OROVILLE DAM CITIZENS ADVISORY COMMISSION

Meeting 15
November 15, 2023

Hosted by the California Natural Resources Agency

CALIFORNIA NATURAL RESOURCES AGENCY

ITEM 1
WELCOME AND COMMISSION UPDATES

ROLL CALL

- Commissioner Bateman
- Supervisor Connelly
- Supervisor Conant
- Secretary Crowfoot
- Senator Dahle
- Sargent Evans
- Supervisor Flores
- Supervisor Fuhrer
- Assemblyman Gallagher
- Director Ward
- Supervisor Kimmelshue
- Deputy Licon
- OES Manager Marin
- Director Nemeth
- Mayor Pittman
- Vice Mayor Smith
- Director Quintero
- Lieutenant Spear
- Lieutenant Commander Stokes

ACTION ITEM TRACKER

OPENING REMARKS CONTINUED

ITEM 2

FORECAST INFORMED RESERVOIR OPERATIONS

Atmospheric Rivers & FIRO

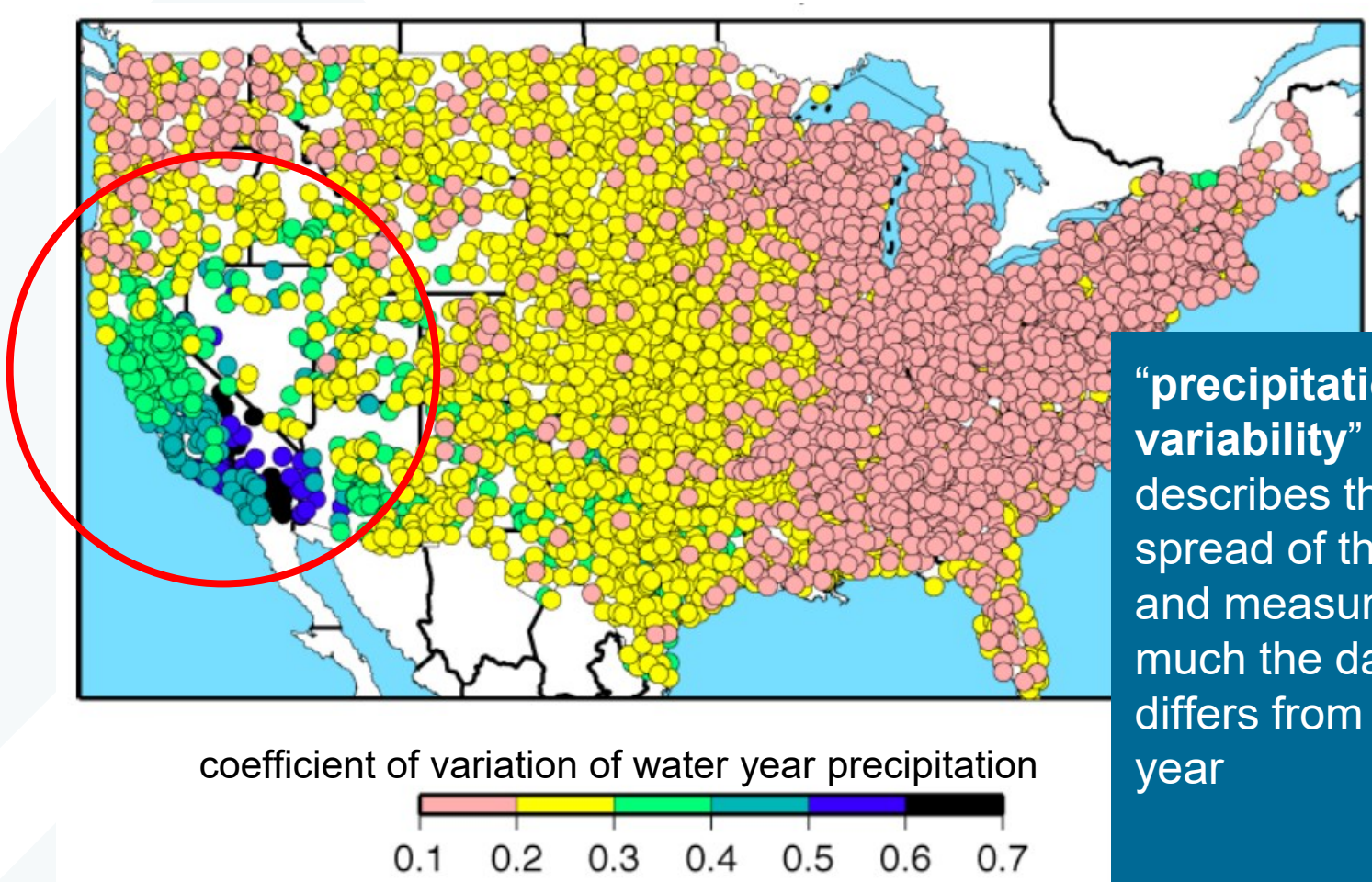
Marty Ralph
November 15, 2023
Oroville Citizen Advisory Commission

