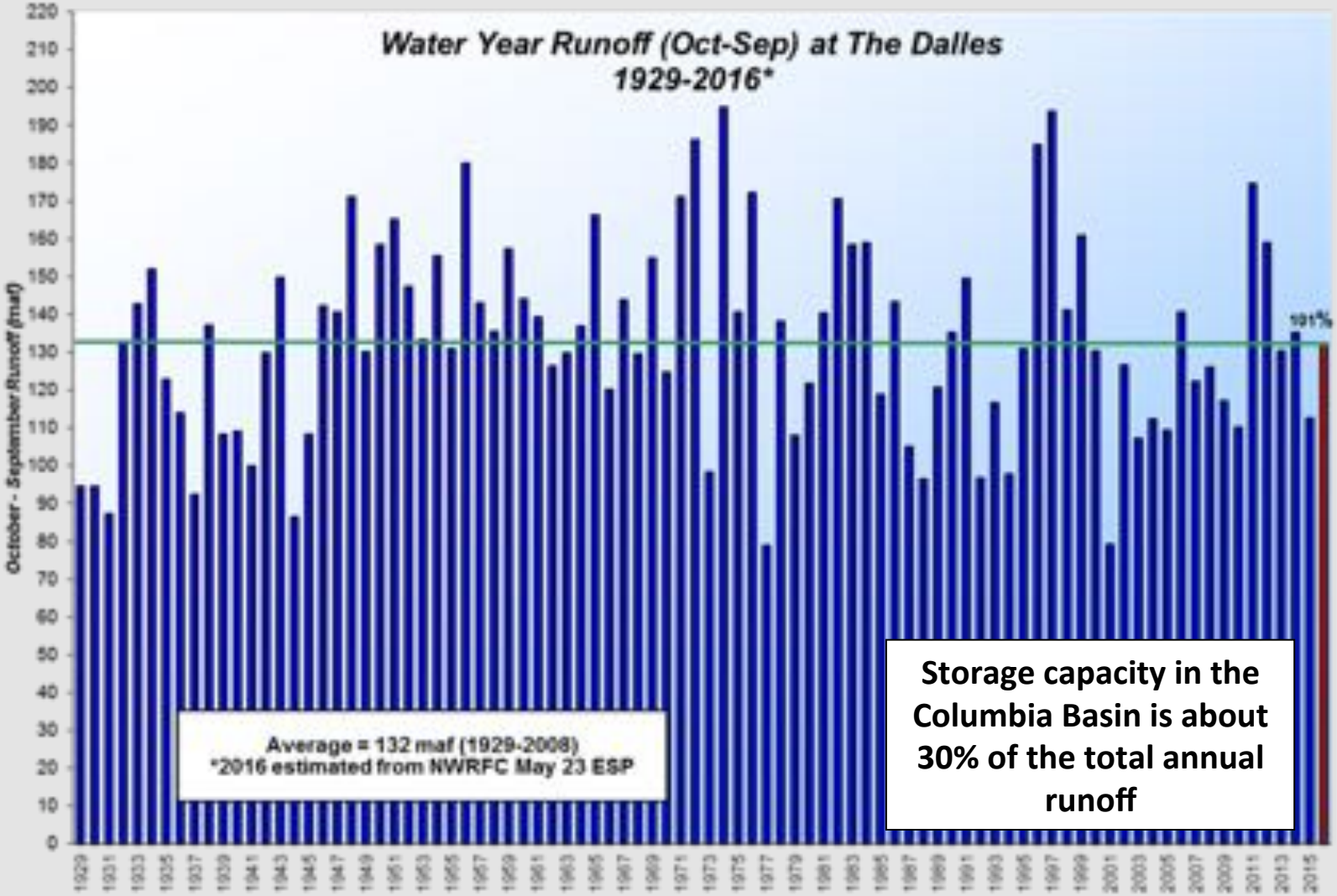
- 31 hydroelectric projects (21 COE/10 BOR)
- 209 turbine-generating units
- Peak capability is ~22,500 MW (nameplate)
- 8,700 aMW of energy production with average water (ranges from 6,800 to 10,300 aMW)
- Generates power worth $3-4 billion annually (power + transmission)

Regional Transmission

- The Federal Columbia River Transmission System spans 300,000 square miles in OR, WA, ID, MT and sections of WY, NV, UT and CA.
- The system enables a peak loading of about 30,000 MW.



