

# Forecast-Informed Reservoir Operations: The Next Five Years

*New Reservoir Configurations and  
Weather Regimes*

**Cary Talbot, PhD, PE**  
FIRO Program National Lead  
USACE-ERDC

**WSWC Improving Subseasonal to Seasonal  
Precipitation Forecasting Workshop**  
August 16, 2023



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**US Army Corps  
of Engineers®**



# Forecast Informed Reservoir Operations (FIRO) R&D



## Current R&D

Weather forecast predictions viable for reservoir management to increase water supply

- FIRO is R&D to define how forecast information can be implemented in water control manual updates and practice
- FIRO viability assessed at reservoirs through collaborative process with a variety of conditions
- “FIRO Phase III: National Expansion Pathfinder” extending nationwide in FY23

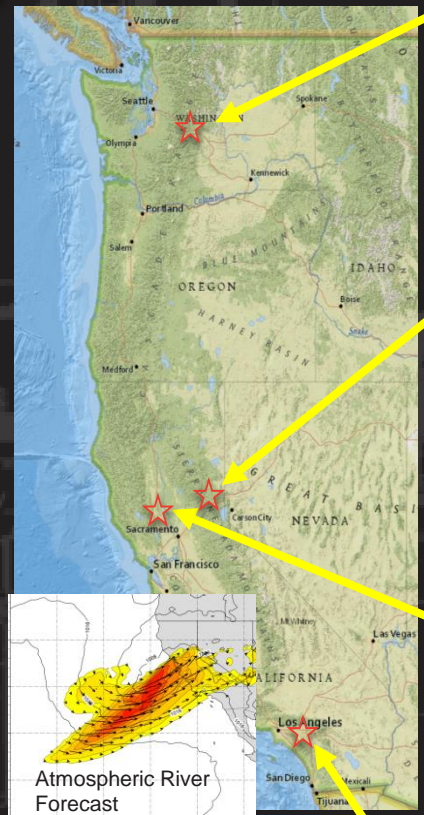
Enabled water supply to  
**23,000**  
 more homes in Spring 2020 –  
**3rd\***  
 driest year on record!

\* at that time

**FIRO R&D: FY15-FY23**

**Congressional Add & FY23 President’s Budget**

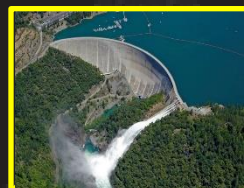
**\$44.5M**



Atmospheric River Forecast



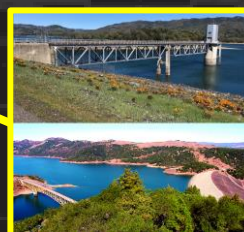
**Howard Hanson Dam**  
 Green River, Seattle District  
 USACE



**New Bullards Bar Dam**  
 Yuba River, Yuba Water Agency



**Oroville Dam**  
 Feather River, CA Dept. of Water Resources



**Lake Mendocino & Lake Sonoma**  
 Russian River, San Francisco District  
 USACE



**Prado Dam & Seven Oaks Dam**  
 Santa Ana River, Los Angeles District  
 USACE





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# FIRO R&D Viability Assessments – Current Status



Lake Mendocino

Work Plan Completed Sep 2015

PVA Published Nov 2017

FVA Published Feb 2021



Prado Dam

Work Plan Completed Jul 2019

PVA Published Jul 2021



New Bullards Bar & Oroville Dams

Work Plan Completed Mar 2021

PVA Published Dec 2022



Howard Hanson Dam

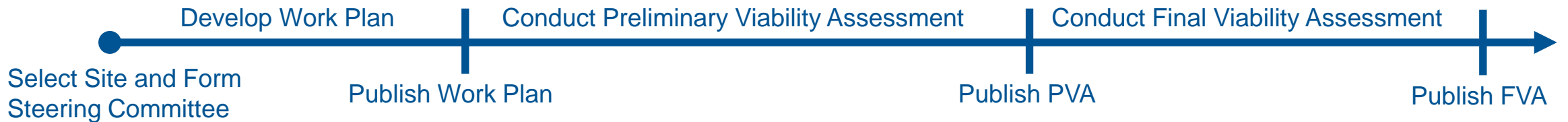


Lake Sonoma

Work Plan Completed Apr 2022



Seven Oaks Dam



FIRO Viability Assessment Timeline



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# Collaboration is Key to FIRO Success



- FIRO pilots are led by interagency Steering Committees carefully formed with senior representatives from stakeholder agencies and academic partners
  - Blend of engineers and scientists from research, operations and regulatory perspectives
  - Each agency responsible for supporting their engagement



Sonoma Water







# Phases of FIRO Research & Development



## Phase I – Lake Mendocino

- Oct 2014 – Dec 2020
- Initial FIRO pilot, defined viability assessment process and use of steering committees
- Preliminary Viability Assessment: Jul 2017
- Final Viability Assessment: Feb 2021

## Phase II – Expanded Effort

- Oct 2019 – Dec 2023
- Added three more pilots:
  - Prado Dam
  - New Bullards Bar/Oroville Dams
  - Howard Hanson Dam
- Screening Process Development
  - USACE South Pacific Division dams as testbed

