

Forecast Informed Reservoir Operations (FIRO) Within the US Army Corps of Engineers: Nationwide Screening Process

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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



USACE FIRO Requirements



WRDA 2024:

145

1 **SEC. 1162. FORECAST-INFORMED RESERVOIR OPERATIONS.**

2 (a) IN GENERAL.—In updating a water control man-
3 ual for any reservoir constructed, owned, or operated by
4 the Secretary, including a reservoir for which the Sec-
5 retary is authorized to prescribe regulations for the use
6 of storage allocated for flood control or navigation pursu-
7 ant to section 7 of the Act of December 22, 1944 (33
8 U.S.C. 709), the Secretary shall, to the maximum extent
9 practicable, incorporate the use of forecast-informed res-
10 ervoir operations, subject to the availability of appropria-
11 tions.

18 (c) ASSESSMENT.—

19 (1) REQUIREMENT.—The Secretary shall carry
20 out an assessment of geographically diverse res-
21 ervoirs described in subsection (a) to determine the
22 viability of using forecast-informed reservoir oper-
23 ations at such reservoirs.

House Water & Env. Subcom. Hearing – 10 Sep 2025
ASA(CW) Mr. Telle: “We can make the pie bigger, in terms of water supply [...], if we’re willing to do what it takes to optimize the use of the reservoirs [...] in the form of water control manuals using FIRO.”
LTG Graham: “We want to deploy [FIRO] throughout the country [...] wringing every ounce of value we can from these facilities. If this different way of looking at managing water is applicable, we absolutely want to apply it.”



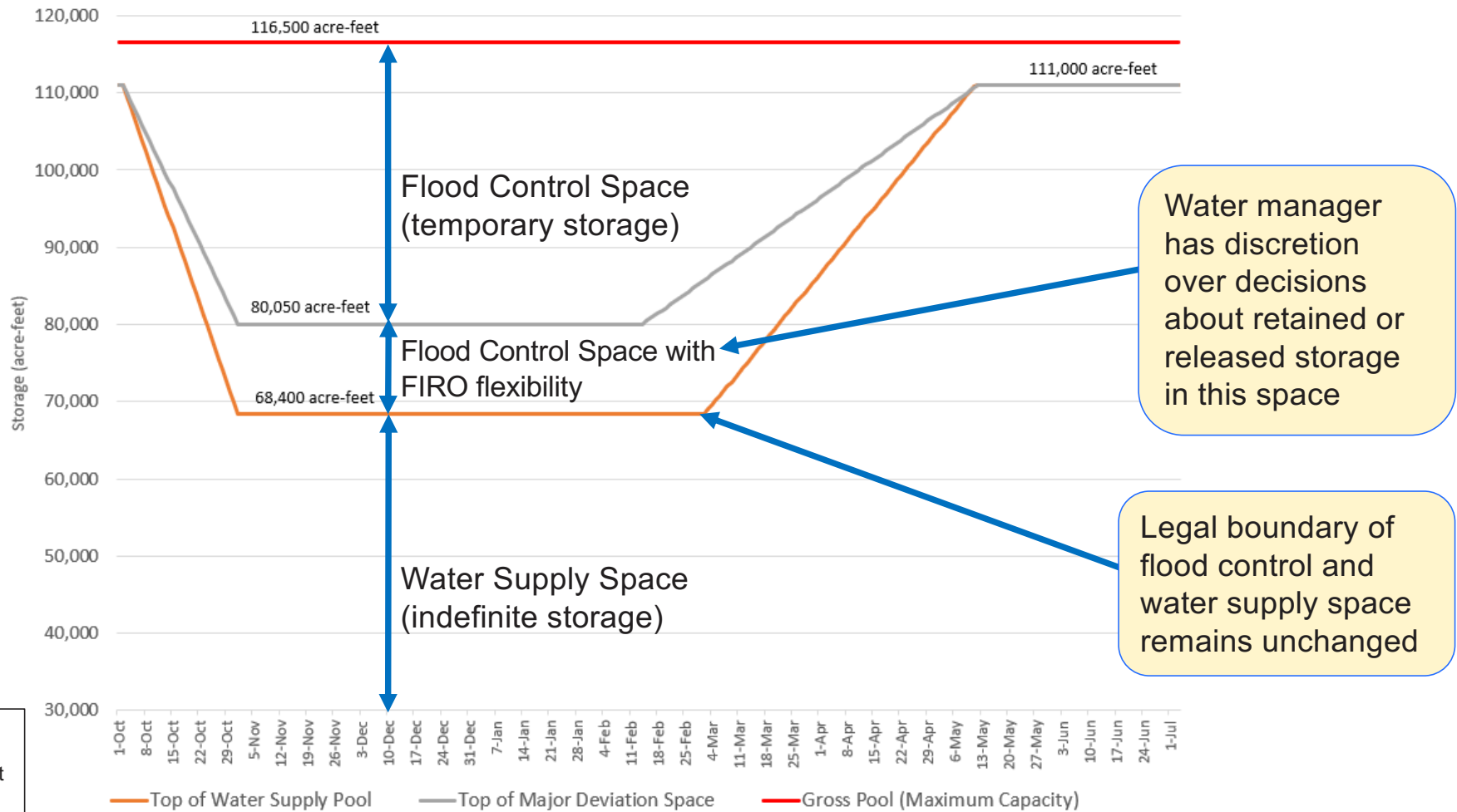
Forecast Informed Reservoir Operations (FIRO) Definition and Goal



