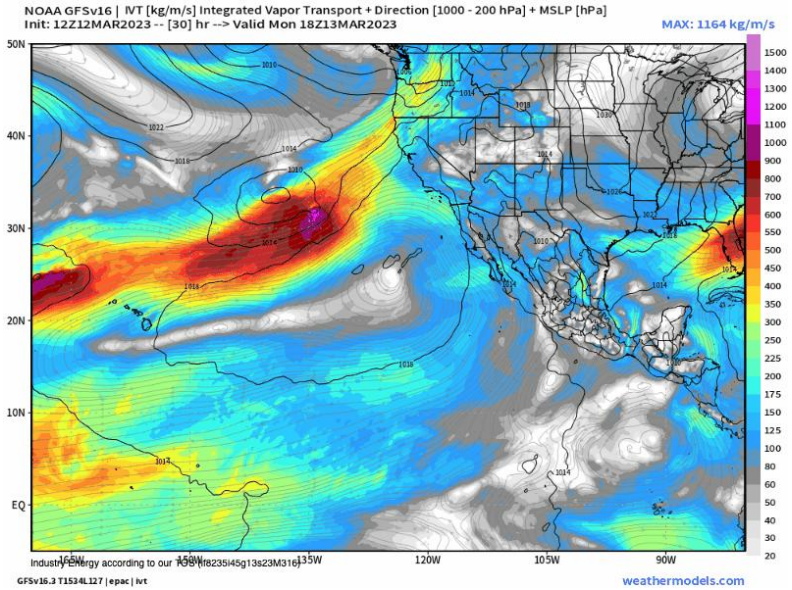
Enhanced Water Management through Forecast Informed Reservoir Operations (FIRO)

Annual Meeting of the **C**alifornia **W**ater and **E**nvironmental **M**odeling **F**orum

May 13, 2025 | Folsom, CA



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Purposes of the Presentation

- Explore the engineering and institutional challenges encountered during the JFP's implementation
- Highlight FIRO's role in shaping plans for the dam's 3.5-foot raise
- Using Folsom as a case study, provide insights into the broader challenges and opportunities that FIRO presents for water managers, engineers, and policymakers

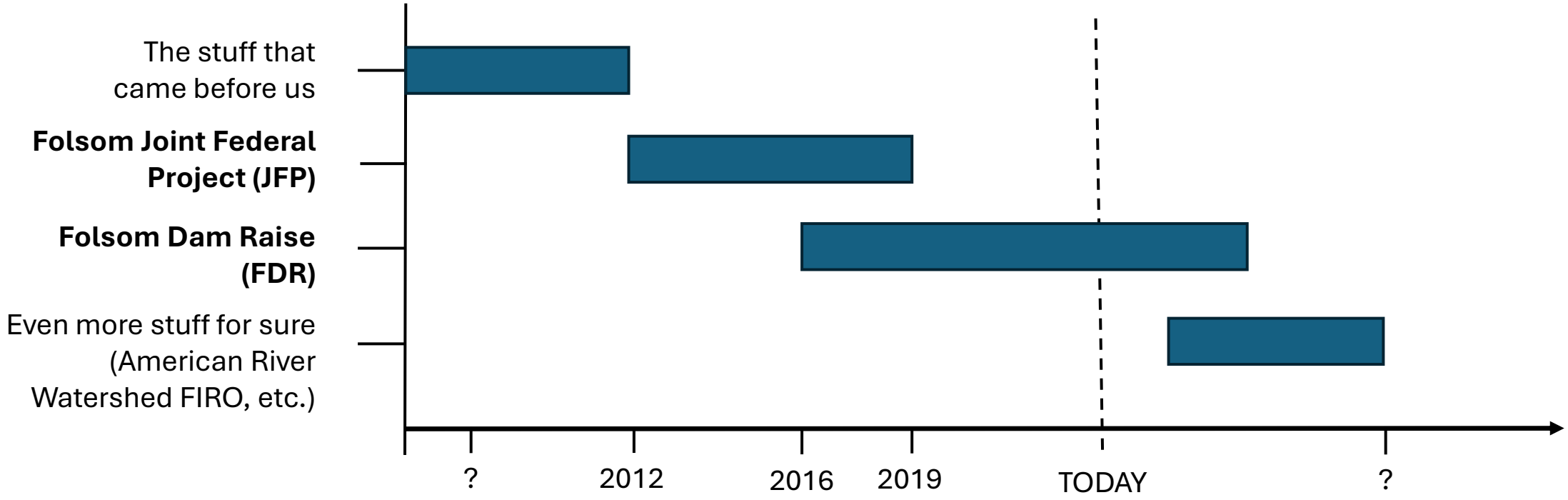
Multi-objective reservoirs

How about storing less in the winter, in case we get a big inflow then?

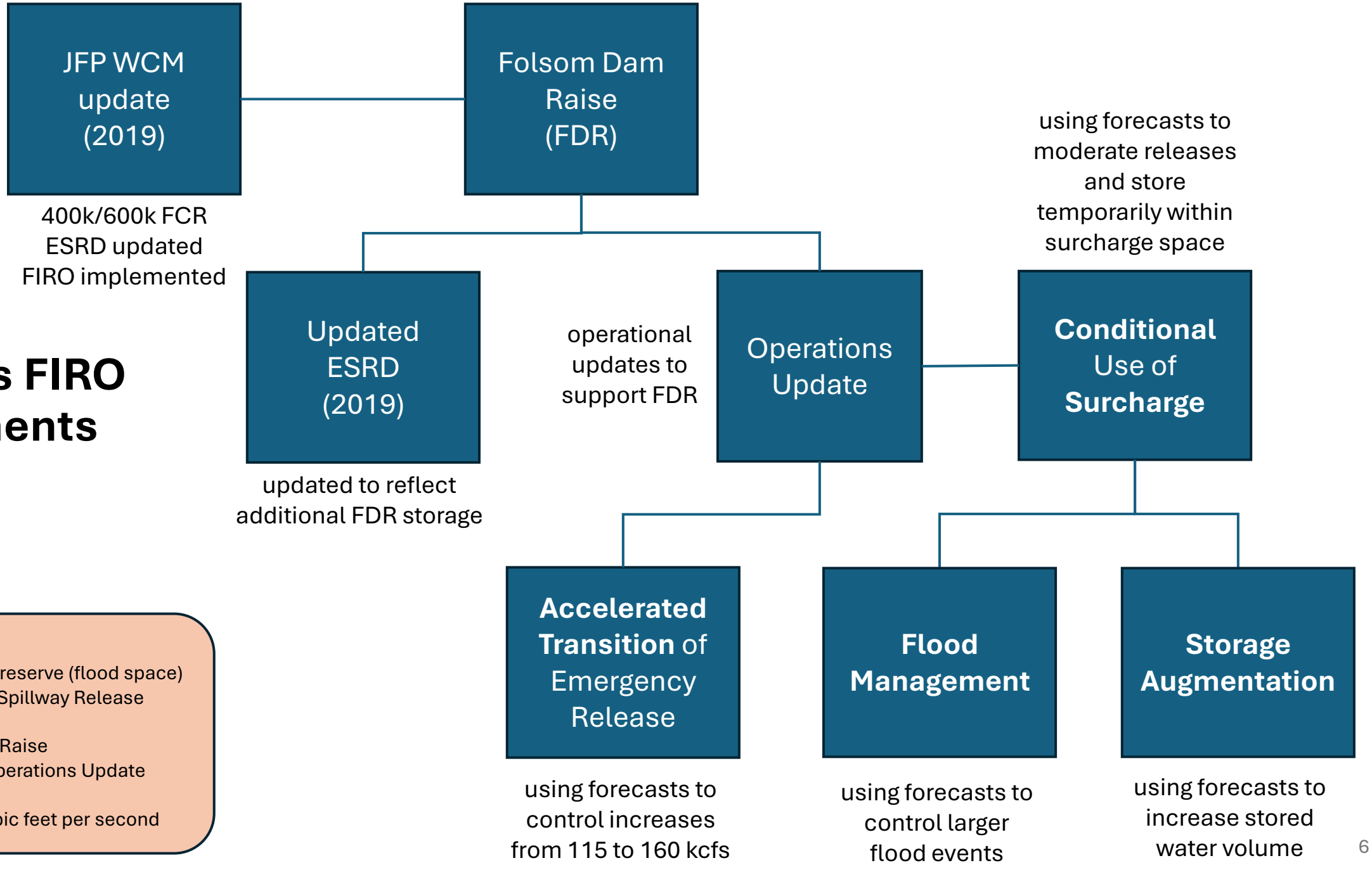
How about storing more in the winter, so we have more to beneficially use later?