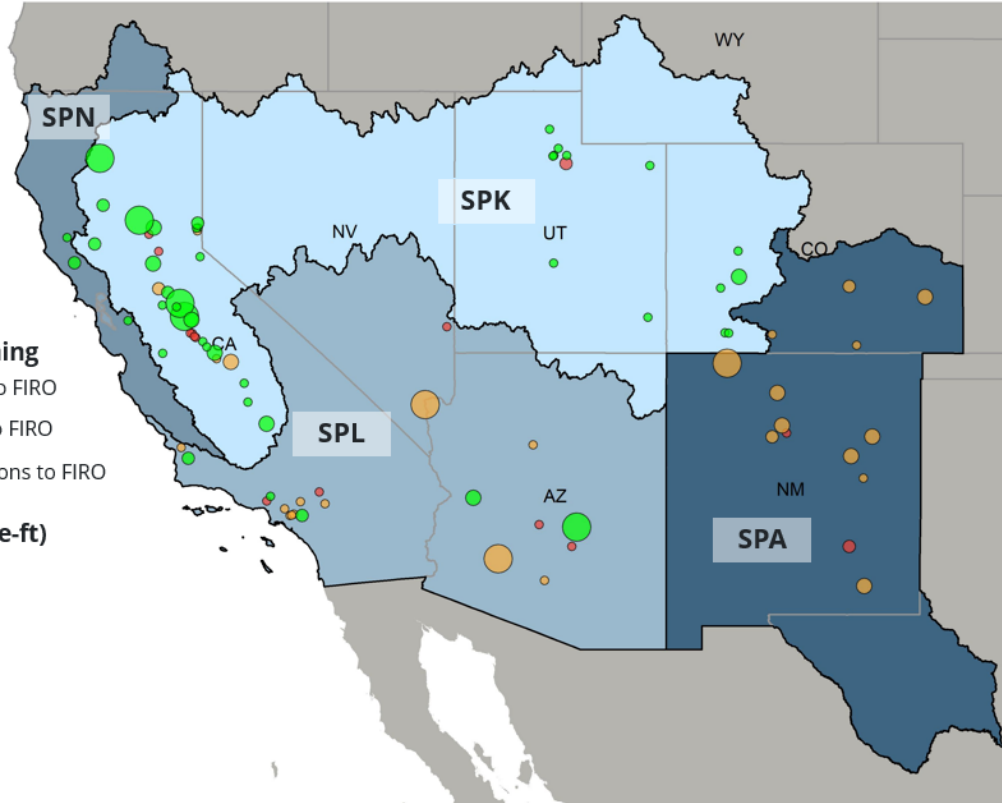
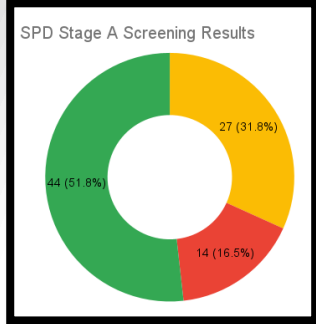


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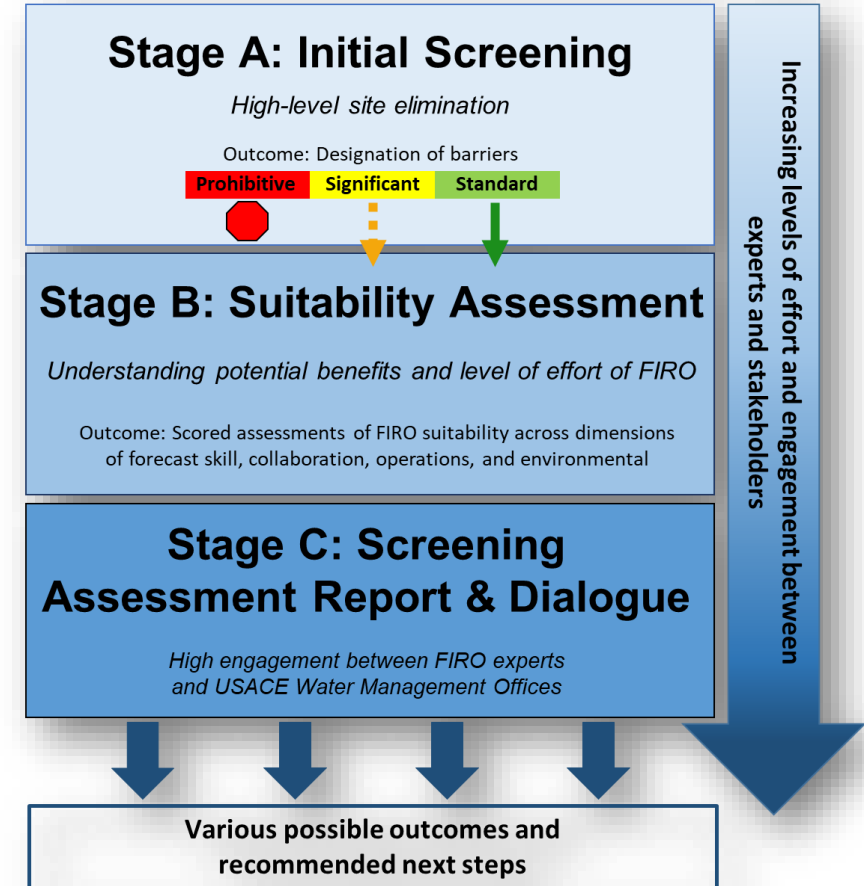
# FIRO Phase II – Developing the Screening Process *SPD Beta test*



FIRO Screened Reservoirs  
USACE South Pacific Division



- 85 SPD reservoirs screened in Stage A
- 14 reservoirs eliminated from FIRO consideration
- 13 reservoirs nominated for Stage B beta



- Stage B analysis in progress now
- 13 site reports will be produced in 2023
- Outcomes include recommended steps