Highly Variable Annual Runoff



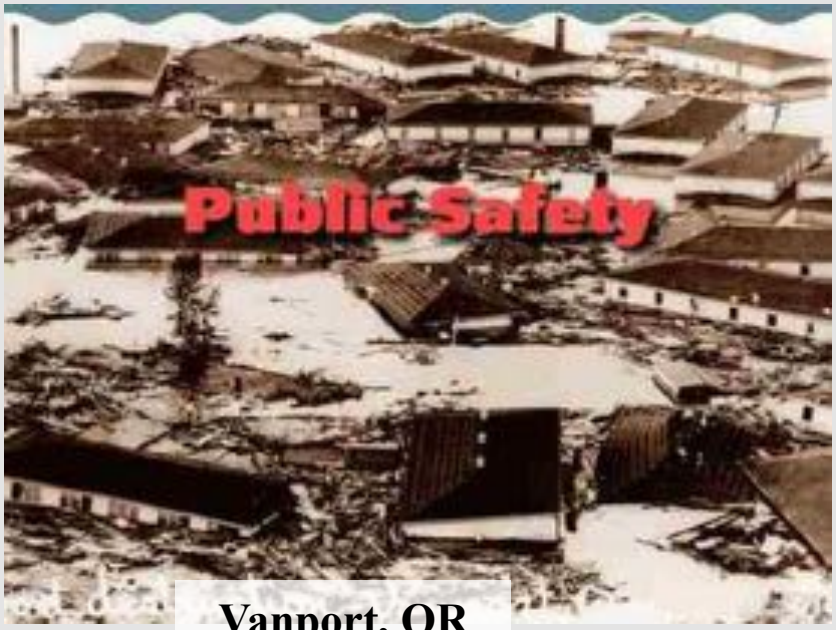
Storage capacity in the Columbia Basin is about 30% of the total annual runoff

Streamflow Volatility

- Flow at Canadian border varies from 14,000 to 555,000 cfs
- Unregulated flow at The Dalles varies from 36,000 to 1,240,000 cfs
- Much wider variation than Mississippi or St. Lawrence Rivers
- Much less storage capacity than CO/MO Rivers

Treaty Projects (clockwise): Mica, Arrow, Duncan, Libby

1948 Columbia River Flood



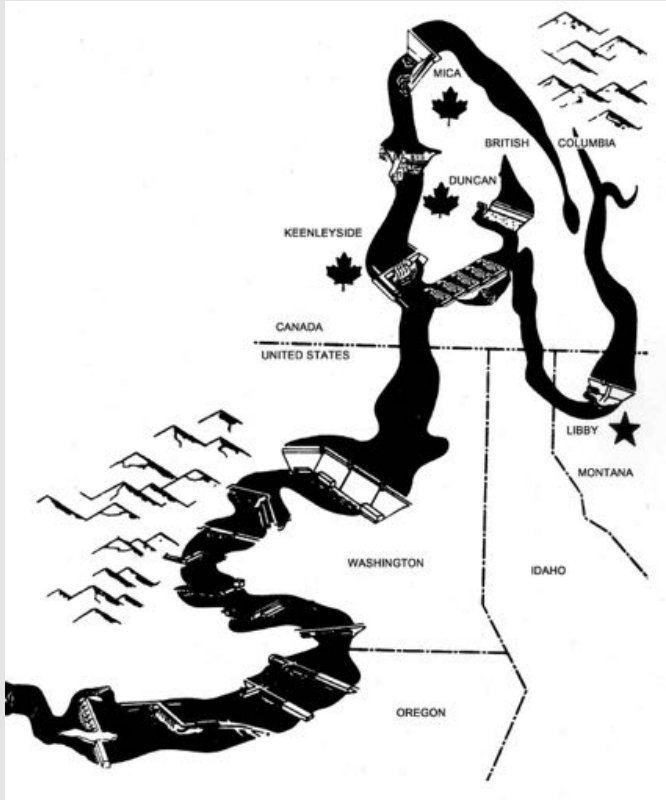
Vanport, OR in 1948

Trail, B.C. in 1948

- 1948 flood destroyed Vanport, Oregon's 2nd largest city of ~ 35,000.
- >50 people were killed, >$100 mill. in damages in US & Canada.
- Damaged homes, farms, and levees from BC (e.g. Trail) all the way to Astoria, OR.