UC San Diego | SCRIPPS INSTITUTION OF OCEANOGRAPHY

California has very high precipitation variability, meaning it is less consistent and more difficult to predict and manage.

California experiences the greatest variability from year to year in annual precipitation amounts.

These annual variations are mostly determined by have active or inactive the wet season is in terms of **Atmospheric Rivers**

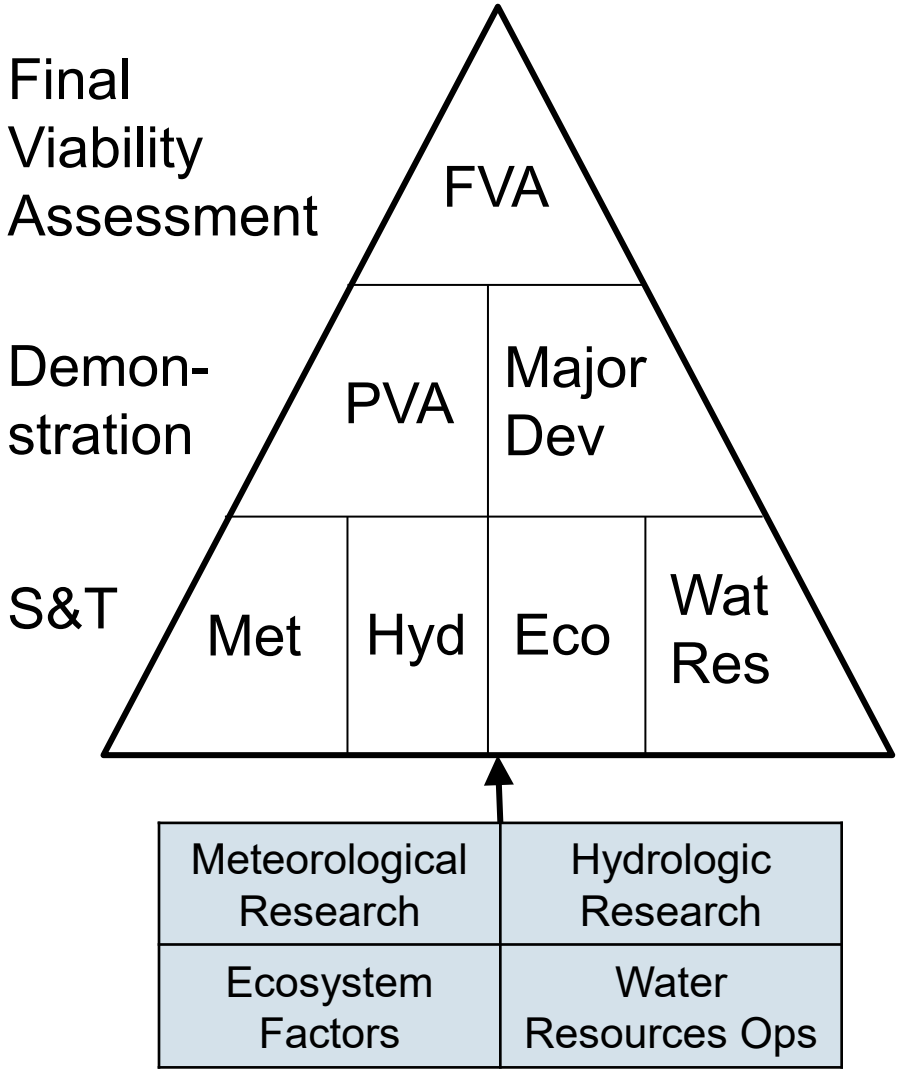


"**precipitation variability**" describes the spread of the data and measures how much the data differs from year to year