FORECAST INFORMED
RESERVOIR OPERATIONS
FIRO
SACRAMENTO

Folsom Operations Key Event Timeline



Folsom's FIRO Components

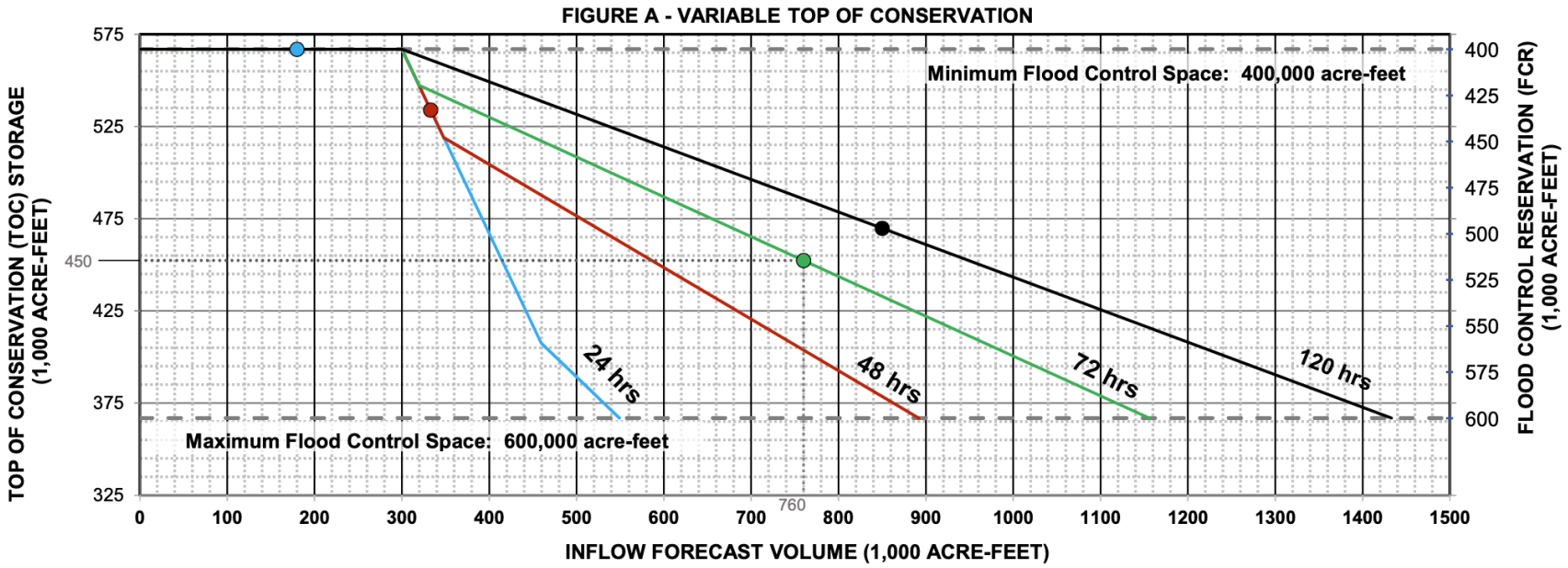


Terminology:
FCR – flood control reserve (flood space)
ESRD – Emergency Spillway Release Diagram
FDR – Folsom Dam Raise
SOU – Surcharge Operations Update
k – thousand
kcfs – thousand cubic feet per second

JFP: You mean there are two spillways!?

Folsom's Post-JFP Plumbing

JFP: Elements of an existing operation using forecasts



RELEASE SCHEDULE

(Releases shall not exceed 115,000 cfs unless specified by the ESRD)

SEASONAL RELEASES
(EFFECTIVE MAR 1 THRU NOV 18)

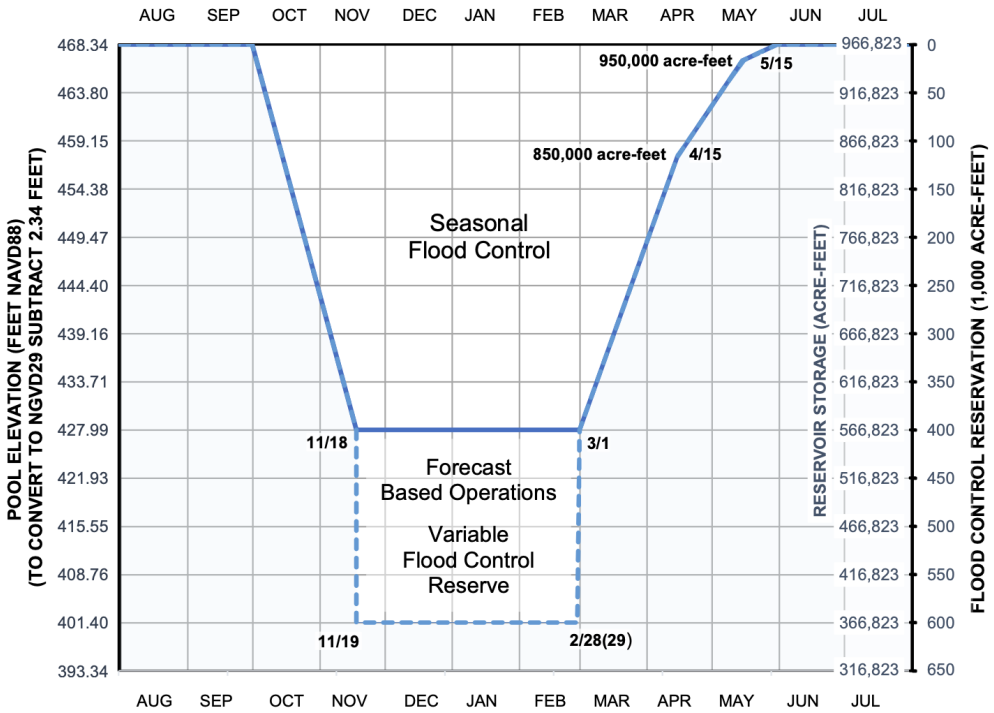
Release peak inflow for current event.