The Columbia River Treaty

The Columbia River Treaty is an international agreement between Canada and the United States of America for the cooperative development and operation of the water resources of the Columbia River Basin for the benefit of flood control and power.



What does the Treaty Do?

The Treaty required Canada to:

- Construct the Mica, Arrow, and Duncan storage reservoirs on the Columbia River system with 15.5 Maf of storage,
- Operate these reservoirs for optimum power generation and flood control downstream in both countries

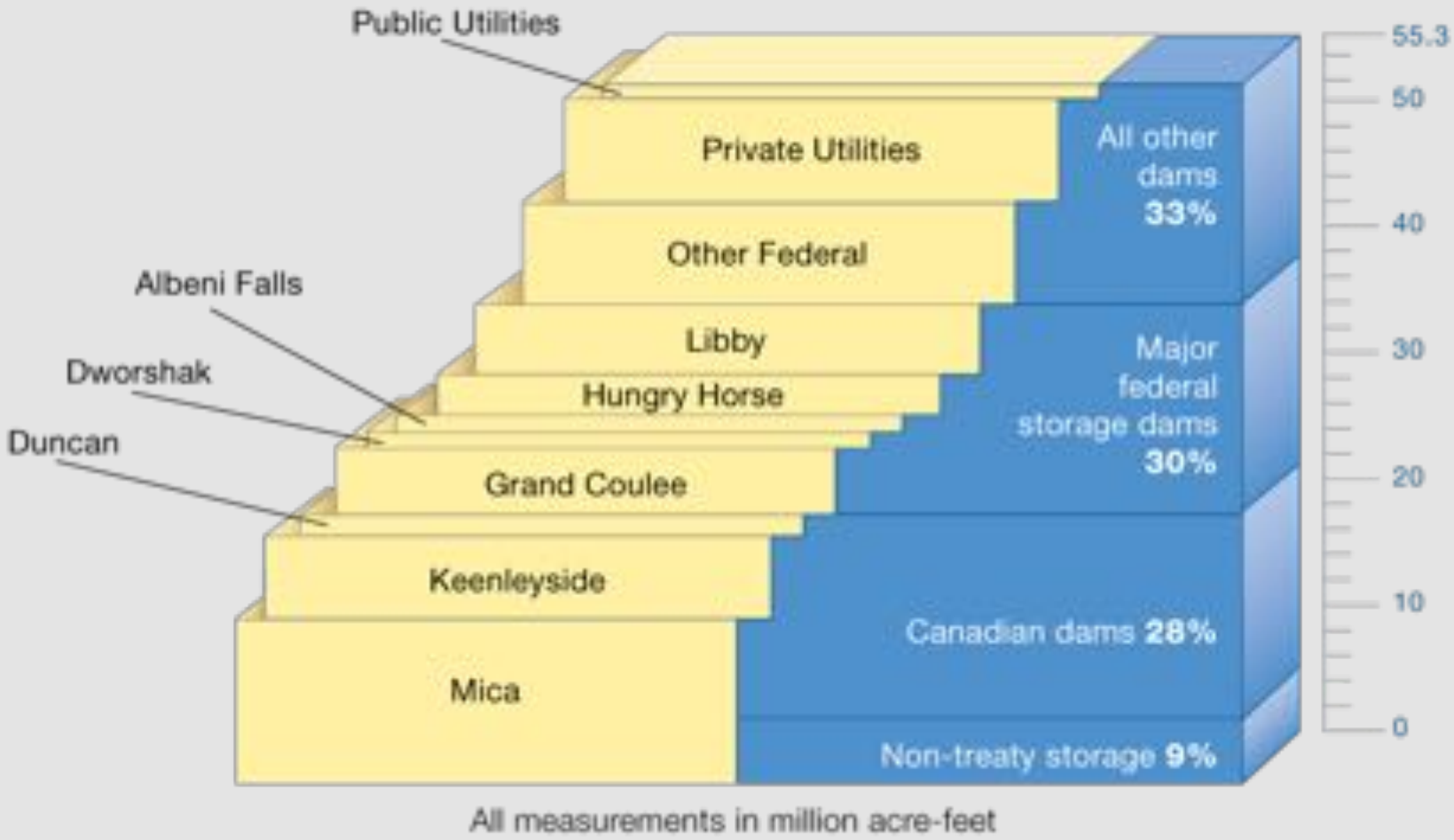
The Treaty required the U.S. to:

- Pay Canada 50% of the estimated value of the future flood control benefits
- Deliver to Canada 50% of the increased power generated downstream at U.S. plants

The Treaty also allowed the U.S. to:

- Construct and operate the Libby project on the Kootenai River in Montana, with 5 Maf of storage
- Libby creates power and flood control benefits downstream in Canada and the U.S., and these benefits remain in the country in which they occur.