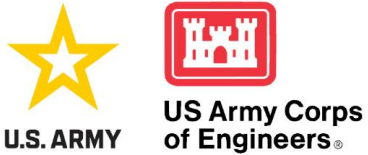
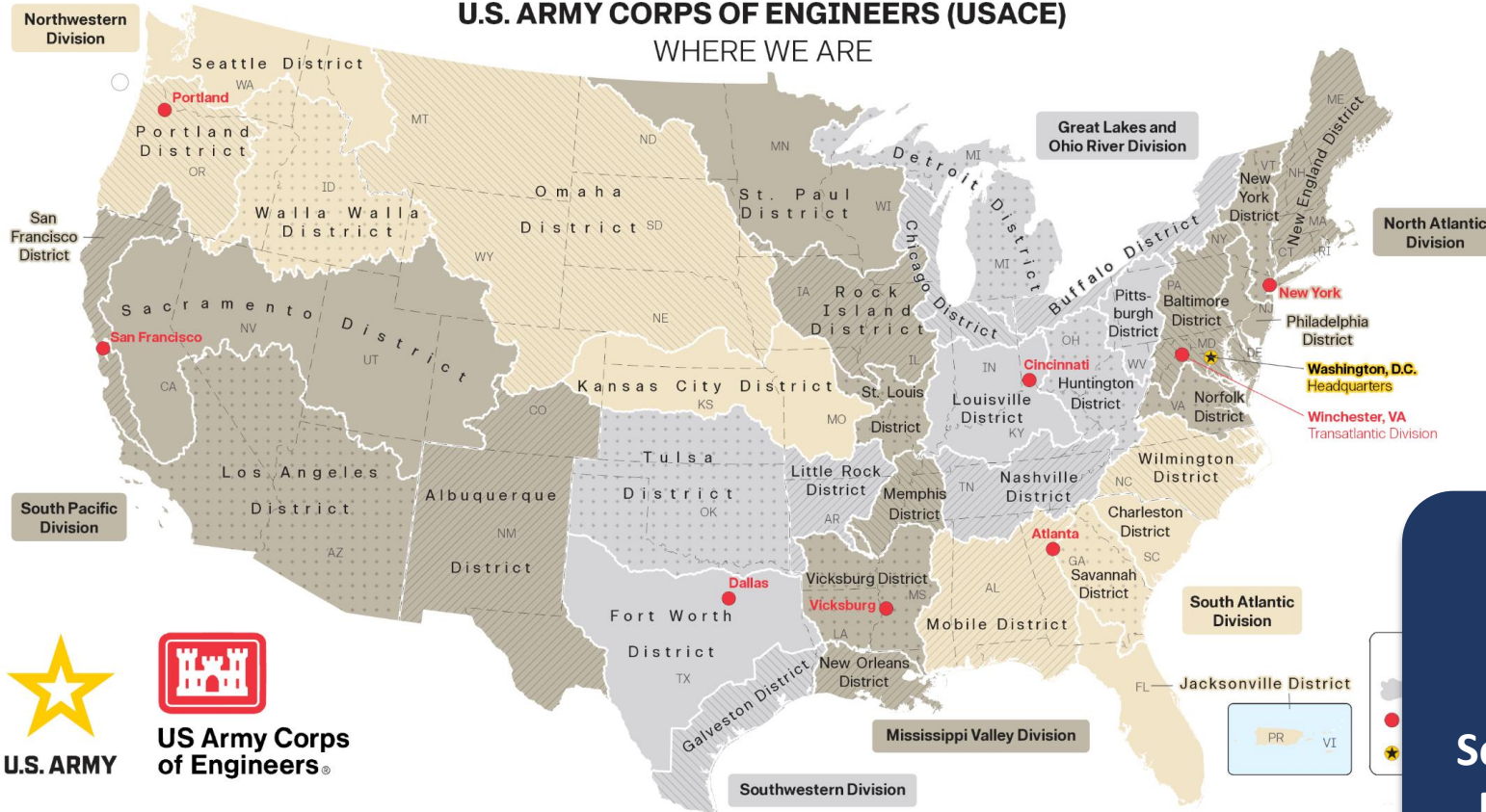
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# FIRO Phase III – Applying the Screening Process Nationwide

## U.S. ARMY CORPS OF ENGINEERS (USACE)

WHERE WE ARE



- Willamette – FIRO in systems
- Expansion into different contexts – Phase III pilots
- Pilot screening in each region to adjust the process
- Interplay between the site-specific and the generalizable
- Incorporating environmental justice analysis
- Training and education



This must be a **capacity-building** exercise.