FORECAST-BASED RELEASES
(EFFECTIVE NOV 19 THRU FEB 28/29)

1. If FCR = 400,000 acre-feet, release peak inflow
2. If FCR < 500,000 acre-feet, Table A Release.
3. If FCR ≥ 500,000 acre-feet, release the greater of peak inflow for the current event or Table A Release.

TABLE A

INFLOW FORECASTED VOLUME	RELEASE
120-HR > 300,000 ACRE-FEET	25,000 CFS
72-HR > 300,000 ACRE-FEET	50,000 CFS
48-HR > 300,000 ACRE-FEET	80,000 CFS
24-HR > 300,000 ACRE-FEET AND INFLOW ≥ 115,000 CFS	115,000 CFS



JFP: FIRO Water Control Plan Applied

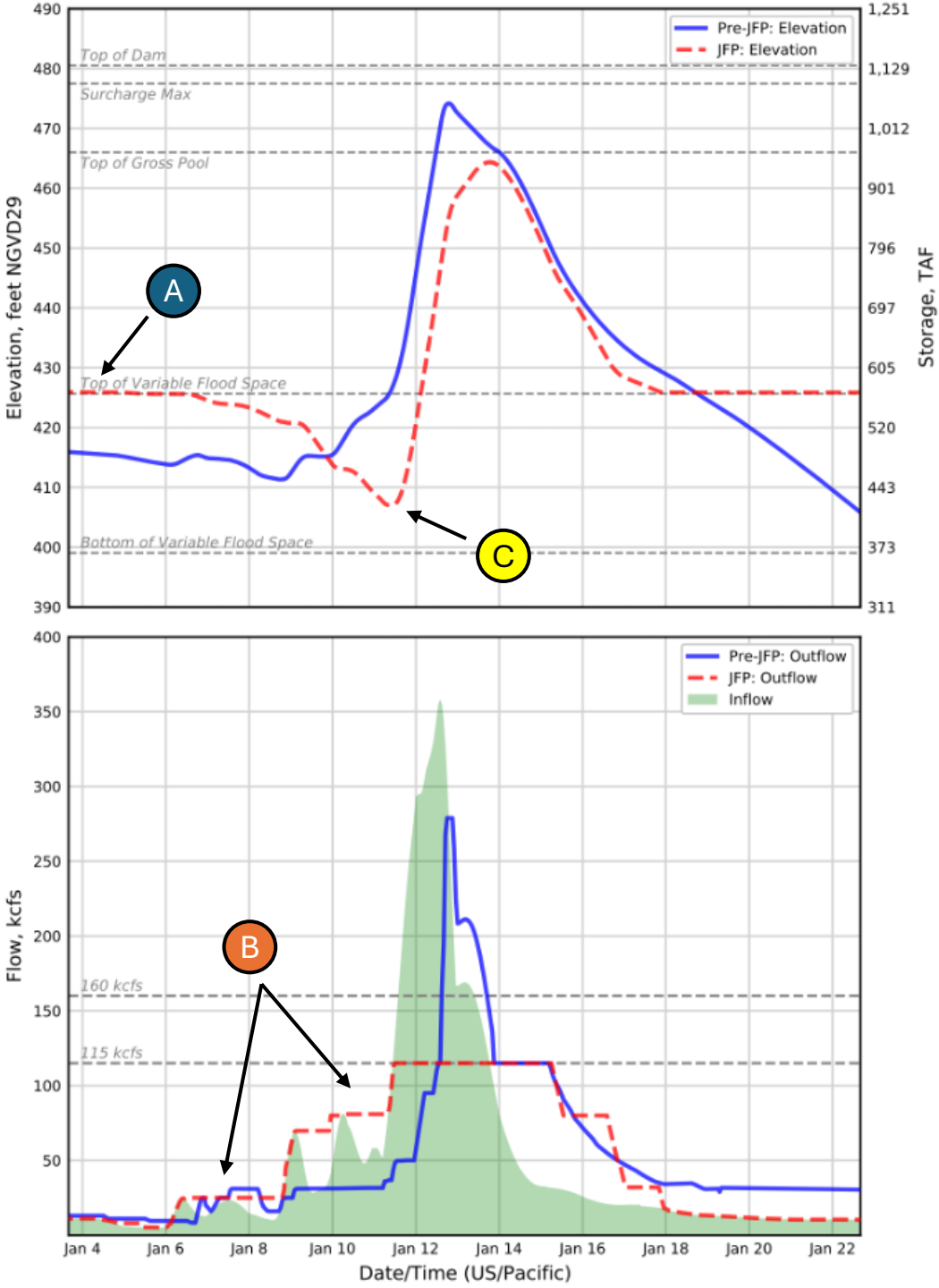
Allowed to start higher than previously; 400 TAF Flood Control Reserve (FCR) (A)

Release steps (25, 50 , 80, 115 kcfs) **based on Folsom inflow forecast volumes** (B)

Steps increase to require higher release rates as forecast volumes increase

This will draw reservoir down, creating **additional FCR** (up to 600 TAF) to store expected future inflow volume (C)

Terminology:
TAF: thousand acre-feet
FCR: flood control reserve
kcfs: thousand cubic feet per second



Folsom Dam Raise (FDR) Project

- Provide flood risk reduction to Sacramento area and maximize flood control benefits during extreme flood events & pass the PMF
- The FDR project consists of:
  - Raise dam by 3.5ft (42 TAF)
  - Modify main dam tainter gates
  - Ecosystem Restoration: Construction of automated TCS at main dam to benefit fisheries and habitat restoration
  - Folsom Dam Bridge, completed in 2009
- Project Partners: USACE, CVFPB-DWR, SAFCA

Terminology:
PMF: Probable Maximum Flood
TAF: thousand acre-feet
TCS: temperature control shutters
USACE: U.S. Army Corps of Engineers
CVFPB: Central Valley Flood Protection Board
DWR: California Department of Water Resources
SAFCA: Sacramento Area Flood Control Agency

FDR - Main Dam Wing Dams

Multipurpose dam: flood risk management, fish and wildlife, water quality, water supply, hydroelectricity, recreation, and navigation

Proposed improvements Include:

- Raise piers by 3.5 ft with new platforms, hoists and electrical systems
- Top seals on all 8 gates
- Gate strengthening of existing frames
- New trunnion anchorage system utilizing the existing anchors
- Raise wing dams by 3.5 ft floodwall

