Forecast Informed Reservoir Operations (FIRO): Status of the Nationwide Screening Process

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Improving Subseasonal to Seasonal (S2S) Precipitation Forecasting
Western States Water Council
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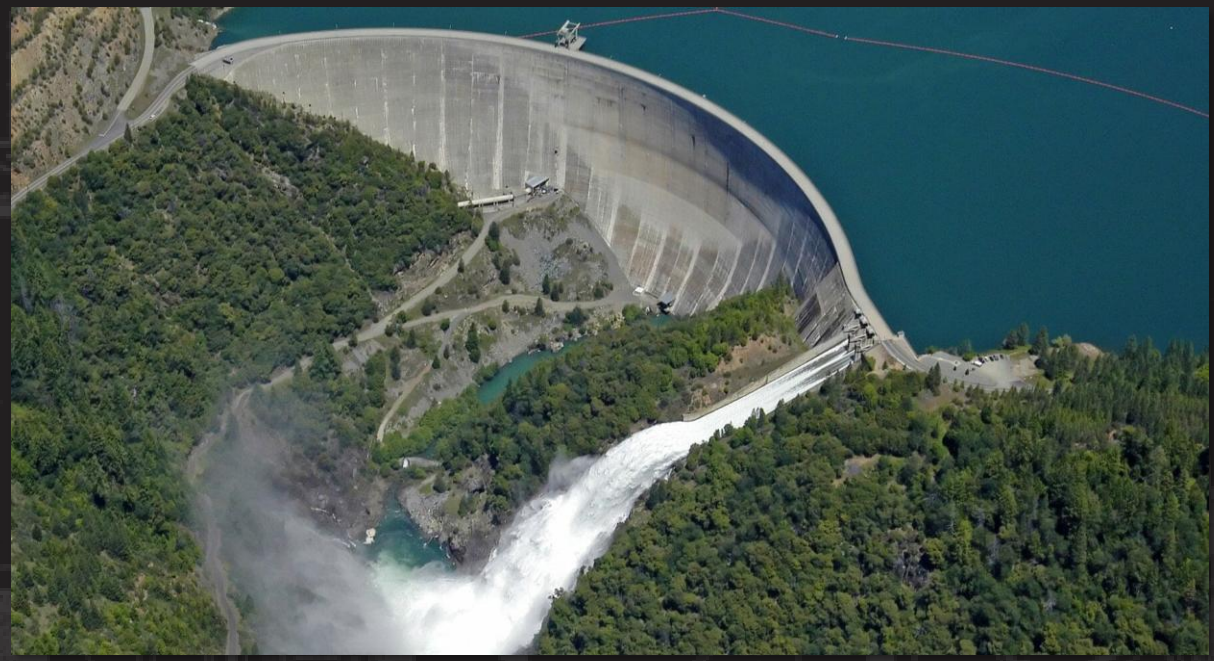


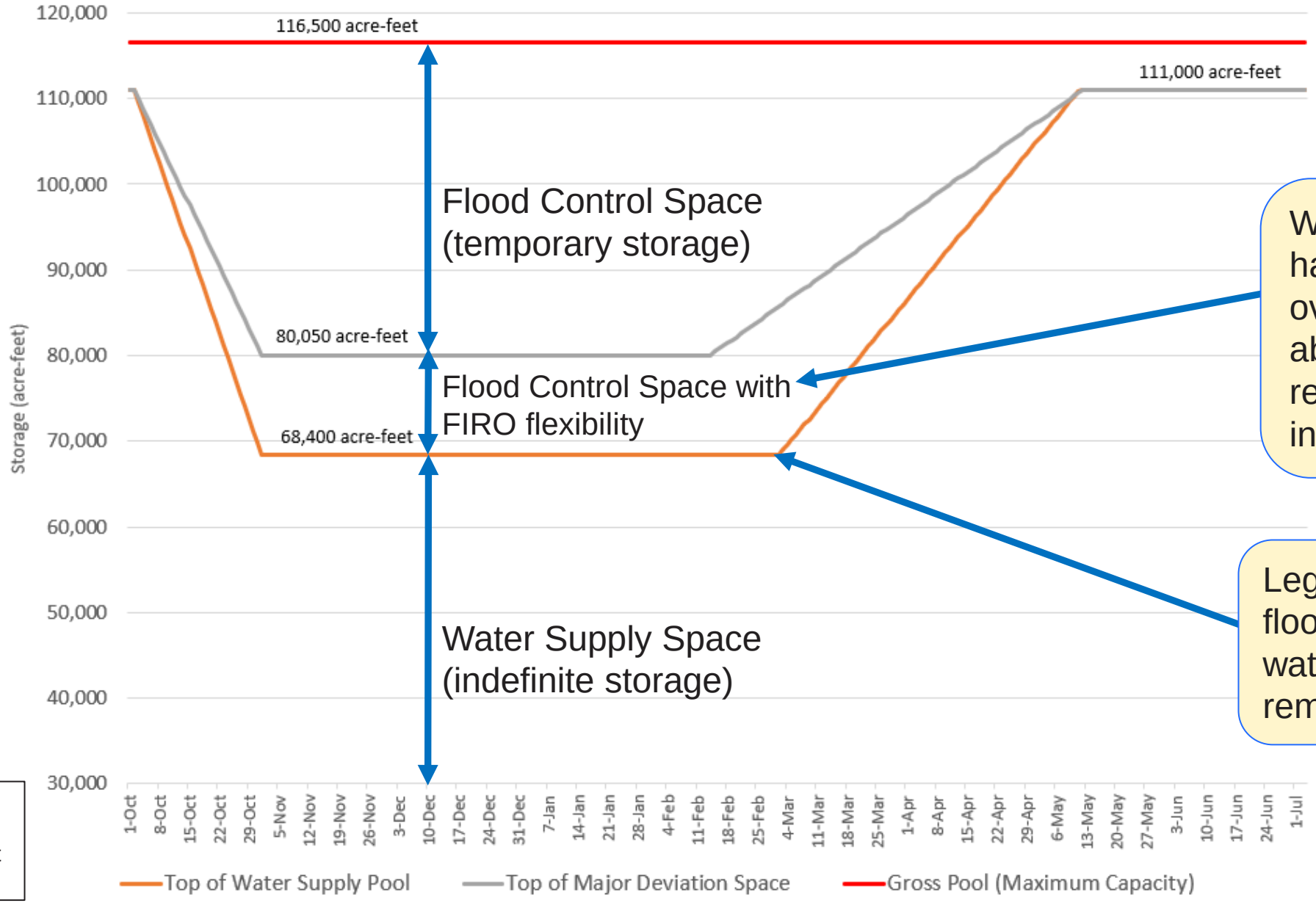
Forecasts in USACE Water Management

- May 2016 update to Water Control Management regulation adds this sentence:
  - "Forecasted conditions may be used for planning future operations, but releases should follow the water control operations plan based on observed conditions within the watershed to the extent practicable." *(emphasis added)*
- Policy change to *allow* Corps use of forecasts in water operations is in place, but doesn't define how the change is to be implemented
- Since 2015, FIRO is R&D effort to define how forecast information can be safely and effectively implemented officially in water control manual updates and practice