- 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.**



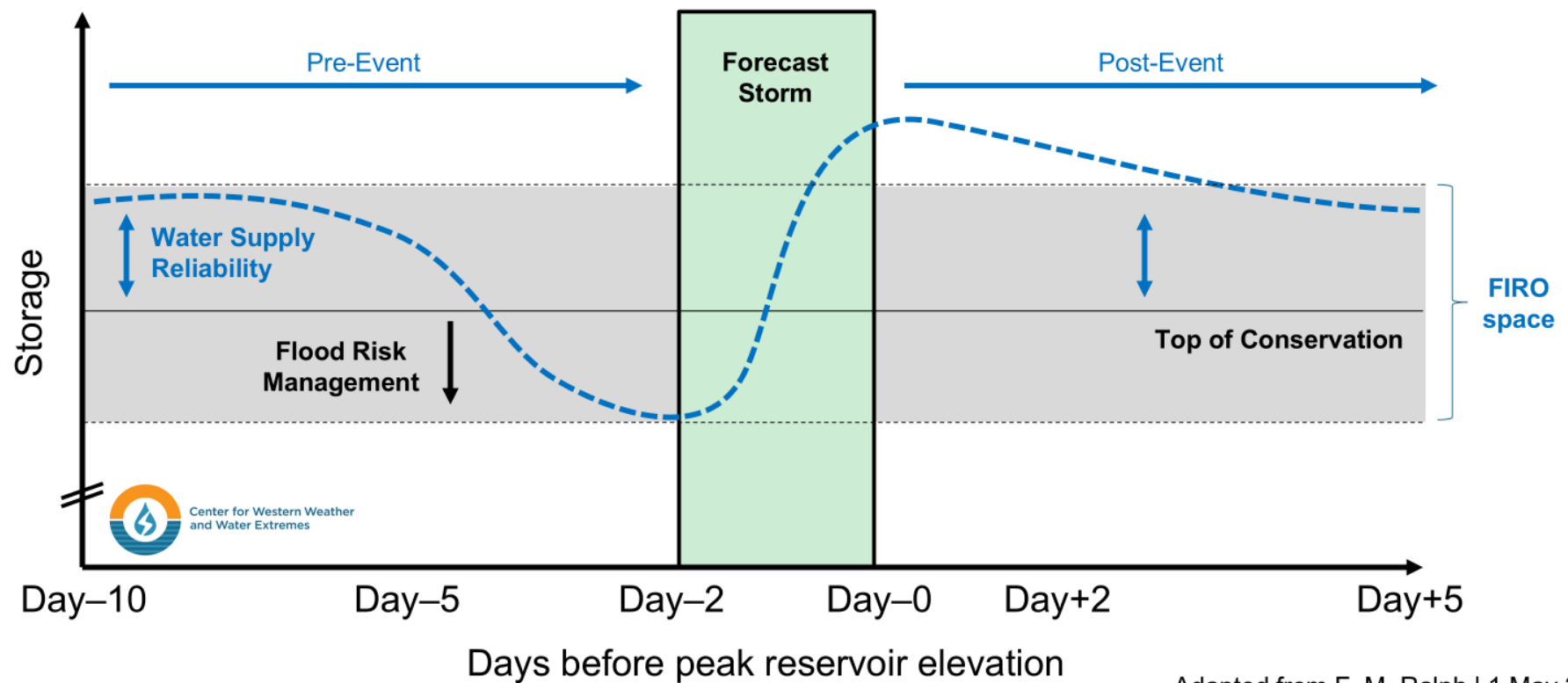
Concept of FIRO Space



Plot courtesy
Patrick Sing,
San Francisco District
Water Manager



FIRO Space Gives Flexibility in Operations



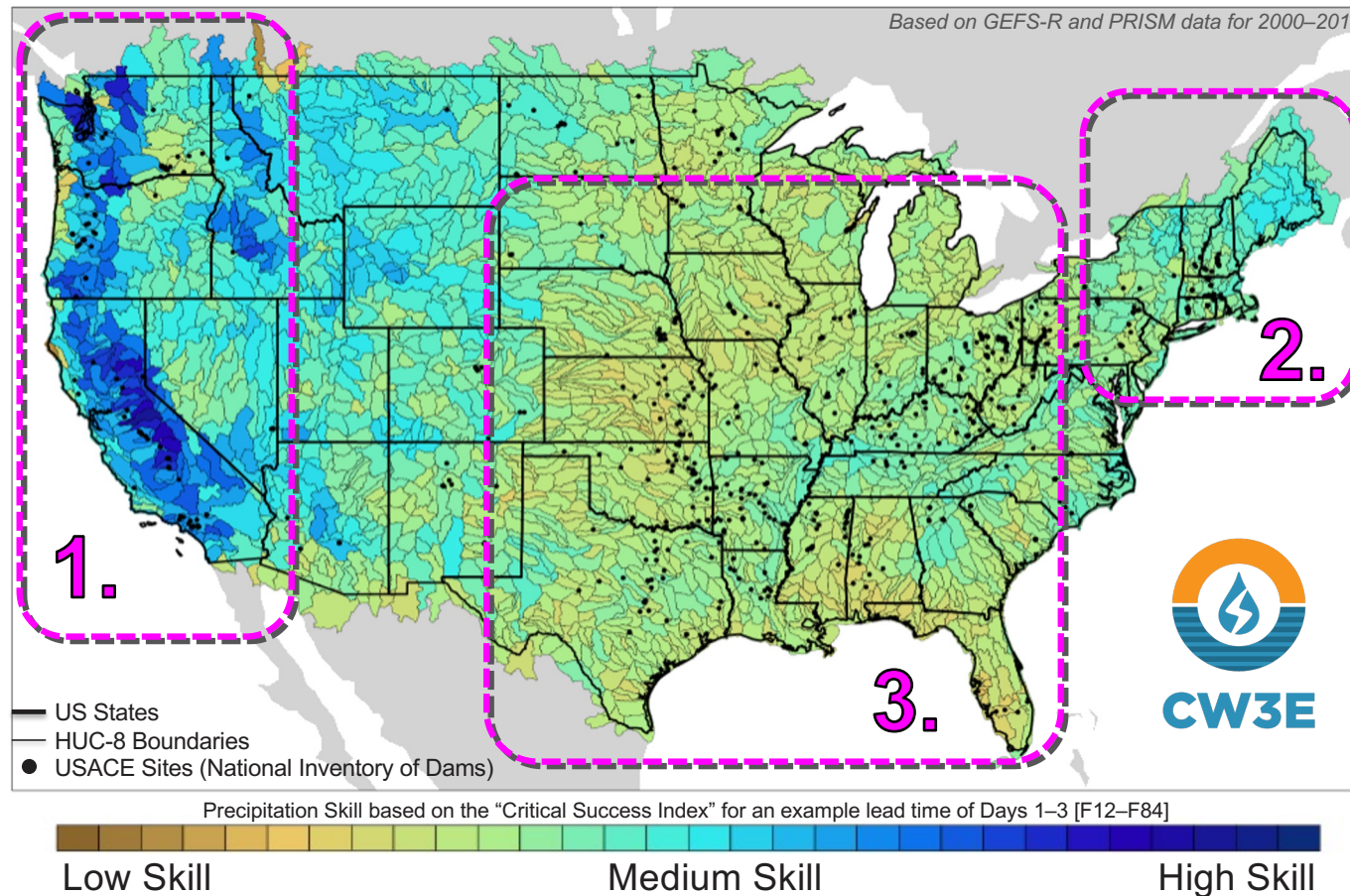
Adapted from F. M. Ralph | 1 May 2024



Nationwide Forecast Skill Varies Greatly



