RECLAMATION
Managing Water in the West

Bighorn Lake Operating Criteria Review

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

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.***
- **Methods:**
  - **Statistical (and graphical) review of historical data**
  - **Planning modeling studies**
  - **Technical working group review and independent review**

Presentation outline

- Statistical review results (presented April 24, 2018)
- Modeling study methods
- Modeling study results and conclusions
- Improving operations in three ~~easy~~ steps
  - Forecasting
  - Operating Criteria and Rule Curves
  - General Operations
- Conclusions

Statistical Review Draft Conclusions

- Significant differences between periods for inflows, pool elevations, hydropower generation, and releases.
- Post-2010:
  - Anticipated low-flow benefits were realized
  - Flows >6000 cfs occurred with much greater frequency
  - Flood control releases and duration greater than expected by criteria report
  - Pool elevations were higher than anticipated by criteria report
- Statistical review cannot isolate cause of differences

Modeling Study Methods

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

https://www.usbr.gov/gp/mtao/yellowtail/bighorn_longterm.html

RECLAMATION
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RiverWare Modeling Review of Bighorn Lake Operating Criteria

Great Plains Regional Office
Billings, Montana

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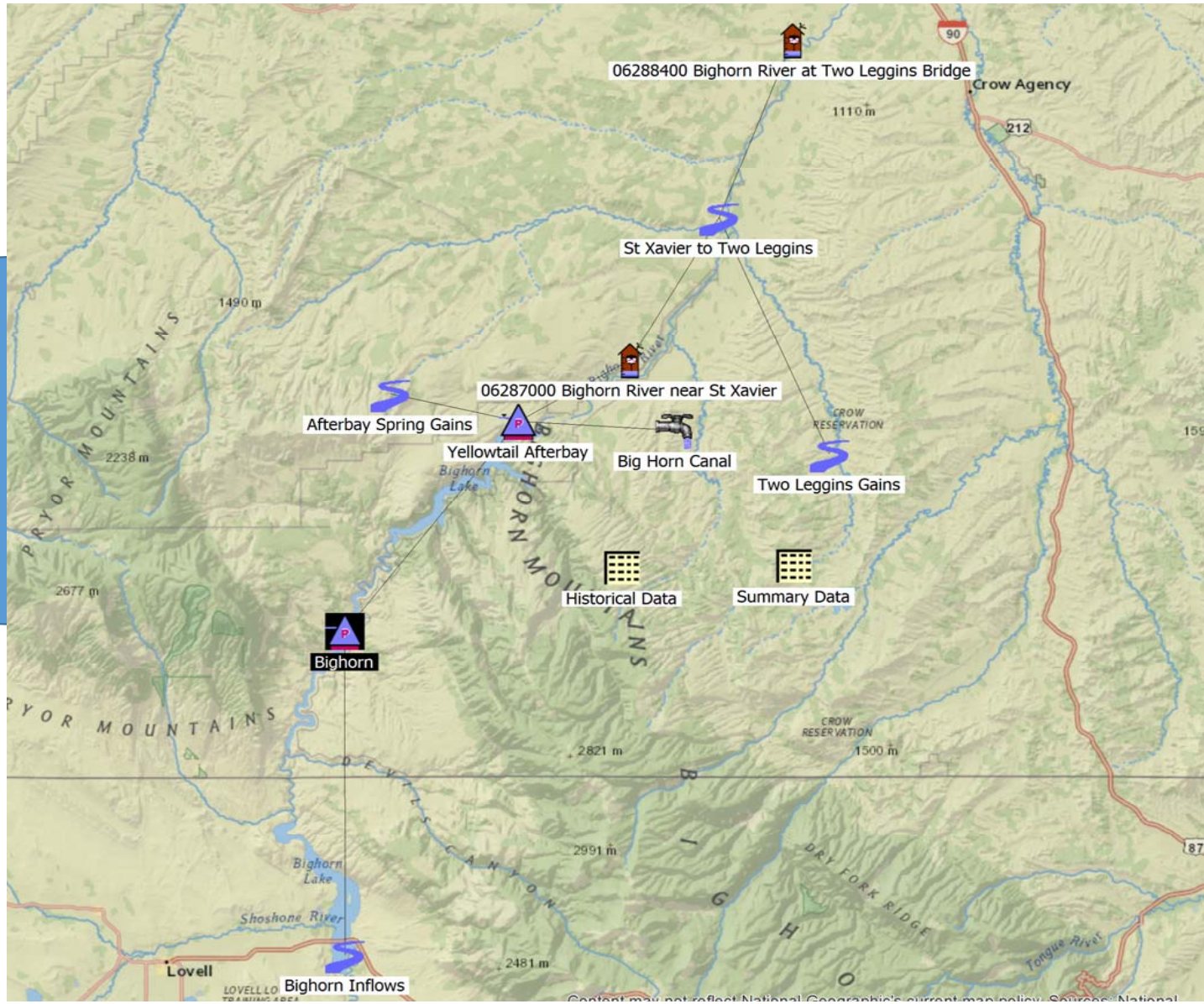
Peer Reviewed by: Patrick J. Erger and Dale J. Lentz, P.E.

U.S. Department of the Interior
Bureau of Reclamation

Draft Report
April 2019

General RiverWare Modeling



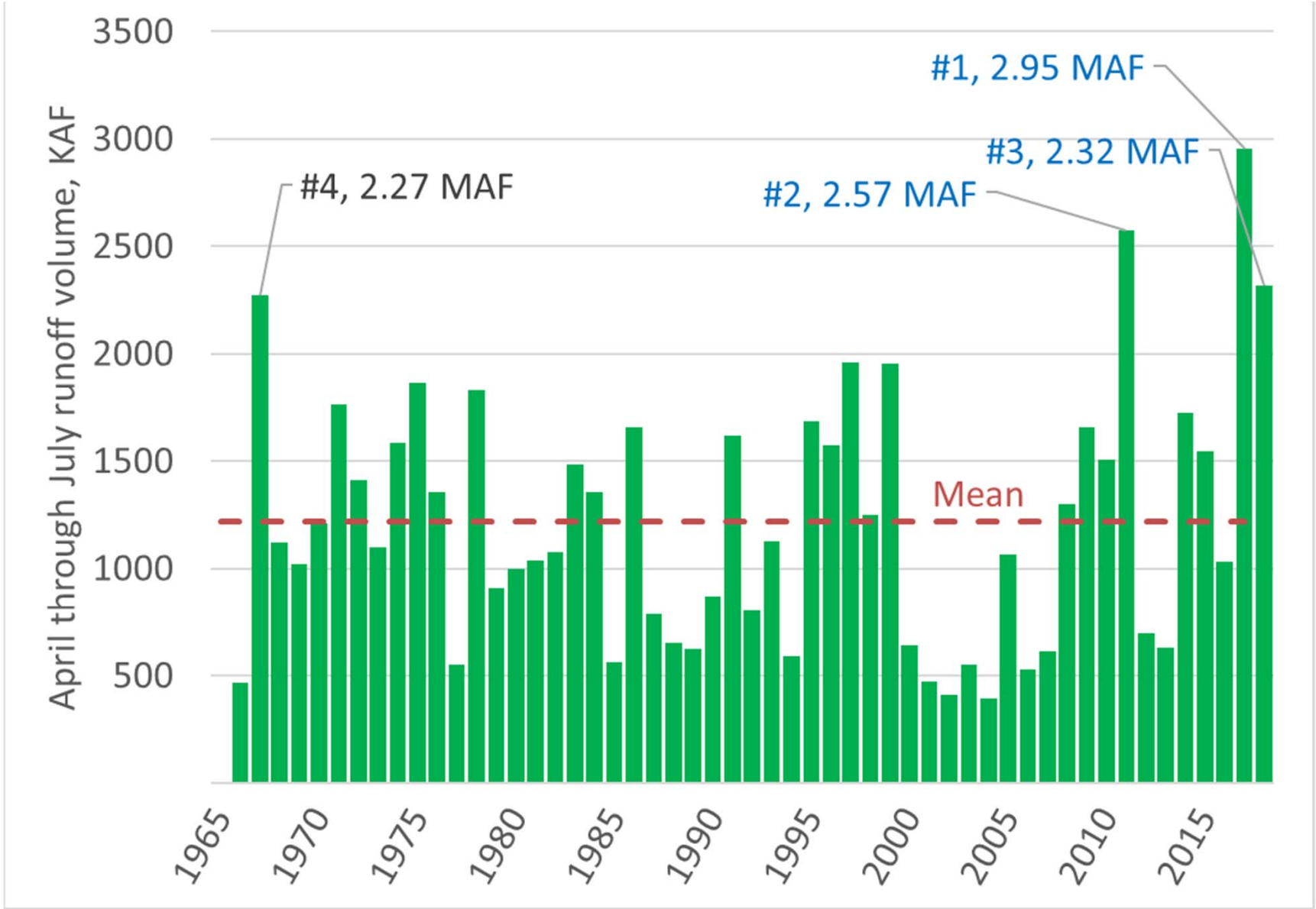
Modeling experiments:

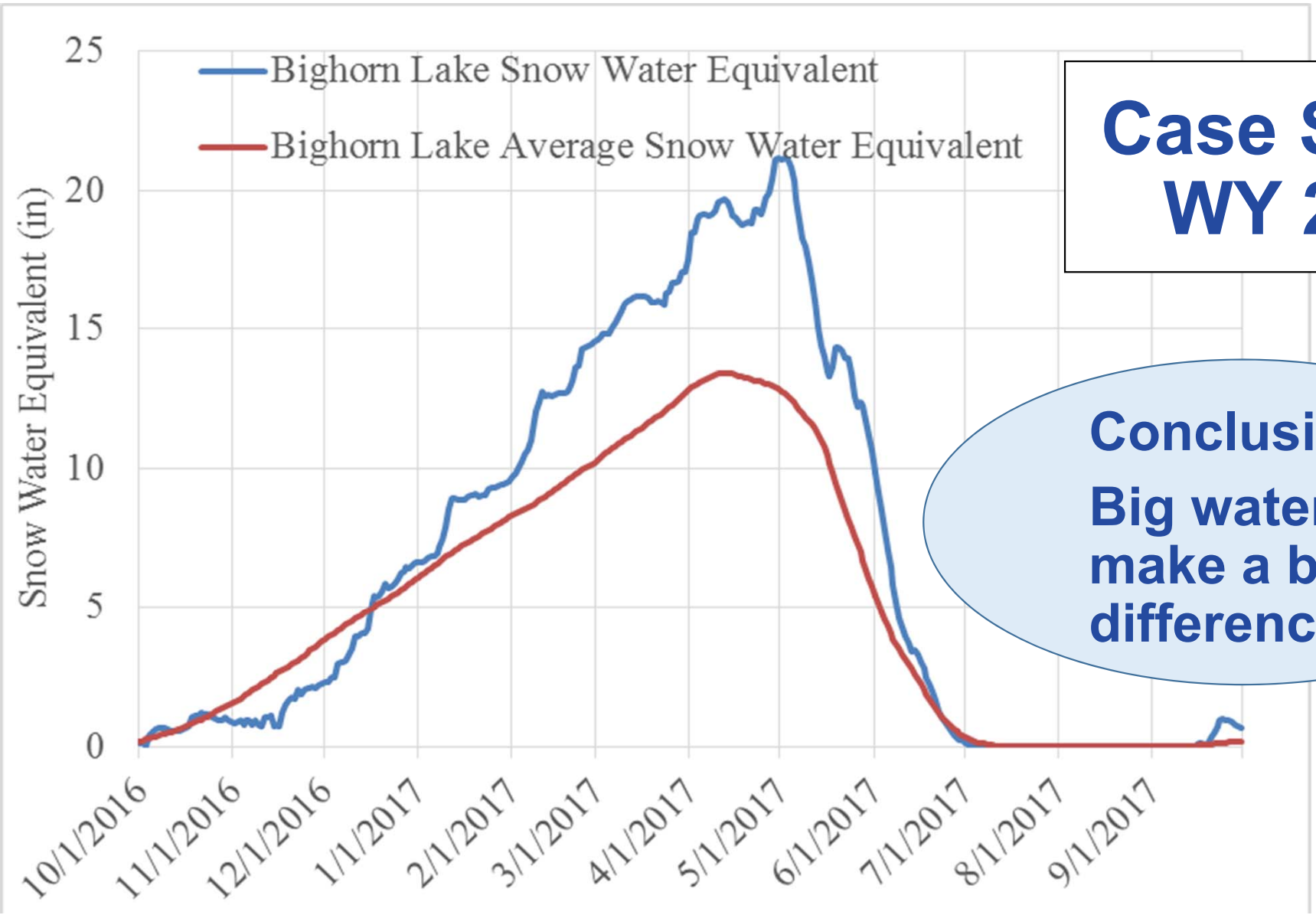
- **Overarching goals:**
  - **Were the anticipated benefits of the 2010 Operating Criteria realized?**
  - **Where the actual operations did not meet expected benefits, explain the differences.**
- **Study goals:**
  - **Determine if benefits were realized/Isolate impacts of operational criteria**
  - **Isolate the impacts of forecasting**
  - **Isolate the impacts of operators**
  - **Isolate hydrologic impacts**