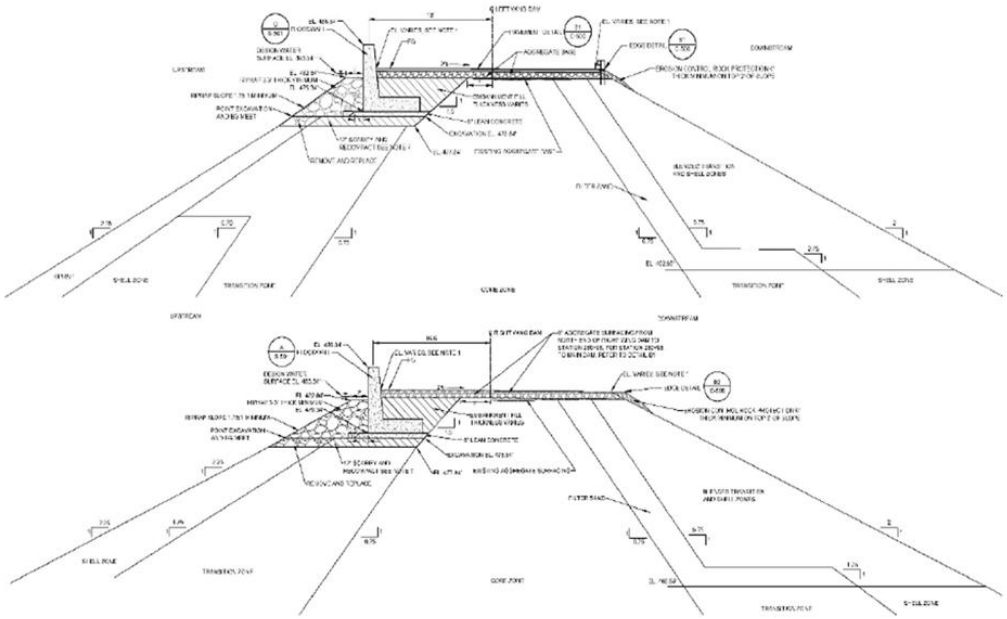
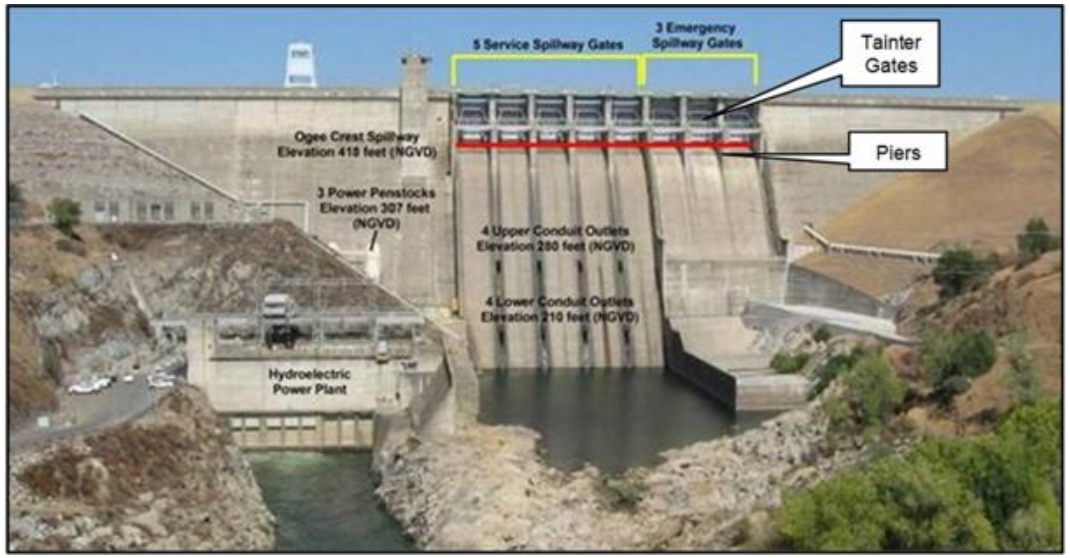


Figure 2-4. Anticipated typical cross sections for the concrete floodwall raise at the Right-Wing Dam (RWD - top) and the Left Wing Dam (LWD - bottom).



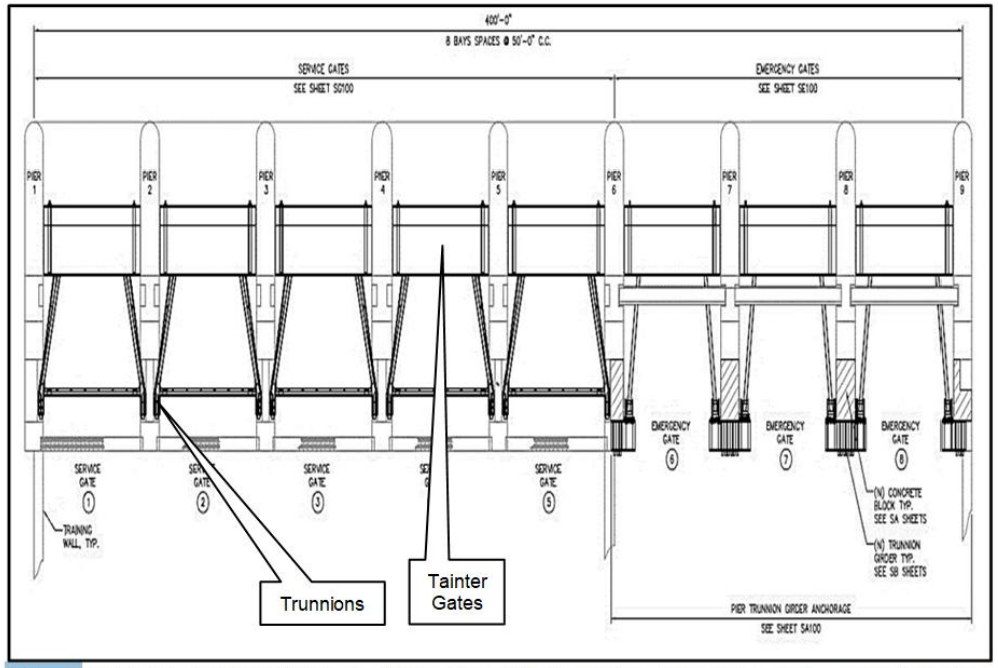
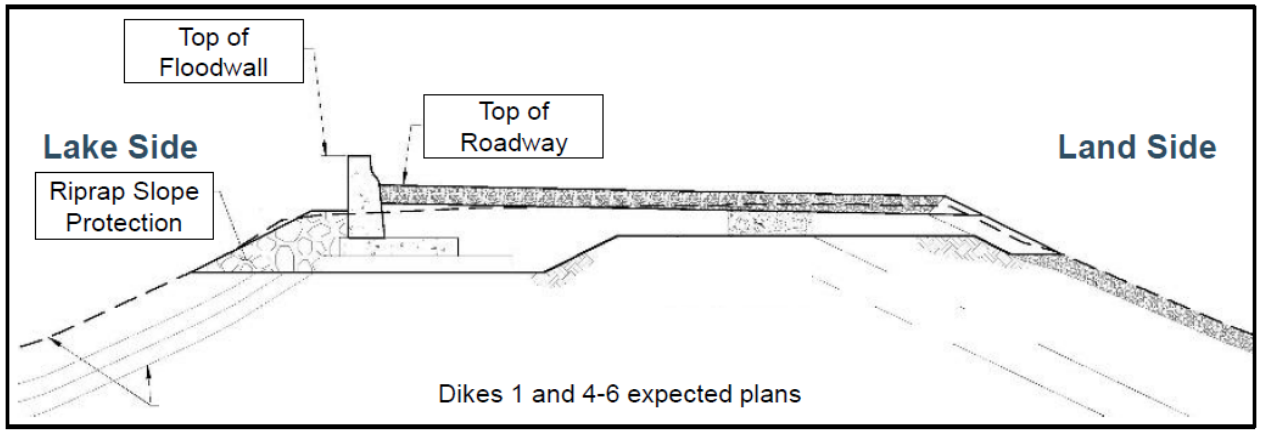
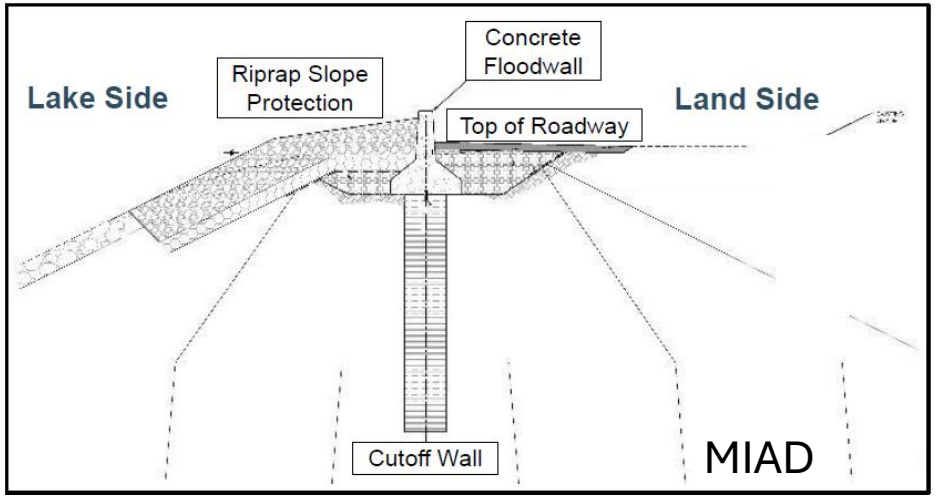