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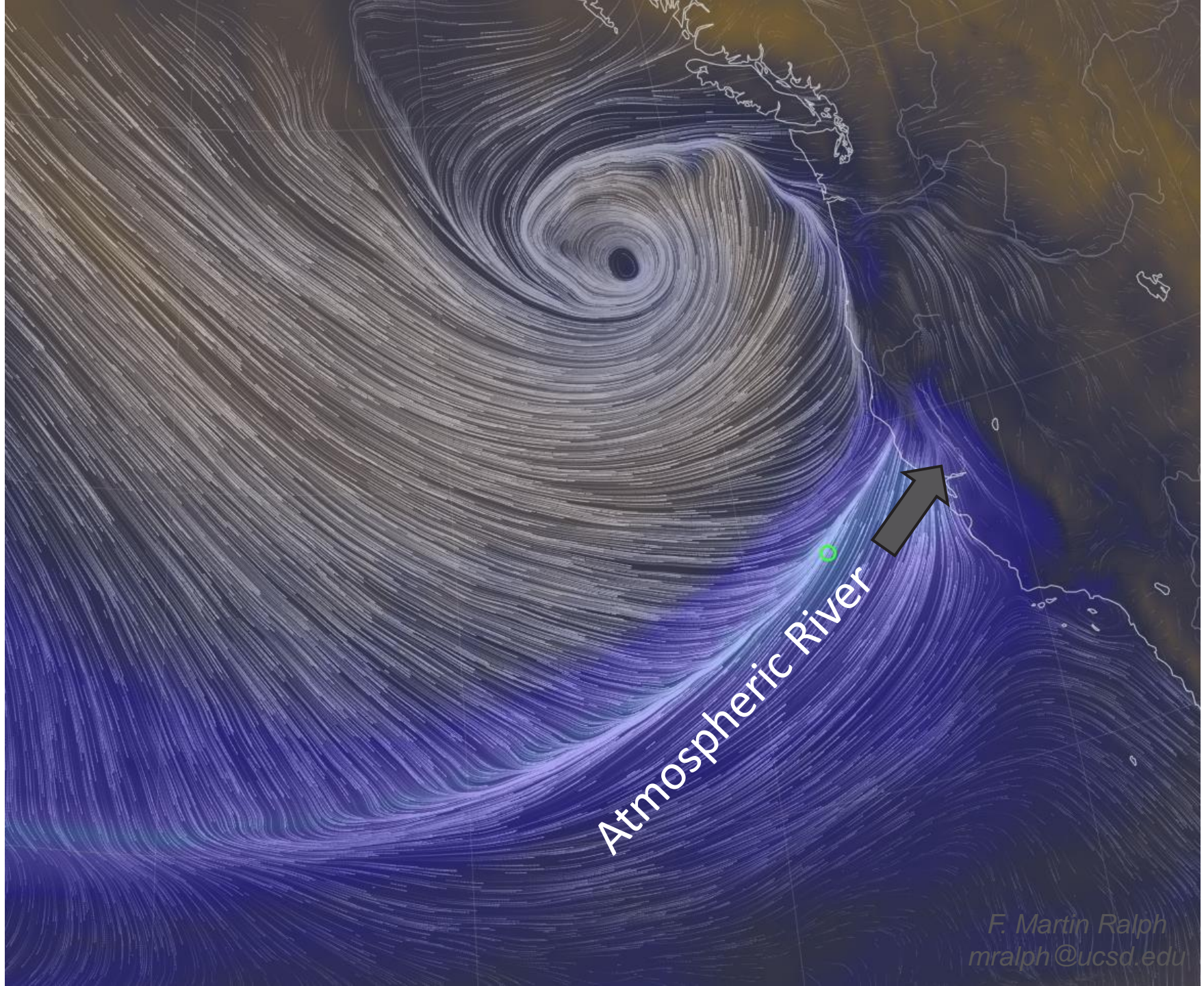
# FIRO Phase III: National Expansion Pathfinder

FY23-FY27



1. National forecast skill assessment and improvement campaign (*Putting the F in FIRO*)
  - Continued investment in Atmospheric River (AR) and other storm type forecast improvements that have yielded significant benefits



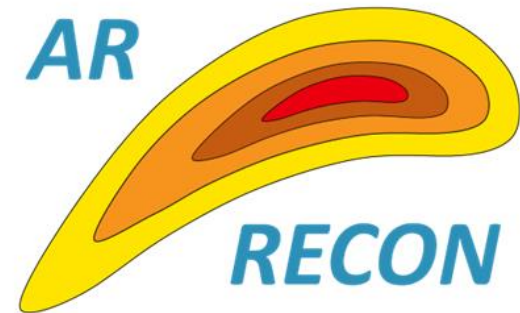


*F. Martin Ralph  
mralph@ucsd.edu*





AR



RECON

*Research And Operations Partnership*



**F. Martin Ralph, PI** (UC San Diego/SIO/CW3E)  
**Vijay Tallapragada, Co-PI** (NOAA/NWS/NCEP)

Air Force C-130WJs at Mather airfield in Sacramento, CA for AR Recon 2023  
Photo on 5 Jan. 2023 courtesy of USAF 53<sup>rd</sup> Weather Reconnaissance Squadron

# ATMOSPHERIC RIVER RECONNAISSANCE

Filling Gaps in Pacific Weather Observations

## Observational innovations

GPS SATELLITE

AIRBORNE  
RADIO  
OCCULTATION

TOP OF AR

EDGE OF AR

Air Force C-130

Air Force C-130

DROPSONDE

DRIFTING  
BUOY

Ralph et al. 2019 BAMS  
Zheng et al. 2021 BAMS  
Stone et al. 2020 MWR  
Reynolds et al. 2019 MWR  
Lavers et al. 2018 GRL  
Lavers et al. 2020 Wea Fore  
Lavers et al. 2020 Nature Comms  
Zhang and Ralph 2021 MWR  
Prince et al. 2021 GRL  
Haase et al. 2021 JGR







