

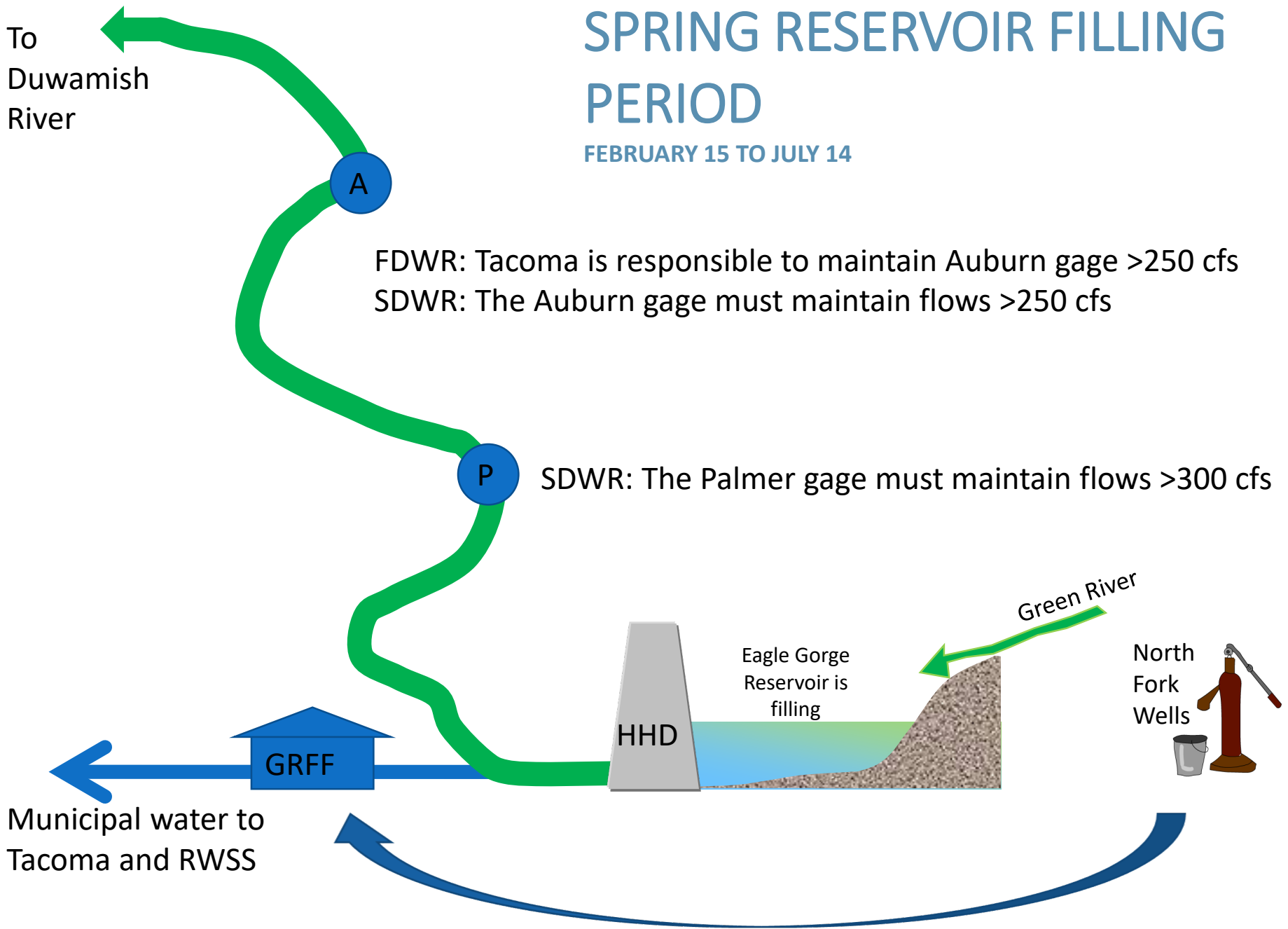
# HOWARD HANSON DAM FIRO PROJECT

## “FORECAST INFORMED RESERVOIR OPERATIONS”



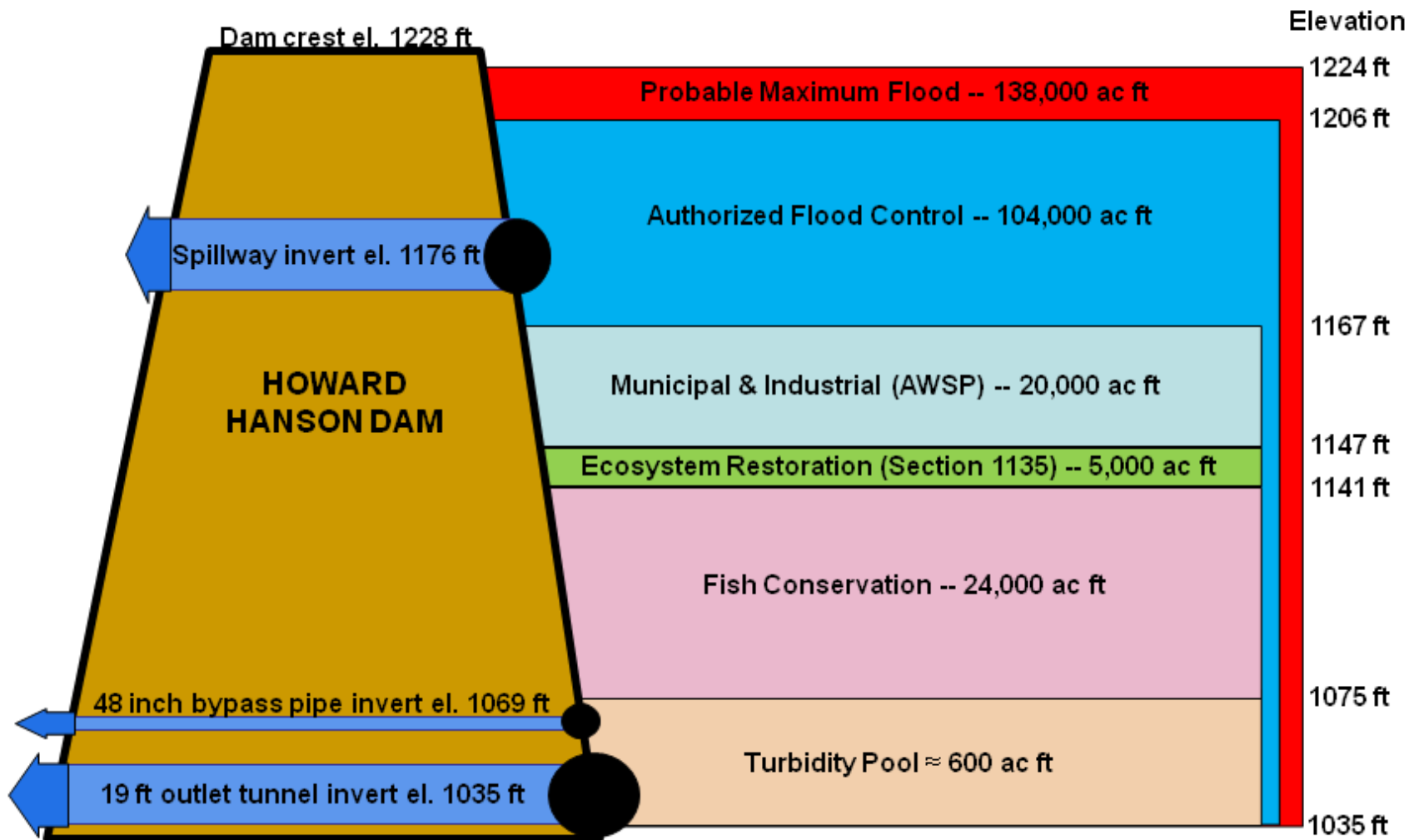
