Center for Western Weather and Water Extremes

UC San Diego | Scripps Institution of Oceanography

US Army Corps of Engineers

# Forecast Informed Reservoir Operations: A Collaborative Process

**This document provides an overview of the collaborative interagency process that is central to Forecast Informed Reservoir Operations (FIRO) projects. It reflects the FIRO experience of the Center for Western Weather and Water Extremes (CW3E), Scripps Institution of Oceanography, UC San Diego, California Department of Water Resources (DWR), the U.S. Army Corps of Engineers (USACE), and local partners.**

## What is Forecast Informed Reservoir Operations and Why Does it Matter?

California has the most variable precipitation in the country, driven by the presence or absence of atmospheric rivers (ARs) (Figure 1). ARs provide half of the state's annual precipitation but also cause more than 90 percent of its floods. Climate projections indicate that ARs will become more extreme, with longer droughts, punctuated by stronger and wetter ARs.

Water managers are pursuing FIRO to build resilience to climate extremes. While traditional reservoir management decisions rely on historical weather patterns and "water on the ground," FIRO uses advanced precipitation and runoff forecasts to release water in advance of a storm or, when no major storms are predicted, store more water to buffer against possible drought. Thus, FIRO increases flexibility to reduce flood risk and to improve water availability. Research to increase forecast skill can lead to greater FIRO benefits.

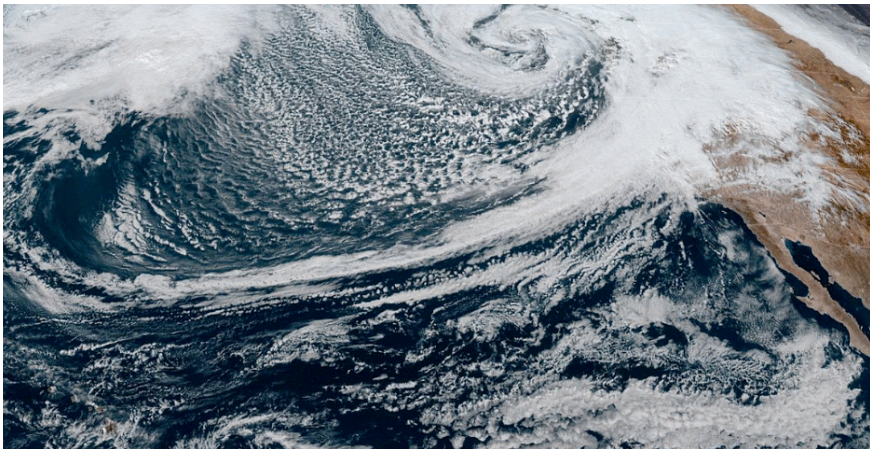

*Figure 1. Satellite image of an AR that hit California in October 2021.*

When implemented at Lake Mendocino in the Russian River watershed, FIRO operations resulted in about 20 percent more storage in 2020 to improve water supply reliability in a drought year (Figure 2). FIRO is also underway at Lake Sonoma (Russian River), Prado Dam and Seven Oaks Dam (Santa Ana watershed), Lake Oroville and New Bullards Bar (Yuba-Feather watershed), and Howard Hanson Dam (Green River watershed, Washington). A national FIRO screening process has begun to assess FIRO suitability at USACE reservoirs nationwide.

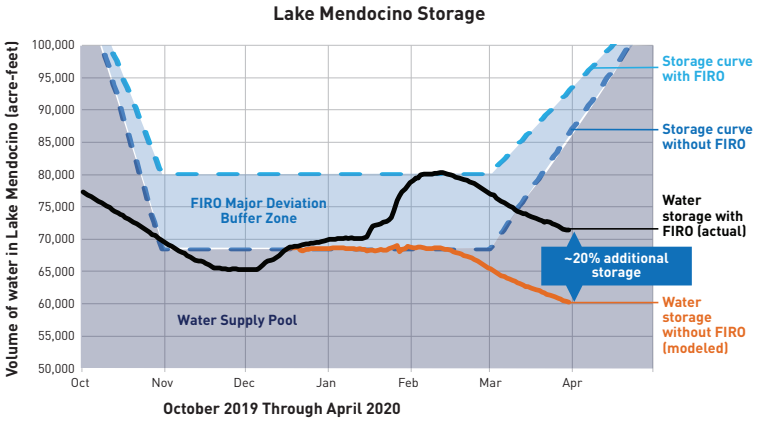


*Figure 2. FIRO operations at Lake Mendocino created 20 percent additional storage in 2020.*

**FIRO is a Research and Operations Partnership (RAOP). The "and" in RAOP indicates the reciprocity between research and operations: research informs operations and operational needs inform research direction.**

## What is the FIRO Process?

FIRO follows five main steps, which take approximately five years to complete (Figure 3).