Forecast Informed Reservoir Operations (FIRO) Definition and Goal

- American Meteorological Society definition of FIRO (2021):
  A reservoir-operations strategy that better informs decisions to retain or release water by integrating additional flexibility in operation policies and rules with enhanced monitoring and improved weather and hydrological forecasts.
- USACE FIRO Goal: Through use of advanced forecast and monitoring information, find a better balance between flood risk management, water supply, hydropower, recreation and other purposes **without negatively impacting any authorized purpose, ecologic benefit or dam safety.**

Concept of FIRO Space

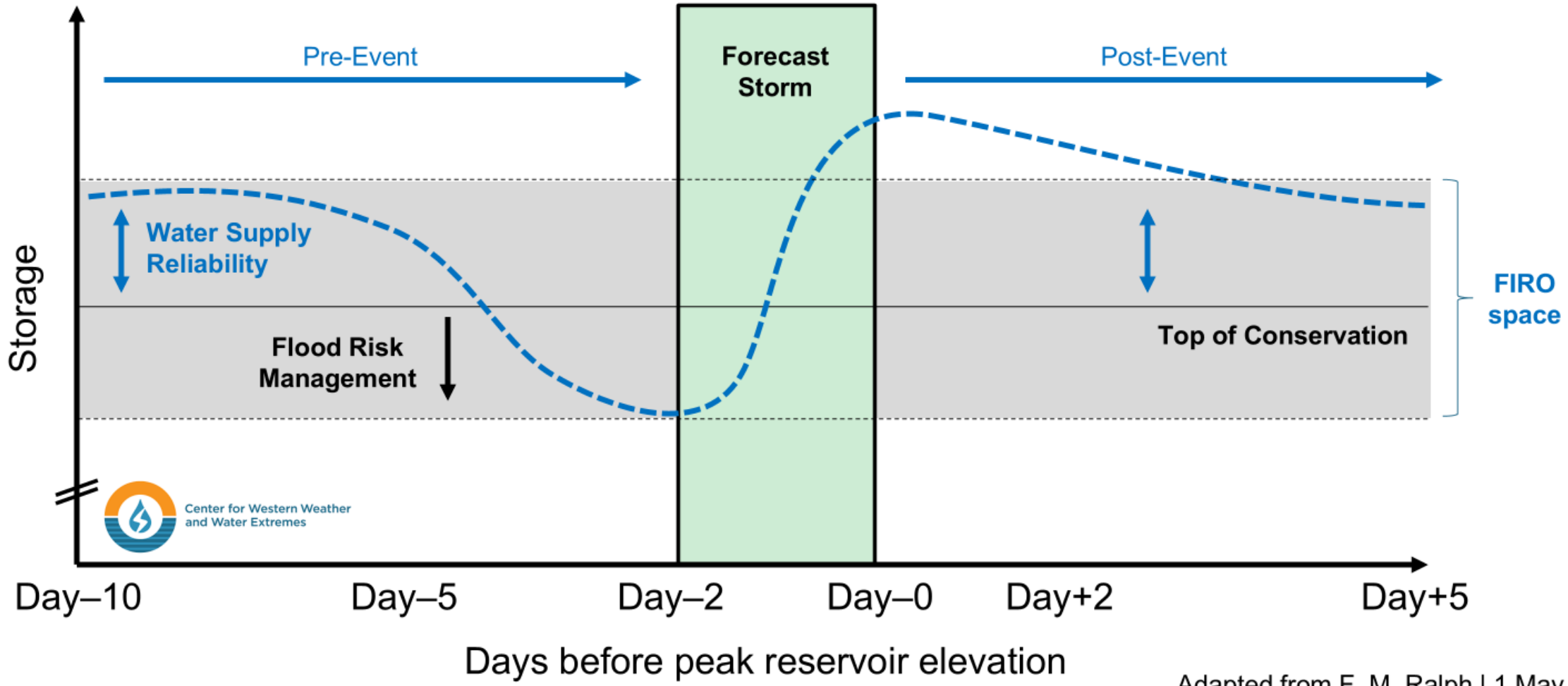


Water manager has discretion over decisions about retained or released storage in this space