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

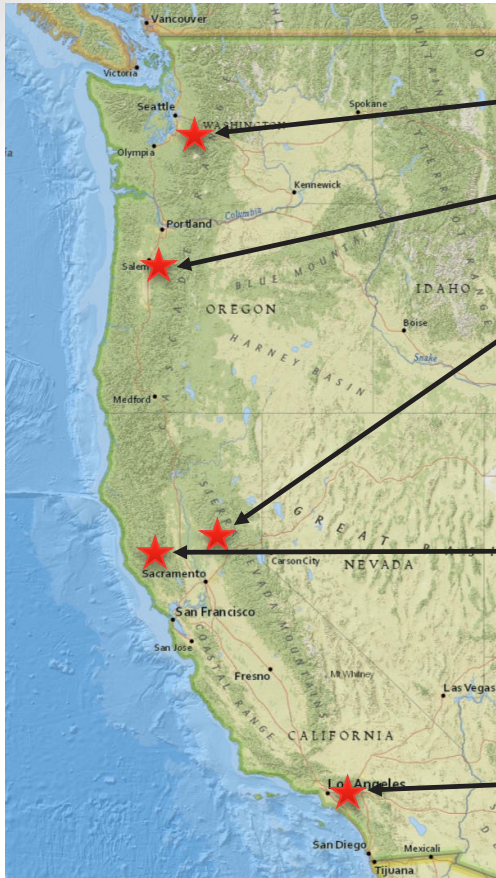


Precipitation forecast skill varies across the US:

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).



FIRO Pilot Sites



Howard Hanson Dam

Green River, Seattle District USACE

Willamette Valley (13 Dams)

Willamette River, Portland District USACE



