Columbia River Operations

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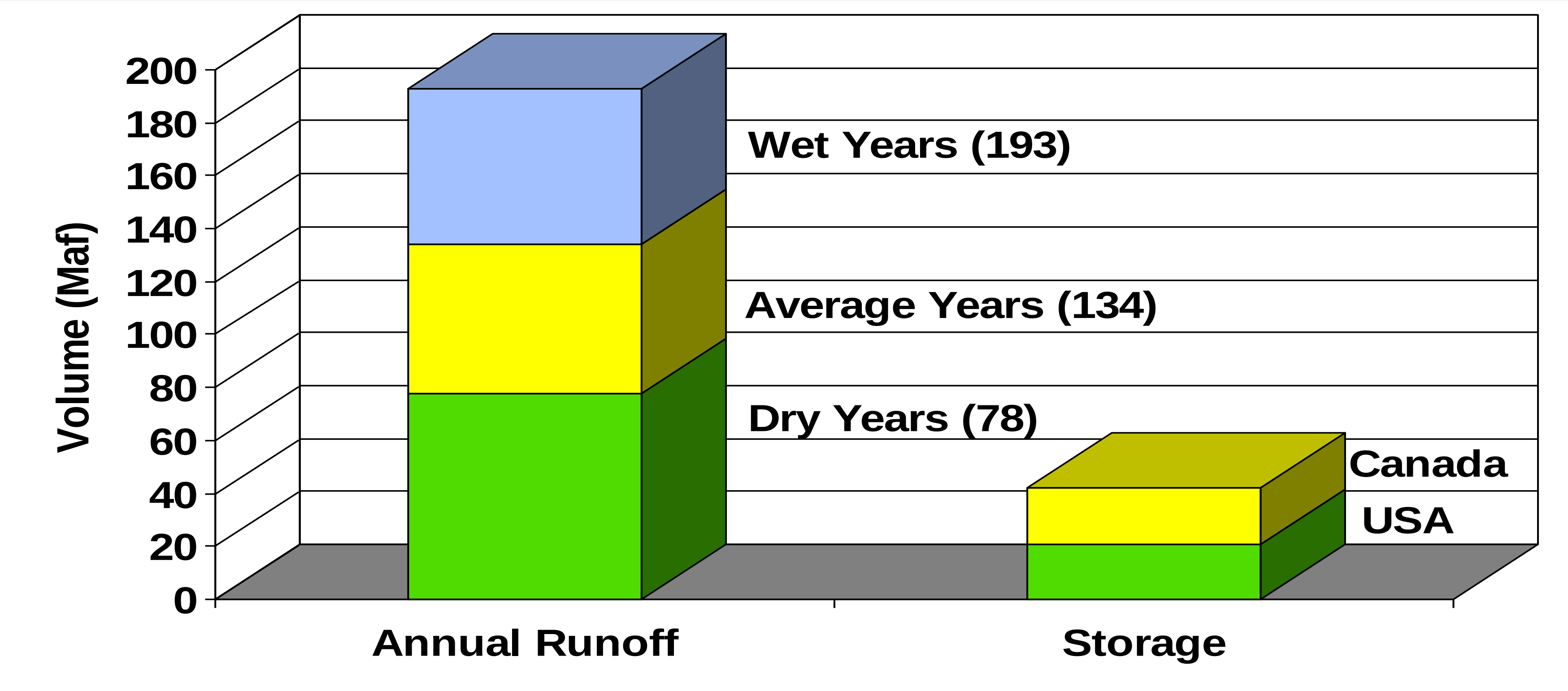
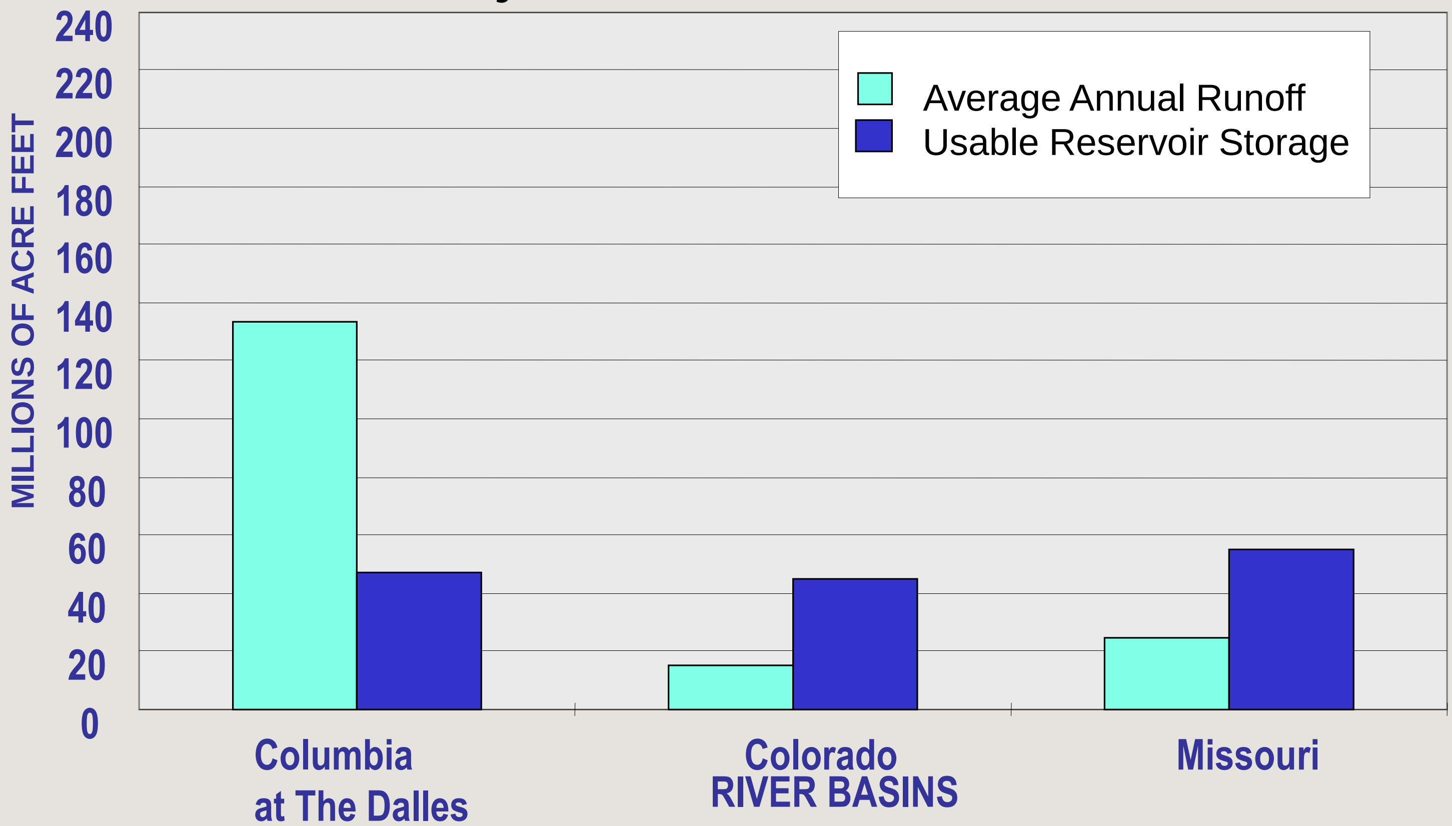
Columbia River Basin