Center for Western Weather and Water Extremes

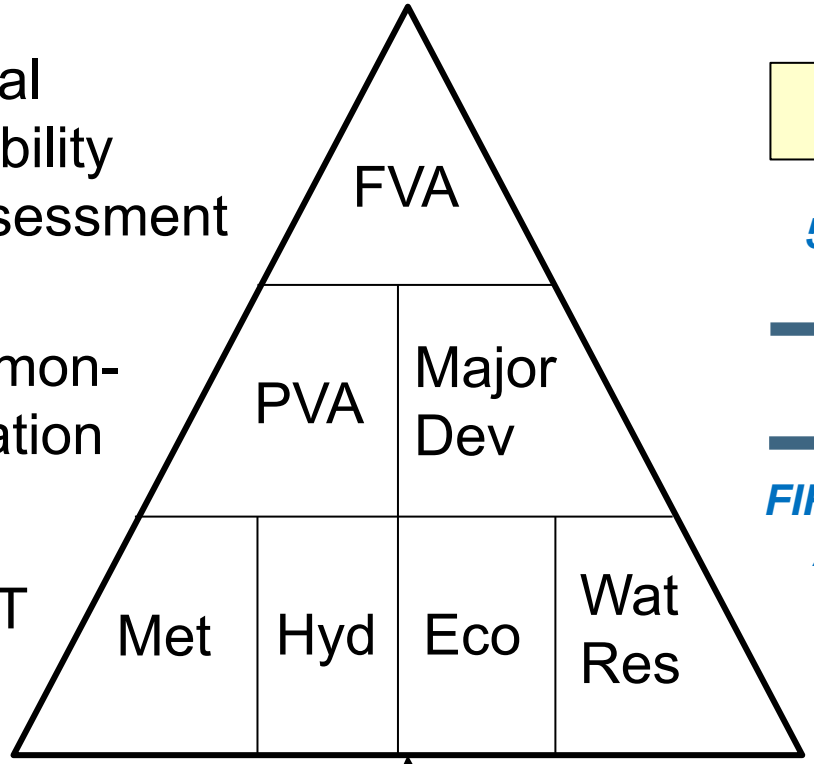
From Dettinger et al., 2011

FIRO Viability Assessment Process



Yuba-Feather FIRO Steering Committee

FIRO Viability Assessment Process



Meteorological Research	Hydrologic Research
Ecosystem Factors	Water Resources Ops

Interim

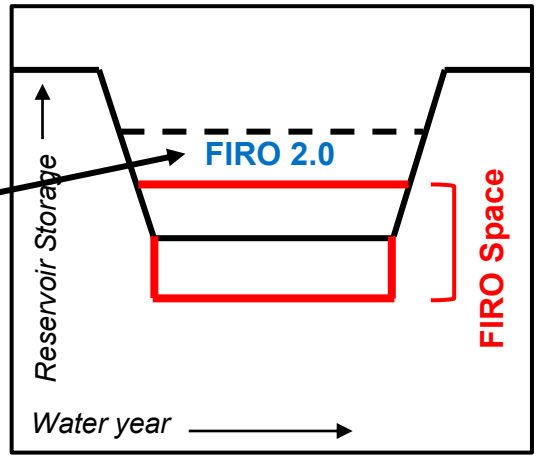
5-year Major Deviation

FIRO 2.0 Viability Assessment (future)