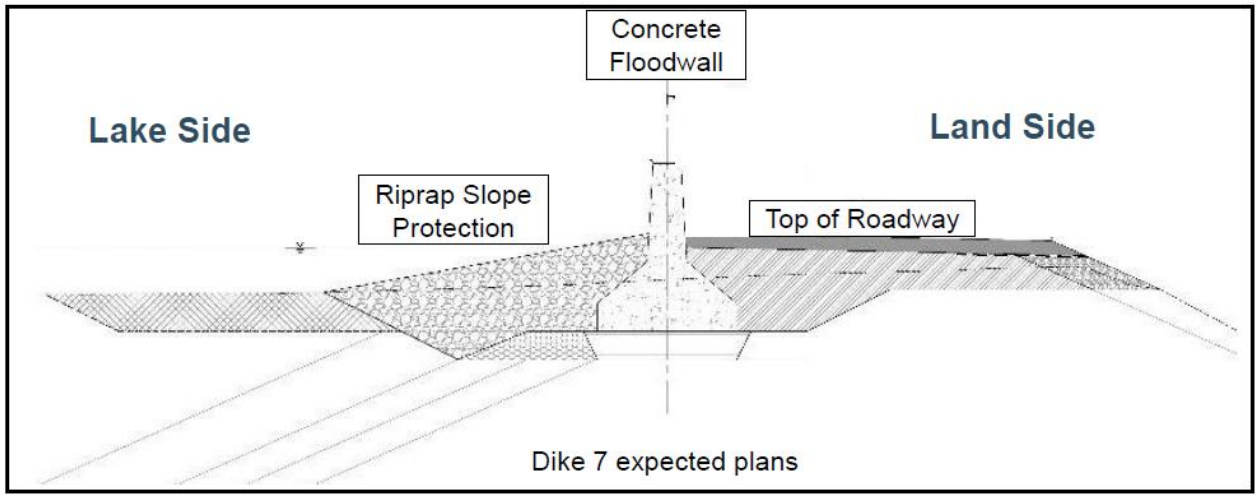
Figure 2-19. Depiction of Folsom Main Dam Tainter gates, trunnions, and associated piers. View from downstream side of dam looking upstream toward dam itself.