- 4th longest river in North America; drains 258,000 square miles
- 15% of the basin resides in Canada, but provides 38% of annual runoff
- 31 large dams and over 60 smaller ones provide over 30 million acre feet of storage space
- Reservoir system storage is a fraction of annual average runoff
- The operation of the US reservoirs is highly constrained primarily due to salmon recovery efforts

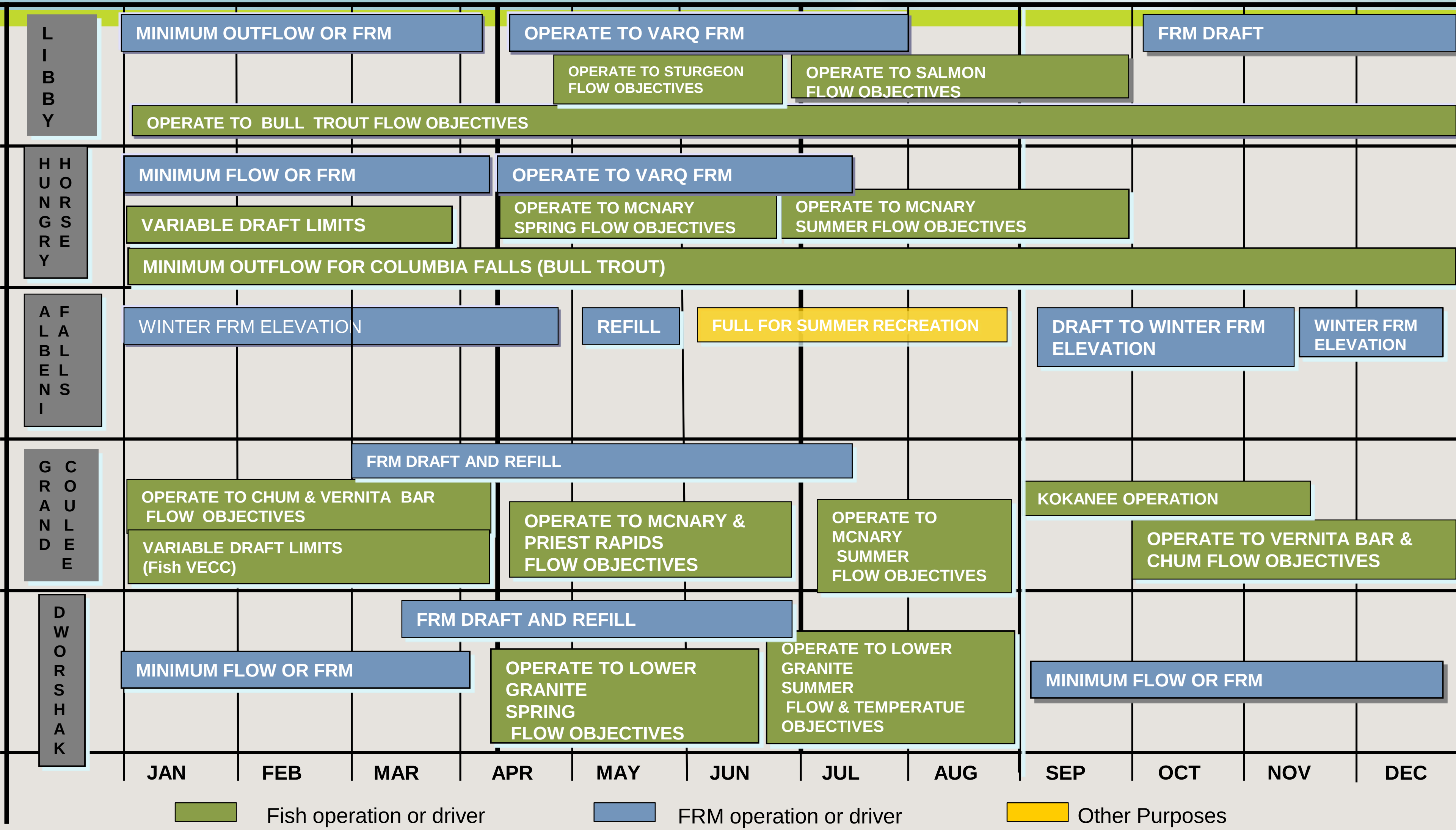
Comparison of Storage Volume to Variations in Runoff