WCM Studies

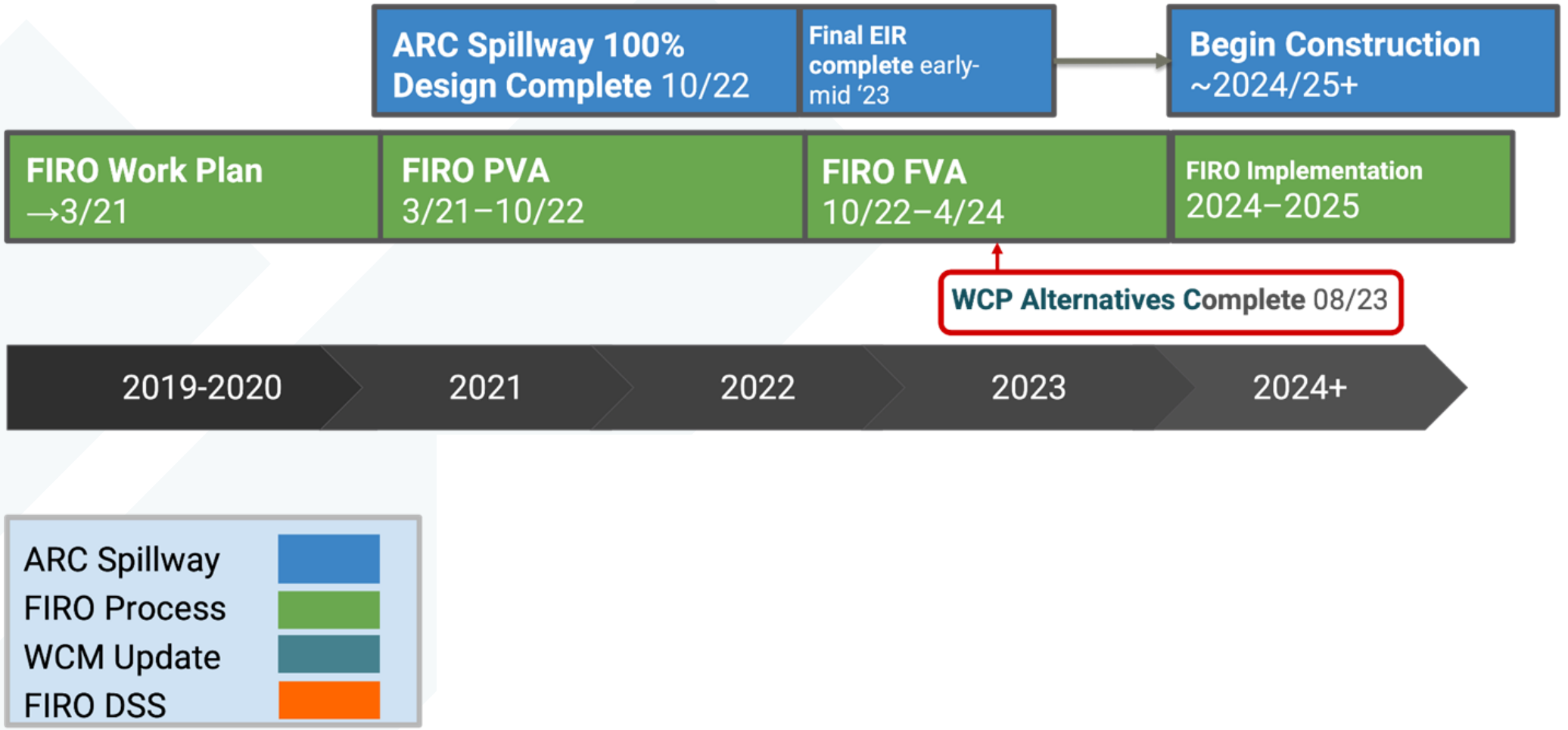
Additional Technical Studies for WCM Update Process
Study 1
Study 2
etc…

WCM Update



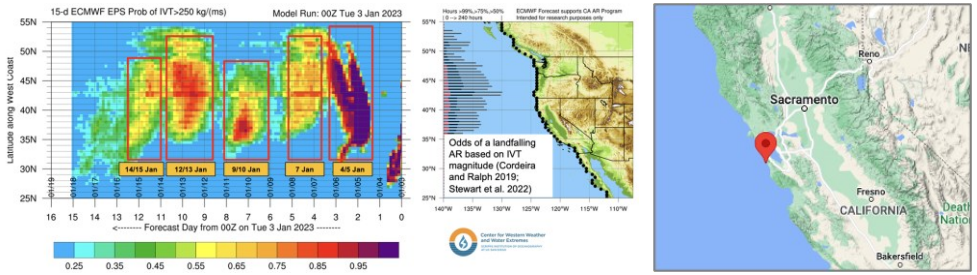
It is important to note that FIRO is a research and operations partnership