Legal boundary of flood control and water supply space remains unchanged

Plot courtesy
Patrick Sing,
San Francisco District
Water Manager

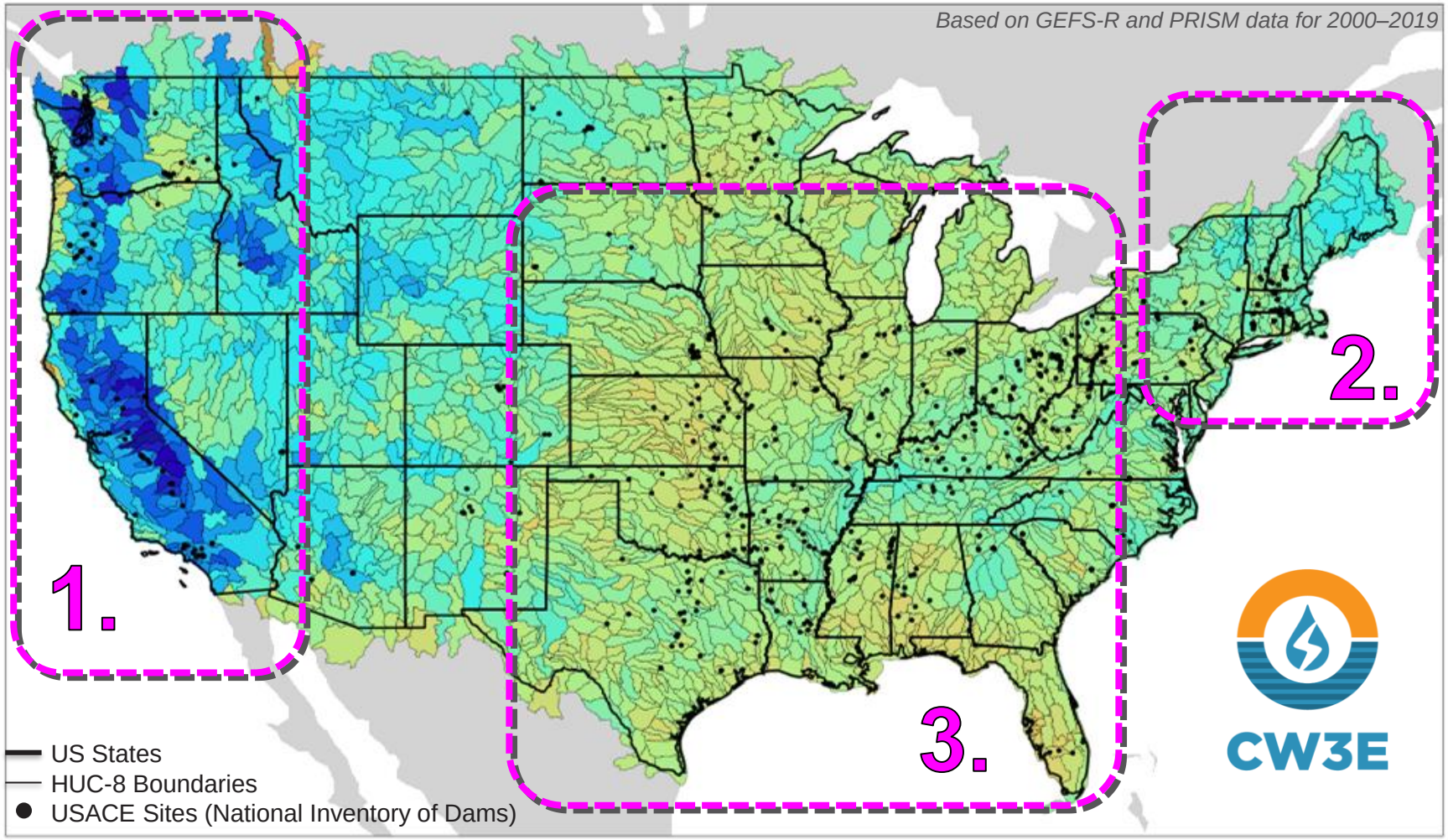
FIRO Space Gives Flexibility in Operations



Adapted from F. M. Ralph | 1 May 2024

Nationwide Forecast Skill Varies Greatly

National Precipitation Forecast Skill | Top-5% | Days 1–3



Precipitation Skill based on the "Critical Success Index" for an example lead time of Days 1–3 [F12–F84]

Low Skill — Medium Skill — High Skill

Precipitation forecast skill varies across the US:

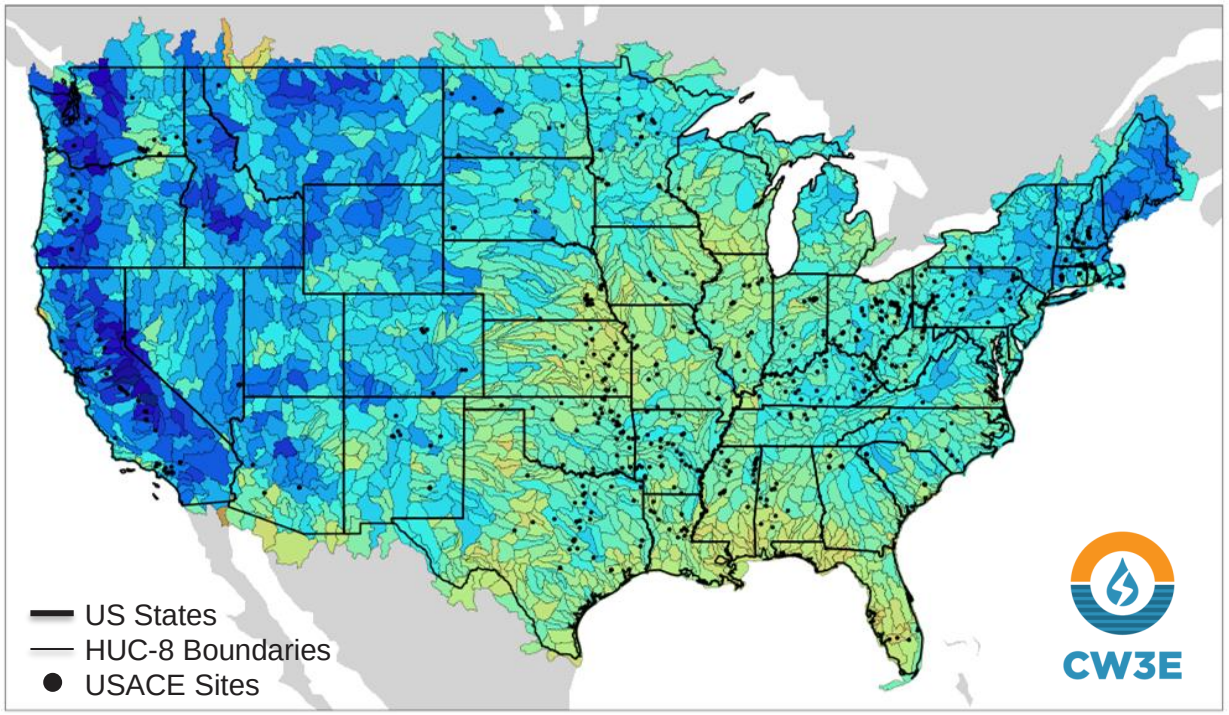
1. Highest skill over West anchored by terrain and atmospheric rivers (ARs).