# SPRING RESERVOIR FILLING PERIOD

FEBRUARY 15 TO JULY 14



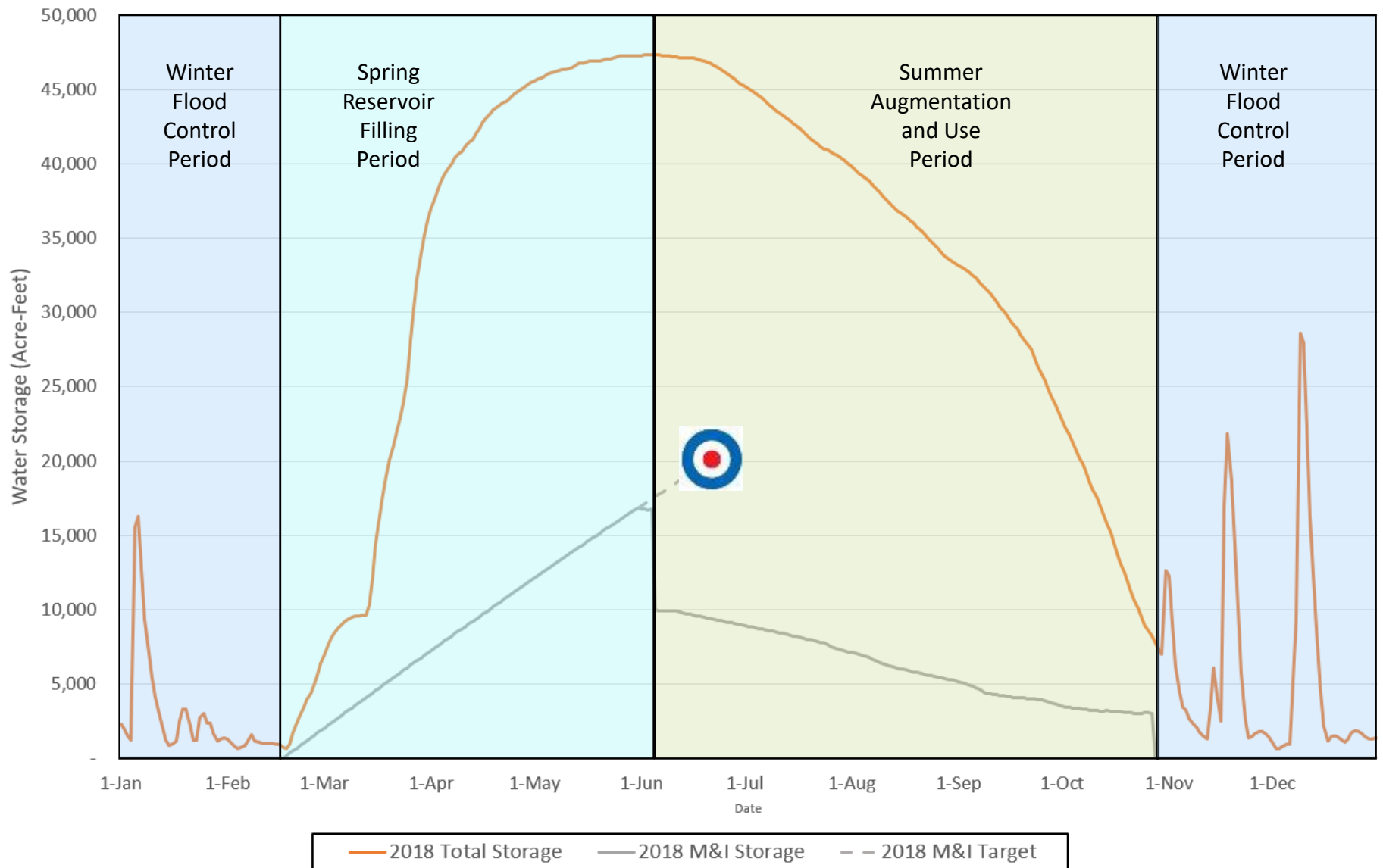
FDWR = First Diversion Water Right; SDWR = Second Diversion Water Right; cfs = cubic feet per second