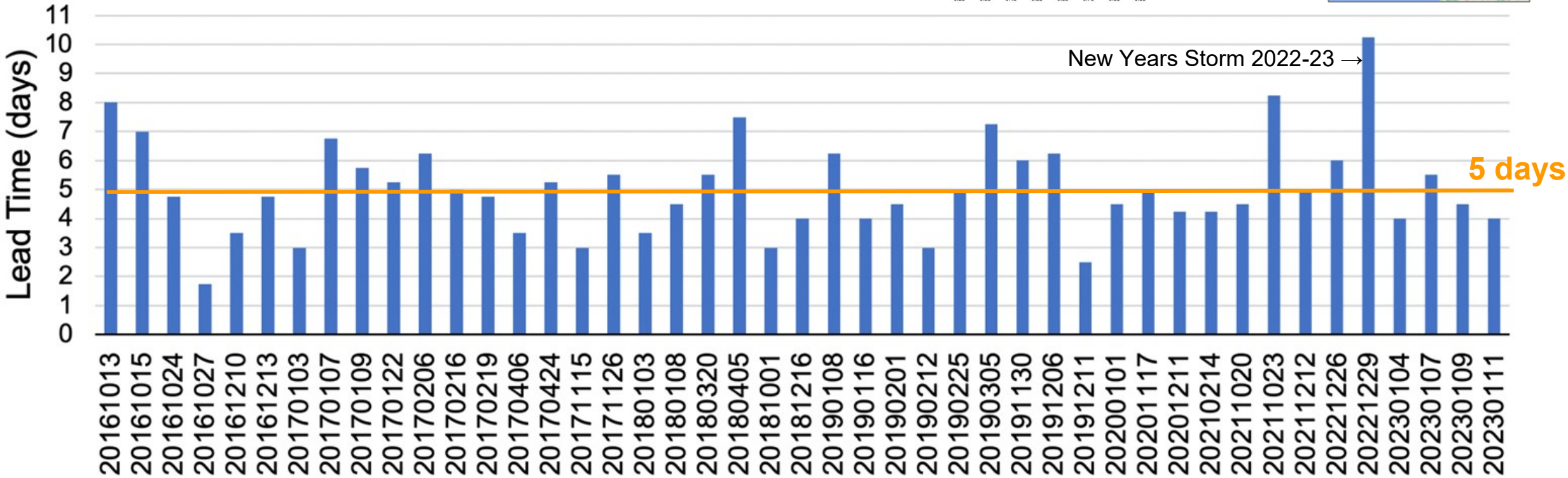
Yuba Feather FIRO, ARC Spillway, and WCM timeline



Meteorology: How far in advance can we forecast ARs?

How far in advance does the CW3E AR Landfall Tool predict 2:1 odds (66%) of a landfalling AR in northern California?