Modeling Study Conclusions

Four primary conclusions shown through two case studies

Case Study: WY 2017



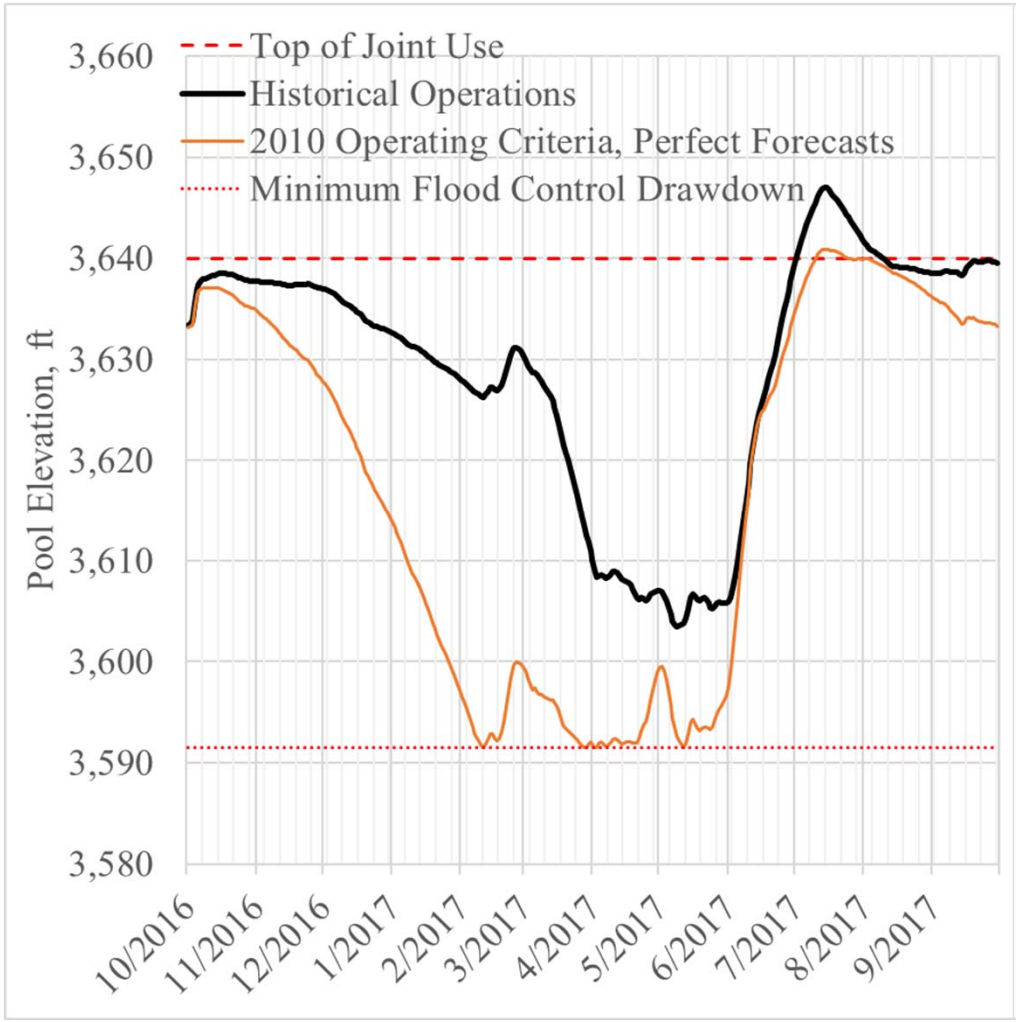


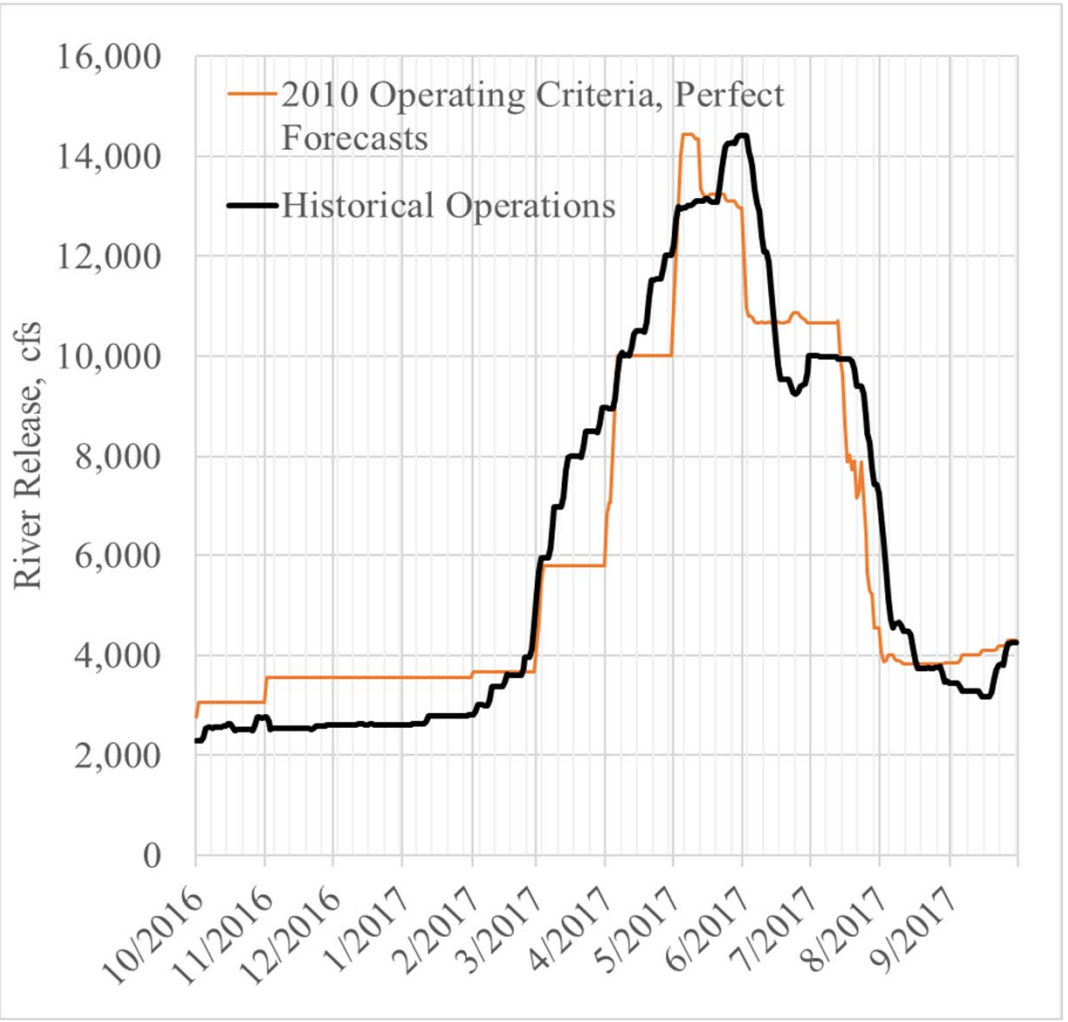
Case Study: WY 2017

Conclusion:

Big water years make a big difference.

Case Study: WY 2017





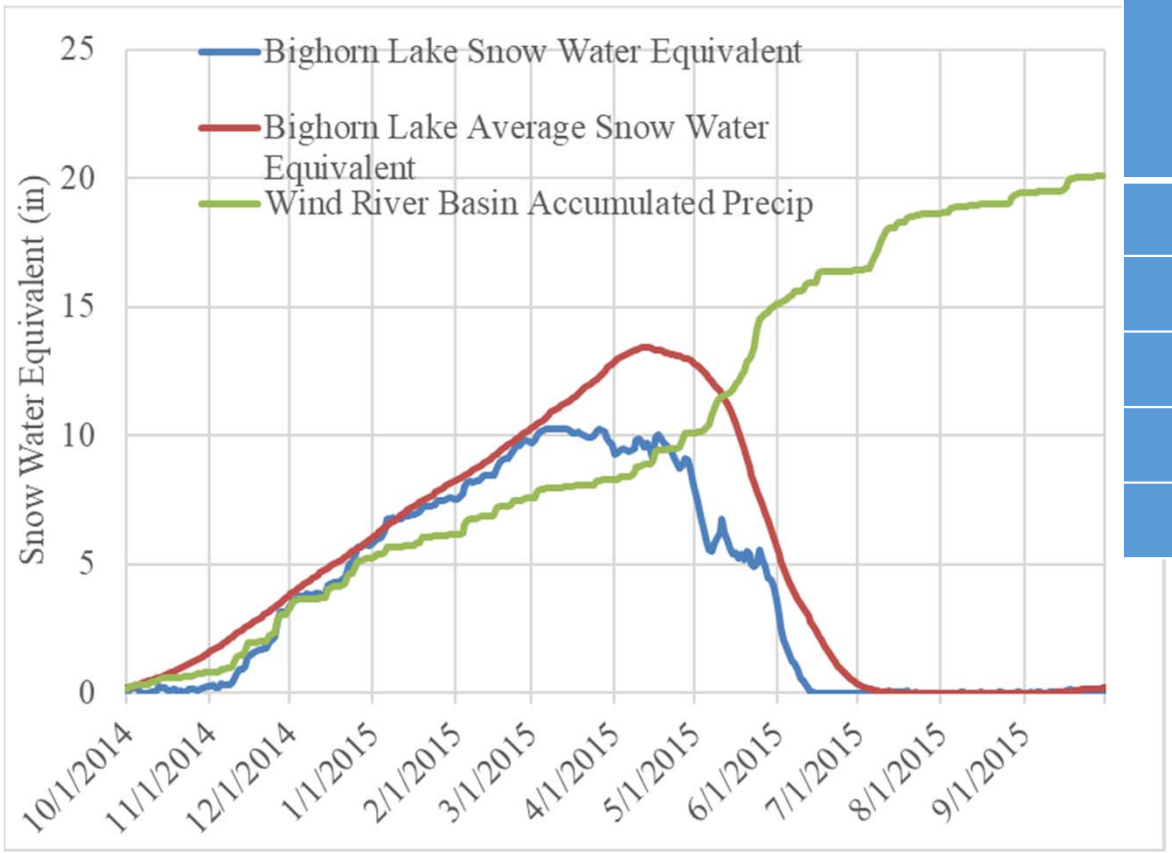
More Conclusions

- Underforecasting resulted in less spring drawdown

- Dry operations not explicitly defined

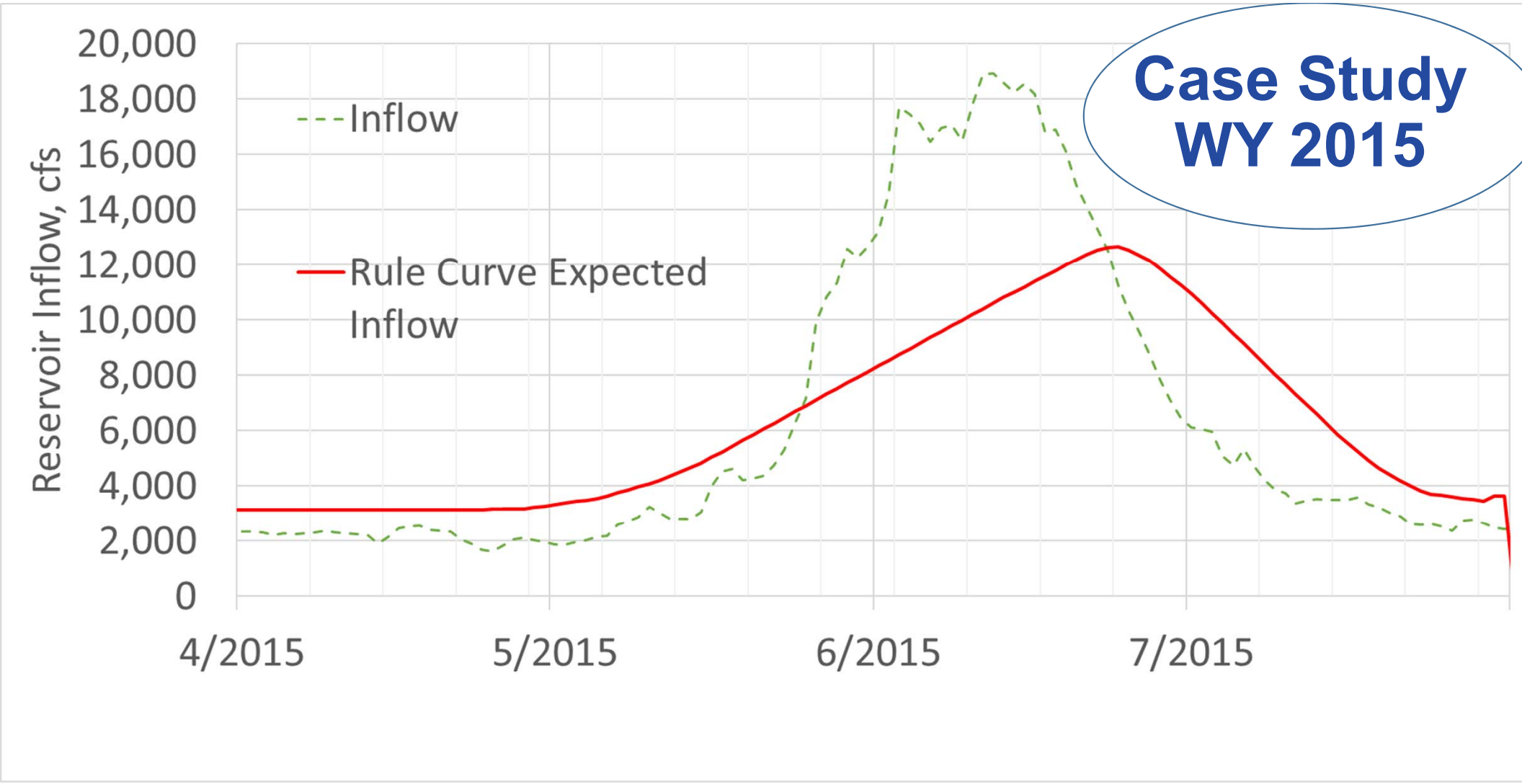
- Rule curves assumed inflow hydrology resulted drawdown/fill timing issues