2. Higher skill also over New England and Mid-Atlantic influenced by ARs and Nor'easters.

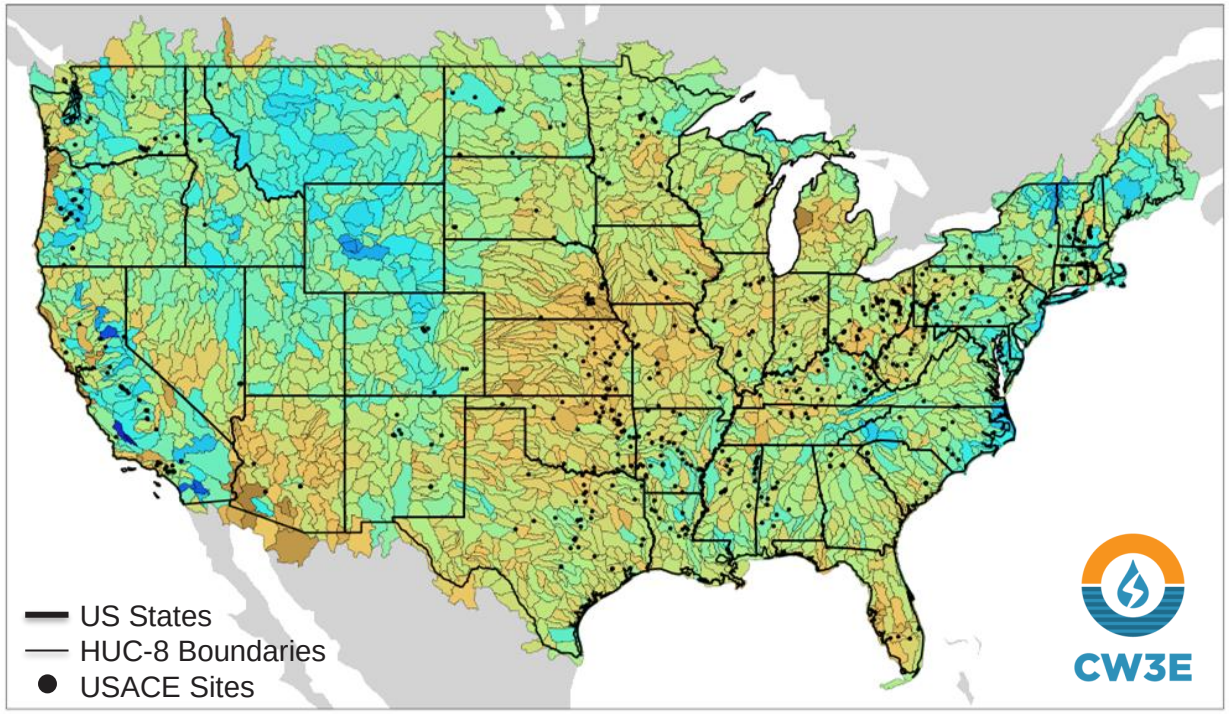
3. Lower skill over Central and Southeast influenced by convection and tropical processes (with some exceptions; e.g., along the Appalachians).

ARs Are Source of High QPF Skill

a. QPF skill for top-5% QPE days with **AR events**



b. QPF skill for top-5% QPE days with **non-AR event types**



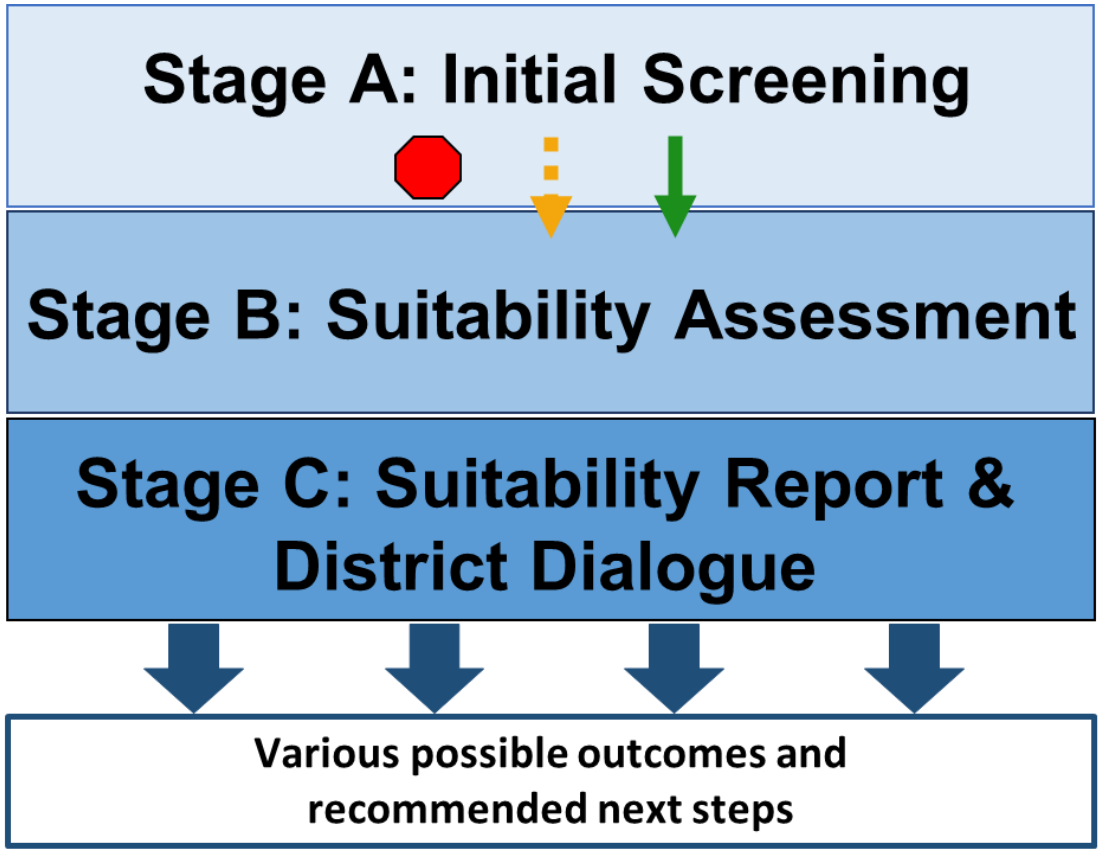
QPF skill from GEFS-R and PRISM data for 2000–2019