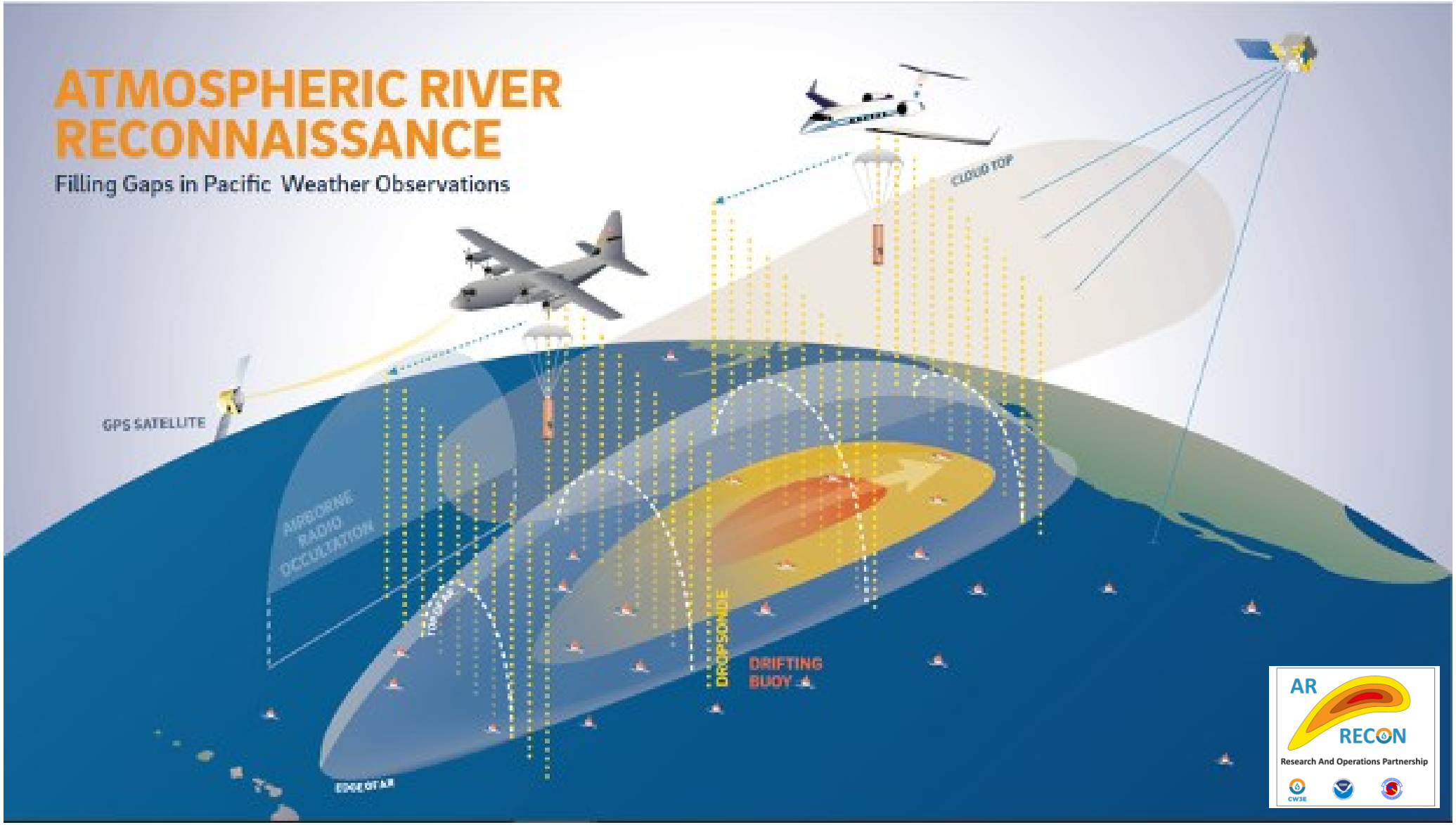




Based on all AR2+ storms to make landfall at SFO (37.5N) derived from NCEP GEFS data for WY17-23

Center for Western Weather and Water Extremes

AR Recon: Better Observations ➡ Better AR Forecasts



Photos: Air Force 53rd Weather Reconnaissance Squadron C-130s on station at Mather AFB - 5 Jan 2023

