

An aerial photograph of a large concrete dam spanning a deep canyon. The reservoir is filled with dark water, and the surrounding hillsides are covered in green vegetation. A road runs along the left side of the dam, and another road curves along the right side. The dam itself is a large, curved structure with a spillway on the right side.

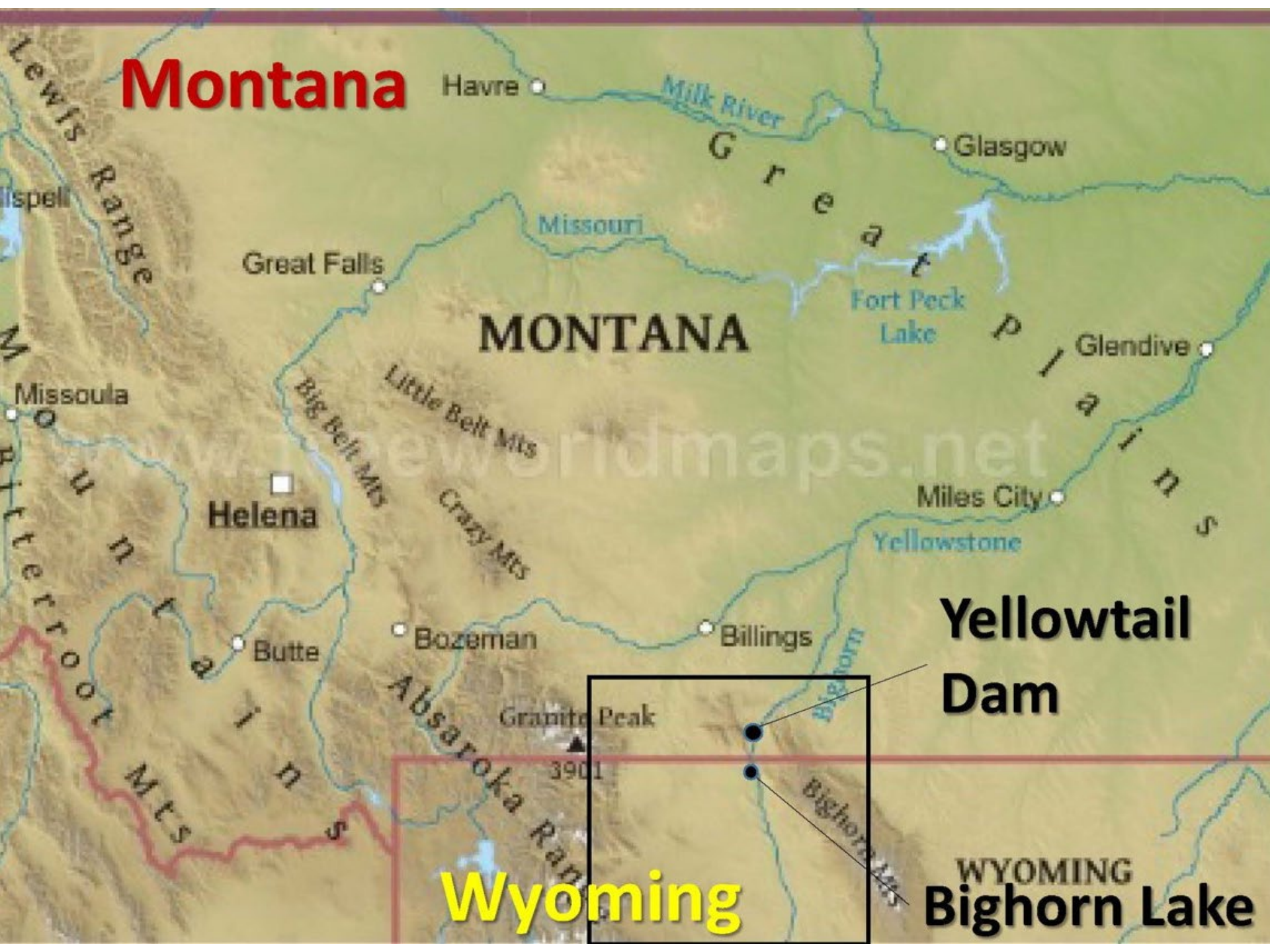
**RECLAMATION**  
*Managing Water in the West*

# Using a RiverWare model to Improve reservoir operations in three easy steps

**Presented By: Jordan Lanini, P.E.  
Great Plains Regional Office**



# Montana



**Yellowtail  
Dam**

**Wyoming**

**WYOMING  
Bighorn Lake**

# Lake recreation viewpoint on 2000's drought

[https://www.youtube.com/embed/rpAjzqDnh\\_U?start=345&end=389&rel=0](https://www.youtube.com/embed/rpAjzqDnh_U?start=345&end=389&rel=0)