Day-1 [F12–F36] Critical Success Index

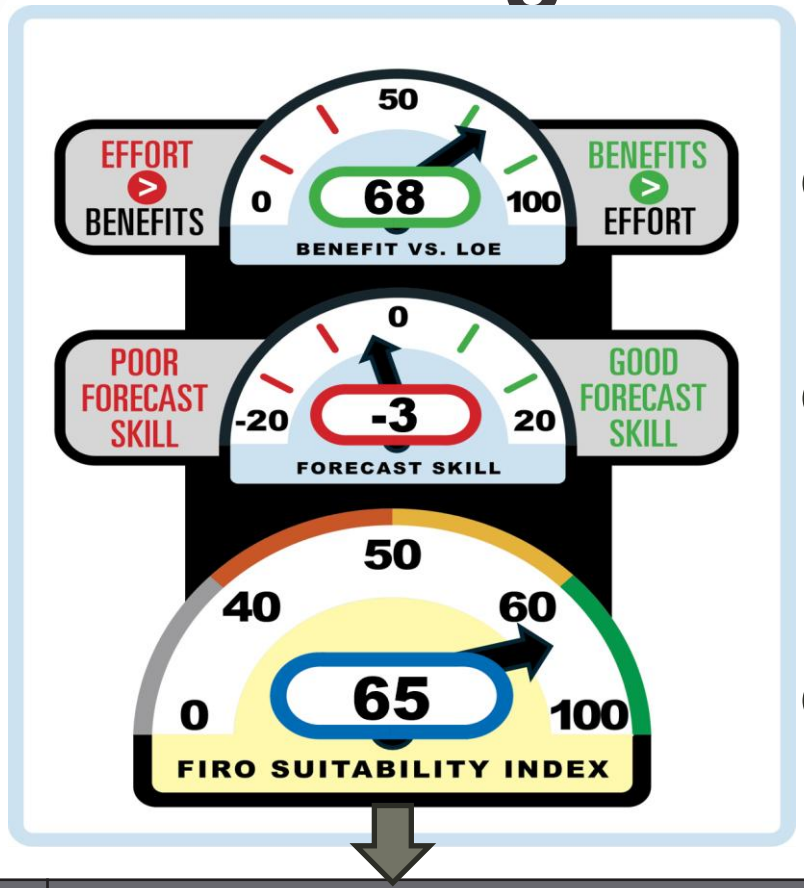
0.000 0.050 0.100 0.150 0.200 0.250 0.300 0.350 0.400 0.450 0.500 0.550 0.600 0.650 0.700 0.750

Number of watersheds with Day-1 CSI >0.33: ALL → 837 (39%), AR → 1295 (61%), Non-AR → 238 (11%)

FIRO Screening Process



Screening Process Stages B & C Output



1. The difference between the **benefit** and **effort** scores highlights whether “the juice is worth the squeeze”.

2. The **forecast skill evaluation score** is added and can increase or decrease the total score.

3. The total score is referred to as the **FIRO Suitability Index (FSI).**

4. The **FSI value** corresponds to a **recommendation** category indicating **next steps**- the outcome of Stage B.

FSI	FIRO Recommendations
60-100	Strongly consider pursuing FIRO, or continue with FIRO efforts
50-60	Consider pursuing FIRO
40-50	Make improvements before pursuing FIRO
0-100	Barriers to FIRO may be prohibitive-do not pursue until significant challenges are addressed

Why Conduct the FIRO Screening Process?

- WRDA 2024 requirements

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SEC. 1162. FORECAST-INFORMED RESERVOIR OPERATIONS.

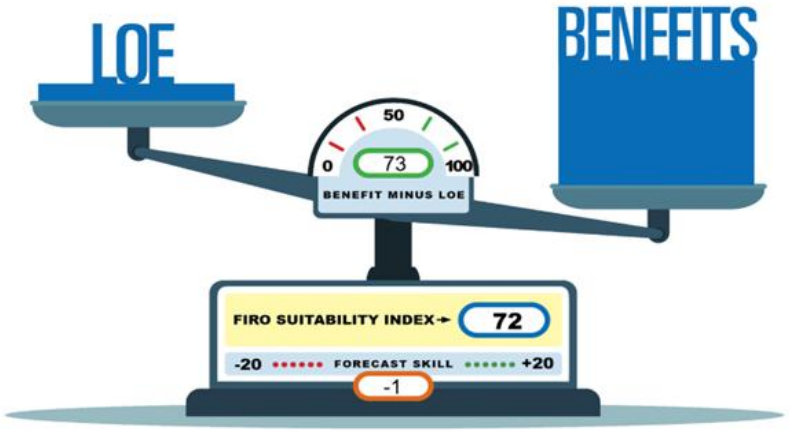
(a) IN GENERAL.—In updating a water control manual for any reservoir constructed, owned, or operated by the Secretary, including a reservoir for which the Secretary is authorized to prescribe regulations for the use of storage allocated for flood control or navigation pursuant to section 7 of the Act of December 22, 1944 (33 U.S.C. 709), the Secretary shall, to the maximum extent practicable, incorporate the use of forecast-informed reservoir operations, subject to the availability of appropriations.

(c) ASSESSMENT.—

(1) REQUIREMENT.—The Secretary shall carry out an assessment of geographically diverse reservoirs described in subsection (a) to determine the viability of using forecast-informed reservoir operations at such reservoirs.

How is the FIRO Screening Process useful?

- Prioritizing FIRO studies
- Informing FIRO Viability Assessment pathways
- Indicating where FIRO is *not* beneficial



FSI	Recommendation
60-100	Strongly consider pursuing FIRO or continue with FIRO efforts
50-60	Consider pursuing FIRO
40-50	Make improvements before pursuing FIRO
0-40	Barriers to FIRO may be prohibitive – do not pursue until challenges are addressed

NATIONAL STAGE A RESULTS*

* - Not yet final

Stage A: Initial Screening

High-level site filtering

INPUT

- Water managers' responses to 8-item site data collection instrument
- Assessment of basin forecast skill for extreme precipitation at minimum lead time

PROHIBITIVE BARRIERS

- No controlled outlet
- No Water Control Plan
- Insufficient forecast skill

Ineligible for Stage B

SIGNIFICANT BARRIERS

- Legal or technical barriers
- Stakeholder engagement barriers
- Indefinite forecast skill