New Bullards Bar Dam

Yuba River, Yuba Water Agency

FVA Complete

Oroville Dam

Feather River, CA Dept. of Water Resources
Sacramento District, USACE

FVA Complete



Lake Mendocino

FVA Complete

Lake Sonoma

Russian River, San Francisco District USACE



Prado Dam

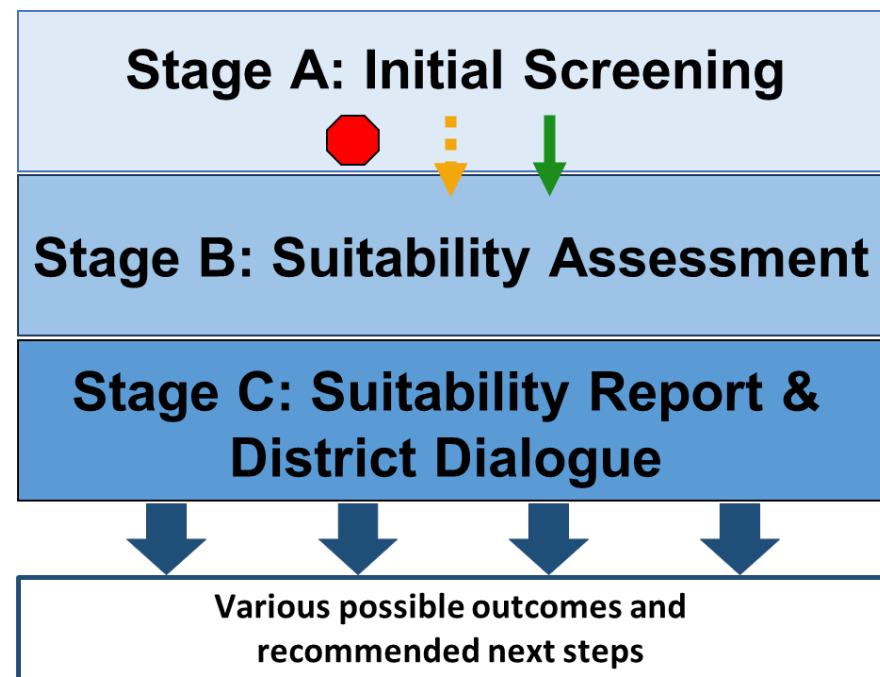
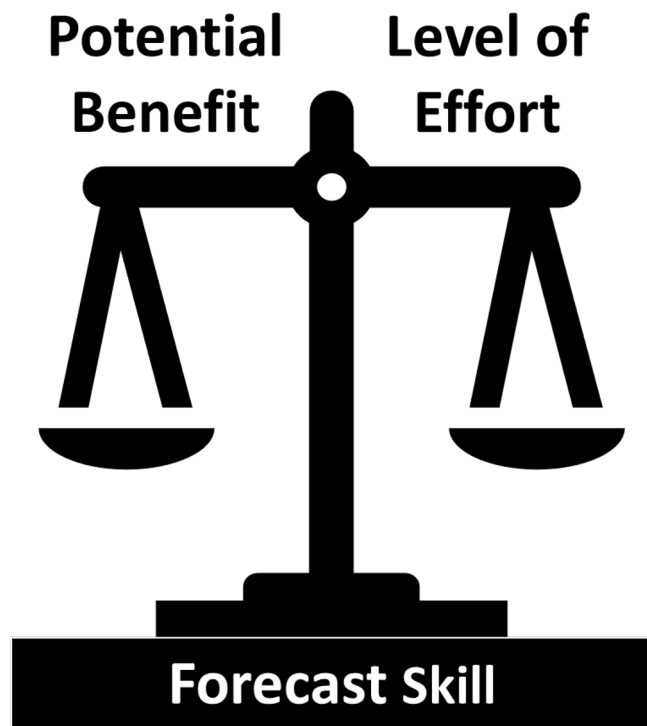
FVA Complete