# Spring Water Storage And Allocation

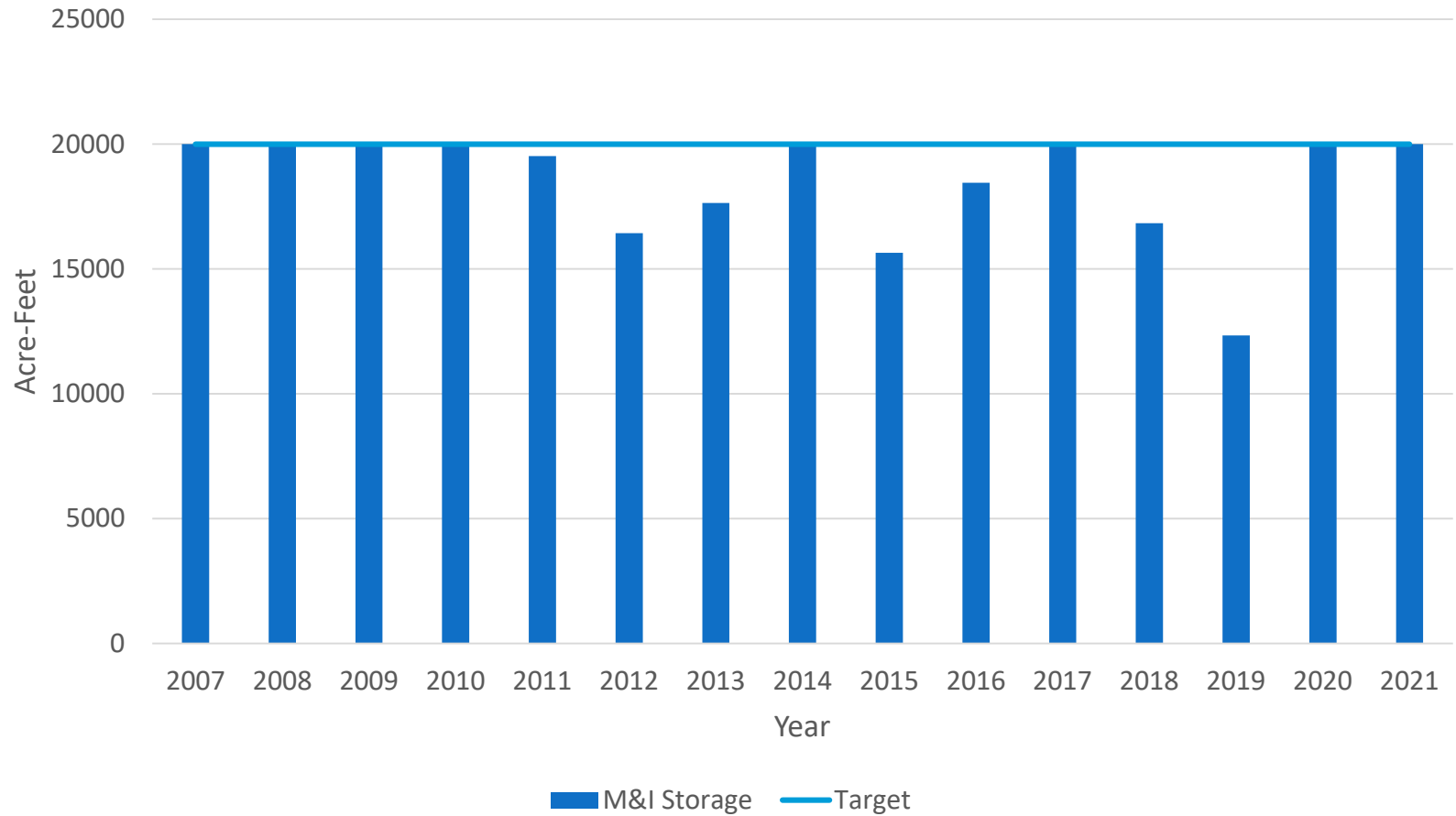


# Typical Storage at Howard Hanson

## Current WCM

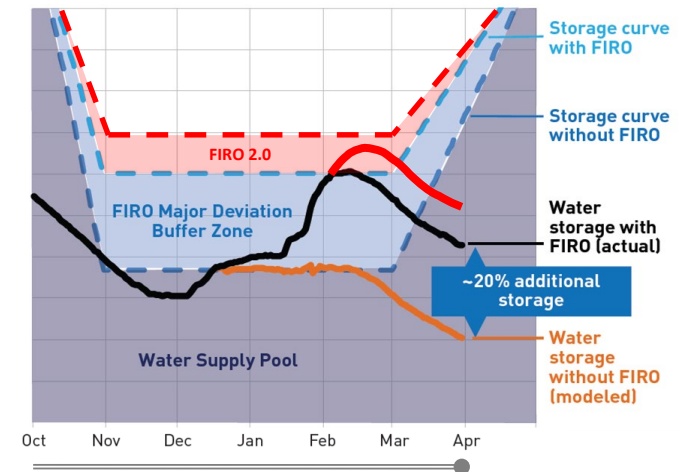
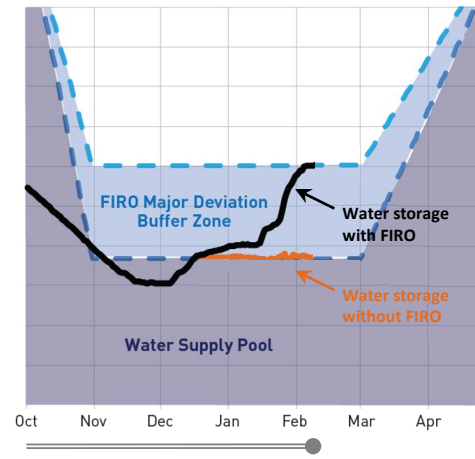
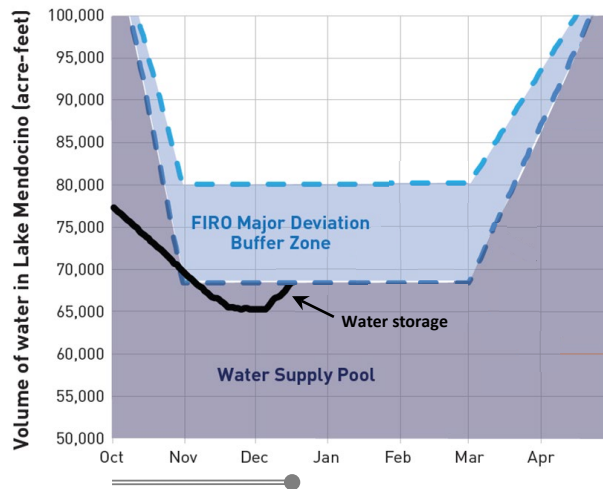