Average Annual Runoff and Usable Reservoir Storage
Major Western River Basins



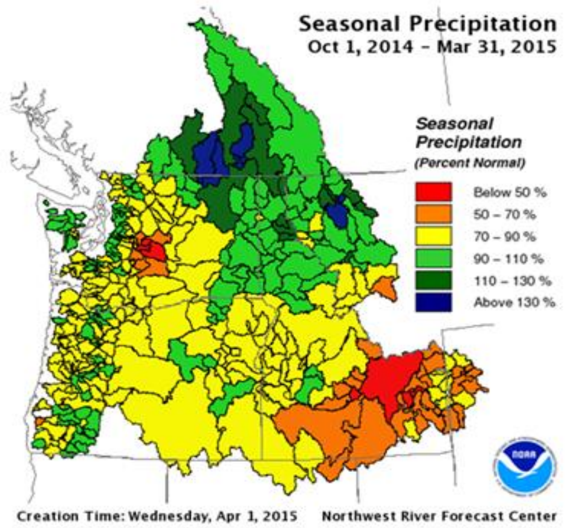
BONNEVILLE POWER ADMINISTRATION

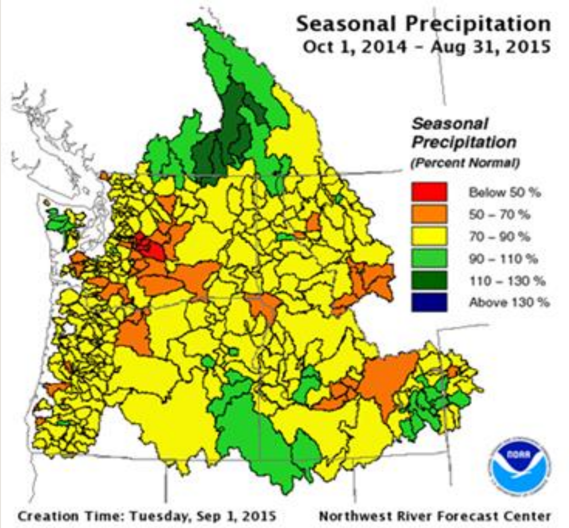


2015 Overview

- Warm Winter led to earlier runoff and impacted Spring/Summer water supplies
- Dry Hot Spring / Summer resulted in water quality challenges
- Storage releases propped up river flows and minimized impacts
- Early runoff resembled some of the climate change scenarios analyzed by BPA, Corps of Engineers and Reclamation