Case Study: WY 2015

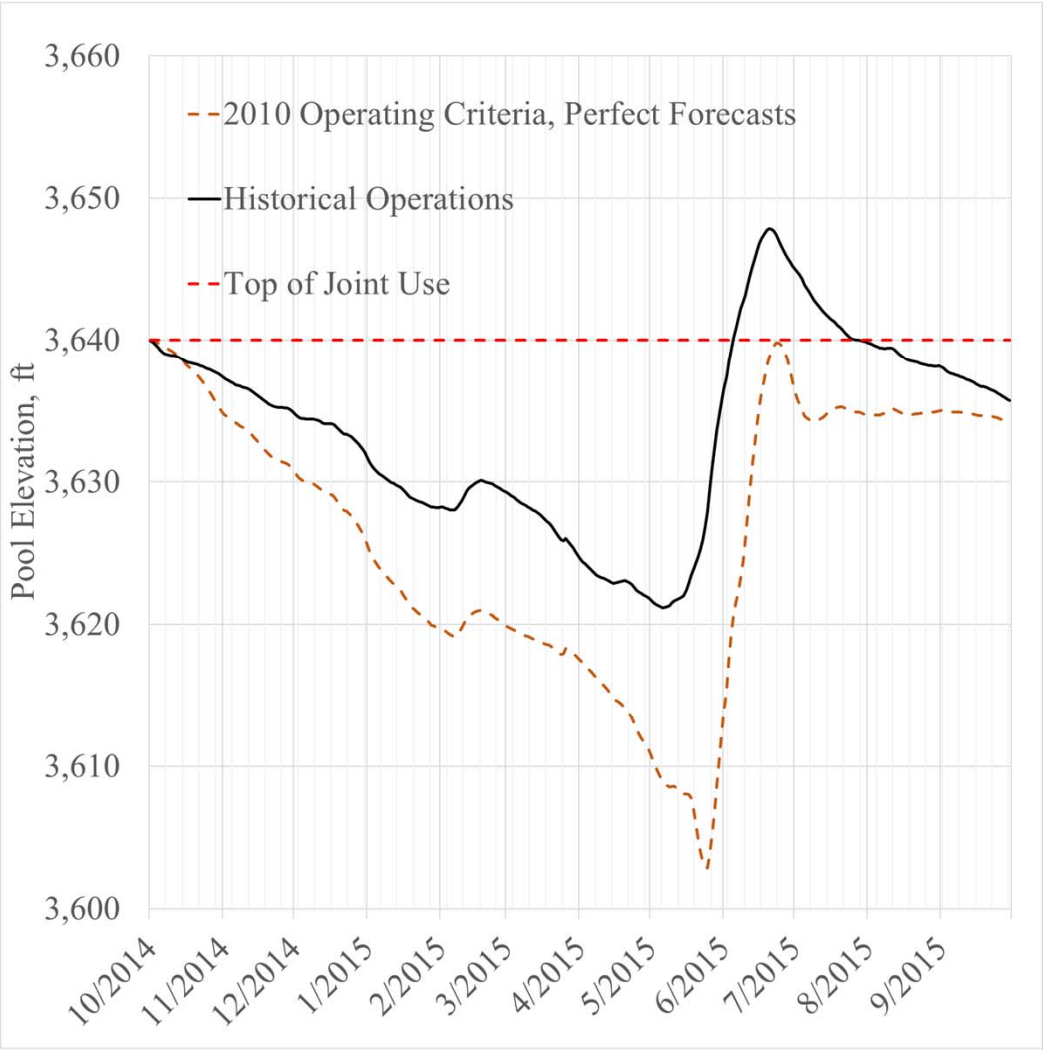


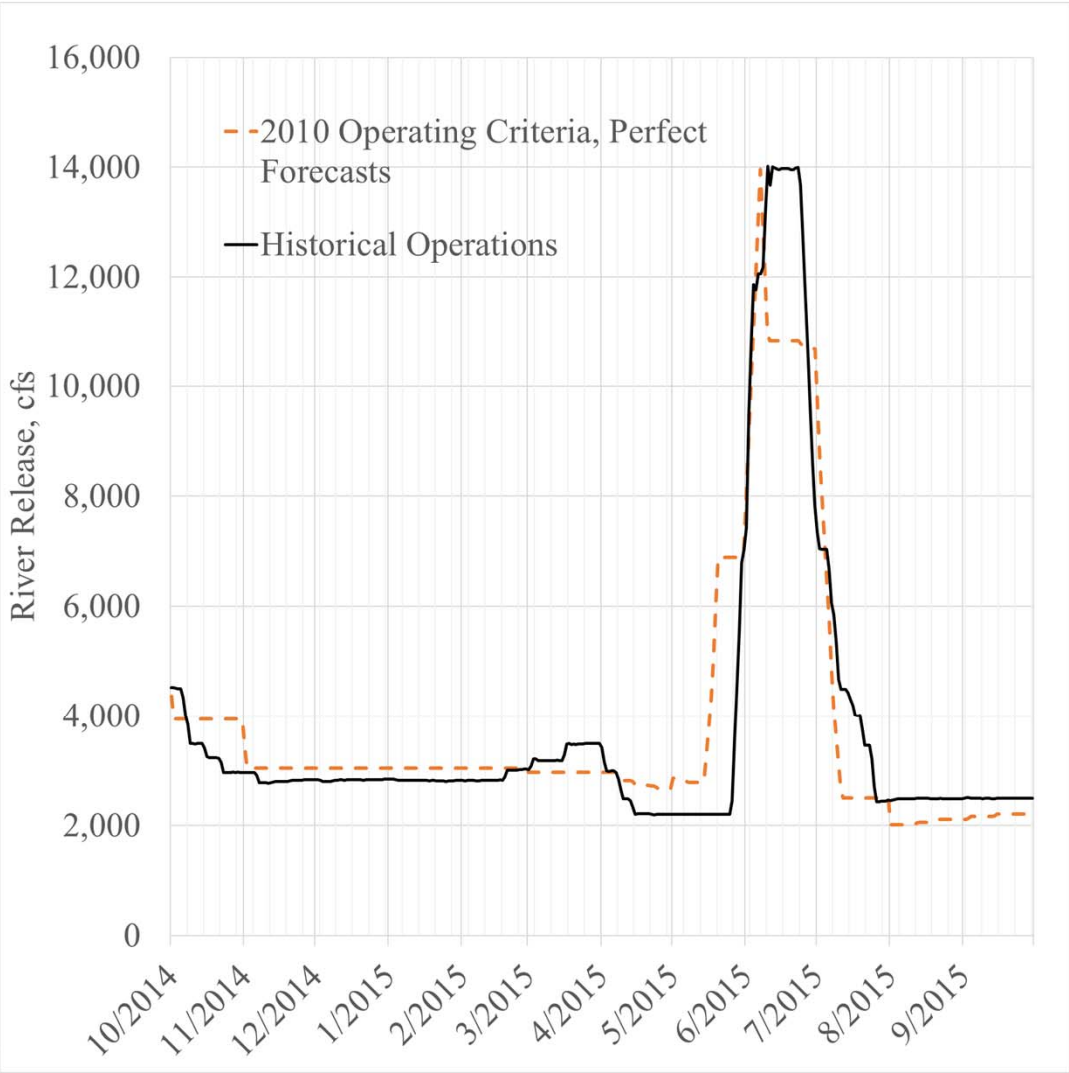
Date	Reclamation April-July Forecast (KAF)
1/1/2015	1,095.60
2/1/2015	1,015.90
3/1/2015	1,065.50
4/1/2015	675.5
5/1/2015	634.3

Historical inflow volume: 1,543 KAF


Case Study
WY 2015
Reservoir Inflow, cfs
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Inflow
Rule Curve Expected Inflow
4/2015
5/2015
6/2015
7/2015

Case Study: WY 2015





Alternative operating criteria and independent review

Scenario	Proposer
Elevated end of May target pool elevation	Loren Smith
Lowered end of March target pool elevation	Anne-Marie Emery
Increased drawdown scenario	Anne-Marie Emery
Raise top of joint use pool 5 feet	Keith Grant
Lower top of joint use pool 5 feet	Doug Haacke
MELS scenario	Mark Elison and Loren Smith
Fixed winter release	Anne-Marie Emery
RiverWise Scenario Manager	
CADSWES independent Review	