# M&I Refill Performance



# What is FIRO?

Forecast Informed Reservoir Operations (FIRO) is 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 water forecasts (American Meteorological Society, 2020).



# Phases of FIRO Research & Development

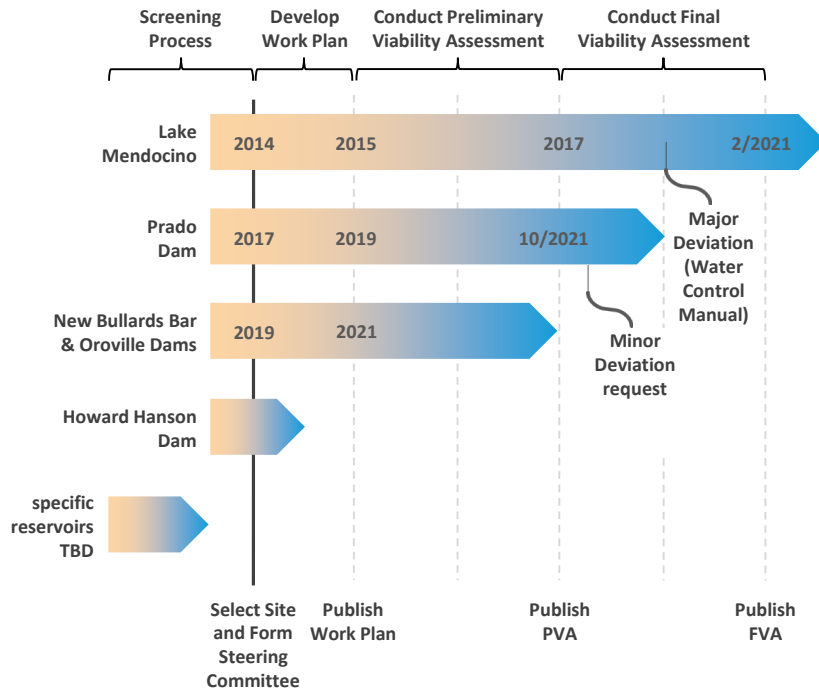
## **Phase I – Lake Mendocino**

- 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**

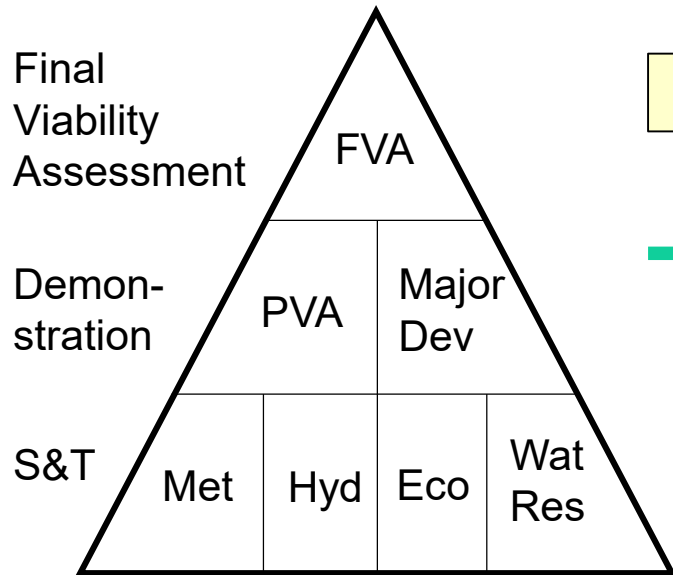
- Oct 2019 – Dec 2023 (planned)
- Added three more pilots:
  - Prado Dam
  - New Bullards Bar/Oroville Dams
  - Howard Hanson Dam

# FIRO pilot programs



Reservoir/River	Total capacity (ac-ft)	Urban/Rural location or use?	Snow a factor?	Ecosystem dimensions
Lake Mendocino (Russian River, CA)	116,500	Rural	No	Salmon Biological Opinion
Prado Dam (Santa Ana River, CA)	174,000	Dense Urban	Small	Songbird
New Bullards Bar (Yuba River, CA)	966,000	Agricultural	Major	Fish, Bay Delta
Lake Oroville (Feather River, CA)	3,538,000	Agricultural	Major	Fish, Bay Delta
Howard Hanson Dam (Green River, WA)	104,000 (authorized flood control)	Urban	Significant	Salmon Biological Opinion

# FIRO Viability Assessment Process



Meteorological Research	Hydrologic Research
Ecosystem Factors	Water Resources Ops