Temperature and Precipitation



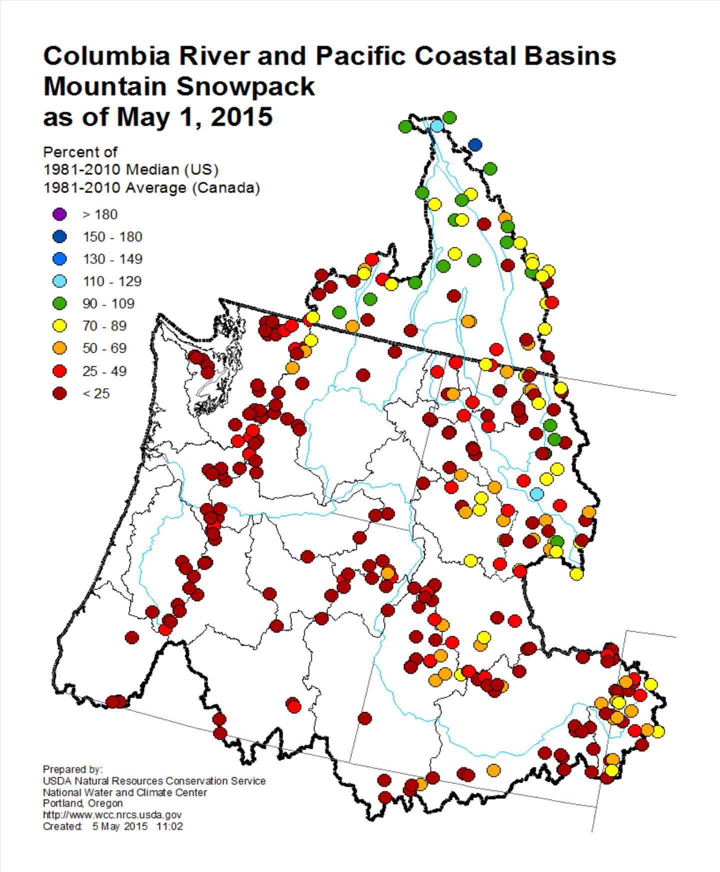


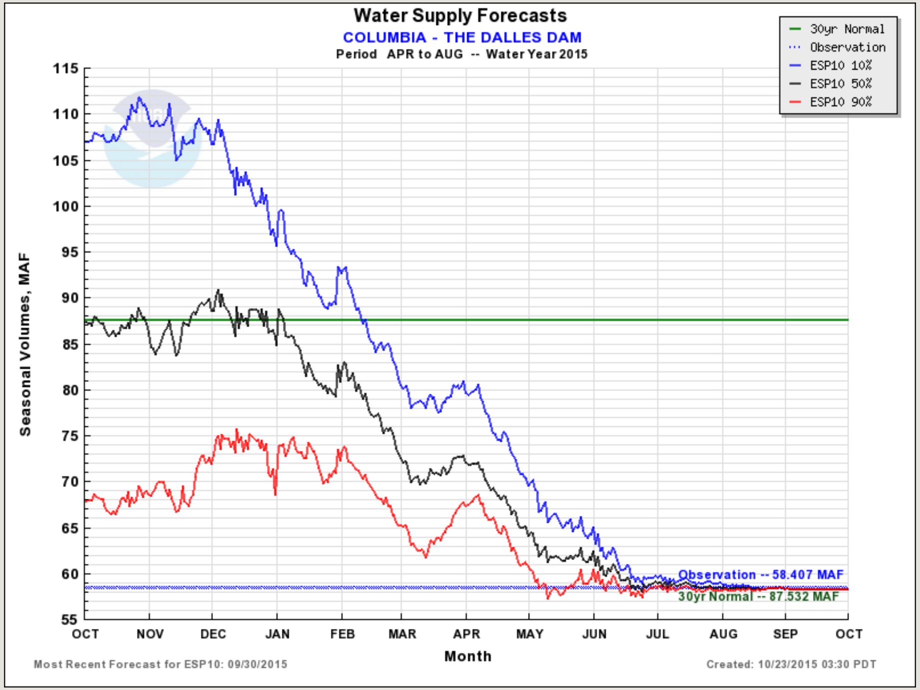
Regional Temperature Departures (°F)

Temp Dep. °F	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Avg °F	Avg °C
Arrow	4.3	-1.1	**4.7**	**5.6**	**7.6**	**6.0**	0.5	2.3	**7.4**	2.4	0.0	**3.9**	**2.0**
Grand Coulee	4.4	-2.2	3.2	**5.5**	**6.2**	**4.6**	0.2	2.7	**6.4**	2.4	1.5	**3.2**	**1.8**
Ice Harbor	4.4	-2.2	3.2	**5.5**	**6.2**	**4.6**	0.2	2.7	**6.4**	0.2	1.6	**3.0**	**1.7**
The Dalles	**4.6**	-1.4	4.0	**5.9**	**7.0**	**5.6**	0.4	2.9	**7.4**	1.9	1.9	**3.7**	**2.0**
Willamette	3.9	-0.1	2.8	**5.1**	**5.0**	**4.6**	-0.3	2.2	**5.4**	3.3	1.7	**3.1**	**1.7**