FDR - Dikes 1, 4-7, & Mormon Island Auxiliary DAM (MIAD) Floodwalls



Dikes 1 and 4-6 expected plans

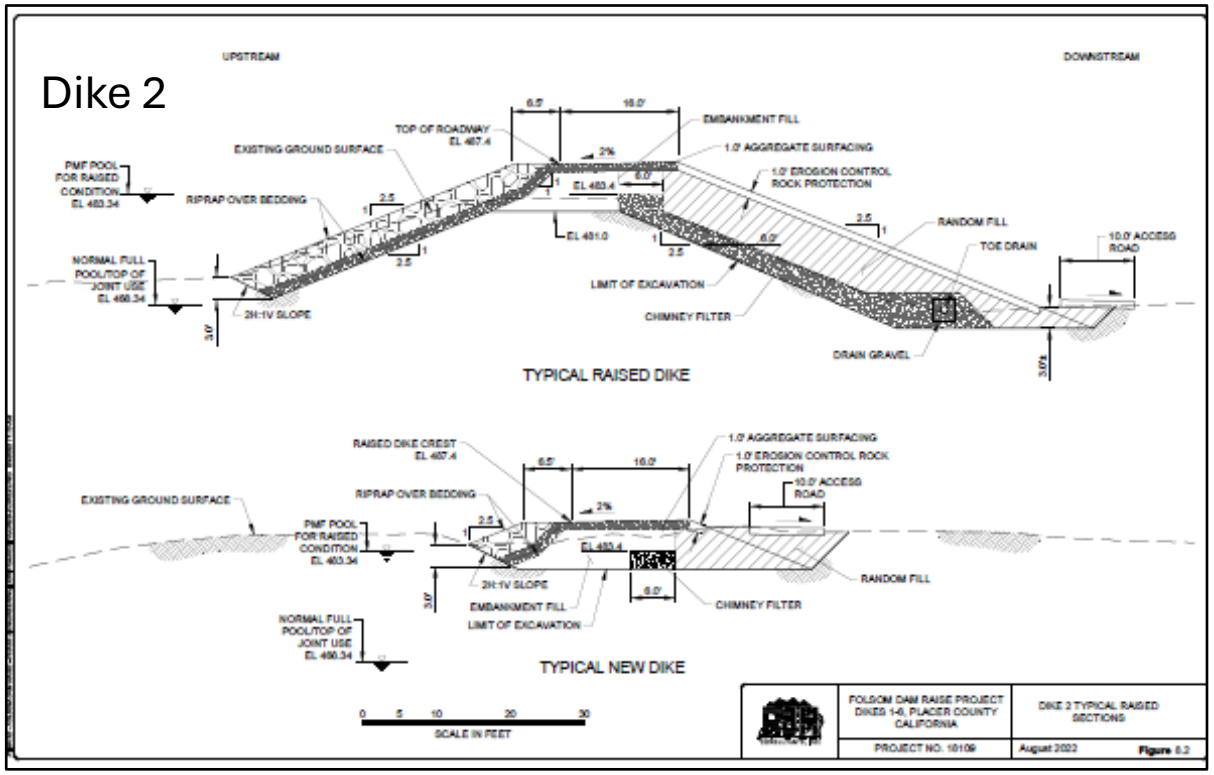




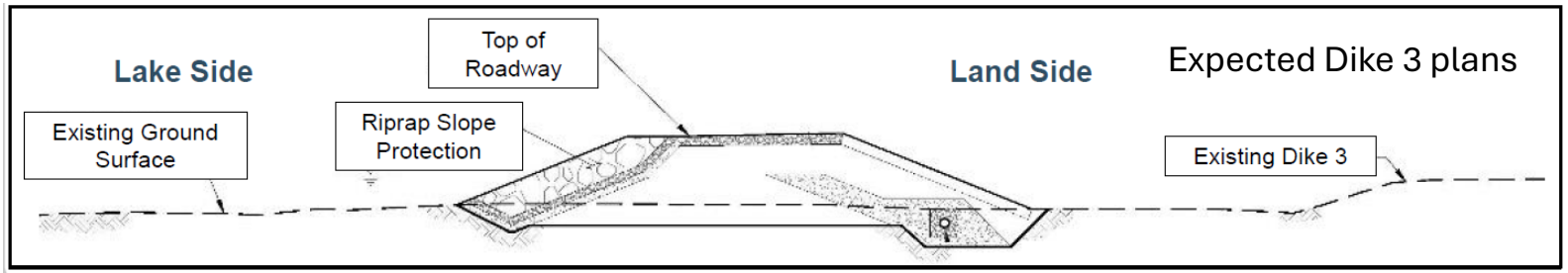
Dike 7 expected plans

FDR - Dikes 2,3, and 8 Embankment Raises

Dike 2



Dike 8



FDR – Operations Update

Accelerated Transition

accelerated
adjective
Occurring or developing at a faster rate than usual

transition
noun
A change or shift from one state, subject, or place to another

Allowing Folsom Dam release levels to **accelerate** the **transition** from the WCM objective release rate (115 kcfs) to a higher manageable rate (160 kcfs) when favorable forecast-informed conditions are met.

Conditional Surcharge

conditional
adjective
imposing, containing, subject to, or depending on a condition or conditions; not absolute; made or allowed on certain terms

surcharge
noun
an additional or excessive load or burden

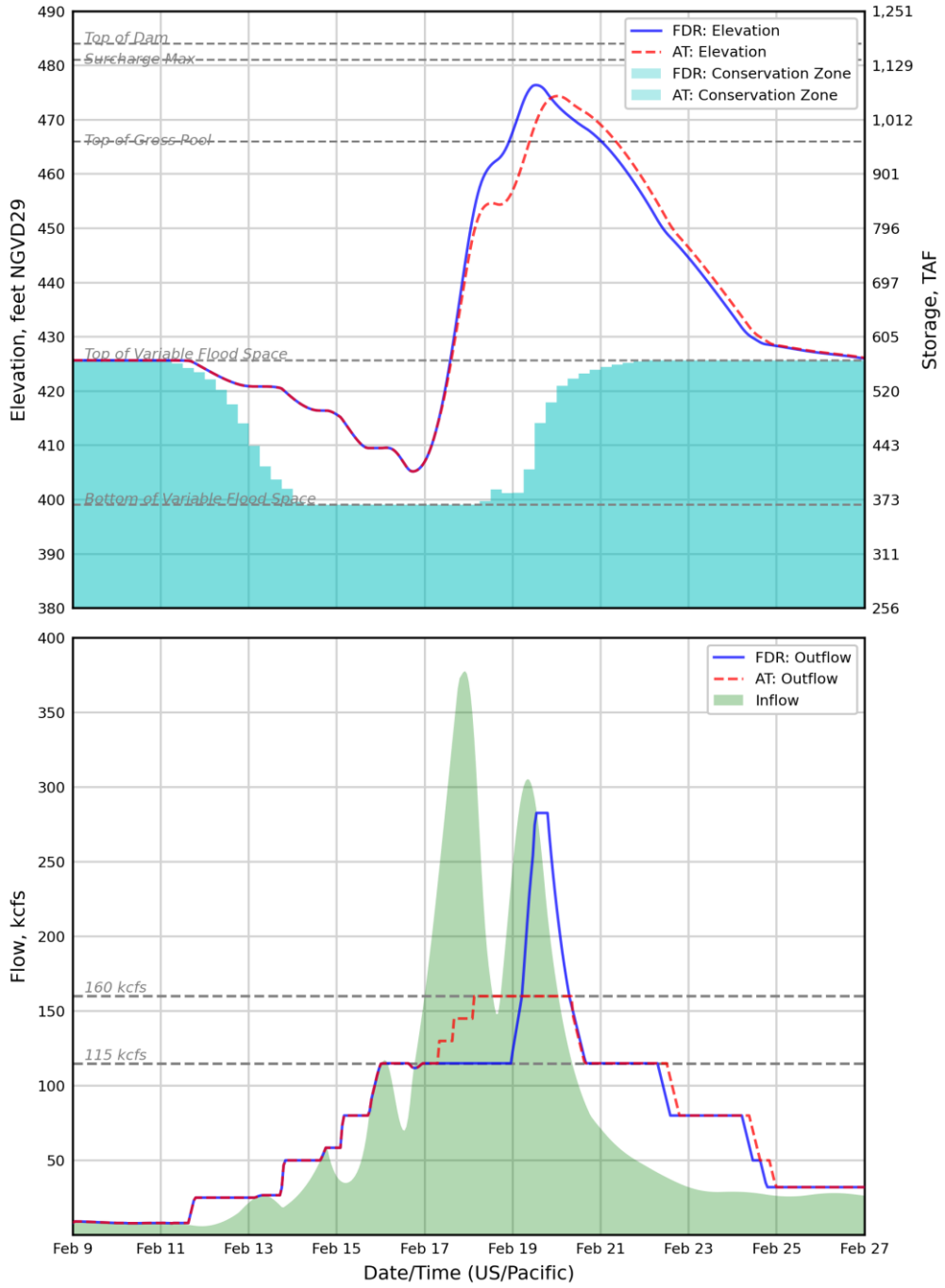
Allowing Folsom Dam Storage levels to **surcharge** (increase) when favorable forecast-informed **conditions** are met.