# AR Recon 21-26 Jan 2021 Sequence



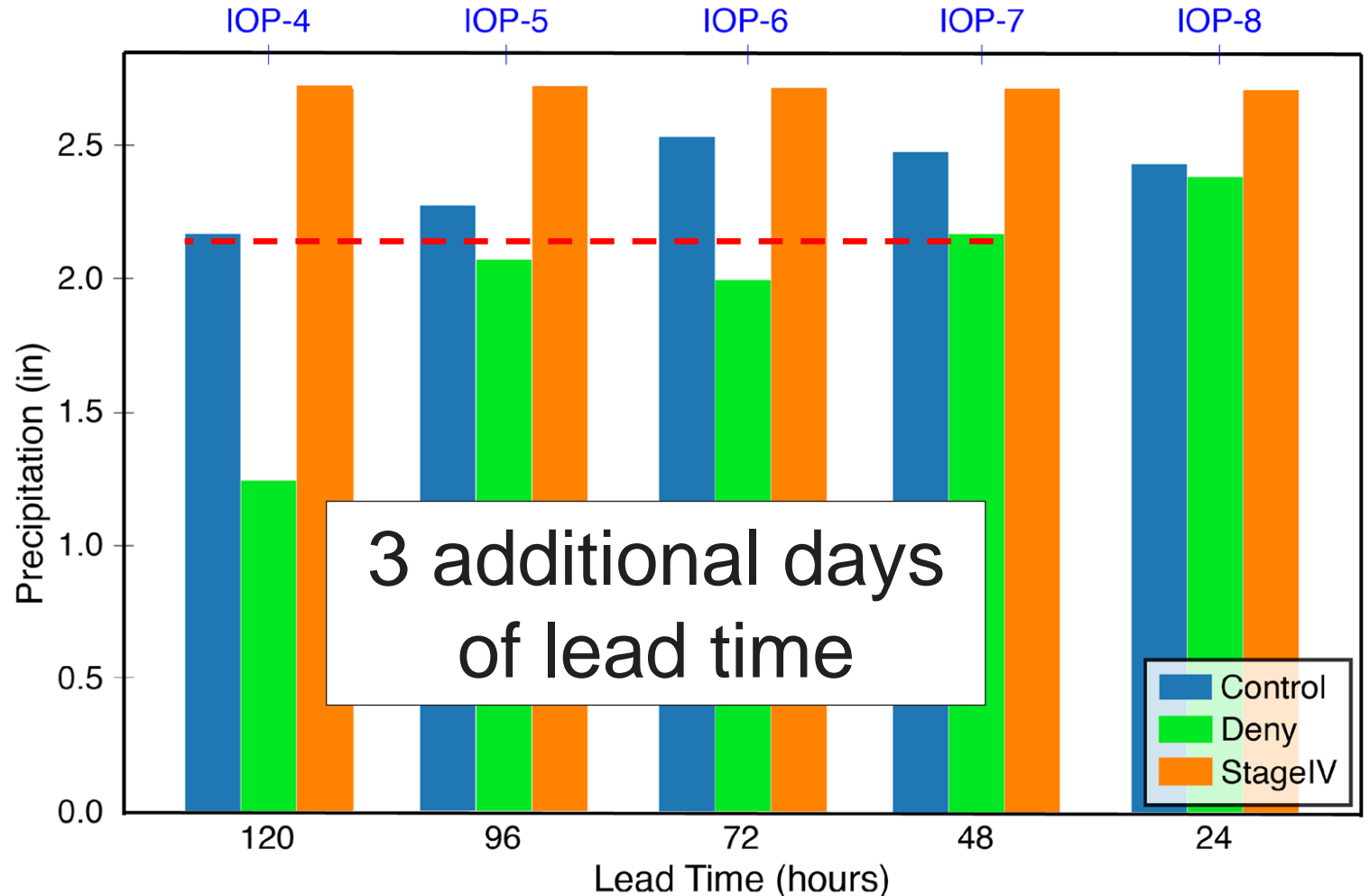
## AR Recon Data Denial Experiments\*

*V. Tallapragada, F.M. Ralph, X. Wu, M. Zheng*

Forecast  
Lead Time =  
Water

Precip (in) by Forecast Hour (ST4 > 1in)

Valid: 29 Jan 2021, Lat: 34-37N, 122-119W



\*in review

Slide courtesy CW3E



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# FIRO Phase III: National Expansion Pathfinder

FY23-FY27



1. National forecast skill assessment and improvement campaign (*Putting the F in FIRO*)
  - Continued investment in Atmospheric River (AR) and other storm type forecast improvements that have yielded significant benefits
2. Completion of Phase II viability assessments to support planned WCM updates
  - Prado, Yuba-Feather, Howard Hanson, Lake Sonoma, Seven Oaks
3. Conduct full FIRO viability assessment on Willamette Valley, Oregon system of dams (14 dams in total)
  - Willamette Valley dam operations are managed in coordinated fashion from a single water management office



# FIRO Phase III: National Expansion Pathfinder

FY23-FY27

4. Conduct full viability assessment of system of 8+ dams in another region nationally
  - Explore a region where different storm types (in addition to ARs) are key to heavy rain and flooding (e.g., tropical storms/hurricanes, long-lived thunderstorm clusters, Nor'Easters)
5. Conduct full viability assessments on two single dams in other regions nationally
6. Apply FIRO screening process nationally across USACE portfolio of dams
  - Result will be identification of FIRO-suitable sites to help prioritize future FIRO viability assessment efforts