Months with departures of 4.5°F or greater are highlighted in red

Snowpack and Runoff Forecasts

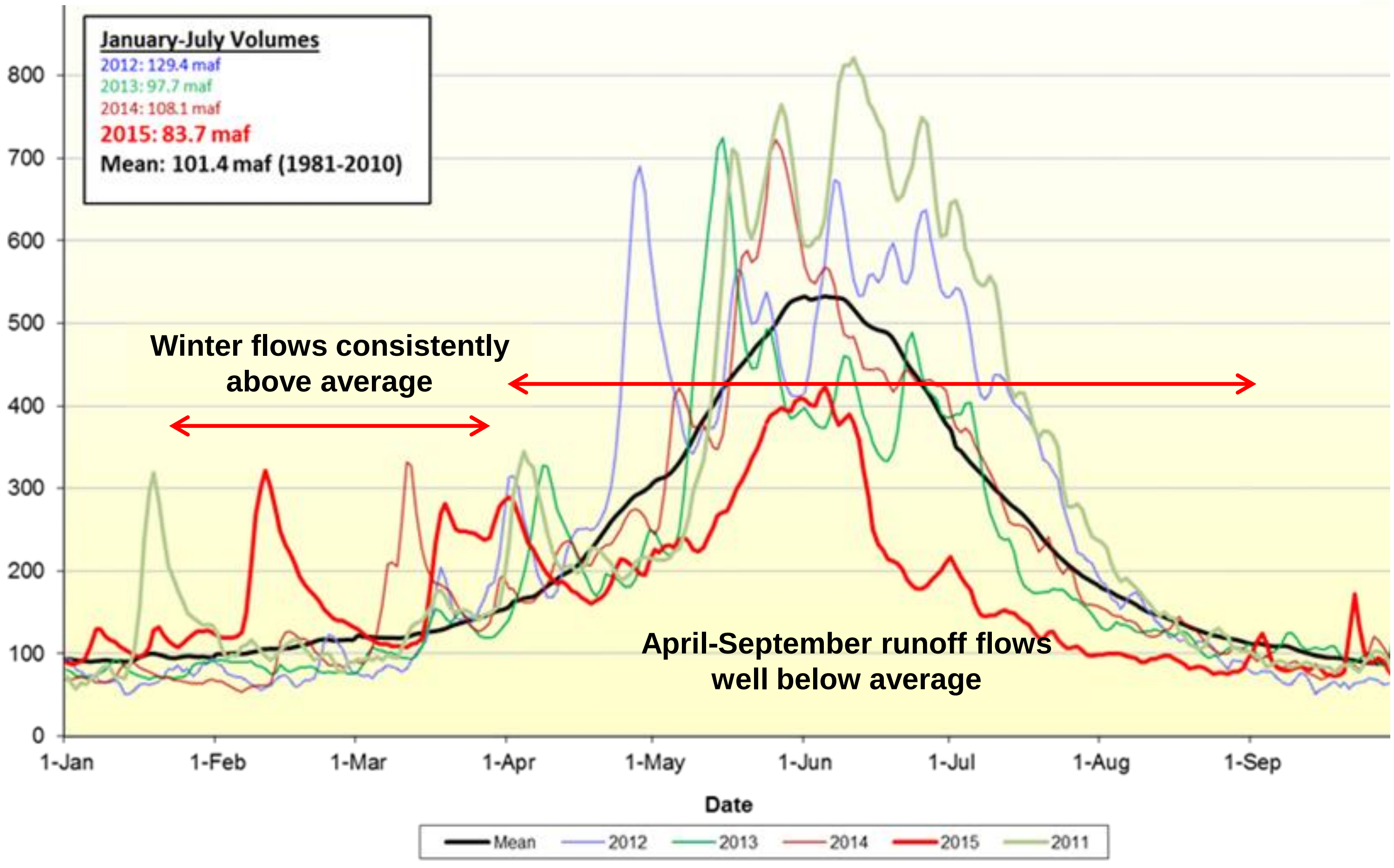




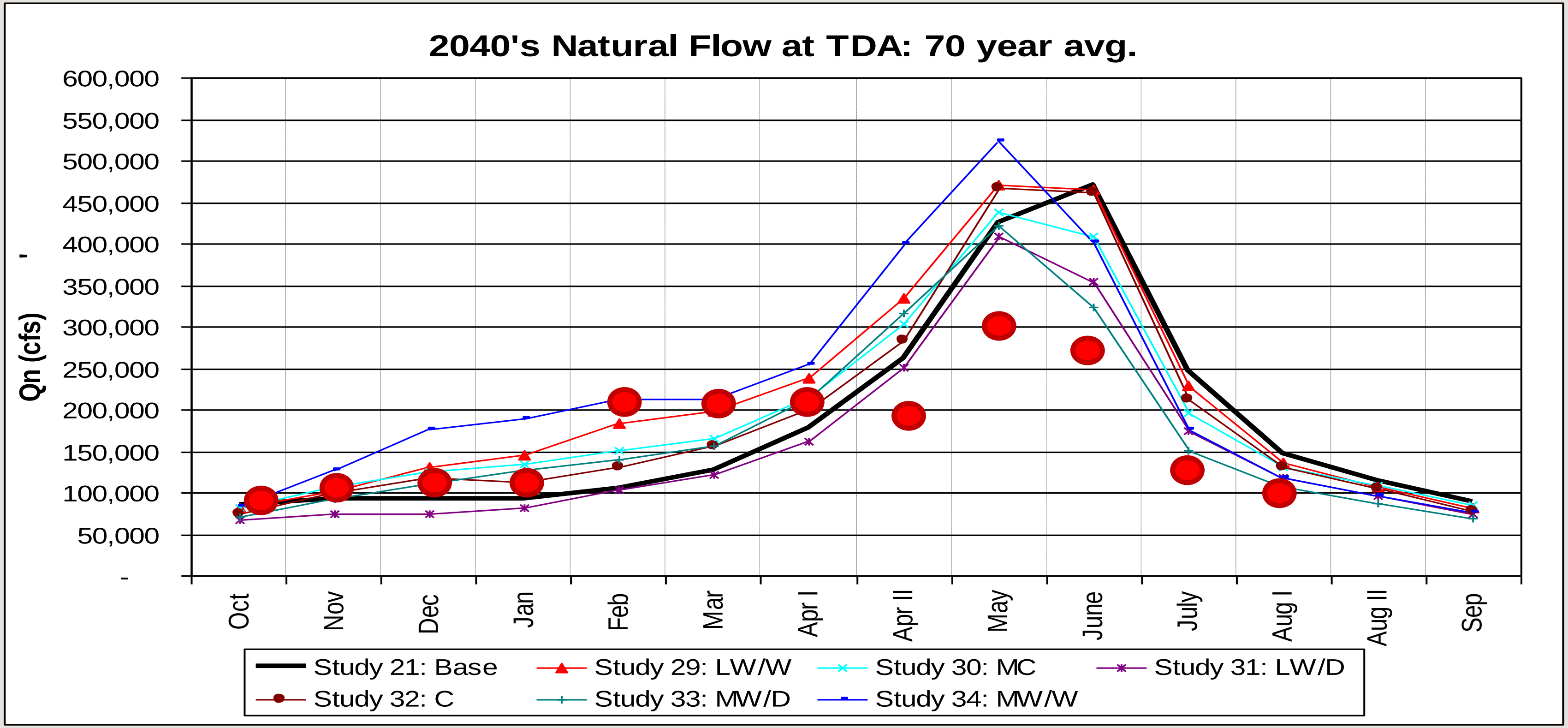
Apr – Aug Observed = 58.4 maf (67%)

Jan – Jul Observed = 83.7 maf (83%)