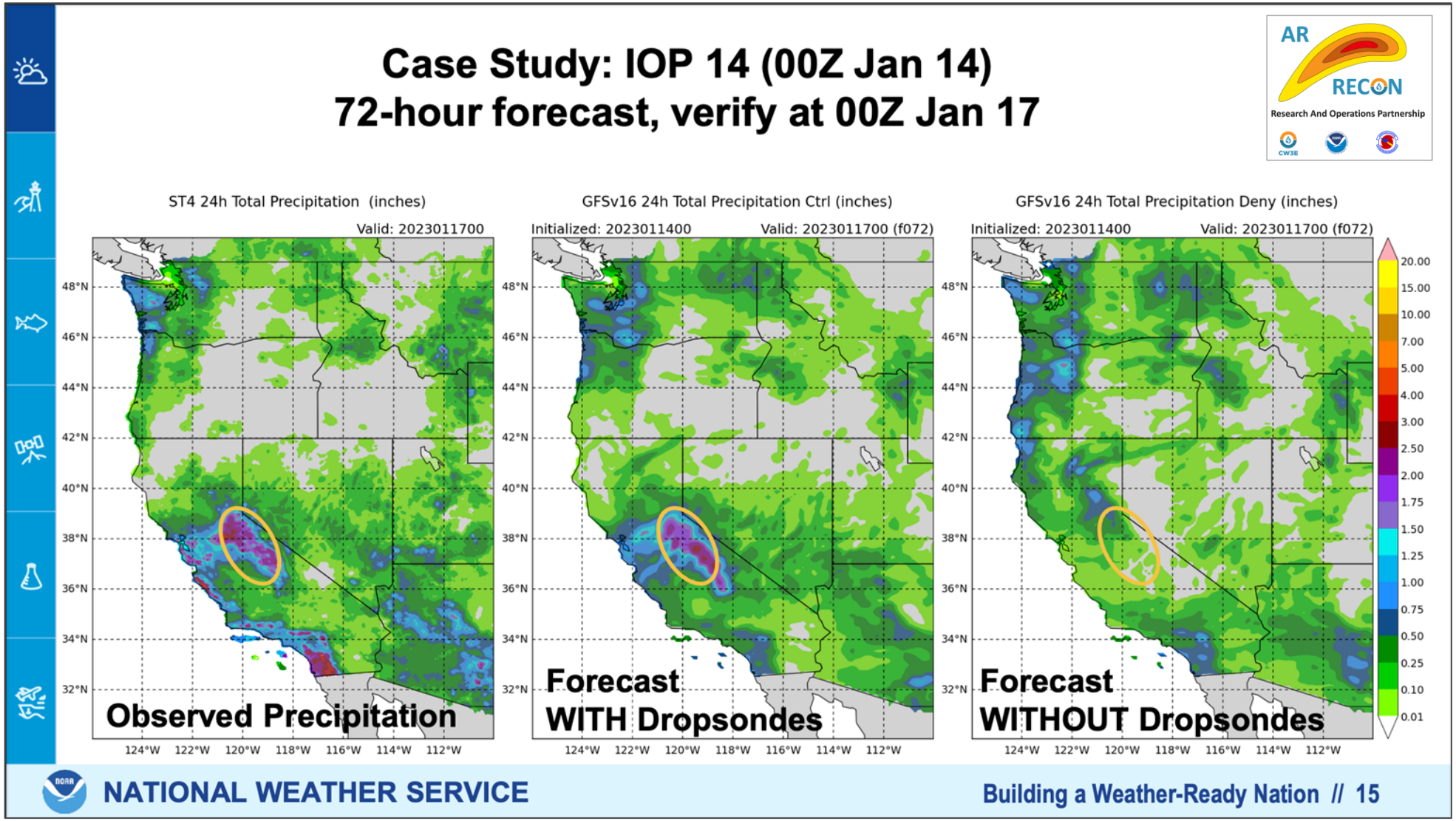
Photos courtesy of Lt. Col. Ryan Rickert

AR RECON
Research And Operations Partnership
CW3E

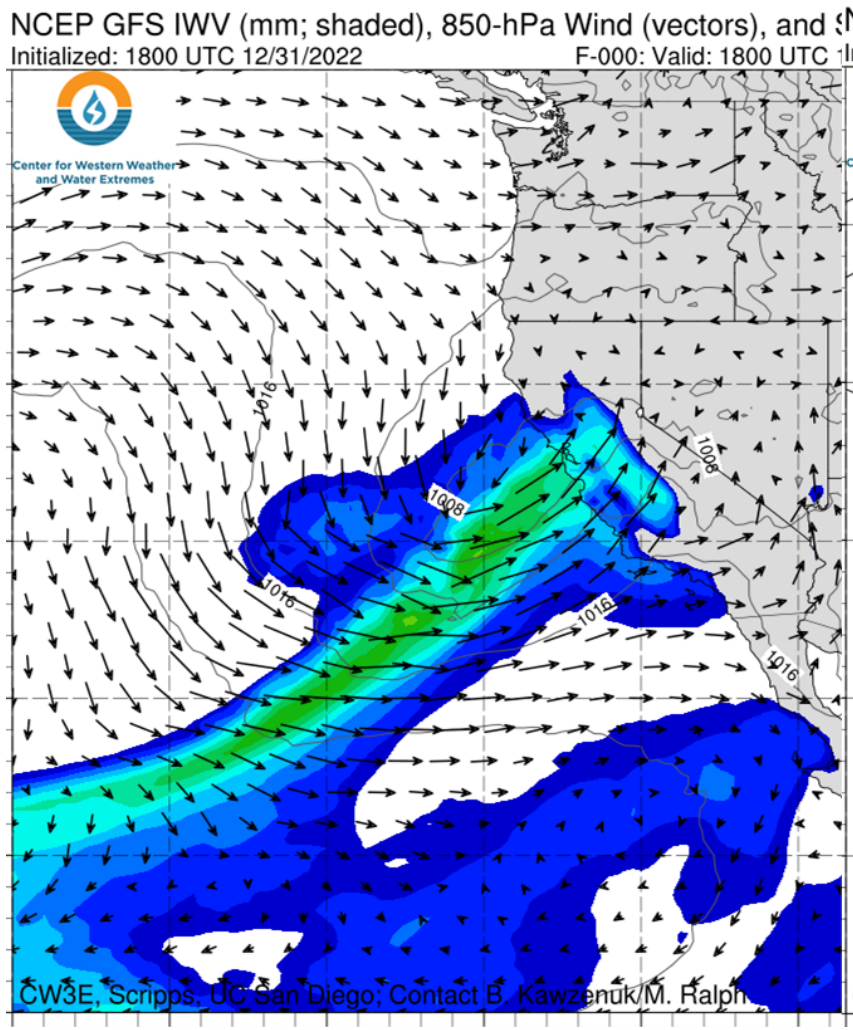
AR Recon: Better observations ➡ Improved Forecast Skill (WY23)