Seven Oaks Dam

Santa Ana River, Los Angeles District USACE,
San Bernardino County Flood Control District



FIRO Screening Process



Stage A: Initial Screening

High-level site filtering

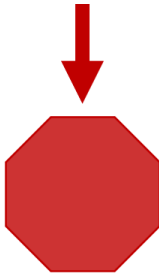
INPUT

- 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



What type of information is solicited in Stage B?



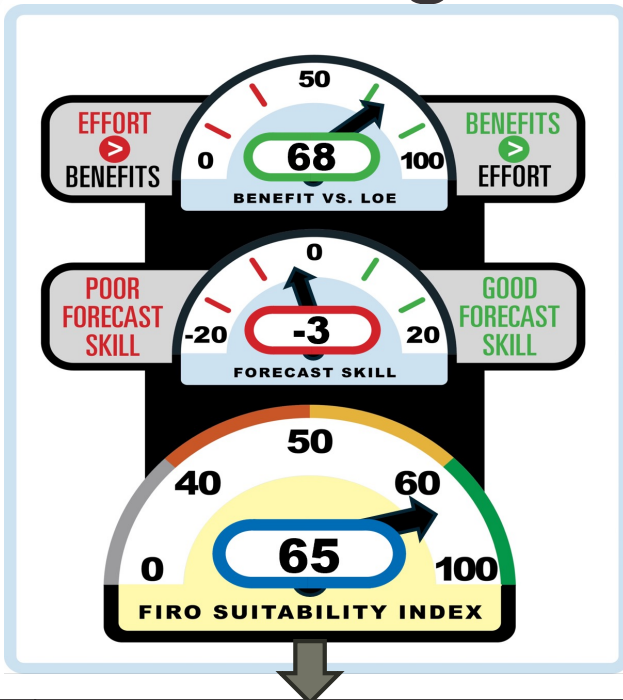
Potential Benefit	
Perceived Need	The perceived need for additional flexibility in reservoir operations to meet the site objectives
Environmental	Environmental functions that could be improved through changes to reservoir operations

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





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**.