# River recreation viewpoint on 2010's high flows

<https://www.youtube.com/embed/9nyWAP70C8M?start=40&end=80&rel=0>

# Bighorn Lake Operational Criteria Review

- **Goals:**

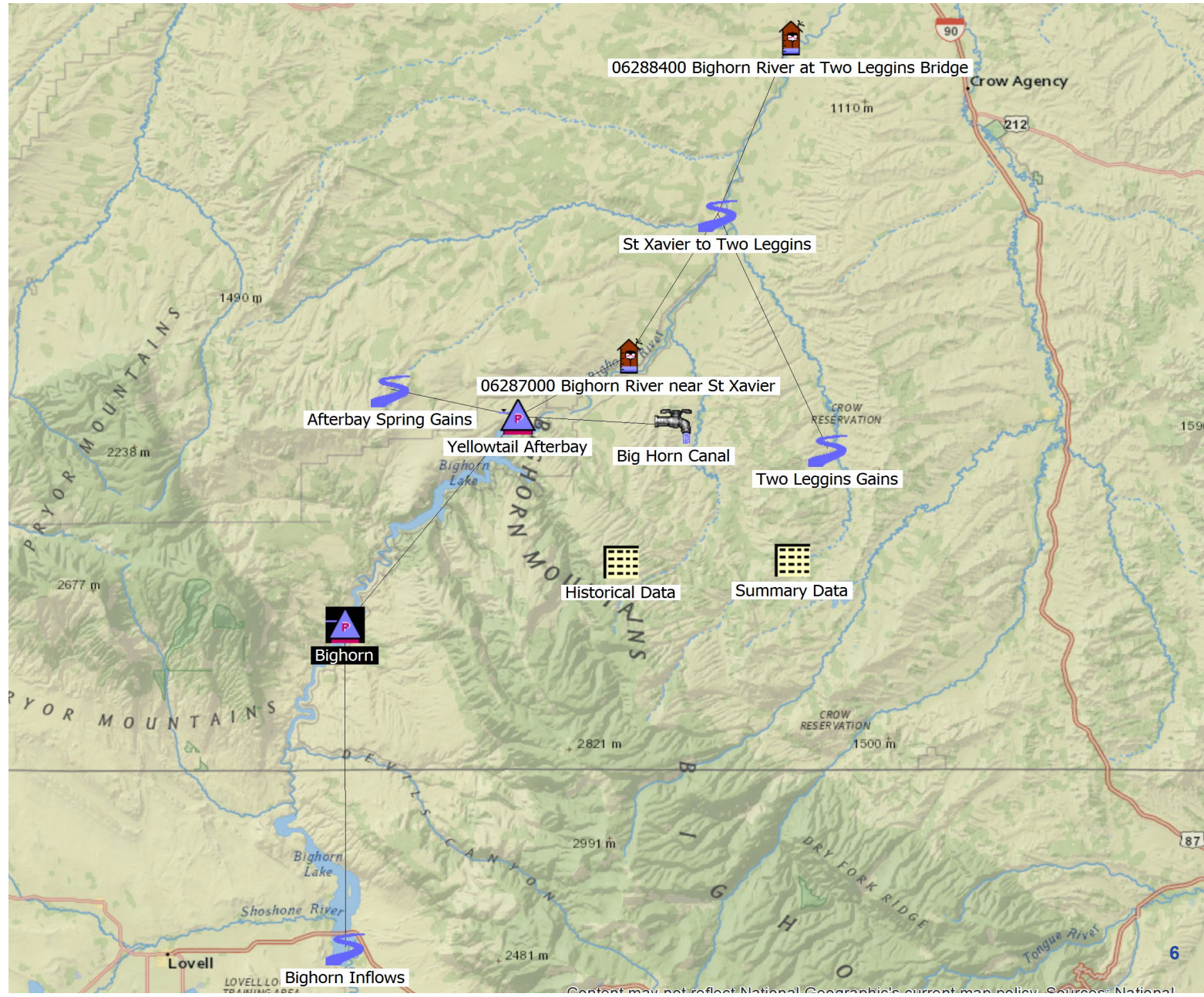
- *Were the anticipated benefits of the 2010 Operating Criteria realized?*
- *Where the actual operations did not meet expected benefits, explain the differences.*
- *Develop proposals to improve current criteria or areas of study.*

- **Technical Working Group Represented:**

- Friends of Bighorn Lake
- Bighorn County, WY
- Wyoming State Engineer's Office
- Wyoming Department of Fish and Game
- National Park Service
- State of Montana Fish, Wildlife and Parks
- State of Montana Dept. of Natural Resources and Conservation
- Western Area Power Administration
- Reclamation
- Bighorn River Alliance



# Easy Step 1: Build a RiverWare Model



# Easy Step 2: Use RiverWare model to perform experiments

- Historical operations with perfect and historical forecasts
- Historical operations with various alternative operating criteria
- Comparisons between actual operations and modeled operations
- Comparisons between time periods
- Study goals:
  - Determine if benefits were realized/Isolate impacts of operational criteria
  - Isolate the impacts of forecasting
  - Isolate the impacts of operators
  - Isolate hydrologic impacts