Natural Flows at The Dalles – 2015

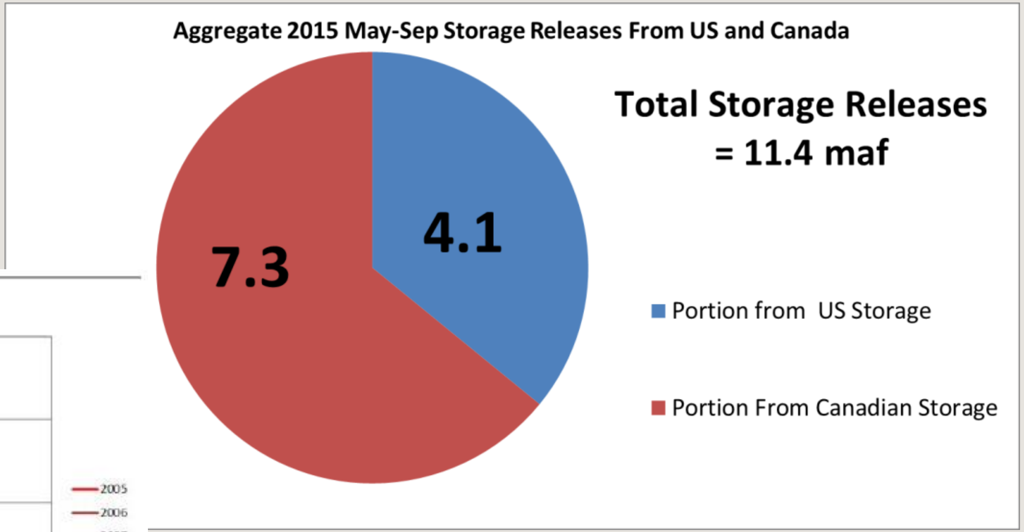


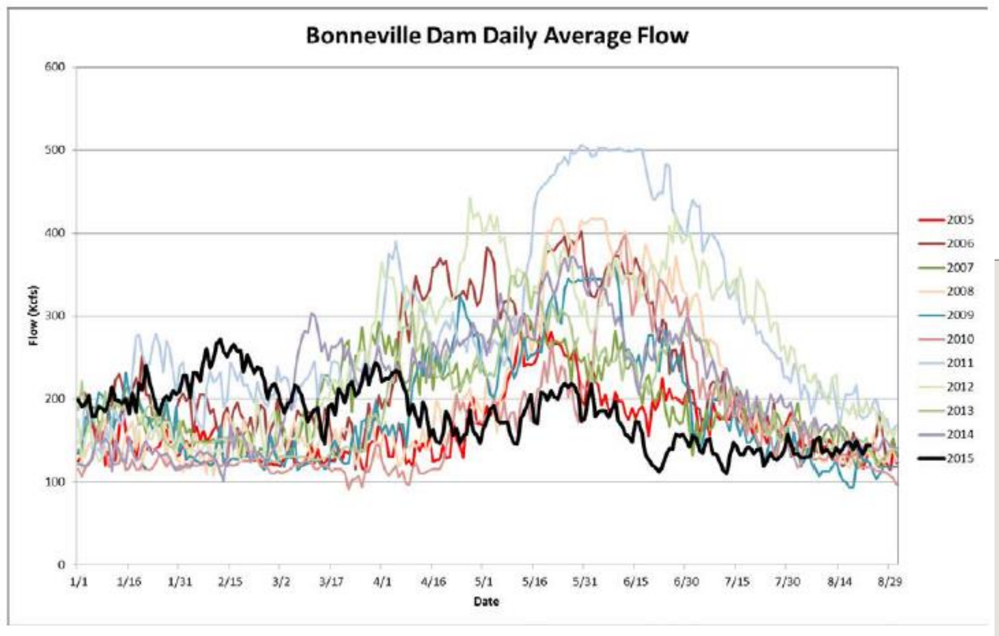
RMJOC-I Natural Streamflows at The Dalles for 2040's vs. 2015 Observed