Terminology:
kcfs, thousand cubic feet per second
WCM: water control manual
NGVD29: National Geodatic Vertical Datum of 1929
FDR: Folsom Dam Raise

Accelerated Transition (AT)

- To enhance the effective flood space, more readily go from objective release (115 kcfs) to emergency objective release (160 kcfs) when prudent per forecasts
- Operation only possible due to downstream bank protection and levee improvements
- Will require updating WCM rules

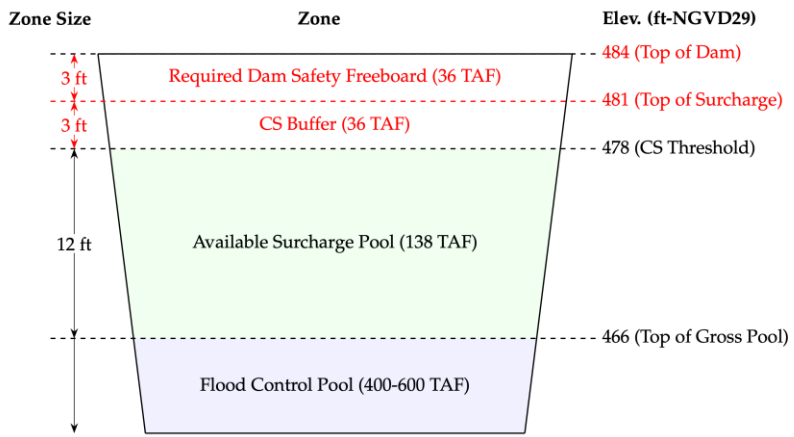
Release (kcfs)	Min Elevation (ft-NGVD29) (Max Flood Reserve (TAF))
130	413.2 (500)
145	425.7 (400)
160	447.1 (200)

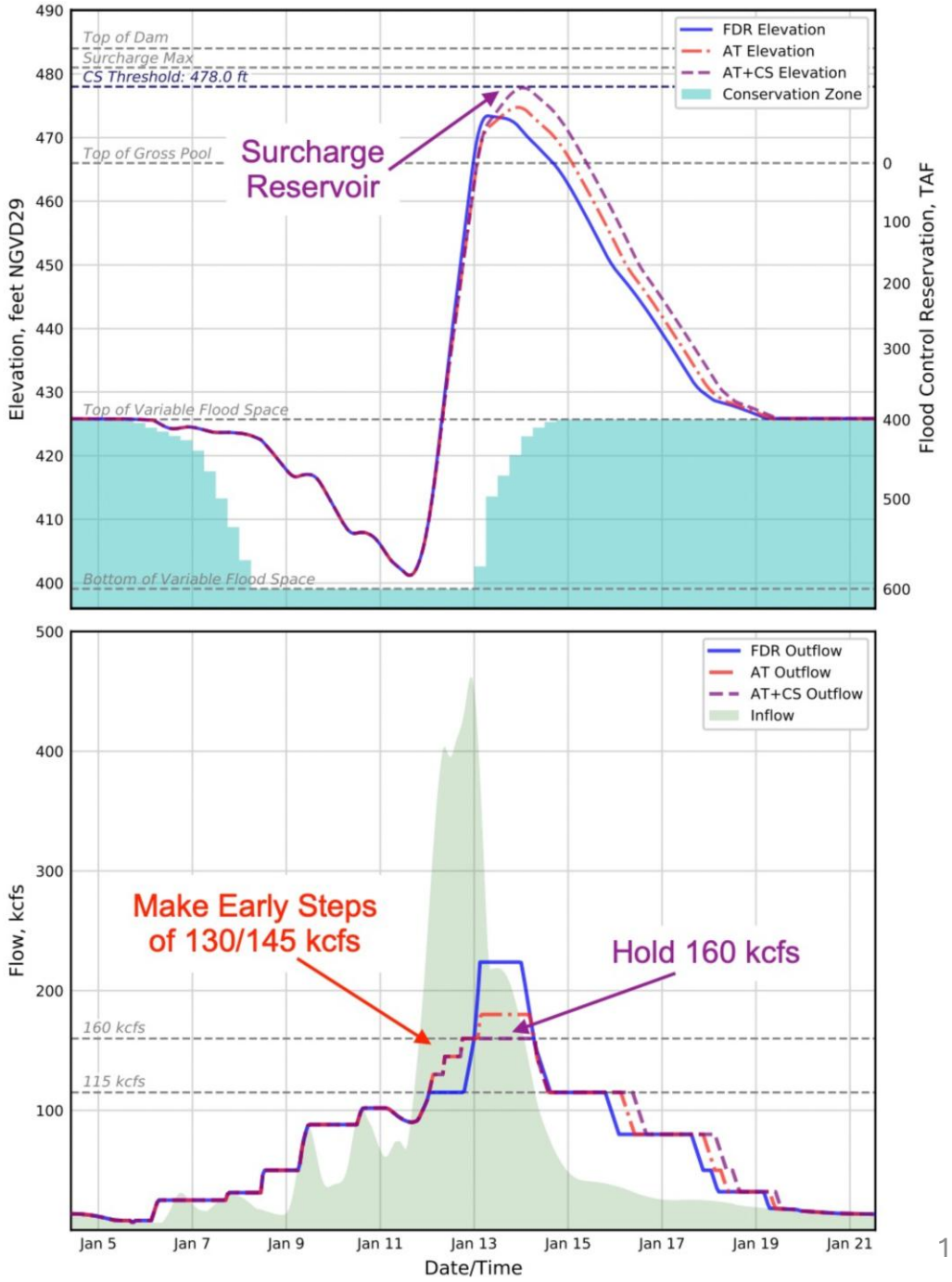


Conditional Surcharge: Flood Risk Management

Terminology:
kcfs, thousand cubic feet per second
WCM: water control manual
NGVD29: National Geodatic Vertical Datum of 1929
FDR: Folsom Dam Raise
AT: Accelerated Transition
CS: Conditional Surcharge