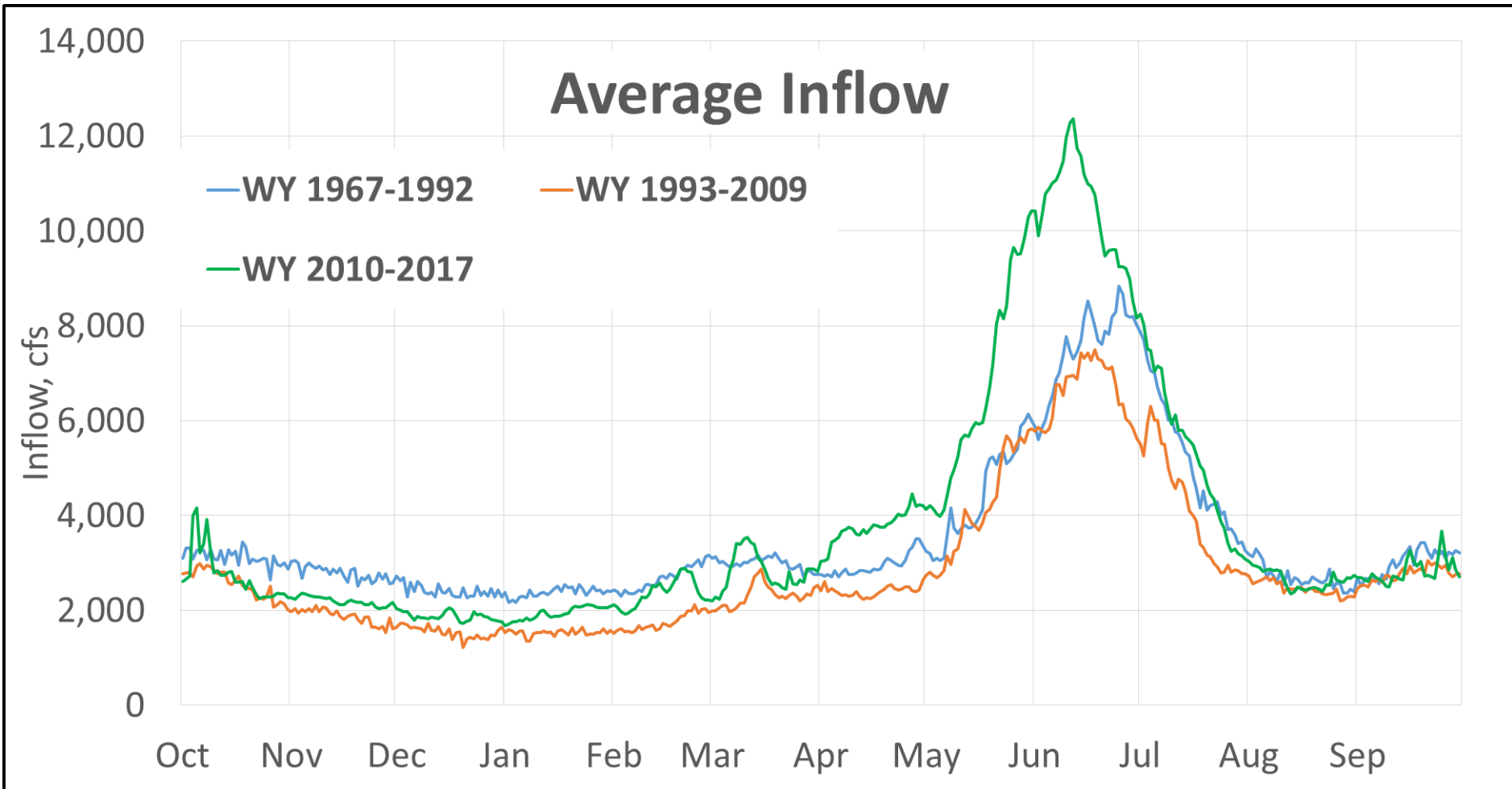
# Easy Step 3: gain stakeholder buy-in and execute operational improvement plan

- a) Present plan of study to stakeholders (meeting #1)
- b) Present plan of study to general public (public meeting #1)
- c) Execute statistical review
- d) Deliver statistical review memo to stakeholders
- e) Present statistical review results to stakeholders (meeting #2)
- f) Revise statistical review based on stakeholder comments
- g) Present draft modeling review results to stakeholders (meeting #3)
- h) Prepare draft modeling review report
- i) Execute stakeholder requested alternative operating policies
- j) Present results of alternative operating policies and report executive summary (meeting #4)
- k) Deliver modeling report to stakeholders
- l) Review stakeholder comments
- m) Respond to stakeholder comments
- n) Discuss stakeholder comments with stakeholder (meeting #5)
- o) Independent review by CADSWES
- p) Provide independent review to stakeholders
- q) Discuss independent review with stakeholders (meeting #6)
- r) Provide model as RiverWISE scenario explorer to stakeholders
- s) Execute additional stakeholder requested scenarios and revise report
- t) Review recommendations for operations improvements with stakeholders (meeting #7)
- u) Develop plan to execute operations improvements studies
- v) Discuss plan for operations improvements to stakeholders (meeting #8)
- w) Present results and plan for operations improvements to general public (public meeting #2)
- x) Execute plan for operations improvements (ongoing, 3-5 years):
  - a) Forecasting Improvements:
    - a) Evaluate improvements to statistical forecasts
    - b) Study enhanced resolution snowmelt runoff modeling
    - c) Examine skill of forecast components
    - d) Evaluate skill of NWS and other forecast ensembles
  - b) Operating Criteria improvements:
    - a) Model and evaluate explicit low-flow rules
    - b) Examine frequency of elevation targeting
    - c) Remove Encroachment into Flood Pool
    - d) Update rule curves to anticipate higher inflow volumes
    - e) Explicitly define relationship between flood pool and releases
  - c) General operations improvements
    - a) Avoid hedging operations using uniform release factor
    - b) Implement daily time-step operations model
    - c) Implement basin-wide operations model
    - d) Incorporate ensemble inflow forecasts
    - e) Examine variable drawdown timing