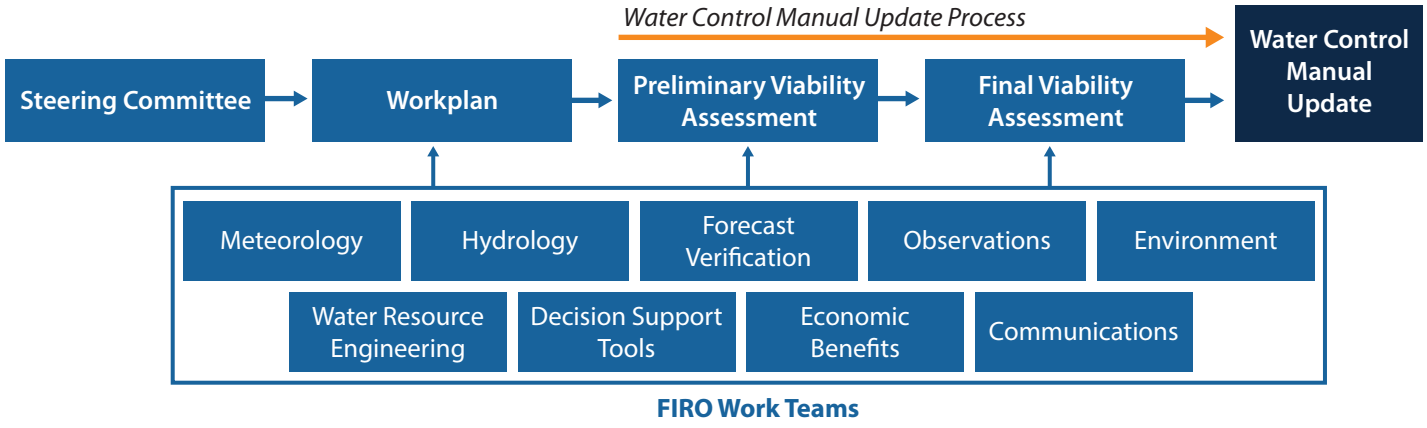


*Figure 3. Overview of the FIRO process.*

If the viability assessment demonstrates that FIRO results in better outcomes than existing operations, then the Steering Committee pursues implementation of FIRO via an update to the Water Control Manual (WCM). The WCM update can occur concurrently with the viability assessment when funding is available. Modifications to the WCM take place under the authority of USACE, informed by the Final Viability Assessment and with input from the Steering Committee.

> The Water Control Manual is a USACE document that governs reservoir management. FIRO centers on the Water Control Plan portion of the WCM, which stipulates reservoir operation such as the elevation (or storage) boundary between the water conservation and flood pools over the water year. If FIRO is found to be viable, the Steering Committee recommends changes to the Water Control Plan, such as creating a "FIRO buffer pool" within the flood pool where the reservoir operator has discretion to retain water. Other plan modifications can include release schedules to enhance aquifer recharge in accordance with the reservoir's authorized purpose.

## What is the Role of Interagency Collaboration?

The FIRO process has three levels of involvement, with some overlap in membership between the concentric rings shown in Figure 4.

### Steering Committee

Each FIRO project is led by a Steering Committee, which typically comprises nine to 12 members who represent major interests in the project. The Steering Committee includes leaders in both research and operations. The composition of the committee depends on the dam's purpose, ownership, use, and impacts, but usually includes the dam operating agency (e.g., USACE), the local partner (e.g., water supply agency), USACE Engineer Research

and Development Center, CW3E, and may include:

- An environmental representative
- Regulatory agencies
- Tribes
- Hydropower utilities
- Public works agencies
- Other federal agencies (e.g., USFWS, USGS, USBR, NOAA, National Weather Service)
- Recreational users

The Steering Committee co-chairs select members who:

- Have the authority to make decisions on behalf of their agency/organization
- Embrace a collaborative problem-solving approach
- Possess knowledge, data, insights, or other information/resources

Steering Committees, which meet quarterly, are governed by Terms of Reference that outline the mission, vision, goals, and strategies for achieving FIRO goals. The Terms of Reference also contain a FIRO objective for the project, which is later refined in the viability assessment.


*Figure 4. Levels of partner and stakeholder involvement in FIRO.*

The FIRO viability assessment, which is generated by problem solving, exploration, and creative solutions, is a product of the Steering Committee. The process is designed to build positive relationships and trust.

## Work Teams

Work teams are formed during the workplan stage and consist of staff from the Steering Committee member agencies and from stakeholders outside the Steering Committee. Work teams meet regularly, develop content for the FIRO viability assessment, and typically focus on the topics shown in Figure 3.

*Yuba-Feather Steering Committee and work team members.*

## Community Outreach and Engagement

Community engagement is different for each FIRO project, and often led by the local partner. It can include meetings with watershed or advisory groups, landowners, and schools in the watershed; newsletters; and conferences. During major storm events, webinars, social media, and broadcast meteorologists reach concerned citizens, in coordination with state emergency managers and the National Weather Service.

# Where Has FIRO Been Assessed to Date?

Interest in FIRO is growing as water managers realize the potential benefits of FIRO to support multiple goals. The table below summarizes these current FIRO projects and the associated objectives.

| FIRO Project | FIRO Objective | Interests |
|---|---|---|
| Lake Mendocino | Water availability and flood risk management | Water availability, flood risk management, fisheries (endangered salmonids), recreation |
| Lake Sonoma | Water availability and flood risk management | Water availability, flood risk management, fisheries (endangered salmonids), recreation |
| Prado Dam | Water availability | Water availability, flood risk management, bird habitat, recreation, infrastructure in the flood pool |
| Seven Oaks Dam | Water availability and endangered species management | Water availability, flood risk management, endangered species |
| New Bullards Bar and Lake Oroville | Flood risk management and water supply (secondary benefit) | Water availability, flood risk management, fisheries (endangered salmonids) |
| Howard Hanson Dam | Water availability and fisheries flows | Tribes (fisheries), water availability, flood risk management |

*Lake Oroville in October 2021 at 27 percent capacity (left) and June 2023 at 100 percent capacity (right). Photos from CA DWR.*