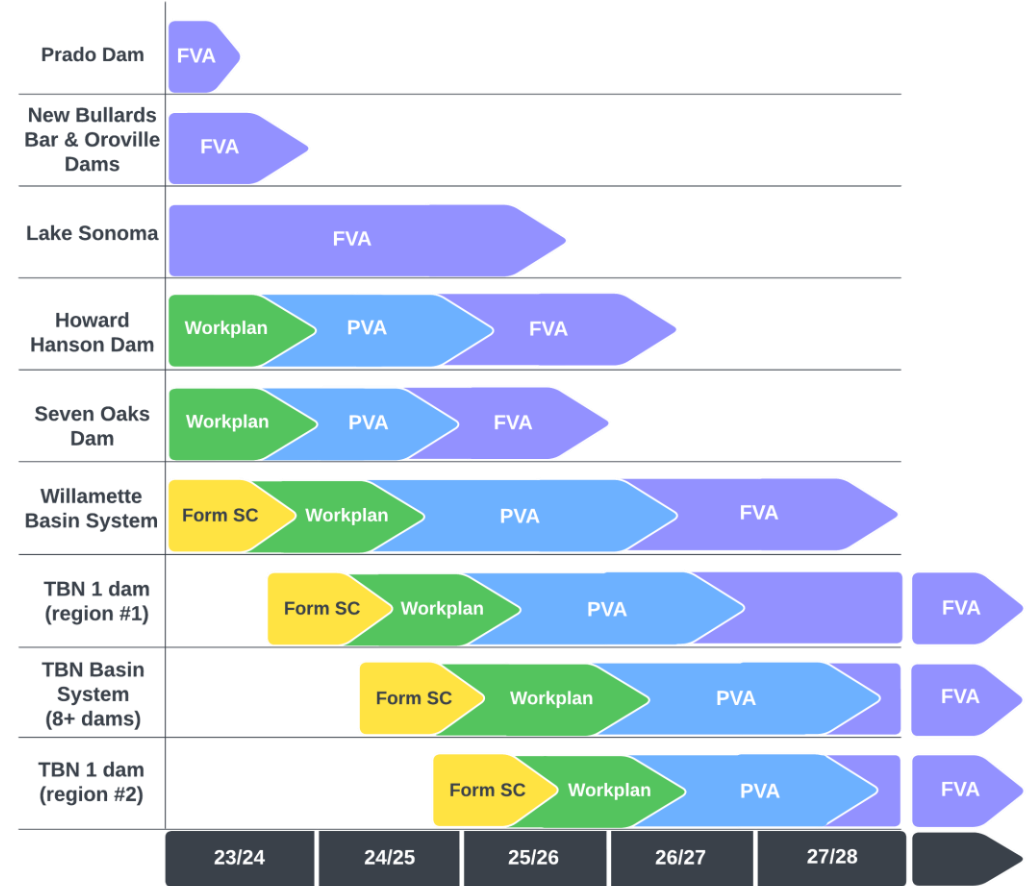
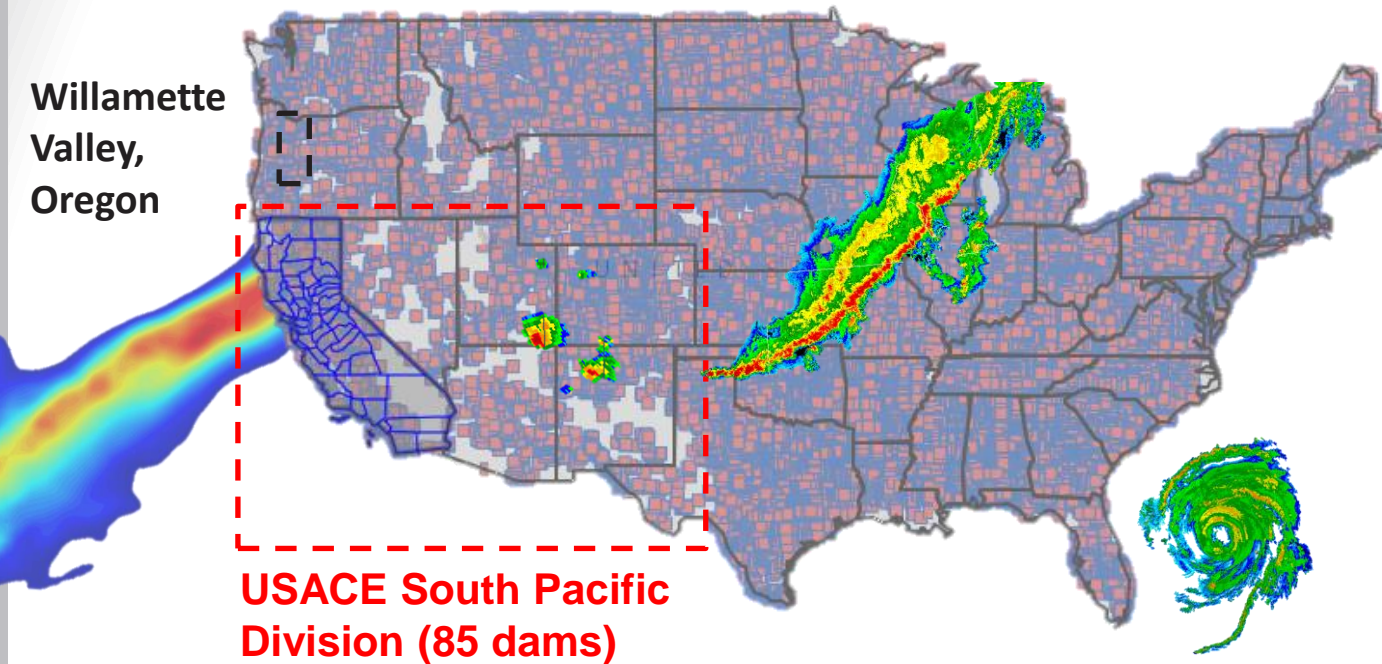




# Projected Timelines for FIRO Phase III Efforts



> 90,000 dams nation-wide (~ 740 operated by USACE)





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# USACE FIRO-Specific Positions

16



- Two national FIRO-specific positions created to support FIRO R&D and implementation going forward
  - National FIRO Program Lead: Cary Talbot
  - Water Management Integration Lead: Joe Forbis