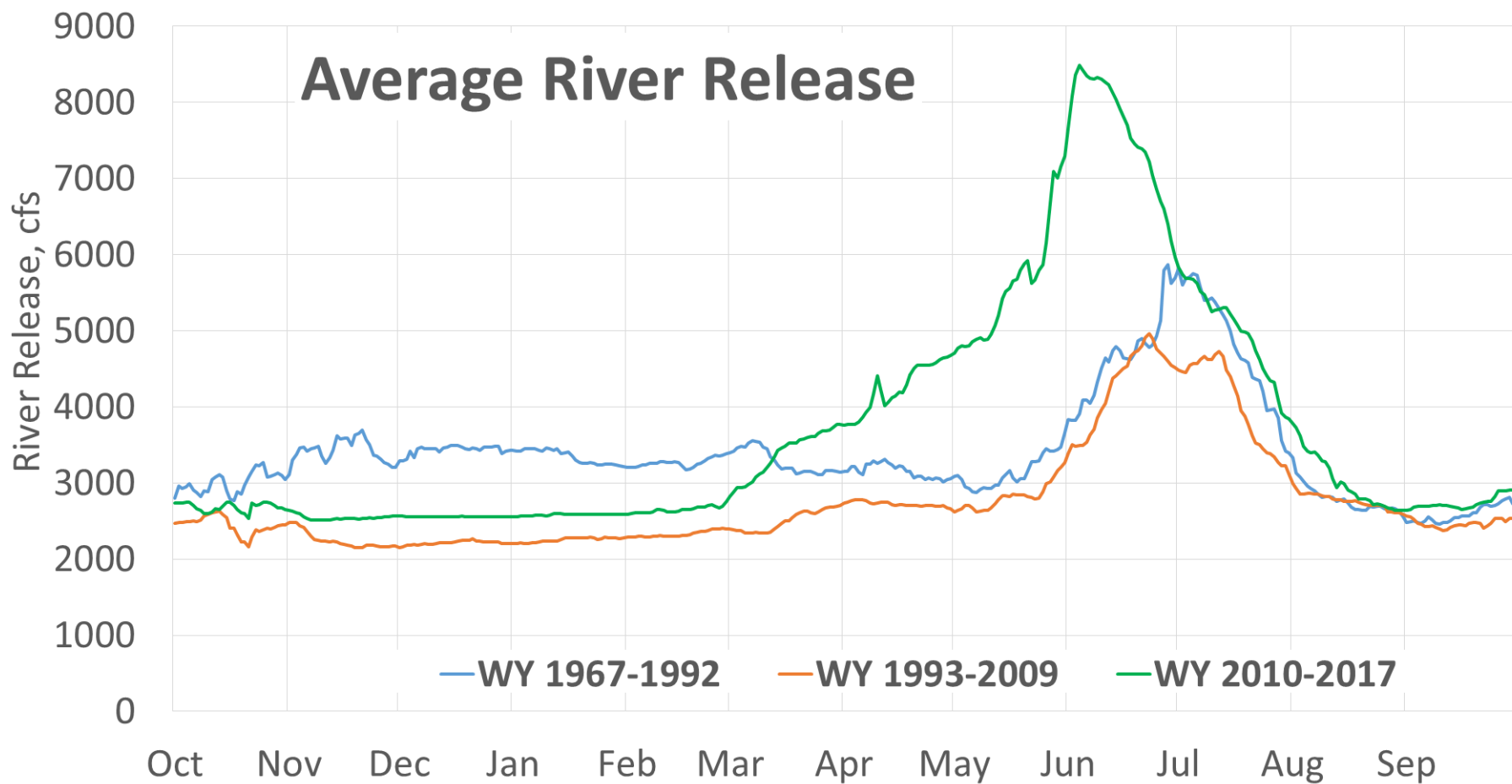


# Findings

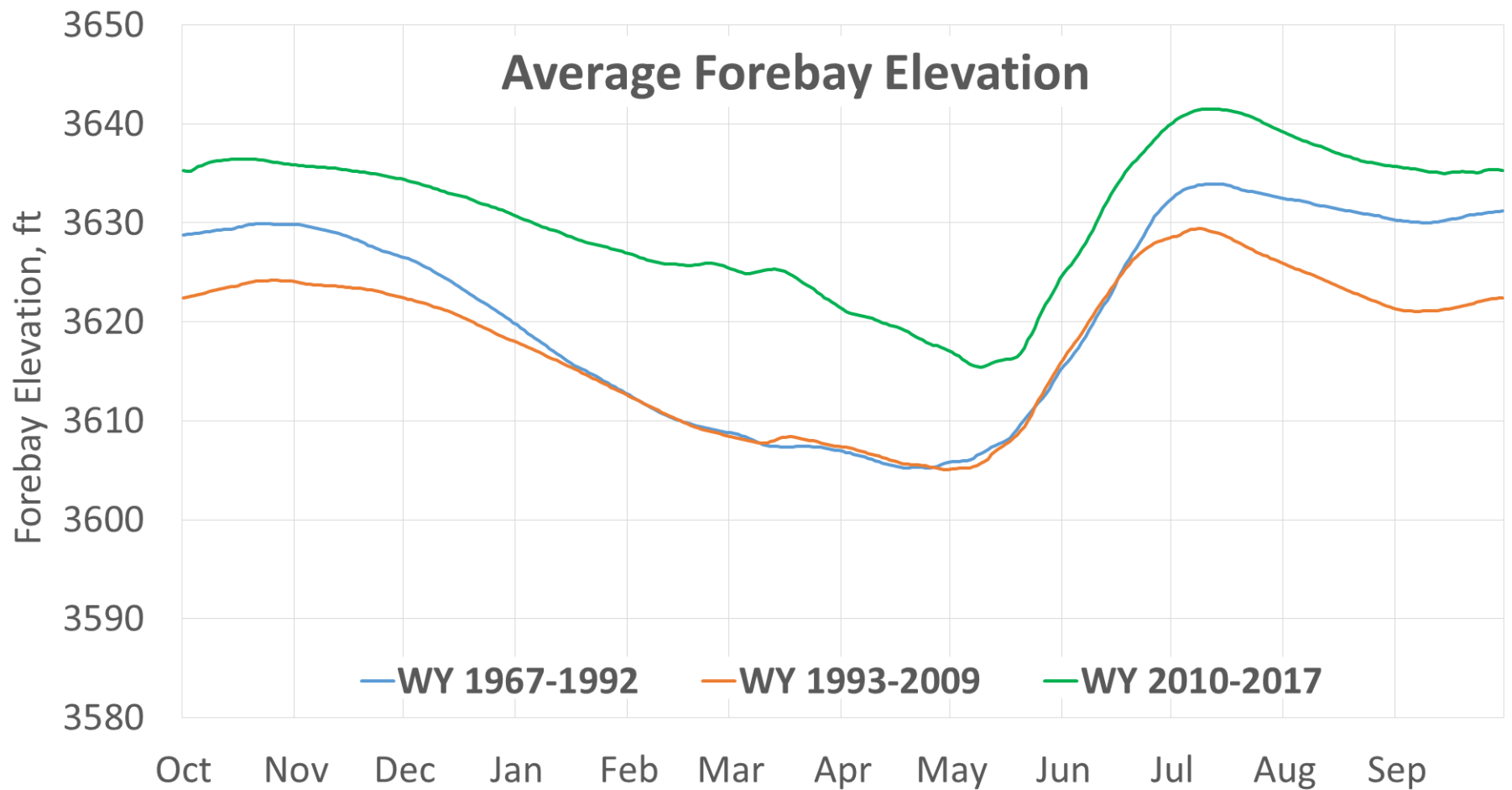
- **Hydrologic variability is a key driver of undesirable river flows and pool elevations**
- **Forecasting error also significantly impacts operations**
- **The operating criteria is reasonably balanced between competing interests...**
- **But operating criteria can be improved without trade-offs between competing interests**