**Interim**

*5-year Major Deviation*

**WCM Studies**

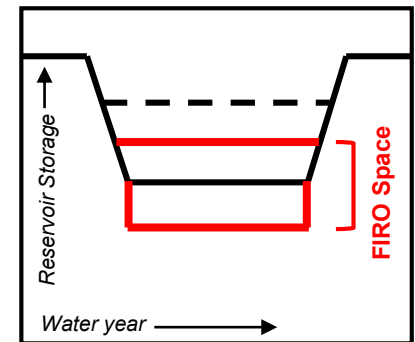
**Additional Technical Studies for WCM Update Process**

Study 1

Study 2

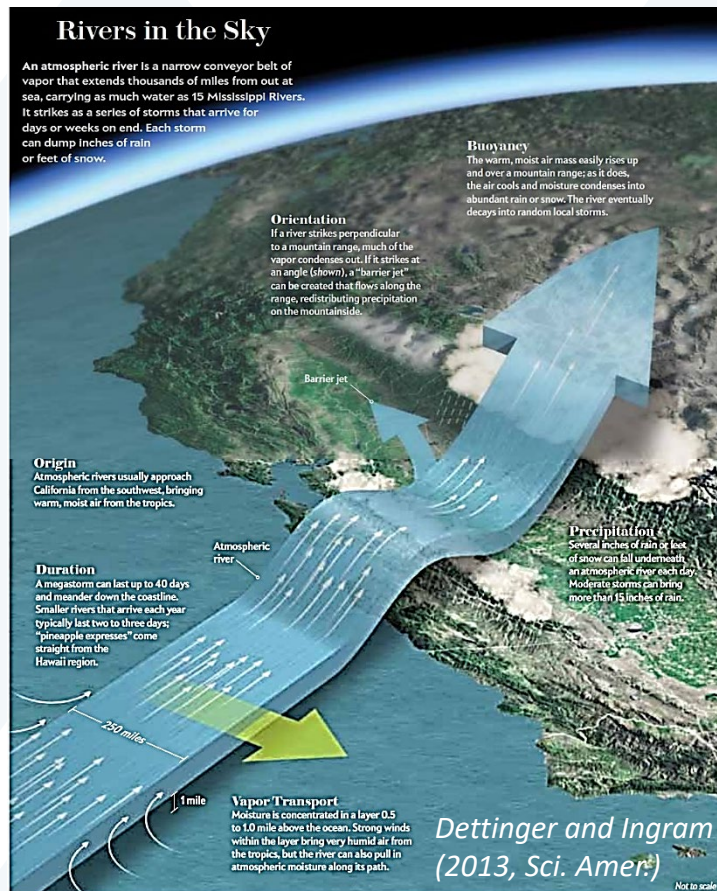
etc...

**WCM Update**

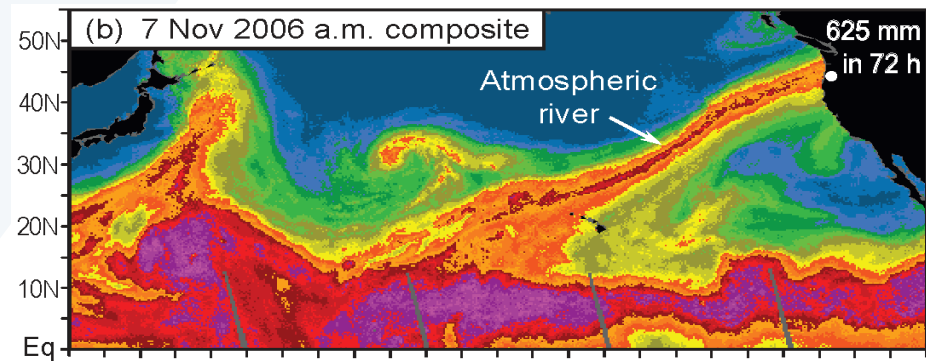


It is important to note that FIRO is a research and operations partnership

# KEY SCIENCE RESULT: ATMOSPHERIC RIVERS: PRIMARY SOURCE OF MOISTURE FOR PRECIPITATION IN THE REGION; USEABLE PREDICTIVE SKILL



Atmospheric Rivers (ARs) are *Rivers in the Sky*, i.e., long narrow bands of airborne water vapor, carrying as much water as 25 Mississippi Rivers\*.



An AR that hit Washington & Oregon produced 25 inches of rain in 3 days.

**ARs Can produce extreme precipitation and flooding.**

**However, ARs also provide up to half of annual precipitation and mountain snow that are key to water supply.**

\*Ralph et al.  
(2017)

National Weather Service

# Weather Prediction Center

Site Map      News      Organization

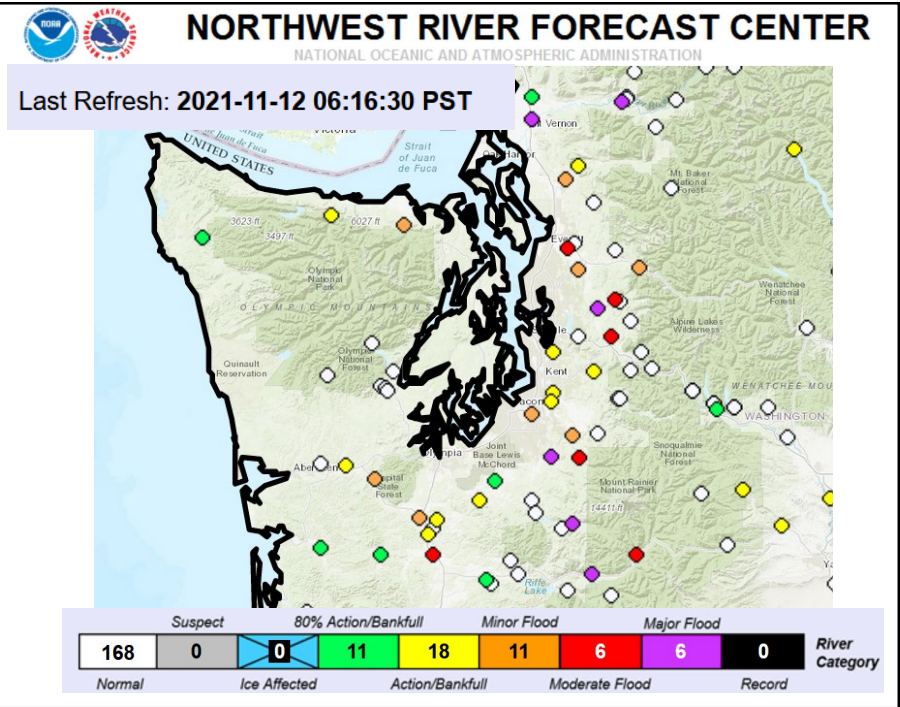
DOC NOAA NWS    NCEP Centers: AWC CPC EMC NCO NHC OPC SPC SWPC WPC