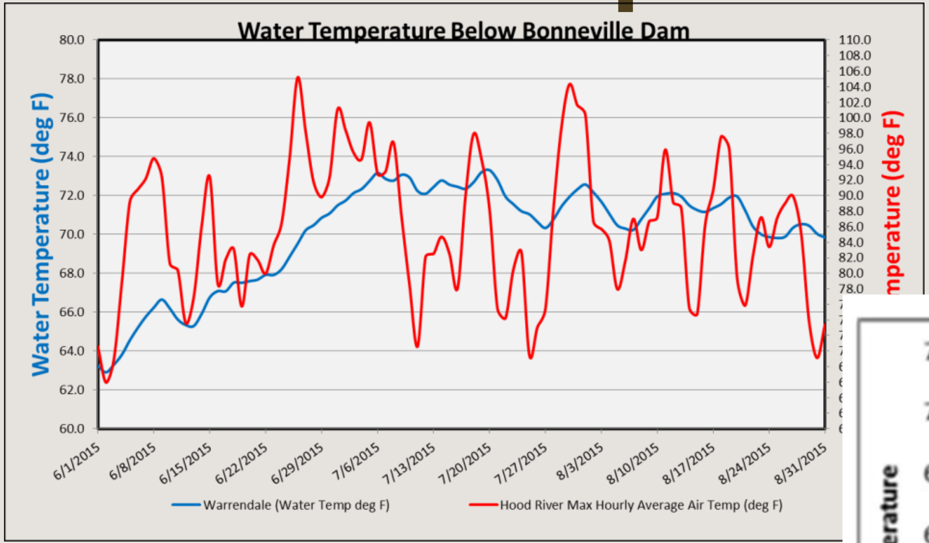
2015 month average flows

Regulated Flows and Augmentation



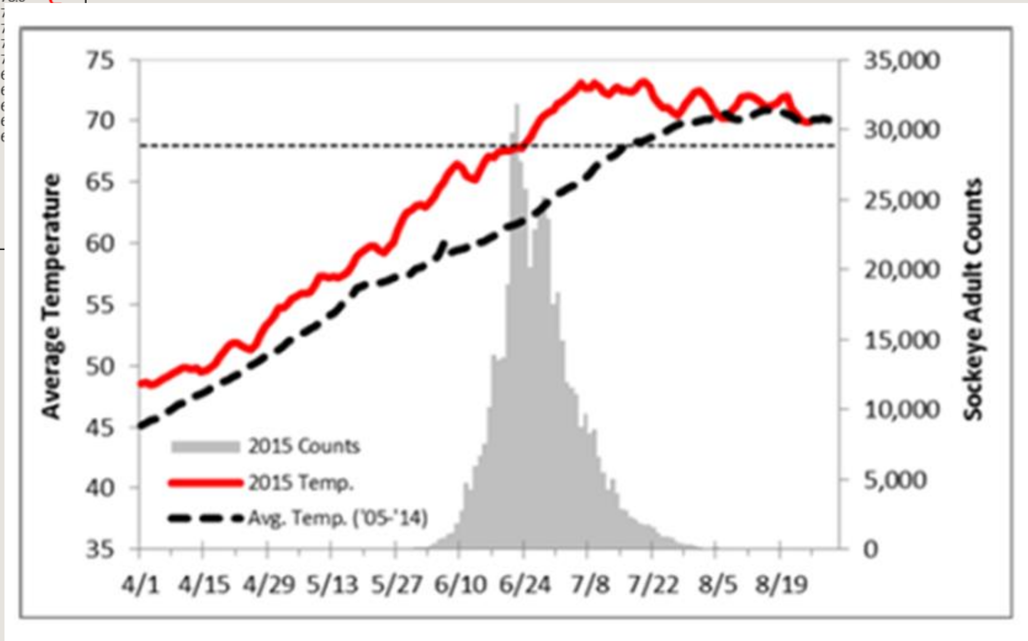


Water Temperature



June 26-July 5 heat wave resulted in water temperatures well above Average

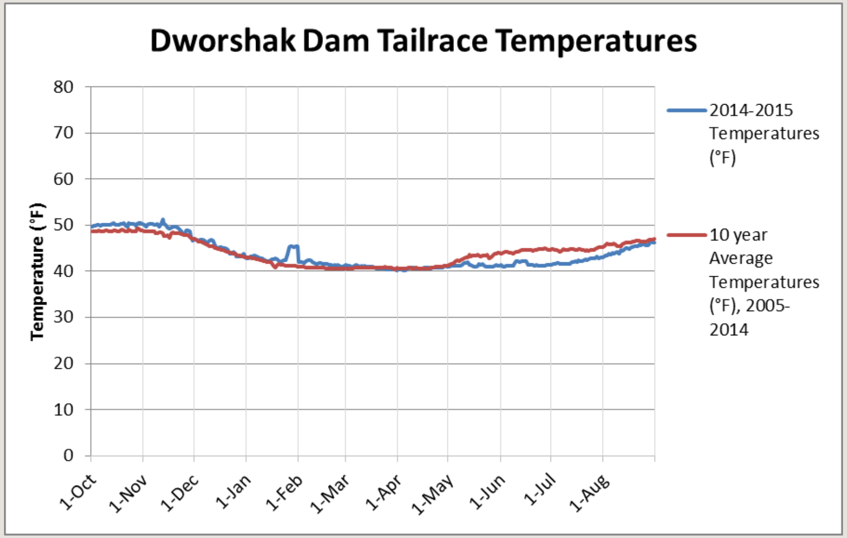
Bonneville Dam Forebay Temperature (F)

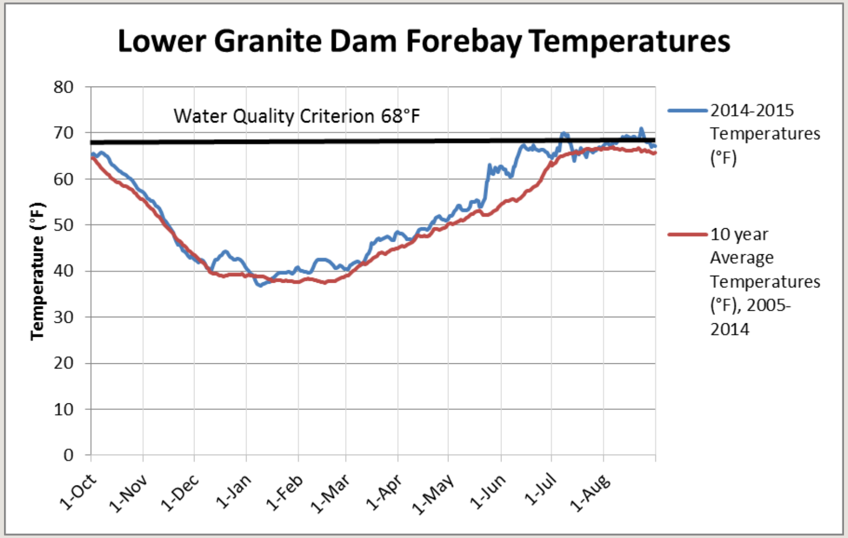


The high water temperatures were coincident with the peak of the sockeye salmon adult migration.

Water Temperatures Augmented by Storage Releases

- Temperature Control Devices at headwater projects make a significant difference in the immediate downstream river reaches
- Dworshak Dam releases can be a high percentage of the total Snake River flow during low streamflow periods
- Temperature augmentation from Dworshak Dam maintained water temperature to Lower Granite Dam at or just above the 68 degree F threshold





Impact of Conditions

- Winter – Normal precipitation and warm temperatures produced high flow and surplus energy
- Spring/Summer –
  - Low precipitation and warm temperatures. Advanced planning mitigated for below average electric generation.
  - Air temperature affected water temperature regionally, temperature control at headwater dams improved conditions immediately downstream.
  - High water temperatures impacted salmon and sturgeon survival.

Adaptability to Climate Change

- Limited storage to augment flows in a dry year, however flow augmentation to mitigate dry conditions benefits both power supply and fisheries needs.
- Headwater projects can mitigate water temperatures in local areas downstream
- While climate change modeling does not suggest the overall poor water of 2015 will be typical, it did provide a good test case for the earlier runoff that modeling does suggest.
- Eighty years of managing water supply volatility for power planning, flood control and salmon protection have given us a solid framework to work within.