Low Priority for Stage B

PARKED SITES

Not assessed further unless barriers are addressed

STANDARD BARRIERS

No prohibitive or significant barriers identified in Stage A

High Priority for Stage B

STAGE A → STAGE B

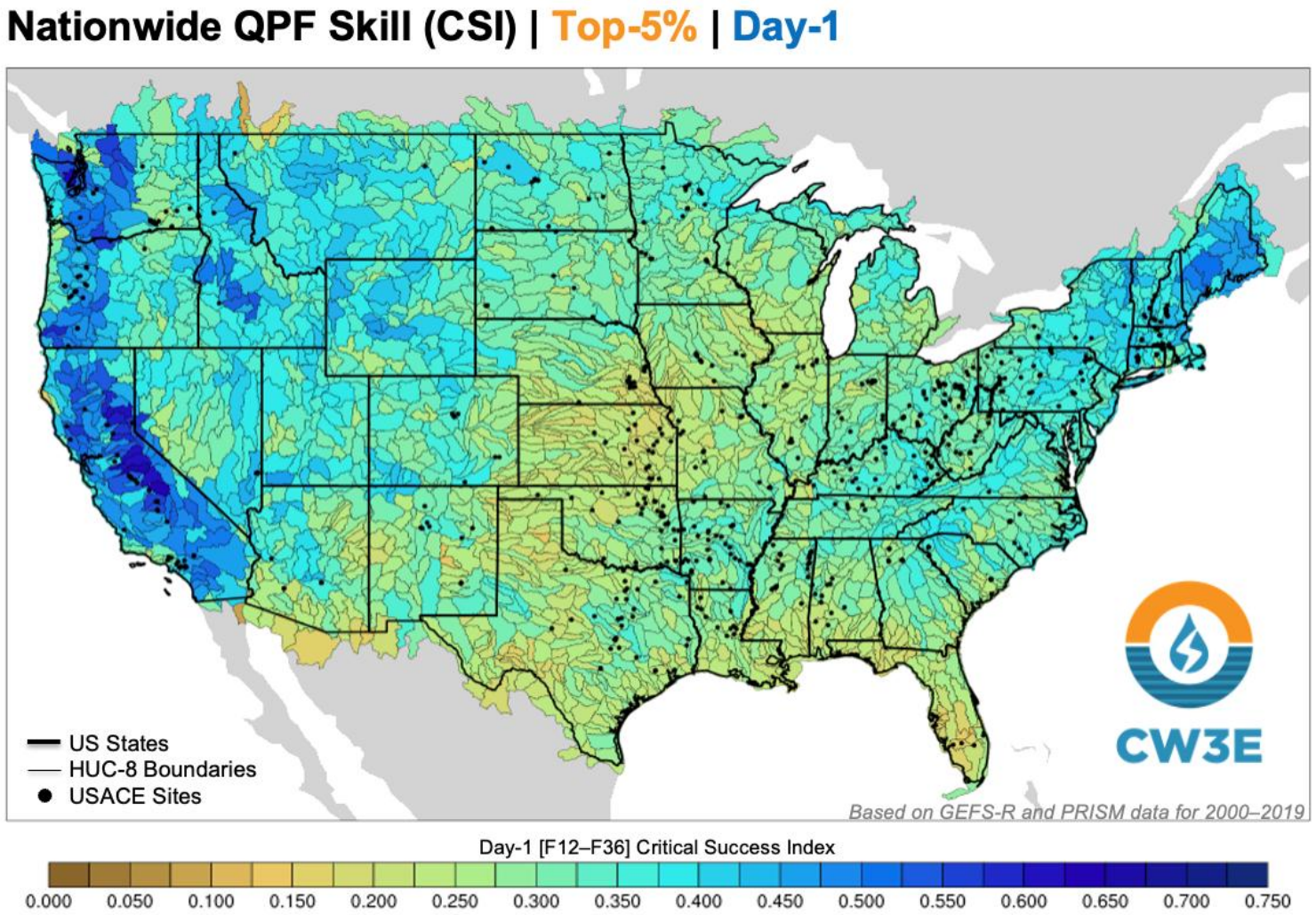
	Green Sites (standard barriers)	**Yellow Sites** (significant barriers)	**Red Sites** (prohibitive barriers)
What does this mean for Stage B?	Strong Stage B candidate	Potential Stage B candidate ?	Ineligible for Stage B ⊗
What happens next?	Moves to Stage B.	Deprioritized for further consideration but can move to Stage B upon request.	Eliminated from consideration for FIRO.

INCORPORATING FORECAST SKILL INTO STAGE A

2-Part Test

Precipitation Forecast Skill (CW3E)

Sufficient inflow forecasts for operational decisions (Districts)



Slide courtesy Jay Cordeira, CW3E

STAGE A FORECAST SKILL

In Stage A, forecast skill is estimated in two ways:

1. Calculation of the **Critical Success Index (CSI)**, which uses historical ***precipitation*** **forecasts** for a reservoir's contributing basin to evaluate skill in predicting extreme events. A CSI of 0.33 or above is considered skillful for this evaluation.

2. Site water manager response to the question, "Do you have sufficiently accurate **inflow forecasts** for which you can make reservoir operations decisions?"

FORECAST SKILL IN STAGES A & B

In Stage A, forecast skill is estimated in two ways:

1. Calculation of the **Critical Success Index (CSI)**, which uses historical ***precipitation*** **forecasts** for a reservoir's contributing basin to evaluate skill in predicting extreme events. A CSI of 0.33 or above is considered skillful for this evaluation.

2. Site water manager response to the question, "Do you have sufficiently accurate **inflow forecasts** for which you can make reservoir operations decisions?"

The Stage B precipitation forecast skill evaluation is more in-depth and considers:

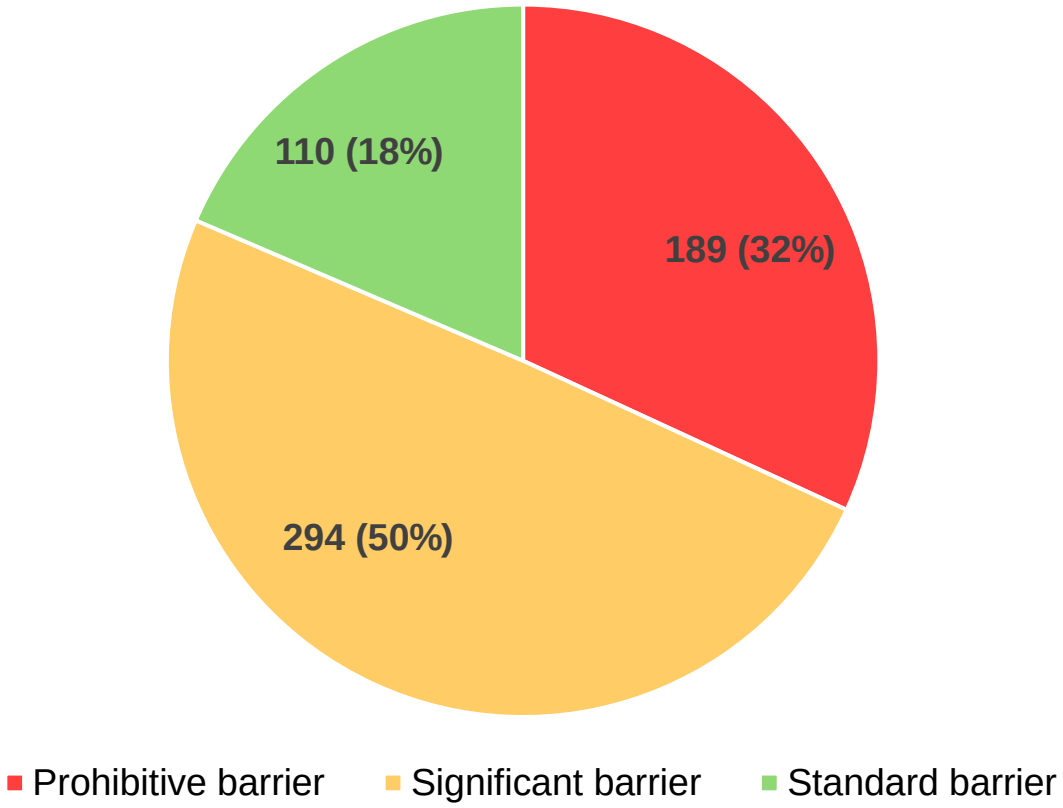
1. Forecast lead time of extreme events (CSI),
2. Dry period forecast accuracy (dry forecast failure ratio),
3. Flood risk from un-forecasted inflow (error tolerance).

NATIONAL STAGE A RESULTS

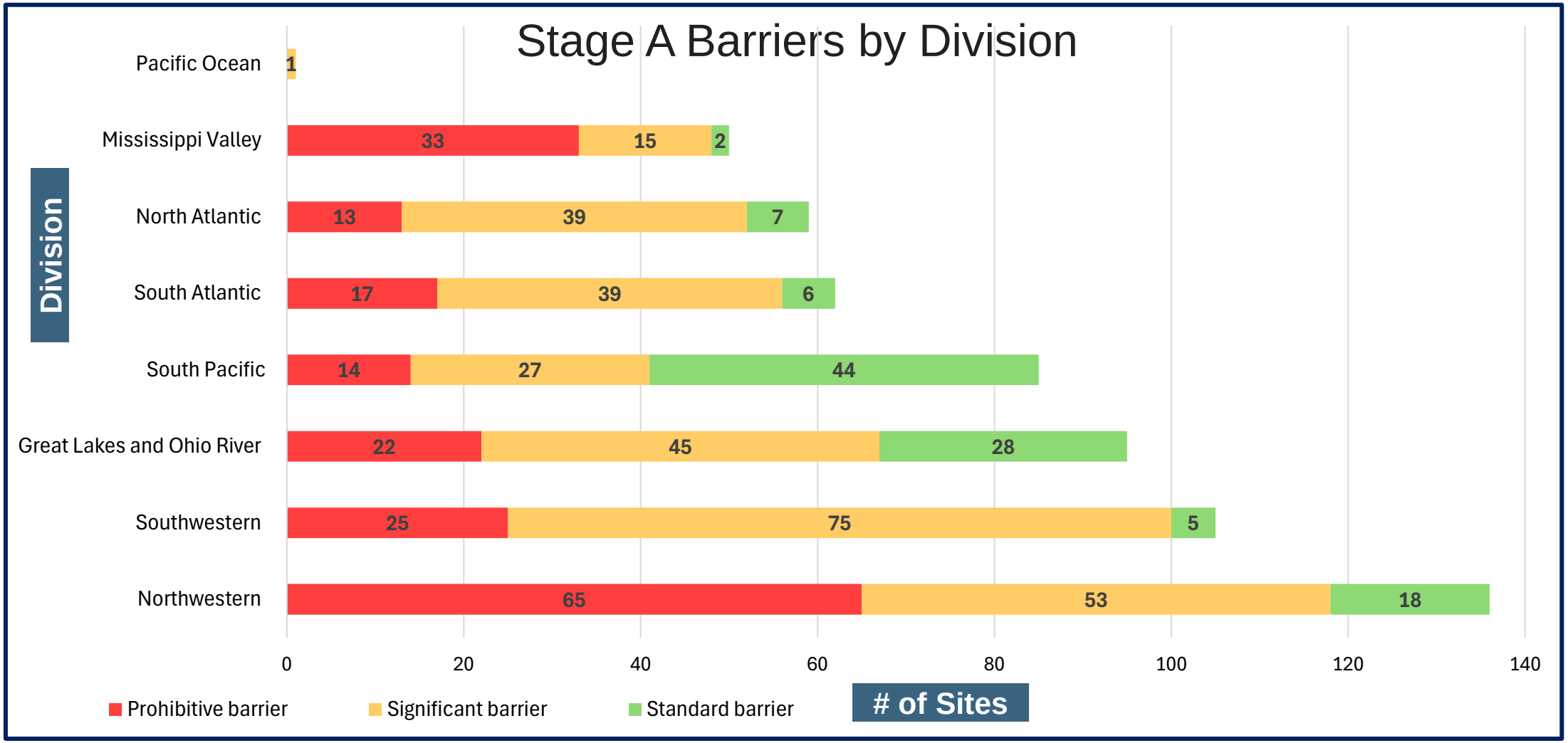
Ongoing District reviews may alter these findings slightly

The South Pacific Division (SPD) underwent Stage A before the national rollout. SPD's evaluation had methodological differences than the national Stage A rollout (e.g., forecast skill evaluations were not included for SPD).

Stage A Barrier Distribution **(All Districts)**



CURRENT STAGE A RESULTS BY DIVISION



What type of information is solicited in Stage B?