Columbia Basin Storage Capacity



- Treaty projects roughly doubled the storage capacity of the river

Storage vs. Run of River

Large Storage Reservoirs:

- Major U.S. reservoirs total about 19.4 Maf in: Libby (5), Horse (3), Kerr (1.2), Noxon (0.2), Albeni Falls (1.2), Grand Coulee (5.2), Chelan (0.7), Brownlee (1), & Dworshak (2)
- Major Canadian reservoirs have about 20 Maf at: Mica (12), Arrow (7.1), & Duncan (1.4)
- Operating criteria typically defined by rule curves, min & max flows & elevations, & spill; vary by time & inflow forecasts, or as modified by adaptive management among agencies.

Run of River Projects (Mid and Lower Columbia and Lower Snake River projects)

- Daily/weekly inflows = outflows; minimal storage (except John Day - has some seasonal flood control storage).
- Operating criteria based on shaping generation to load within min & max flows/elevations, required spill amounts & weekly flow volumes, except as modified by adaptive management among agencies.

The Columbia River Basin

Multiple purposes and interests

- Flood Risk Management
- Ecosystem-based Function
- Tribes & Cultural Resources
- Navigation
- Water Supply
- Recreation
- Hydropower

Many laws and regulations work to strike a balance among these interests

Hydropower Planning & Operations

All reservoir operating plans are designed to meet multiple objectives and project constraints.

- Typically rule curves and/or target flows or elevations, plus:
  - Max/min elevations for flood control, fish, recreation, dam safety, etc.
  - Max/min rates of change in reservoir elevations for bank stability, navigation, fish, etc.
  - Max/min outflows for fish, navigation, water quality, etc.
  - Max/min rates of change in outflows for fish, navigation, bank stability, etc.
  - Required spill or bypass flows for fish or navigation (locks)

Biological Opinions

Salmon species listed as endangered in early 1990's, White Sturgeon in '94, Bull trout threatened in '98

- Multiple Biological Opinions altering river operations
- System will be operated to minimize the harm to & aid the recovery of listed salmon, steelhead, and freshwater species

Action Agencies (COE, BOR, BPA) develop:

- Water Management Plan
- Fish Operations Plan
- Fish Passage Plan

In season management:

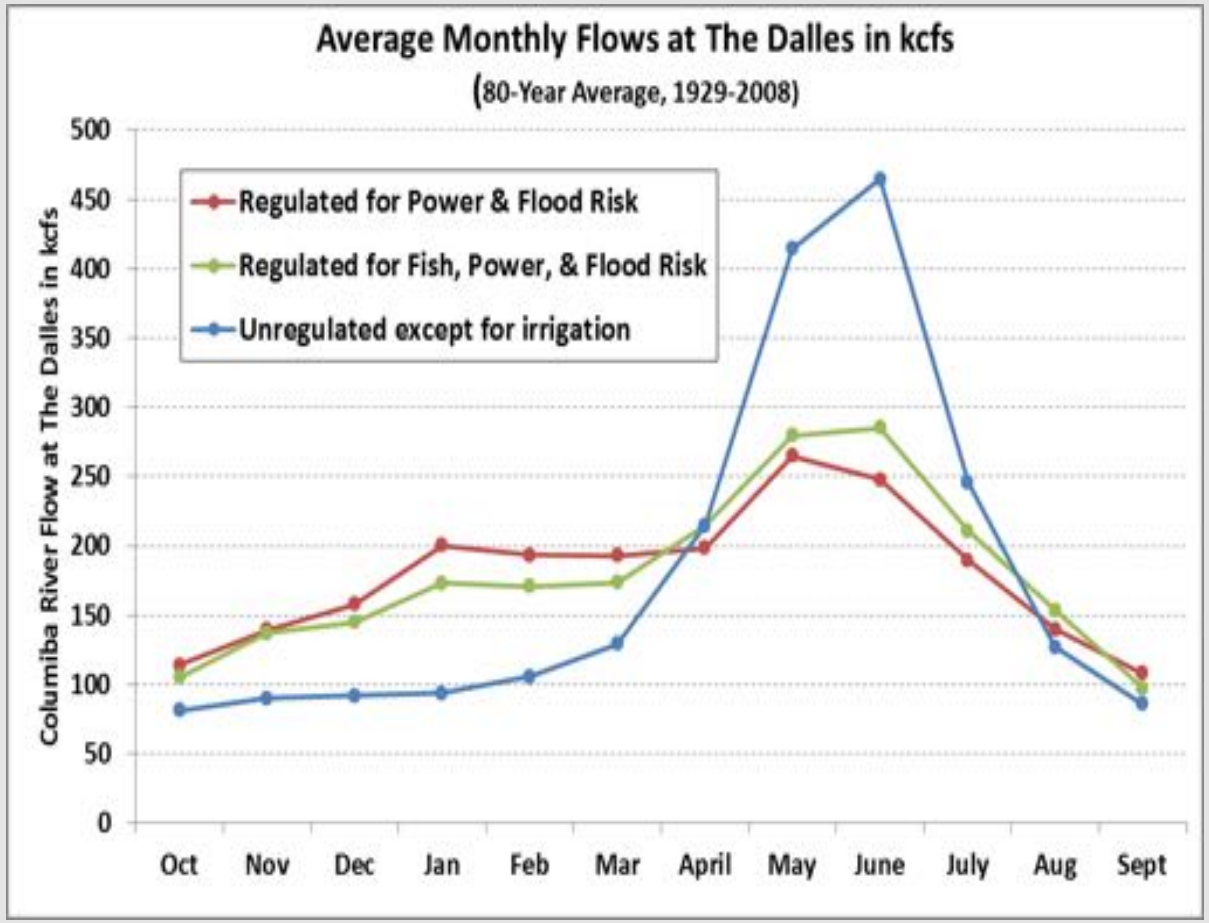
- Technical Management Team weekly meetings