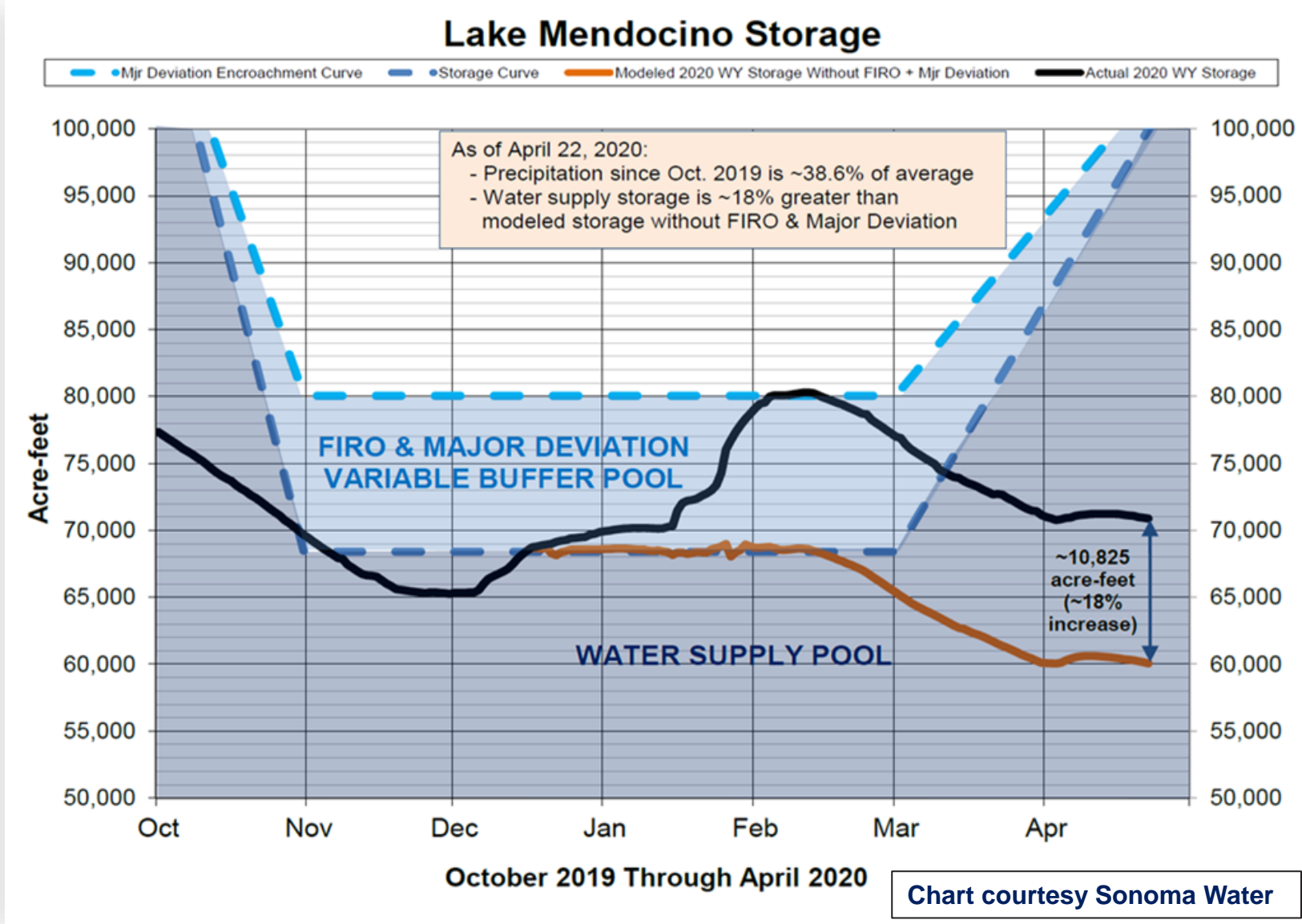
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# Lake Mendocino FIRO Benefits – WY 2020



3<sup>rd</sup> driest winter on record in Russian River watershed

10,825 ac-ft is enough water for ~22,000 homes for a year



Seeing the lake so full makes Kyle Farmer, a rancher in Potter Valley, happy every time he drives by it. “It’s a huge deal to become adaptive like that. I don’t think bureaucracies do that naturally,” he said. “It restored my faith in the government, obviously, a little bit.”

*Drought or dangerous flooding? Research aims to tame atmospheric river risks — and save California’s rain*  
By Rachel Becker  
[www.CalMatters.org](http://www.CalMatters.org)  
25 February 2020