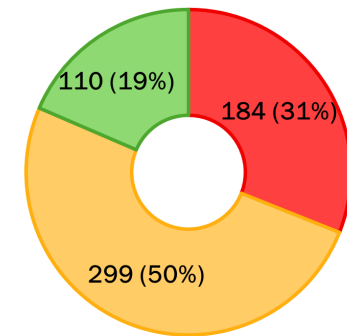
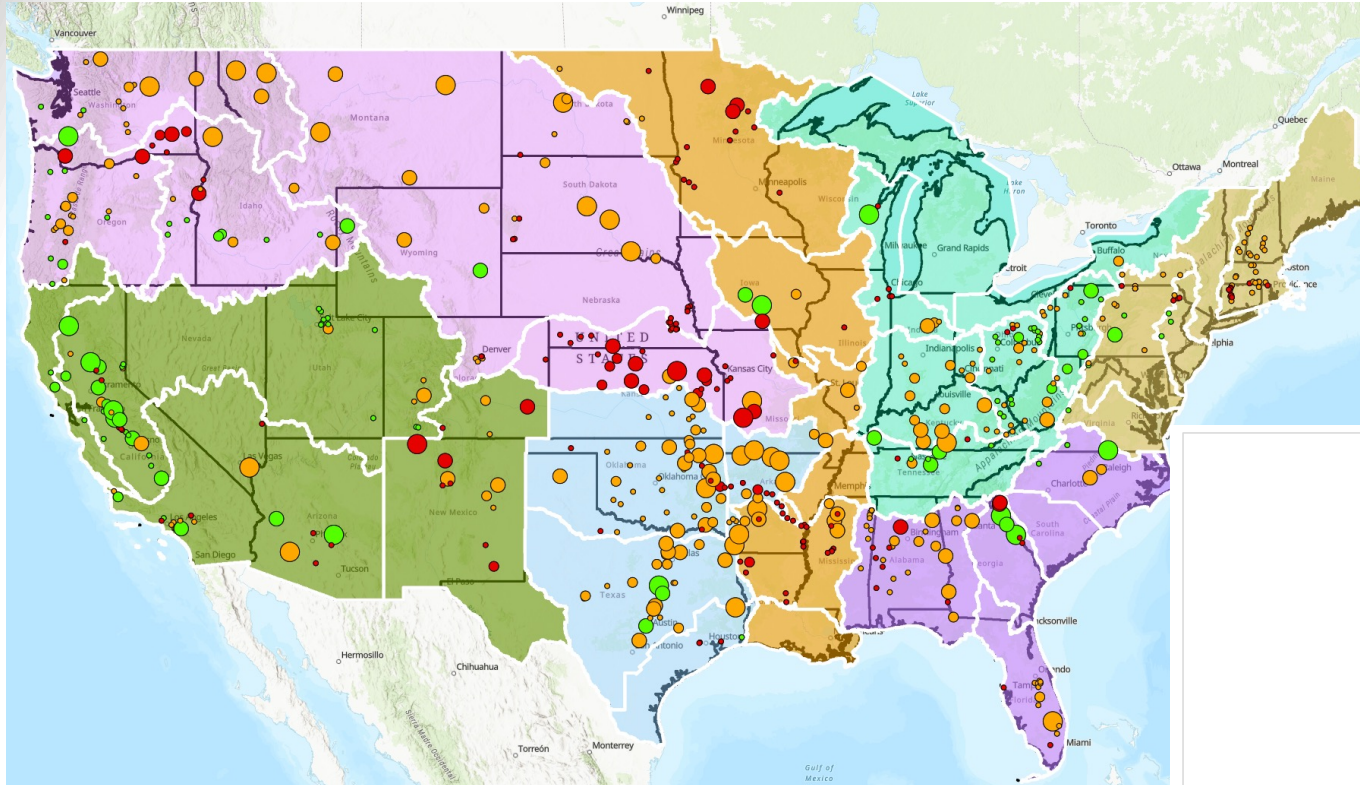
FSI	FIRO Recommendations
60-100	Strongly consider pursuing FIRO, or continue with FIRO efforts
50-60	Consider pursuing FIRO
40-50	Make improvements before pursuing FIRO
0-100	Barriers to FIRO may be prohibitive-do not pursue until significant challenges are addressed