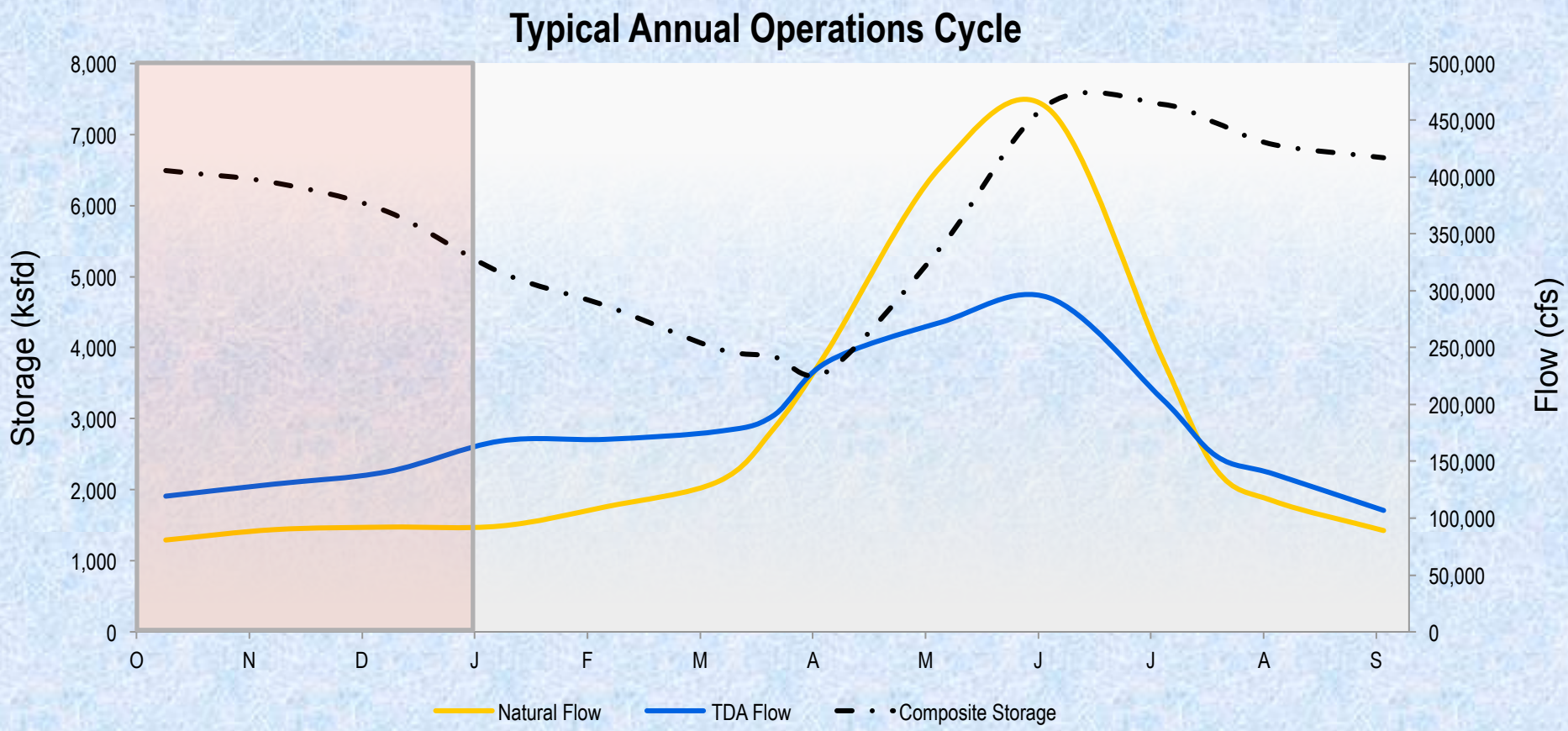
Non-Treaty Storage Agreement

- Allows for coordinated use of 5 Maf of additional storage in Canada that is not governed by the Treaty (dams were built with more storage)
  - BCH and BPA each have access to 1.5 Maf of active storage
- Provides additional flexibility for power and non-power benefits (primarily fish)
- Allows flexibility to shape flows within the year and between years
- This agreement also provides BPA firm rights to water to support ESA-listed fish in the lowest 20th percentile of water years ←DRY WATER YEAR Provision, used in 2015

Flow Management

- Power operations and flood risk management reduce peak spring flow and increase winter flow
- Fish operations increase spring flows





Fall Objective Examples

- Kokanee Spawning minimum elevation at Coulee, Fall Chinook spawning maximum flow at Brownlee
- Vernita Bar Fall Chinook spawning maximum daytime flow mid-October through November then maintain minimum protection flow through May at Priest Rapids
- Bonneville Chum operation min/max tailwater elevation for spawning Nov/Dec with protection flows through March

Summary:

- Columbia River: 4th largest river, only 30% storage capacity
- Hydropower is a substantial PNW resource (>50% of total capacity)
- Collaboration → One-owner system, managed for multiple objectives
- Streamflow variability contributes to operational challenges
- Annual operations: meet project constraints and objectives for FRM, fish, recreation, dam safety, water quality, navigation, etc.
- Power & FRM operations increase winter flows
- Operating for fish increases spring flows
- Continued collaboration necessary for effective management

Questions?

Extra slides….

General Principles

1. Enable **greatest possible shared benefits in U.S. and Canada** from coordinated operation of Treaty reservoirs

2. Address the **health of the Columbia River ecosystem as a shared benefit and cost** of the United States and Canada

3. Determine a timeframe for a modernized Treaty long enough to allow each country to **rely on the Treaty's planned operations and benefits** for purposes of managing their long-range budgets, resource plans and investments while remaining **adaptable enough to consider new scientific and social knowledge**

4. Treaty **operations should be based on the best available science**

5. Continue to **meet authorized uses of U.S. reservoirs/projects** according to applicable legislation, tribal rights, trust responsibilities, and other U.S. laws.

General Principles (cont.)

6. **Pursue coordinated use of Treaty and Canadian non-Treaty storage** to increase flexibility and benefits

7. Strategy for **adapting the Treaty to future changes in climate should be resilient, adaptable, flexible, and timely as conditions warrant**

8. Ensure that **costs associated with any Treaty operations are aligned with the appropriate party**

9. **Implementation of ecosystem-based function operations in the Treaty should be compatible with rebalancing the entitlement and reducing U.S. power costs**