Local forecast by "City, St" or Zip Code

City, St    Go

## Excessive Rainfall Discussion

(Latest Discussion - Issued 0804Z Nov 12, 2021)

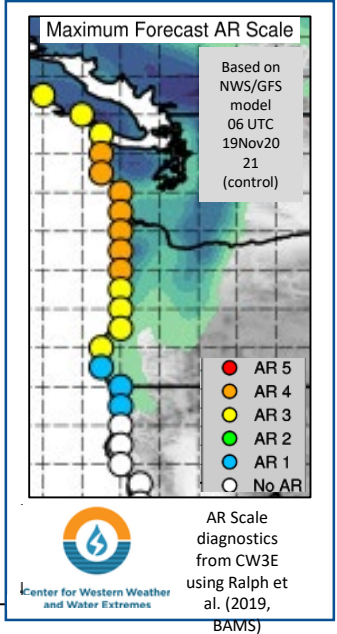


Day 3  
Valid 12Z Sun Nov 14 2021 - 12Z Mon Nov 15 2021

...THERE IS A MARGINAL RISK OF EXCESSIVE RAINFALL ACROSS THE OLYMPIC PENINSULA AND NORTHERN WASHINGTON CASCADES...

A shortwave trough over the Gulf of Alaska early on Sunday will pivot eastward and reach the Pacific NW coast on Monday. During the intervening period, an initial surge of deep-layer tropospheric ascent and moisture transport ahead of the warm front will push into western WA-OR Saturday night. The main Atmospheric River meanwhile will be directed into Vancouver Island by the start of Day 3 (12Z Sunday), then slowly drop southward across the Olympic Peninsula and northern WA Cascades Sun-Sun night ahead of the shortwave trough and associated surface cold front. Per the CW3E AR Scale, the GEFS and ECMWF are both indicating a moderate to strong Atmospheric River with a peak forecast AR rating of 4 on a 5-point scale. Integrated water vapor transport or IVT values peak between 750-800 kg/m/s during day 3 with PW values topping out at 1.25" along the coast. Per the 00Z GEFS...SW-WSW flow of 45-55+ kts within the 850-700 mb layer will lead to moisture flux anomalies of 3-3.5 standard deviations above normal. As with the departing AR, deep-layer instability will be scant -- generally 100-250 J/kg tops. However, considering the aforementioned factors along with the strong upslope component, pockets with 1hr (3hr) rainfall rates of at least 0.50" (1.00") are anticipated, with 24hr total rainfall between 2.5-5.0". Considering the current soil moisture and streamflow trends per the latest FLASH and SPoRT analyses, this next AR Sun-Sun night could certainly cause additional short-term runoff issues.

Hurley



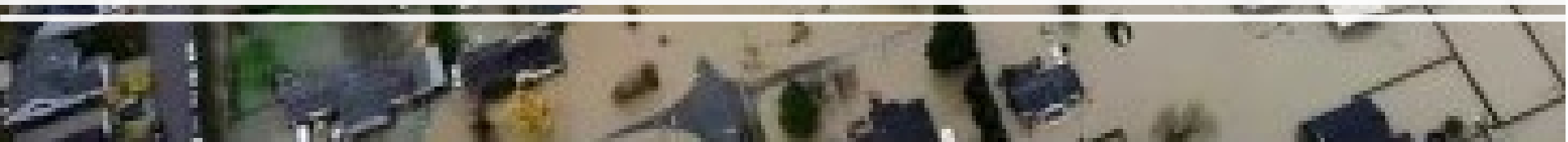
**Friday 12 November 2021: An AR4 is predicted to hit WA/OR**

NWRFC has issued flood warning up to "major flood"

NWS/NCEP/WPC's "Excessive Rainfall Discussion" noted that "Per the CW3E AR Scale, the GEFS and ECMWF are both indicating a moderate to strong Atmospheric River with a peak forecast AR rating of 4 on a 5-point scale."