NATIONAL STAGE A RESULTS



NATIONAL STAGE A RESULTS

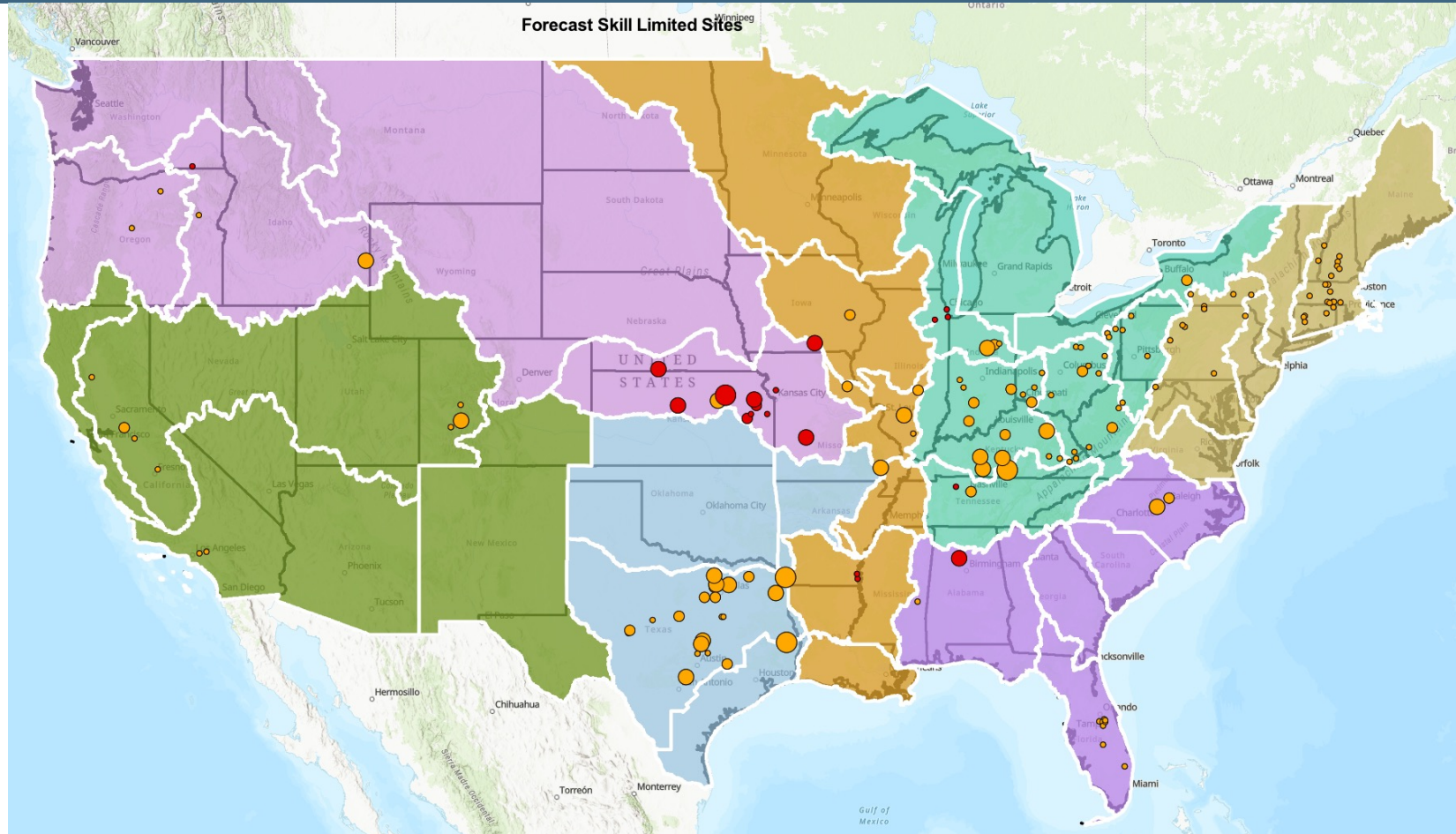


■ Prohibitive Barrier ■ Significant Barrier ■ Standard Barrier

Stage A National Results



FORECAST SKILL LIMITED SITES





STAGE A RESULTS STORYMAP





Screening Process Next Steps



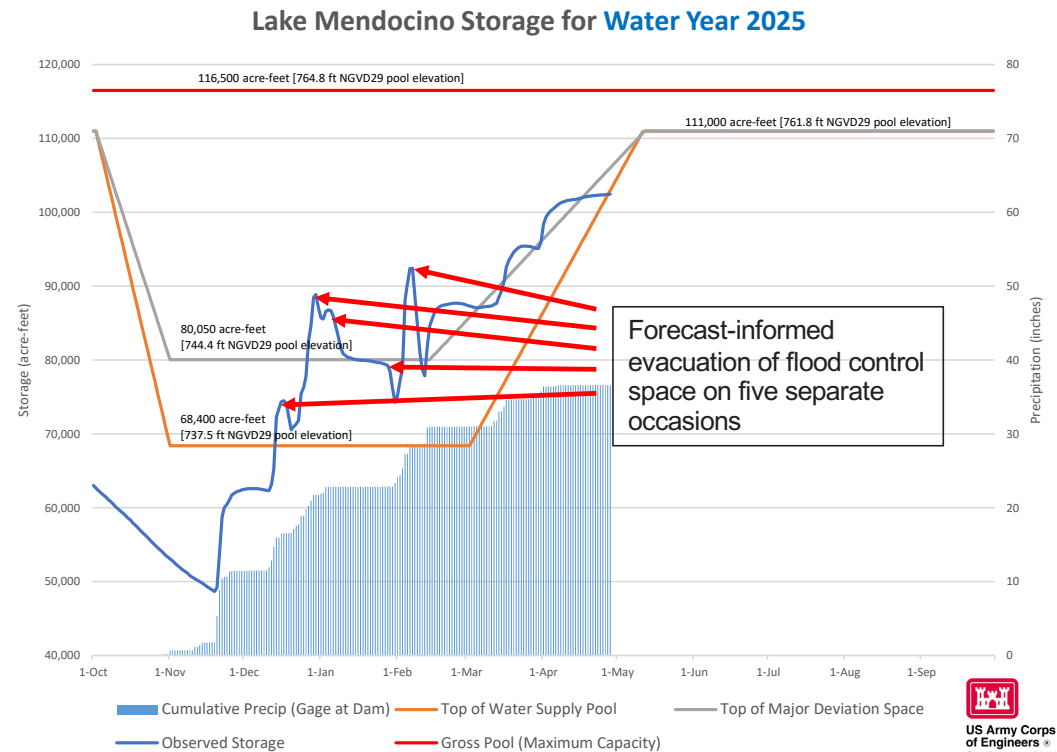
- Stage A Results Report: Oct 2025
- Complete Stage C with remainder of Sacramento District dams (Oct-Dec 2025)
- Roll out Stage B of Screening Process for all **Standard Barrier** and selected **Significant Barrier** classification dams from Stage A
 - Ongoing for Northwestern & South Atlantic Divisions
 - Southwestern, Mississippi Valley, North Atlantic and Lakes and Rivers in 2026