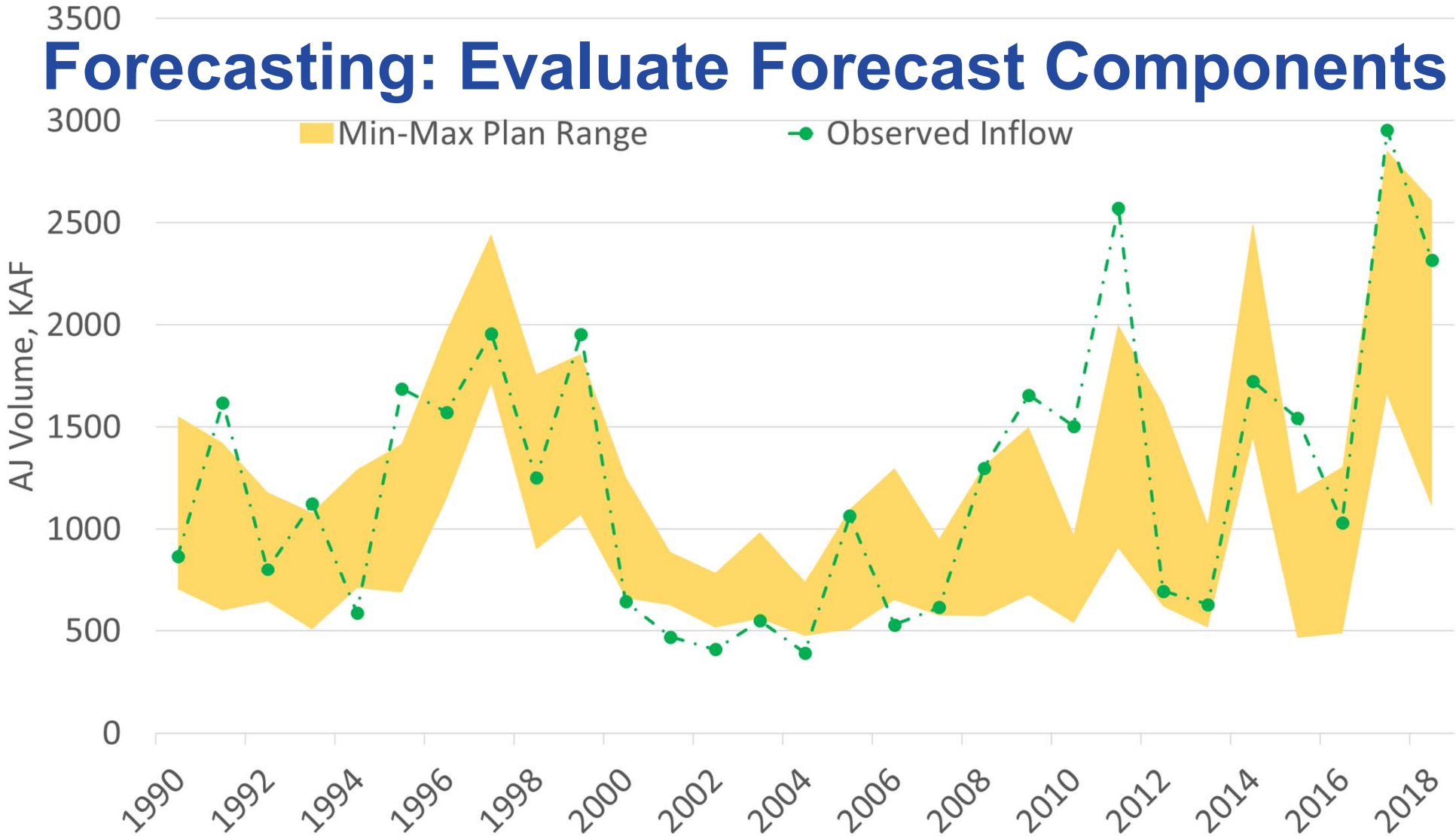
Findings

- 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
- Operating criteria can be improved without trade-offs between competing interests