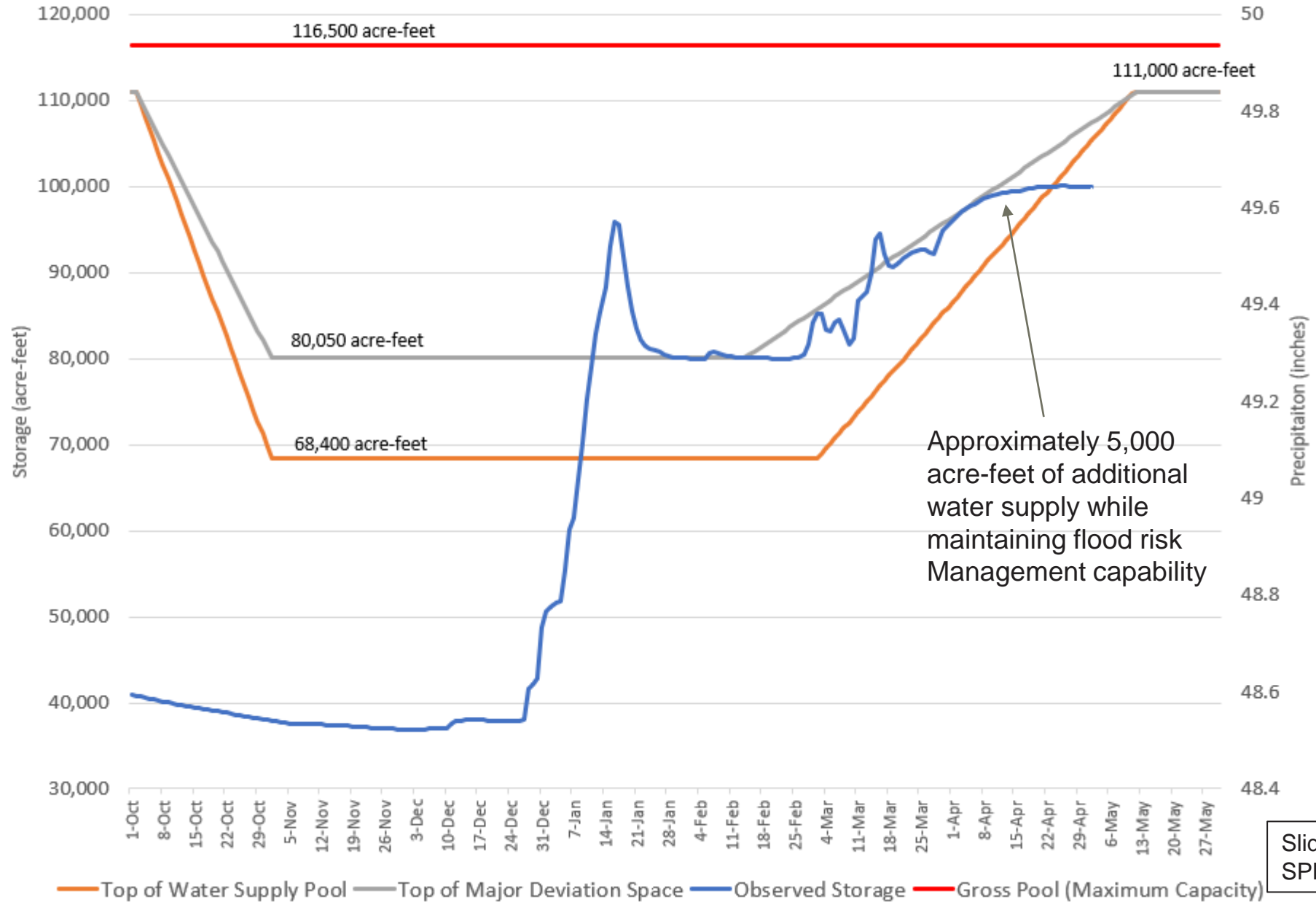




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### Lake Mendocino Storage for Water Year 2023



Approximately 5,000 acre-feet of additional water supply while maintaining flood risk Management capability

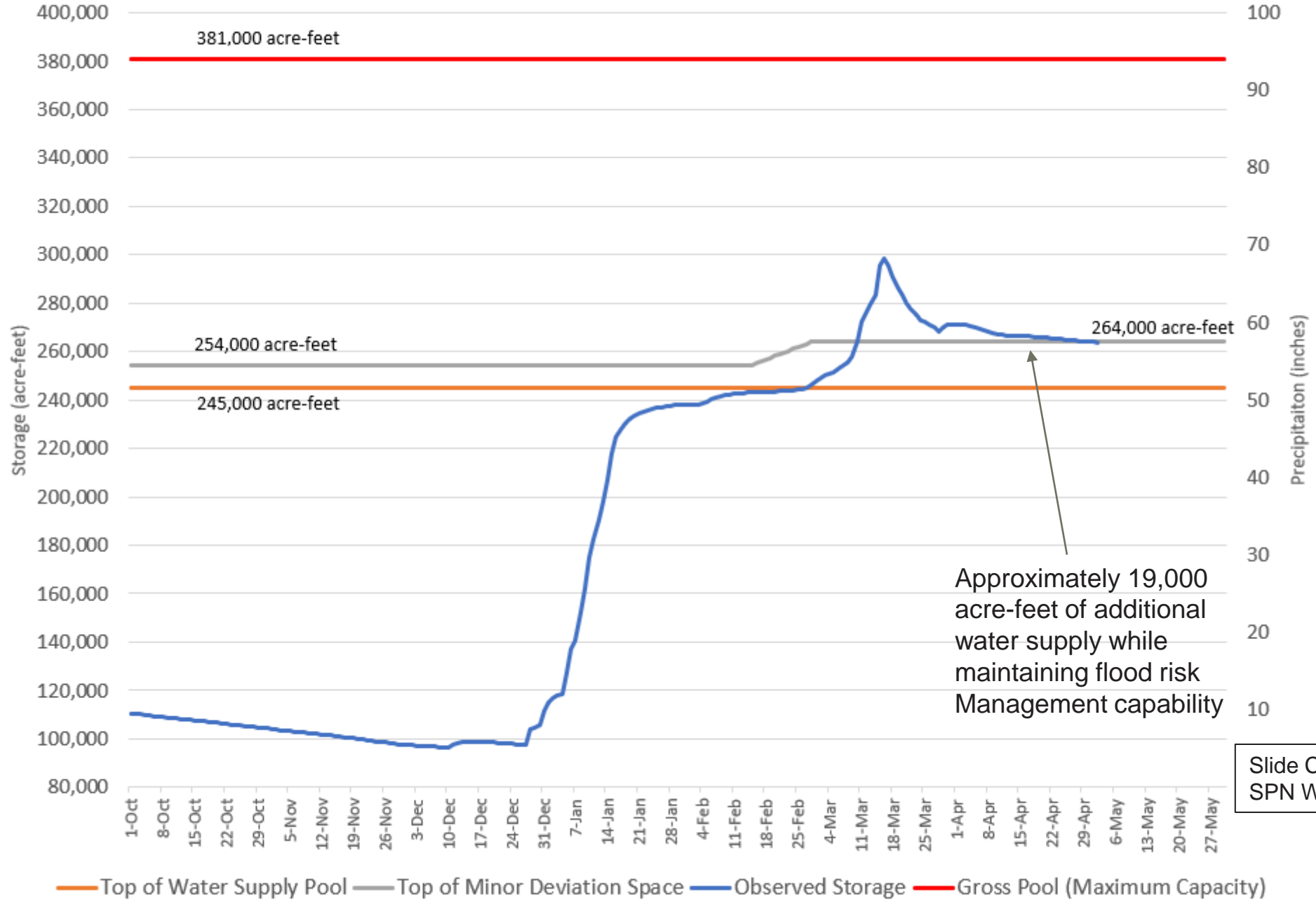
Slide Courtesy Patrick Sing  
SPN Water Manager



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### Lake Sonoma Storage for Water Year 2023



Slide Courtesy Patrick Sing  
SPN Water Manager



**Thank you!**

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