Potential Benefit	
Perceived Need	The perceived need for additional flexibility in reservoir operations to meet the site objectives
Environmental	Environmental functions that could be improved through changes to reservoir operations

Level of Effort	
Hydraulics & Operations	Hydrologic, hydraulic, and reservoir operations characteristics that indicate suitability for FIRO
Collaboration	The likelihood that collaboration will be possible and successful
Environmental	Environmental factors that may complicate FIRO implementation

EXAMPLE STAGE B QUESTION (PERCEIVED NEED)

6. Are there aspects of the project's operations that could be changed to improve performance? ***Select from the response options provided.*** *In the "examples" section, provide a brief example of how project operations could be changed to optimize performance. If there are no examples, please provide context.*

- ◯ No
- ◯ Probably not
- ◯ Probably
- ◯ Very probably
- ◯ Yes, definitely

Examples

EXAMPLE STAGE B QUESTION (HYDRAULICS & OPERATIONS)

16. How frequently do you use short-term forecasts for context in operational decision-making? ***Select from the response options provided.*** *In the "additional information" section, describe how you use these forecasts and the source of these forecasts (e.g., NOAA River Forecast Center).*

- ◯ Rarely or never use short-term forecasts for context in operational decision-making
- ◯ Infrequently use short-term forecasts for context in operational decision-making
- ◯ Sometimes use short-term forecasts for context in operational decision-making
- ◯ Frequently use short-term forecasts for context in operational decision-making
- ◯ Always use short-term forecasts for context in operational decision-making

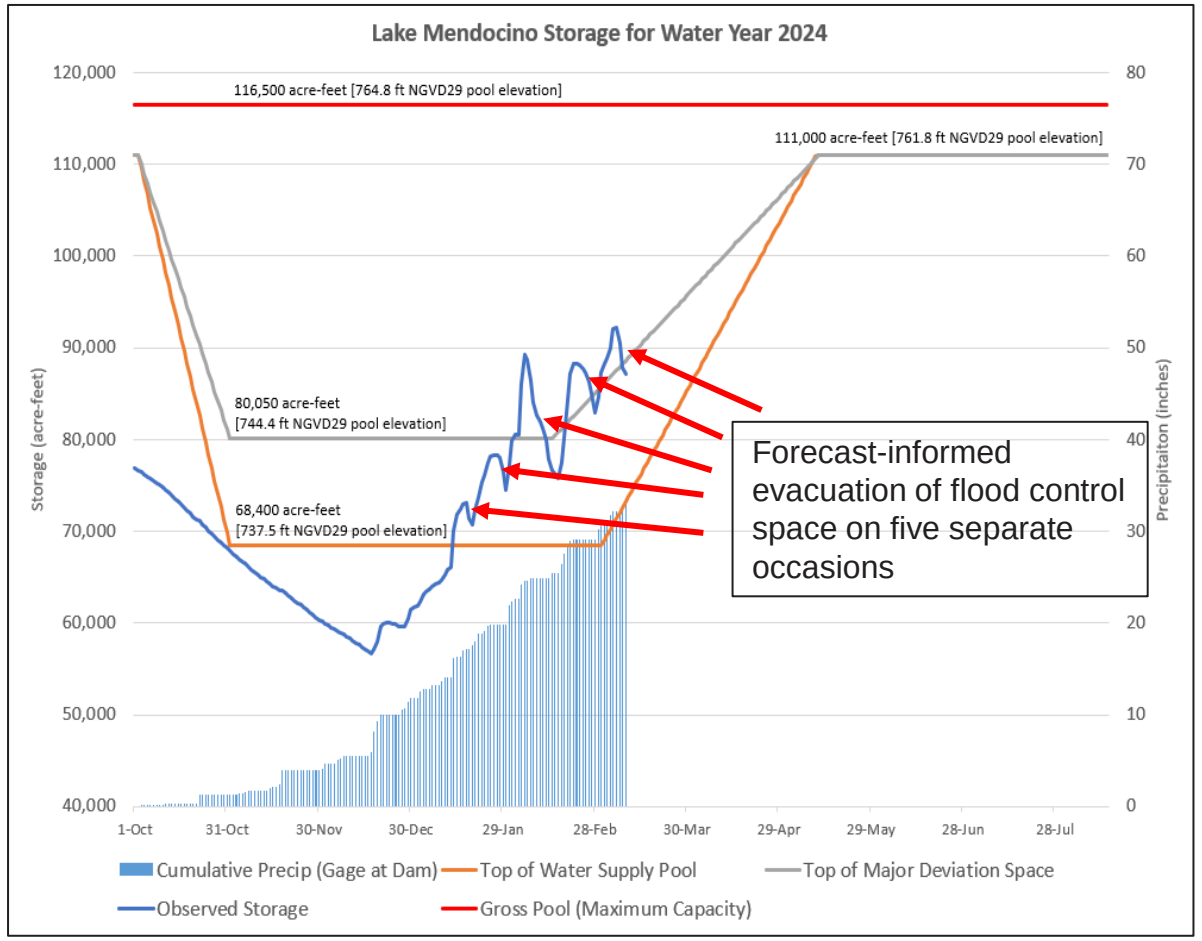
Additional Information

Screening Process Next Steps

- Finalize Stage A results and elimination of dams with prohibitive barriers (May 2025)
- Complete Stages B & C Beta Test with remainder of South Pacific Division dams (Jun 2025)
- Roll out Stage B of Screening Process with all dams having Standard Barrier classification from Stage A and adjust for regional variances (May – Aug 2025)
- Engage Districts for Stage C discussions (Sep – Oct 2025)
- Conduct Stages B & C for selected Significant Barrier classification dams (late 2025-2027)

Value of FIRO in Practice in USACE

- FIRO currently being piloted/implemented at:
  - CA: 6 dams
  - WA: 1 dam
  - OR: 14 dams
- Pilot site annual water availability increases
  - Lakes Mendocino & Sonoma (No. CA)
    - 2020: 22,000 homes (~$11M)
    - 2023: 48,000 homes (~$24M)
    - 2024: 58,000 homes (~$29M)
    - 2025: 50,000 homes (~$25M)
  - Prado Dam (So. CA)
    - 2024: 12,200 homes (~$6.1M)
  - Total: 190,200 homes, $95.1M
  - Total FIRO R&D Investment through FY25: $74M



Plot courtesy Patrick Sing,
San Francisco District Water Manager

Why FIRO in USACE?

- Provide USACE Water Managers with flexibility to operate using improved forecasts and watershed observations
- Achieve better balance between competing authorized purposes of USACE reservoirs
- Updated Water Control Manuals that codify the flexibility provided by FIRO scenarios, a paradigm shift for USACE Water Management
- Improved efficiency, resilience and climate adaptation of USACE Flood Risk Management infrastructure without costly structural changes
- ***FIRO viability across the USACE is driven by forecast skill***
- ***More forecast lead time -> greater flexibility in operations***

Thank you!

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