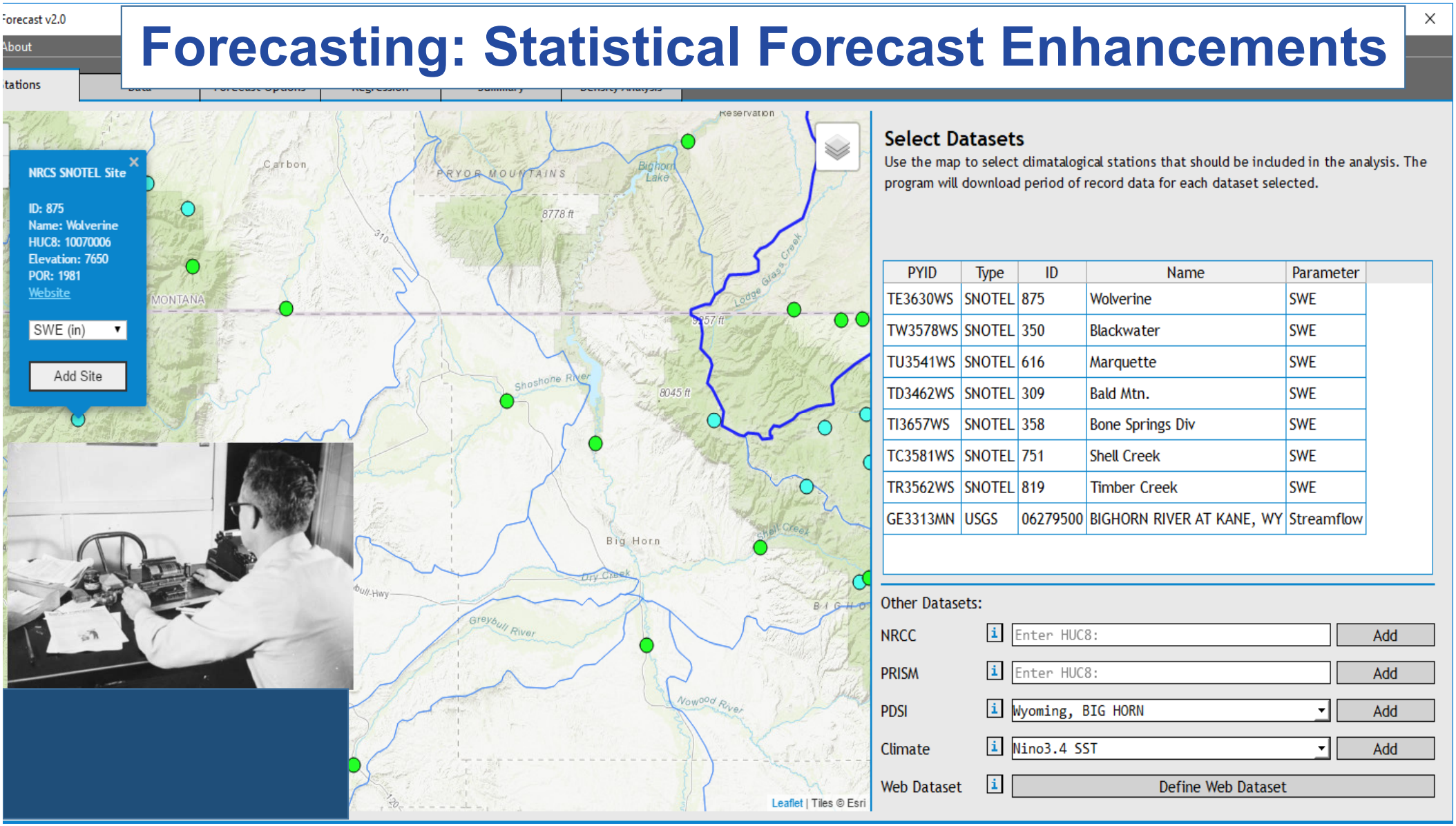
Recommendations

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**

Forecasting: Evaluate Forecast Components

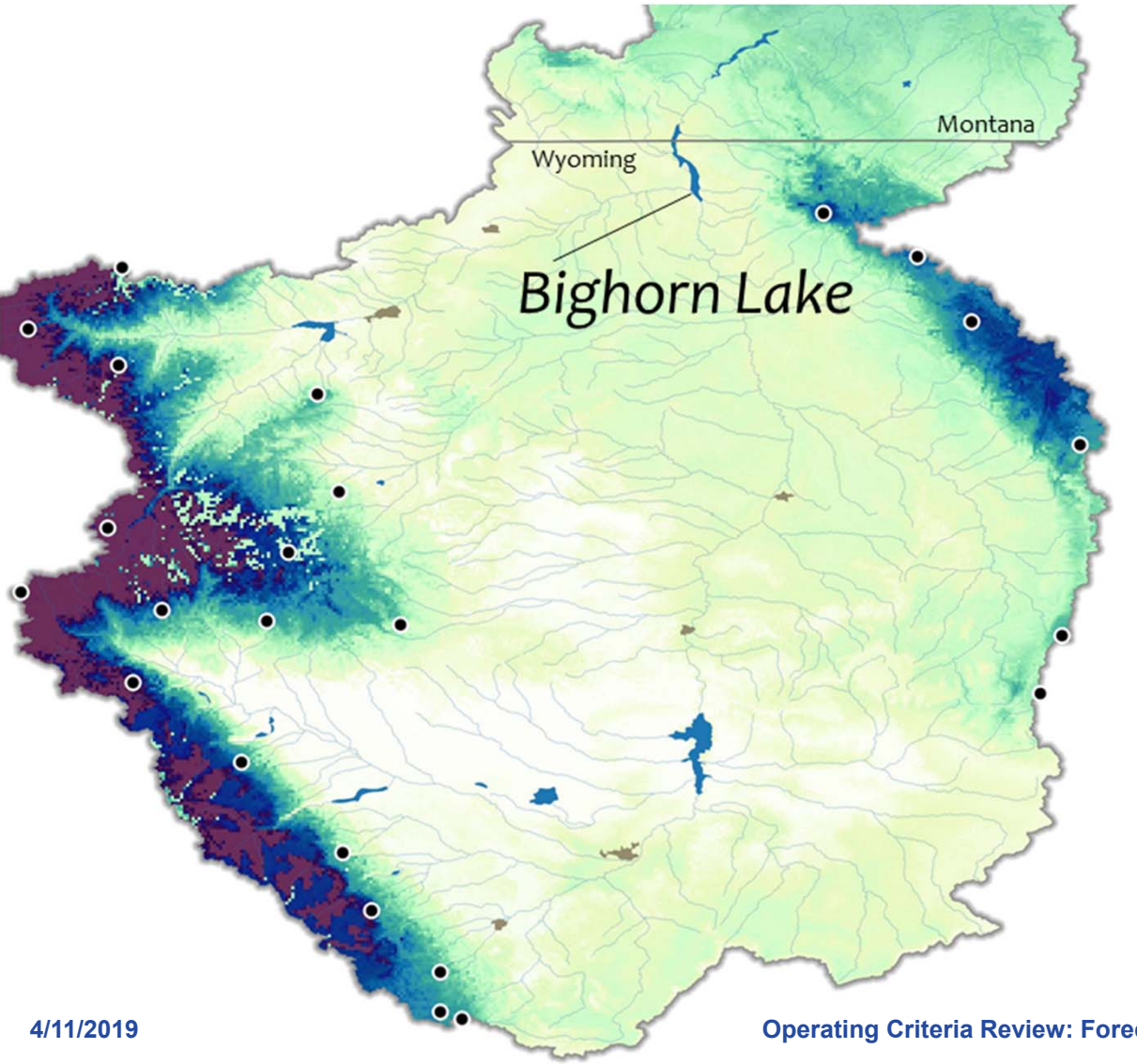


Forecasting: Statistical Forecast Enhancements



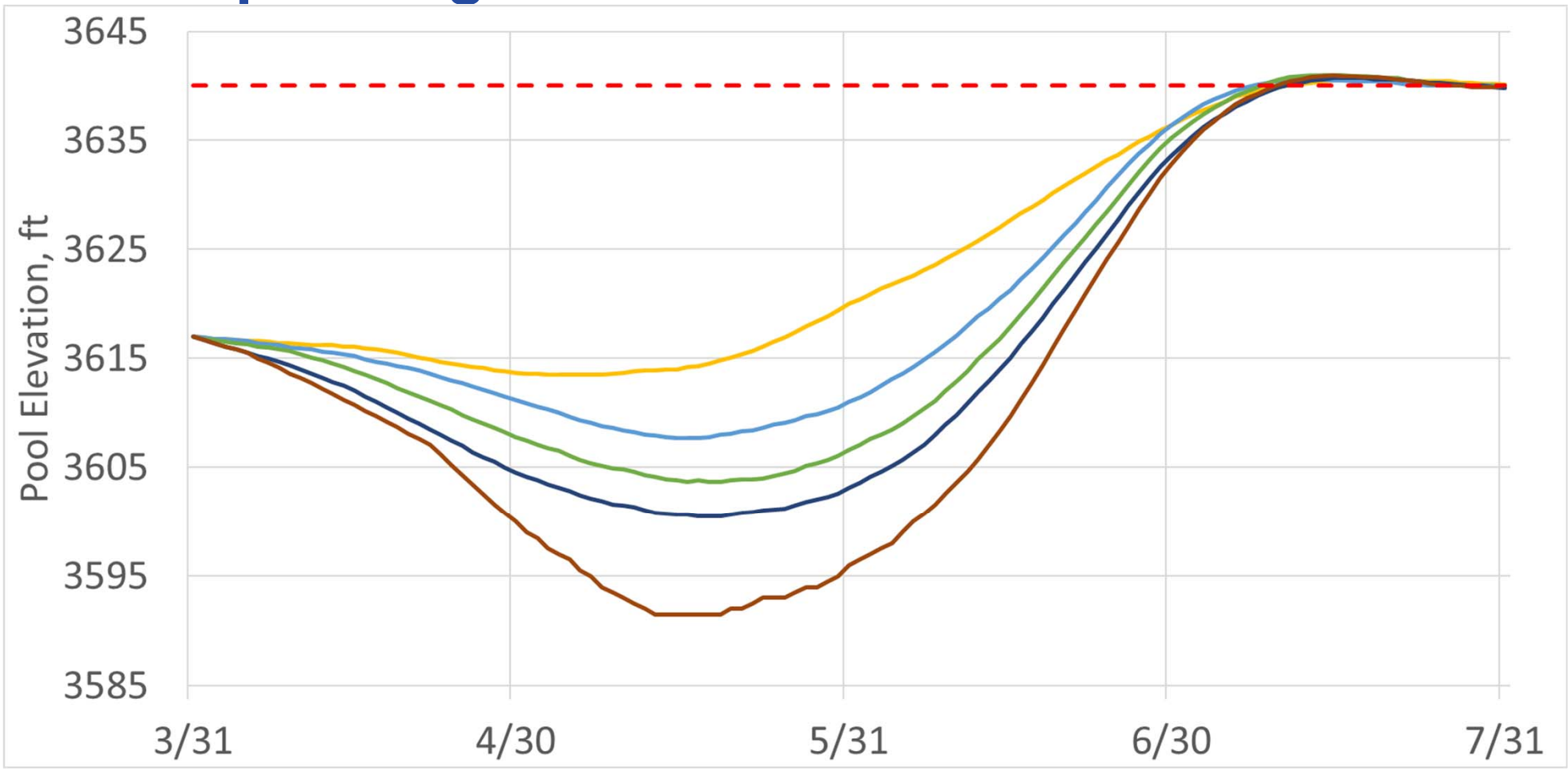
PYID	Type	ID	Name	Parameter
TE3630WS	SNOTEL	875	Wolverine	SWE
TW3578WS	SNOTEL	350	Blackwater	SWE
TU3541WS	SNOTEL	616	Marquette	SWE
TD3462WS	SNOTEL	309	Bald Mtn.	SWE
TI3657WS	SNOTEL	358	Bone Springs Div	SWE
TC3581WS	SNOTEL	751	Shell Creek	SWE
TR3562WS	SNOTEL	819	Timber Creek	SWE
GE3313MN	USGS	06279500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