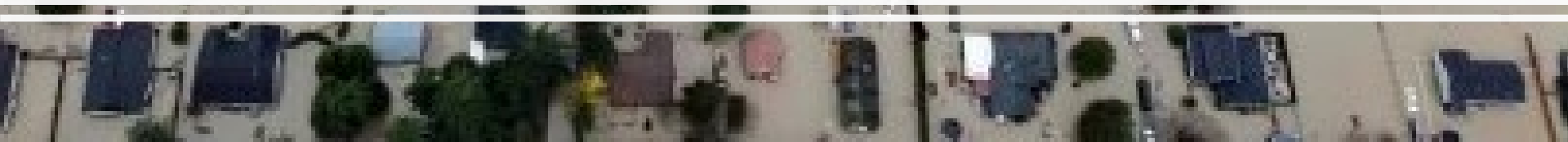


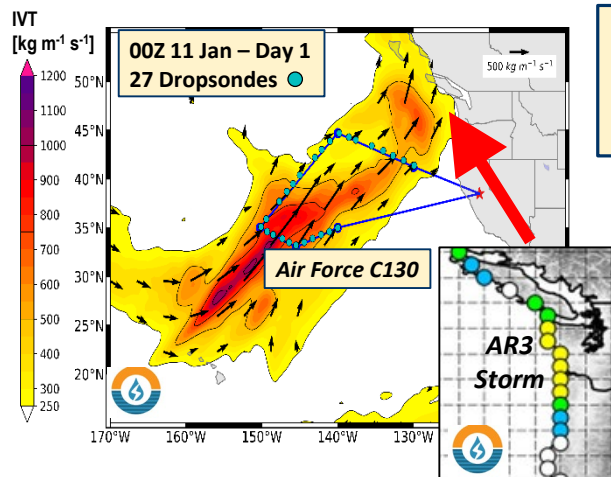
November 2021 - Nooksack





November 2021 - Nooksack



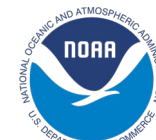


# Atmospheric River Reconnaissance 2022

Preliminary Assessment of Impact on Heavy Precipitation Forecast in GFS  
During the Sequence of 3 days of AR Recon flights from 11-13 Jan 2022

AR Recon flight substantially reduced errors in the  
1-2-day lead-time forecast of heavy precipitation  
from an AR3 storm

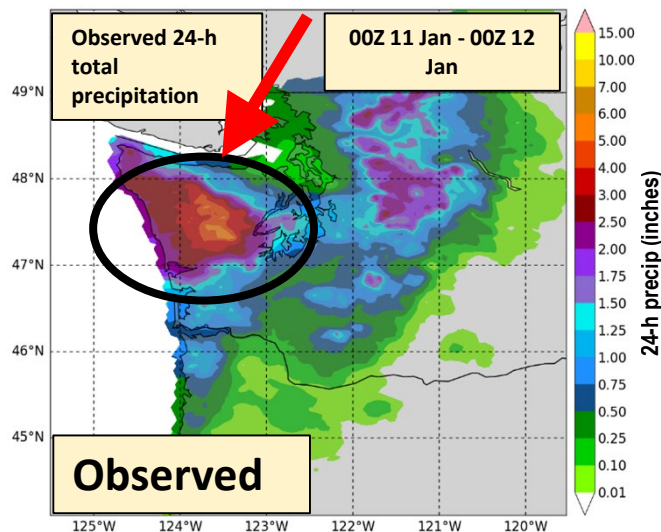
*The region had been experiencing flooding already this winter, and  
WA had requested a Presidential Disaster Declaration for earlier AR  
storms that had hit in Nov-Dec 2021, before AR Recon season  
began on 11 Jan 2022.*



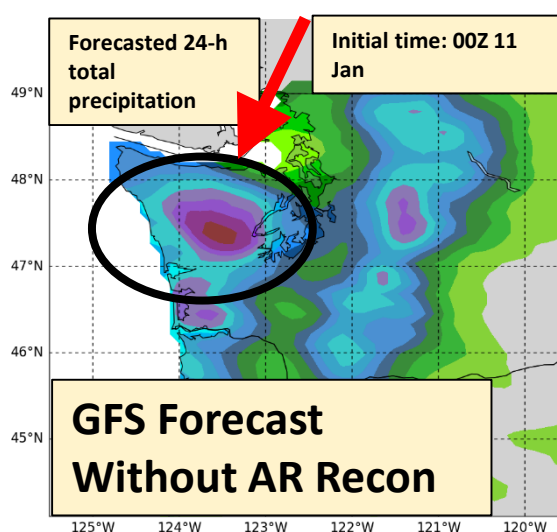
Center for Western Weather  
and Water Extremes

Research And Operations Partnership  
F. Martin Ralph (UCSD/SIO/CW3E) - PI  
Vijay Tallapragada (NWS/NCEP) - Co-PI