Value of FIRO in Practice in USACE



- FIRO currently being piloted/implemented at:
 - CA: 6 dams
 - WA: 1 dam
 - OR: 13 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



FIRO in USACE Benefits

- 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
- Improved efficiency, resilience and 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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Backup Slides

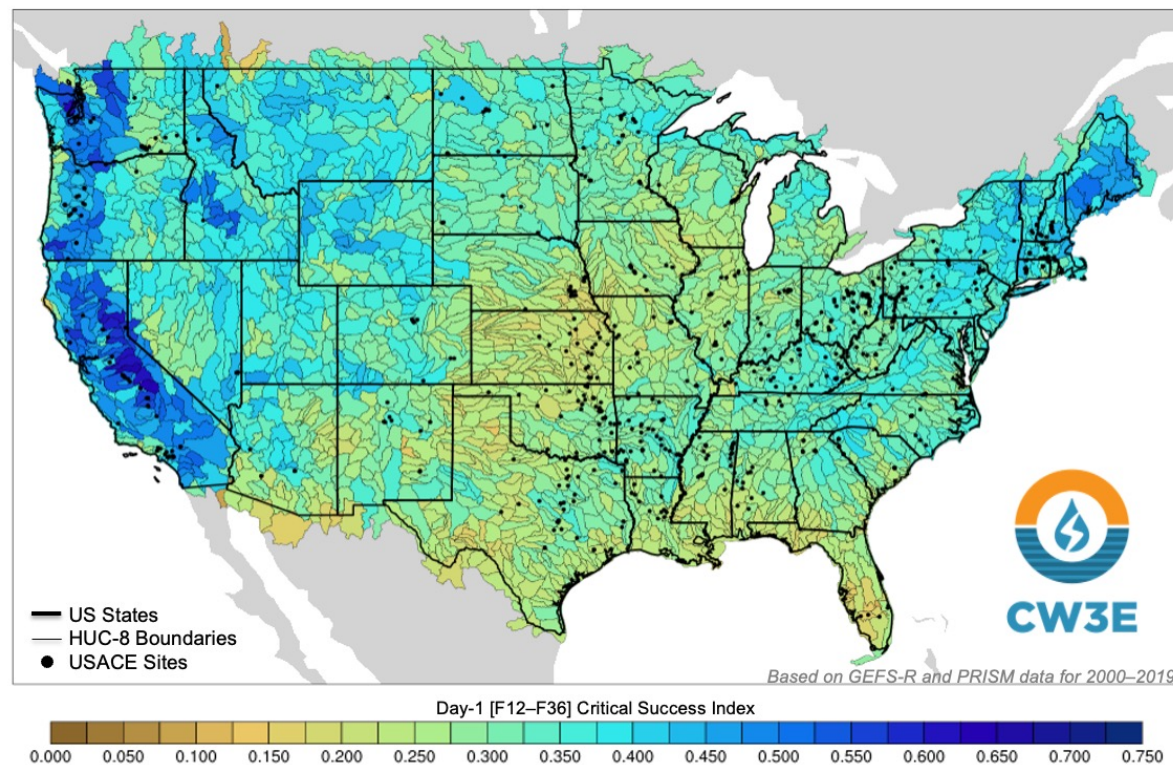
INCORPORATING FORECAST SKILL INTO STAGE A

2-Part Test

Precipitation
Forecast Skill
(CW3E) – CSI
skill ≥ 0.33

Sufficient inflow
forecasts for
operational
decisions
(Districts)

Nationwide QPF Skill (CSI) | Top-5% | Day-1



Slide courtesy
Jay Cordeira,
CW3E



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).