Forecasting: Enhanced Resolution Snowmelt Modeling

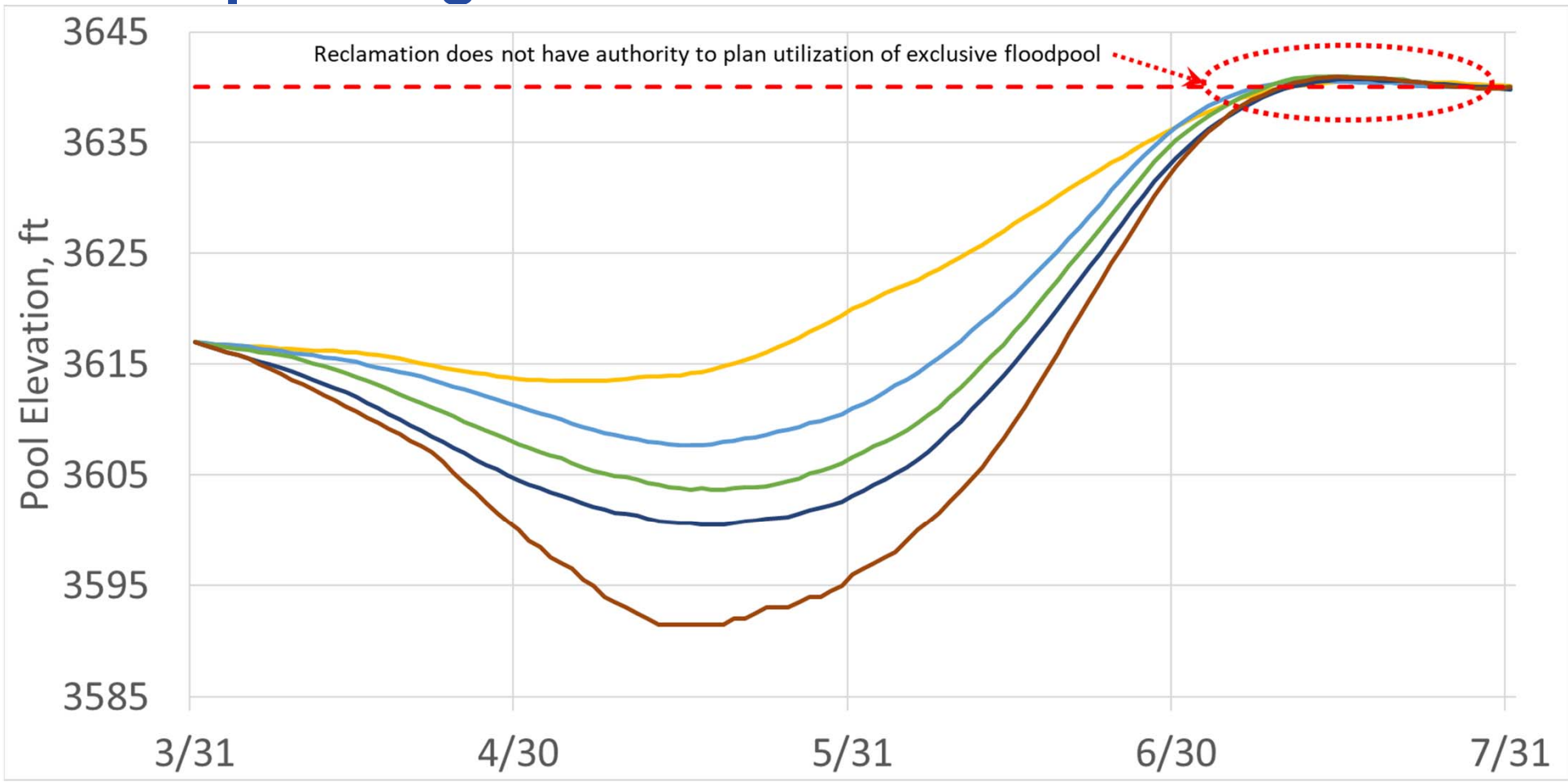


- **Wind/Bighorn Basin Snow Cover on January 24, 2018**

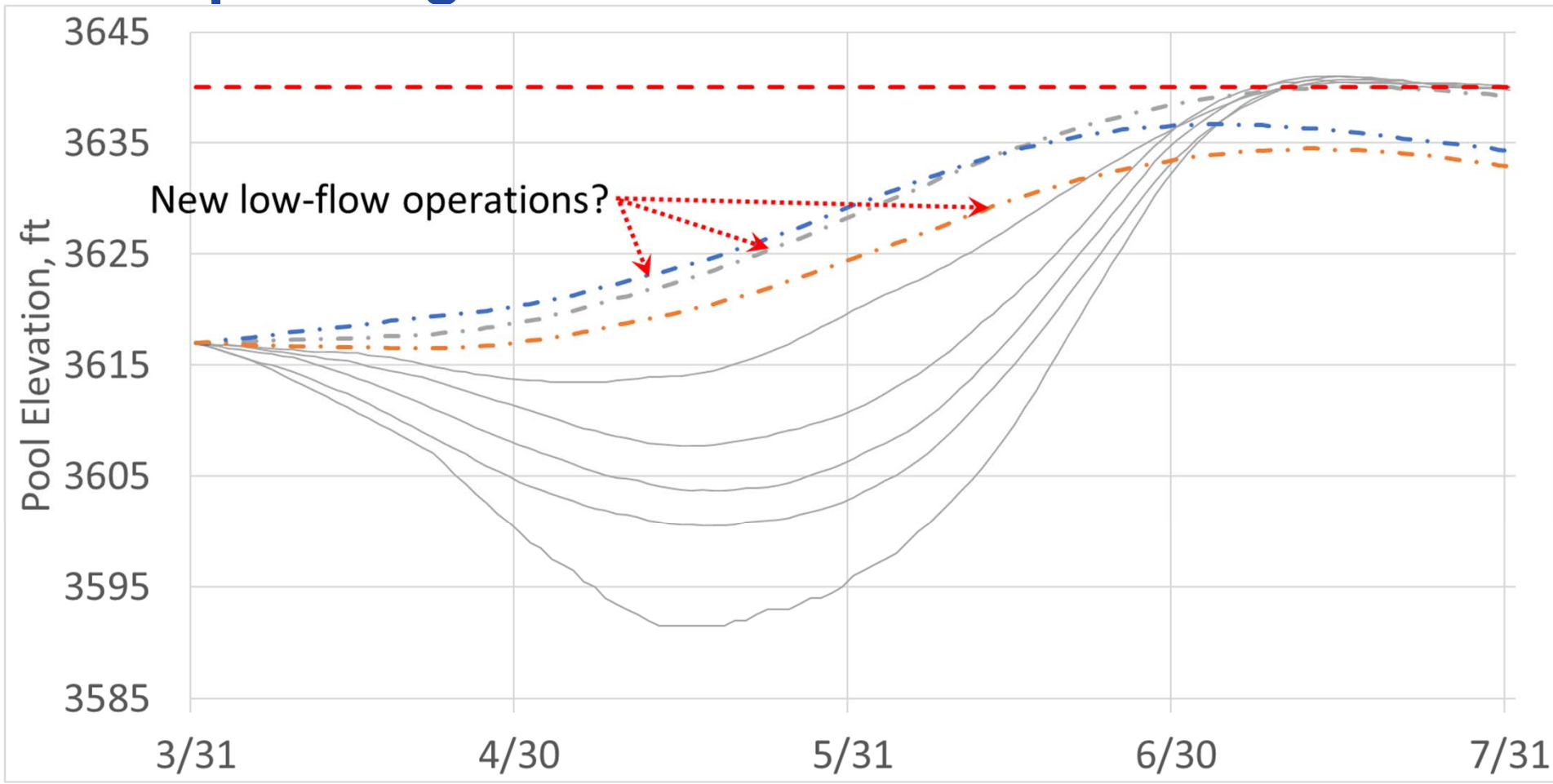
Operating Criteria Recommendations



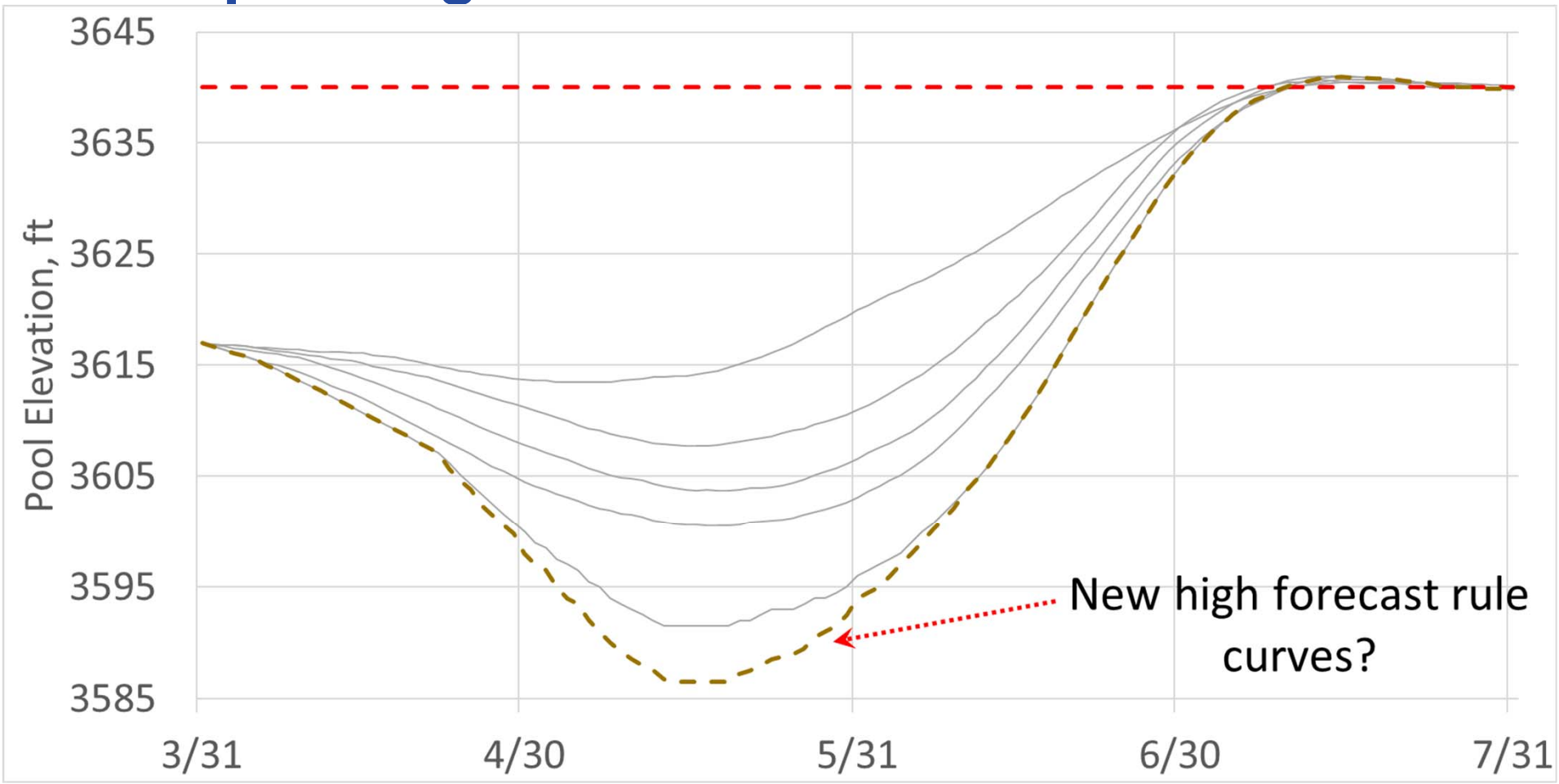
Operating Criteria Recommendations



Operating Criteria Recommendations