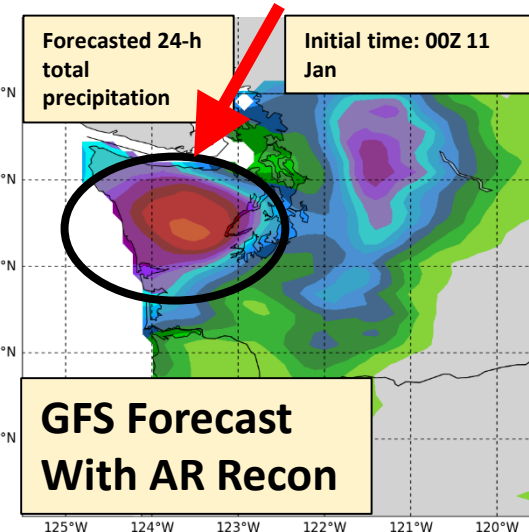
Max > 6 inches in 1 day



Max < half what was observed

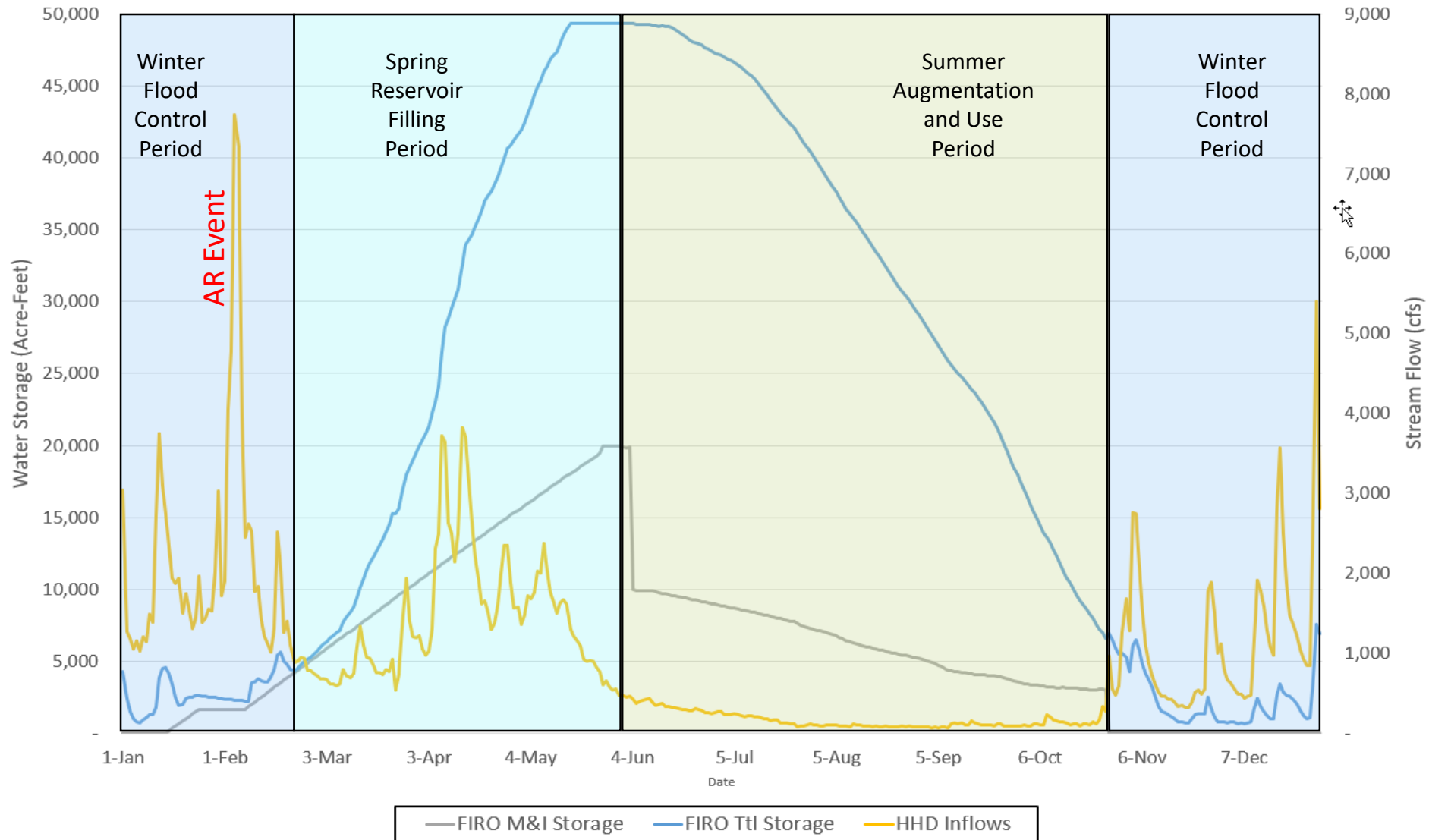


Max > 5 inches in 1 day  
Close to what was observed



# Typical Storage at Howard Hanson

## FIRO Developed WCM Deviation

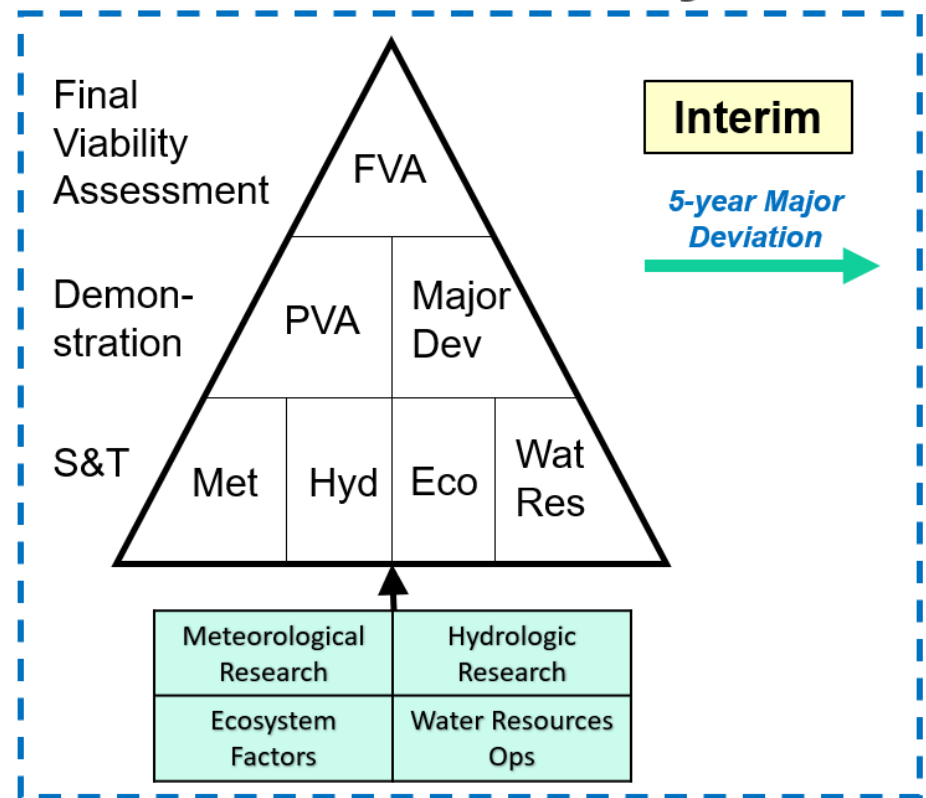


# Project Benefits

- Improved probability of reaching full M&I storage
- Fisheries benefits
  - Leaves more water in the river
  - Creates opportunity for flow enhancements
- Helps mitigate the impacts of climate change on water supply
- Increases opportunity for achieving AWSP Phase 2 storage

# Project Schedule

- October 26, 2022 - PUB considers CW3E contract FIRO Viability Assessment
- 2022 – 2024 Contract Activities
  - Formation of steering committee,
  - Develop work plan
  - Initiate studies and technical analysis to support viability assessment



“This is exactly how we want the Federal Government to operate”  
 Jaime Shimek  
 12 April 2018  
 House Democratic E&W Appropriations Committee Staff