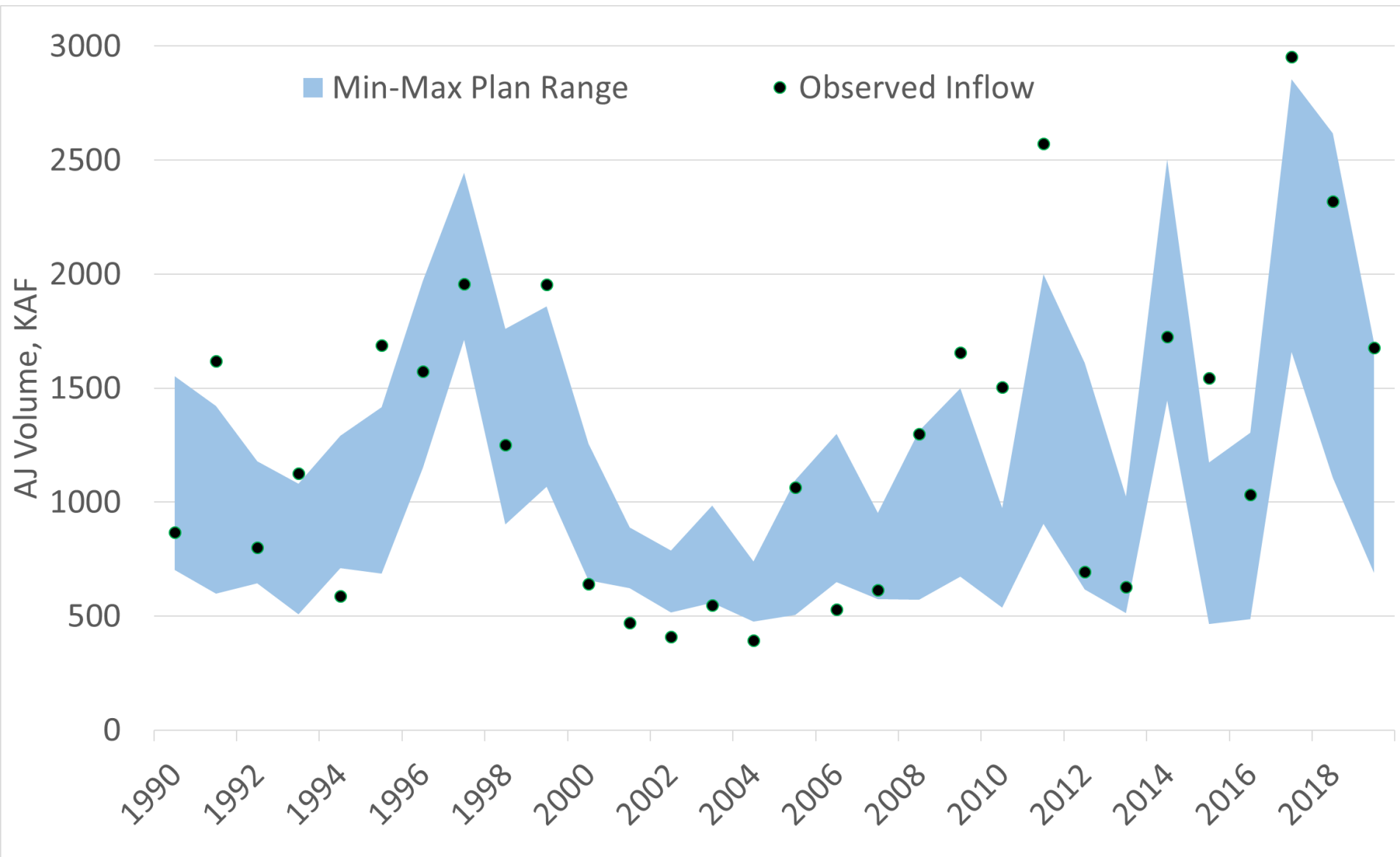
## Average River Release







# “We’re fooling ourselves.”-Jordan Lanini



# Recommendations

Forecasting	Operating Criteria	General Operations
Evaluate improvements to statistical forecasts	Model and evaluate explicit low-flow rules	Avoid hedging operations using uniform release factor
Study enhanced resolution snowmelt runoff modeling	Examine frequency of elevation targeting	Implement daily time-step operations model
Examine skill of forecast components	Remove Encroachment into Flood Pool	Implement basin-wide operations model
Evaluate skill of NWS and other forecast ensembles	Update rule curves to anticipate higher inflow volumes	Incorporate ensemble inflow forecasts
	Explicitly define relationship between flood pool and releases	Examine variable drawdown timing



# Better Forecasting: Statistical Forecast Enhancements

NRCS Montana Snow Survey Supervisor Ashton "Ash" Codd busy water supply forecasting c. 1952. From NRCS, 2006.

## PyForecast

Water Supply Forecasting  
Version 2.0

PyForecast v2.0

File About

Stations Data Forecast Options Regression Summary Density Analysis

NRCS SNOTEL Site

ID: 875  
Name: Wolverine  
HUC8: 10070006  
Elevation: 7650  
POR: 1981  
[Website](#)

SWE (in)

Add Site

Select Datasets

Use the map to select climatological stations that should be included in the analysis. The program will download period of record data for each dataset selected.

PYID	Type	ID	Name	Parameter
TE3630WS	SNOTEL	875	Wolverine	SWE
TW3578WS	SNOTEL	350	Blackwater	SWE
TU3541WS	SNOTEL	616	Marquette	SWE
TD3462WS	SNOTEL	309	Bald Mtn.	SWE
TI3657WS	SNOTEL	358	Bone Springs Div	SWE
TC3581WS	SNOTEL	751	Shell Creek	SWE
TR3562WS	SNOTEL	819	Timber Creek	SWE
GE3313MN	USGS	06279500	BIGHORN RIVER AT KANE, WY	Streamflow

Other Datasets:

NRCC  Add

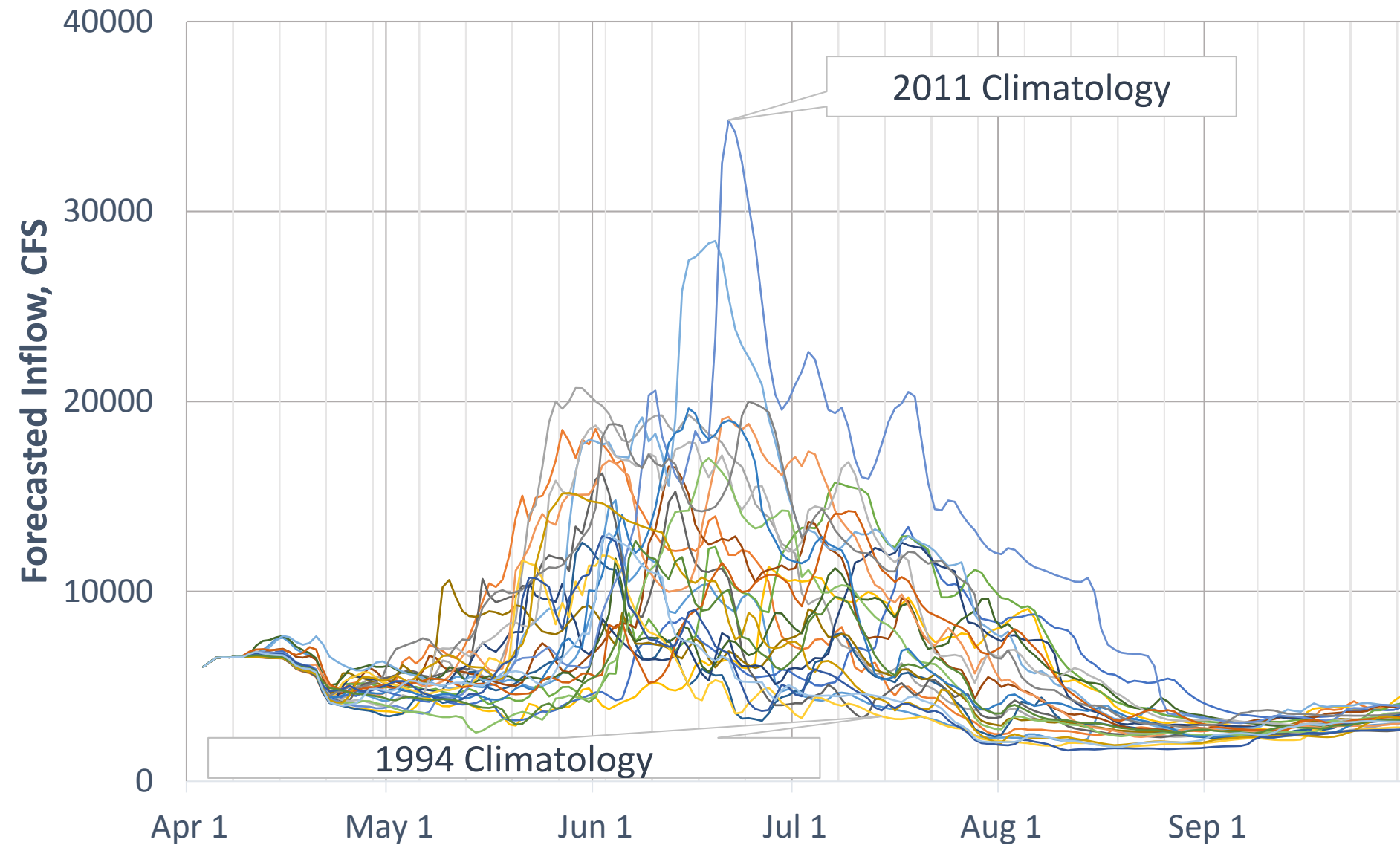
PRISM  Add

PDSI  Add

Climate  Add

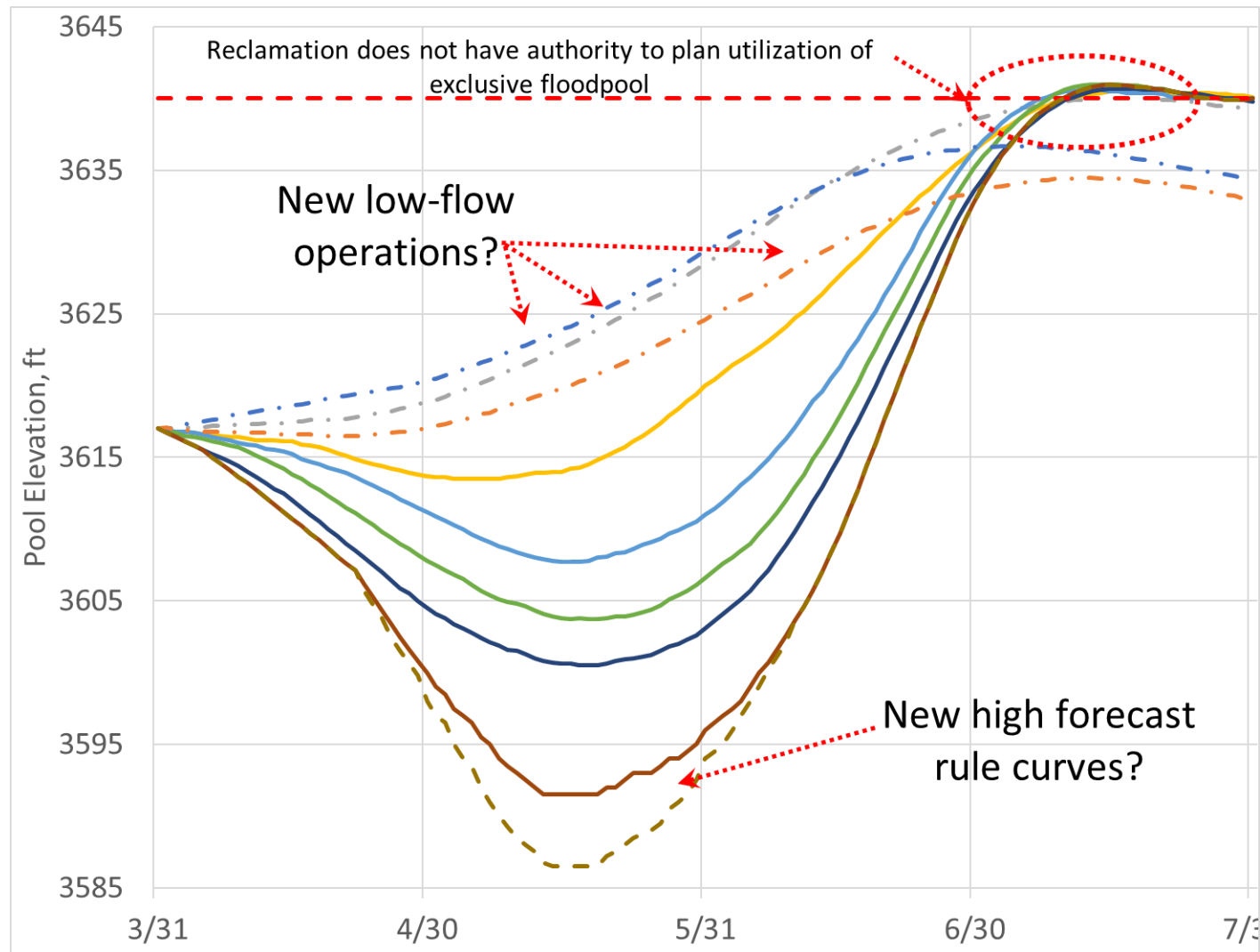
Web Dataset

# Better Forecasting: Ensemble Forecasts



# Better Operating Criteria

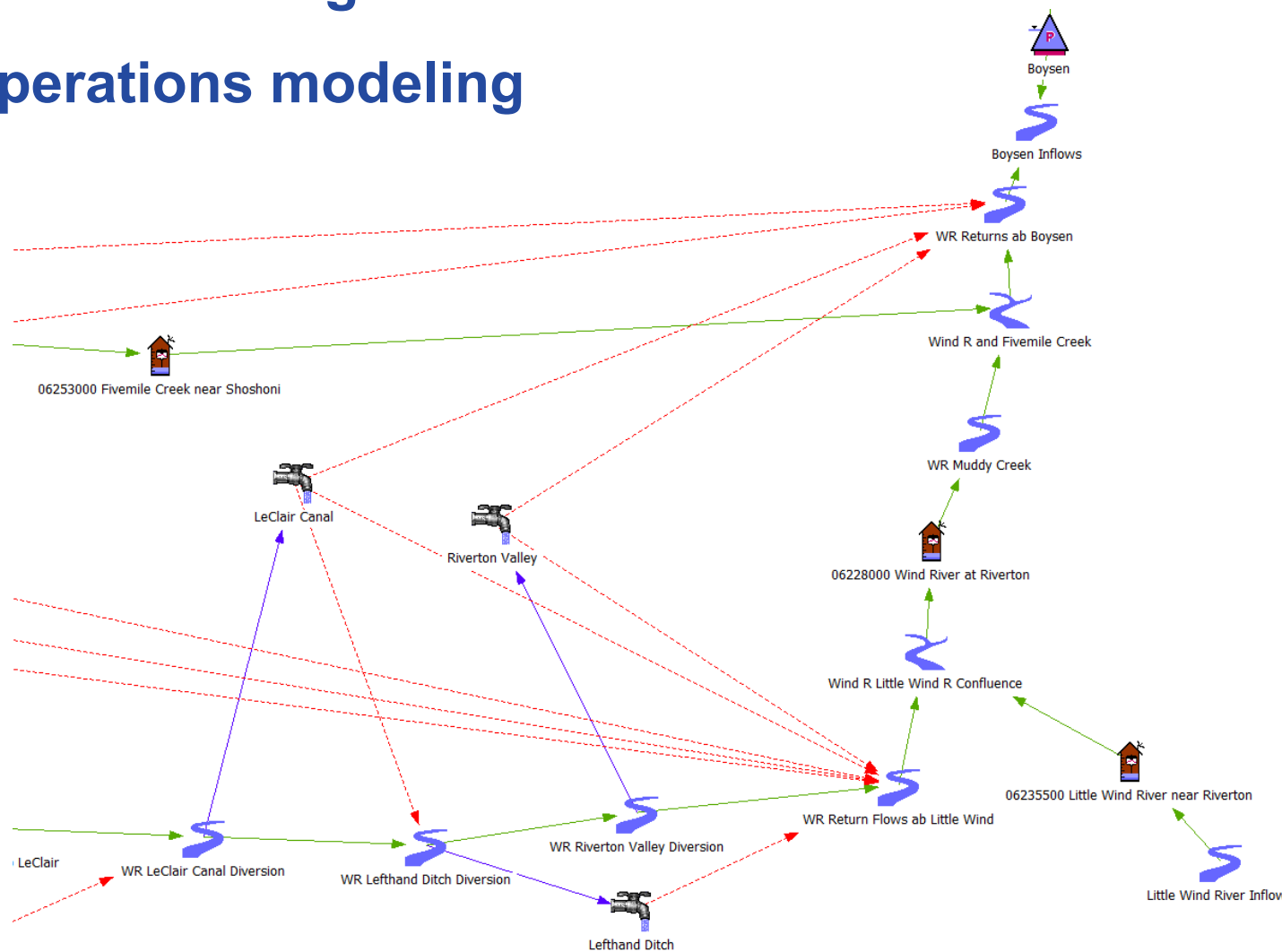
- Develop explicit low-flow operating rules (fcst volume won't fill reservoir)
- Variable drawdown timing (risk-informed operations)





# • Better Models:

- Daily operations modeling
- Basin-wide operations modeling



# Questions

- *Modeling study and statistical review are available online:*

[https://www.usbr.gov/gp/mtao/yellowtail/bighorn\\_longterm.html](https://www.usbr.gov/gp/mtao/yellowtail/bighorn_longterm.html)

## RECLAMATION

*Managing Water in the West*

### RiverWare Modeling Review of Bighorn Lake Operating Criteria

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U.S. Department of the Interior  
Bureau of Reclamation

Draft Report  
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