Operating Criteria Recommendations



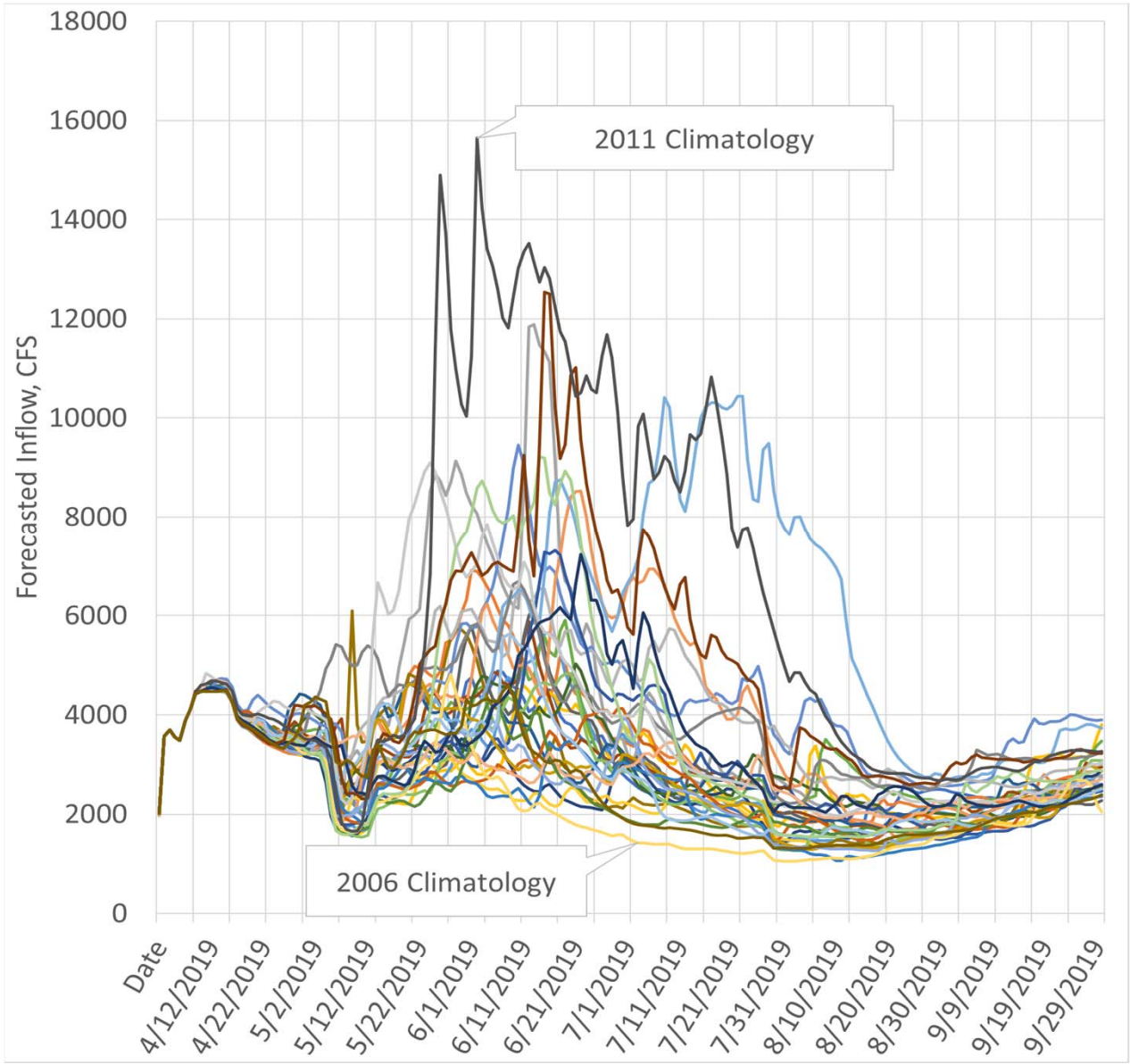
General Operations

Recommendations

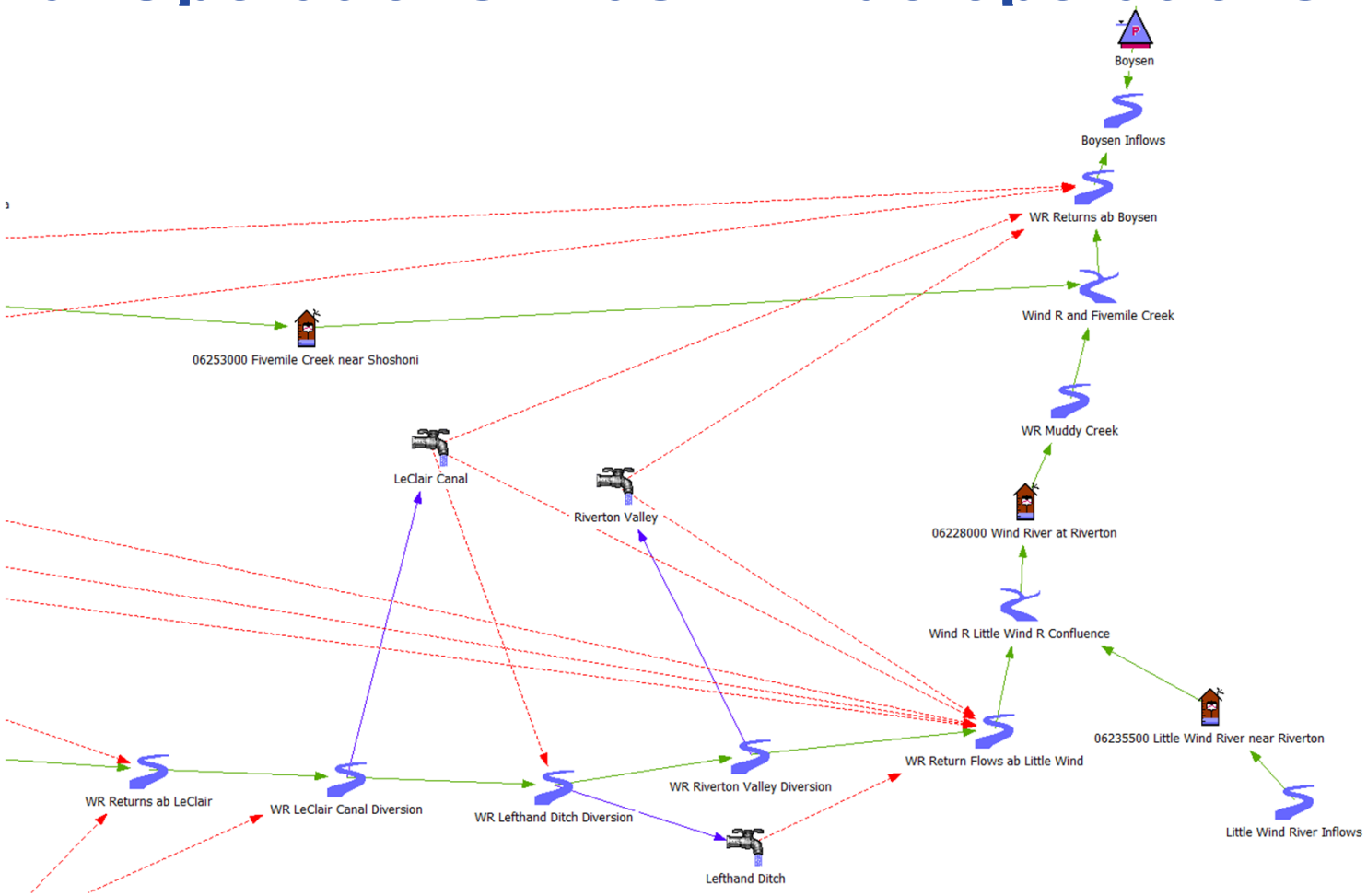
Daily Operations Modeling

Ensemble Forecasts

Variable drawdown timing



General Operations: Basin-wide operations model



Questions?

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