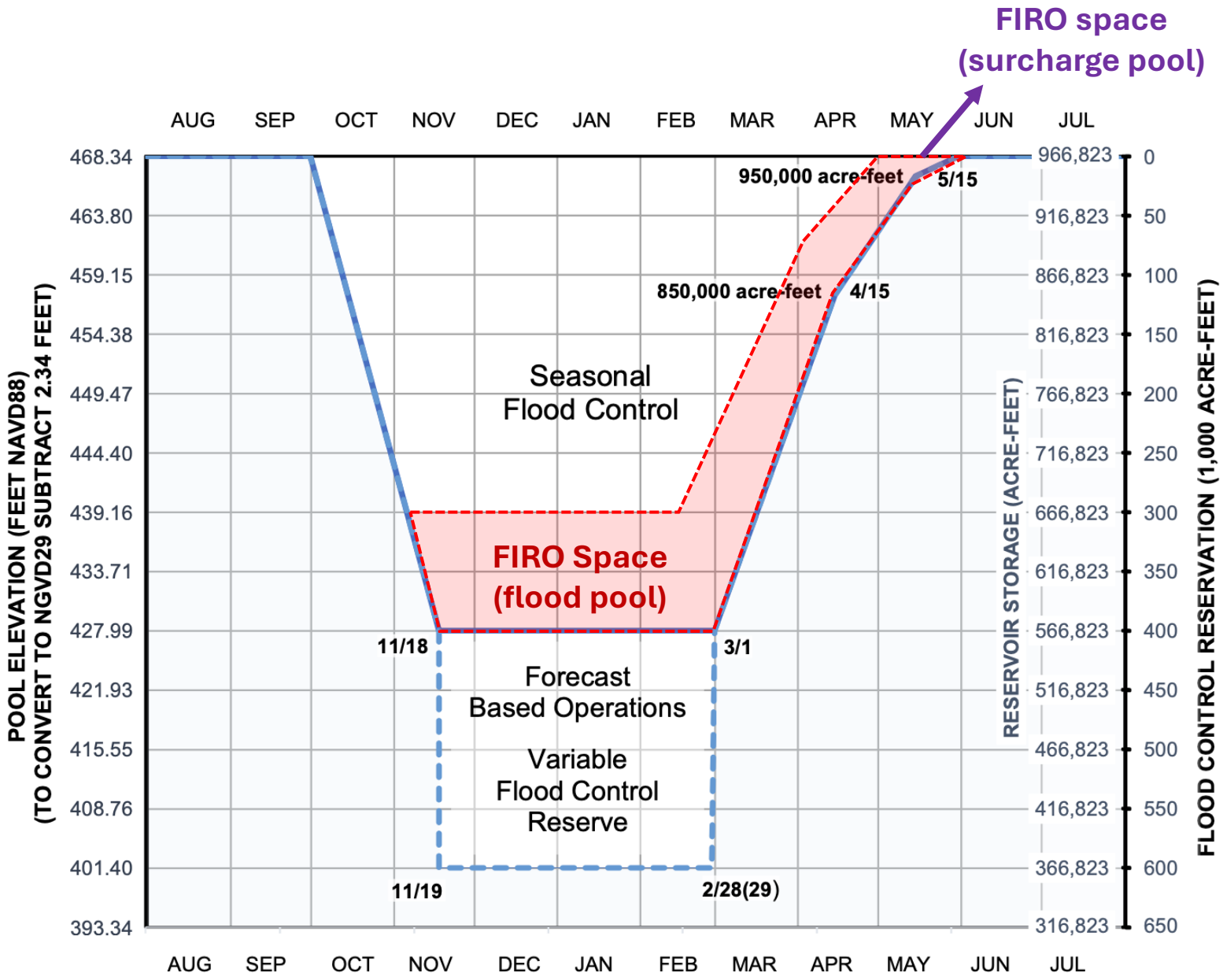
- Temporary deviation from traditional flood control rules
- Avoids releasing damaging flows (over 160 kcfs) if using available surcharge storage space likely to be effective in holding the emergency objective 160kcfs release
- Operation is informed by regulated inflow forecast





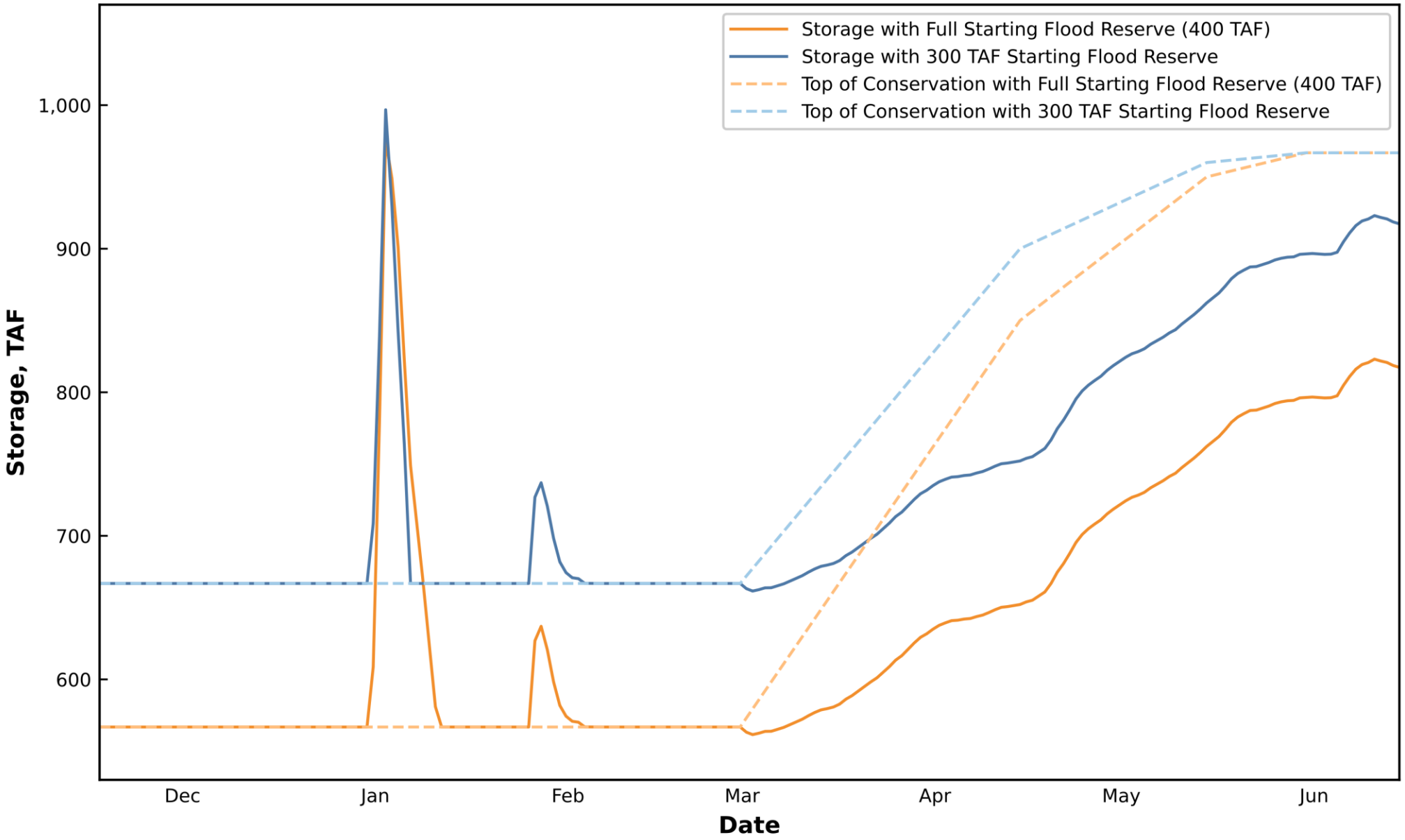
Conditional Surcharge: Storage Augmentation

- Store higher than previously considered when forecast indicates flood risk minimal
- Could possibly store into **flood pool** or **surcharge pool**



Terminology:
FIRO: forecast informed reservoir operation

Conditional Surcharge: Storage Augmentation (Winter) Effects



Terminology:
TAF: thousand acre-feet

Summary

		Folsom Dam Raise	
	Folsom Joint Federal Project (JFP)	**Accelerated Transition**	**Conditional Surcharge**
Technology	• Ensemble regulated inflow forecasts • New water control manual	• New operating rules and a way to institutionalize them	• New operating rules and a way to institutionalize them
Infrastructure	• New auxiliary spillway with its sill 50 feet lower than the existing one with six big gates	• Downstream bank protection and levee fortification	• Dam embankment raising and fortification • Top-sealing main spillway gates
Challenges	• Corps of Engineers hesitation to formally update operations to leverage forecasts due to some poor historical experiences, mainly in other localities	• Concerns on downstream floodway aesthetics and need to support emergency objective (160kcfs) release rate • Forecast precision	• Dam safety risks due to increased loading elevations and durations on lake embankments • Forecast precision

Contact

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