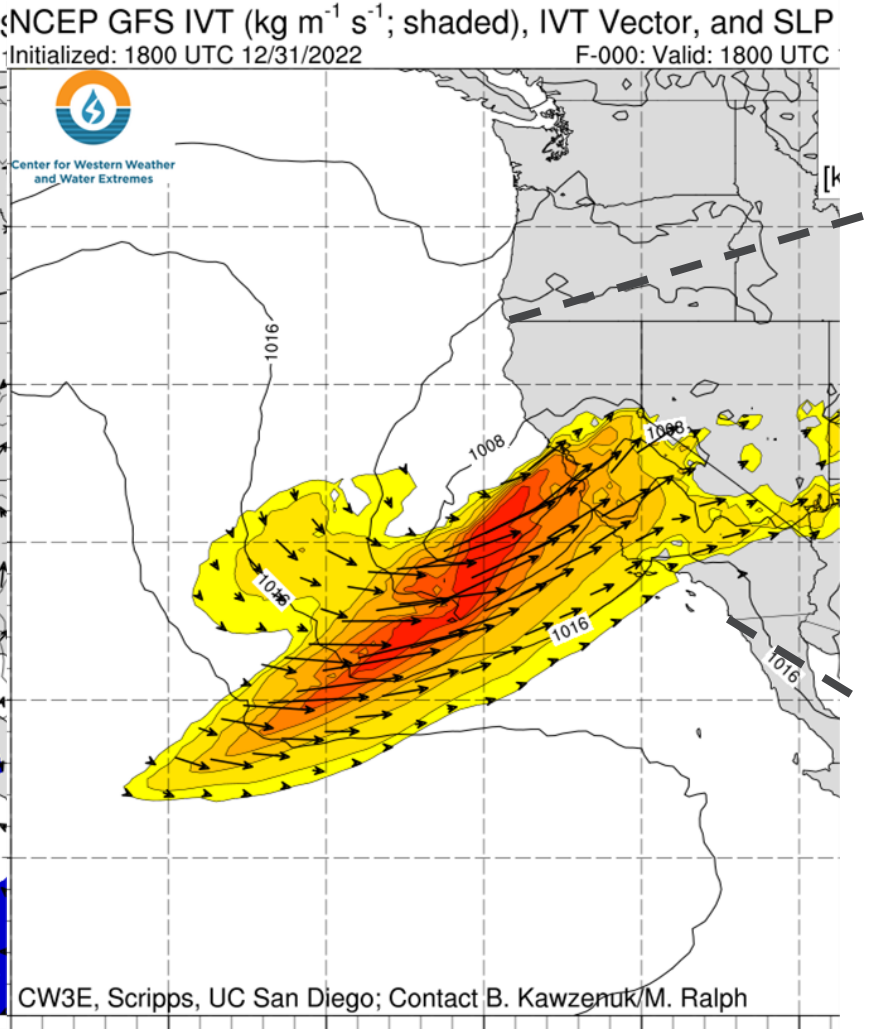
Presentation
by V. Tallapragada

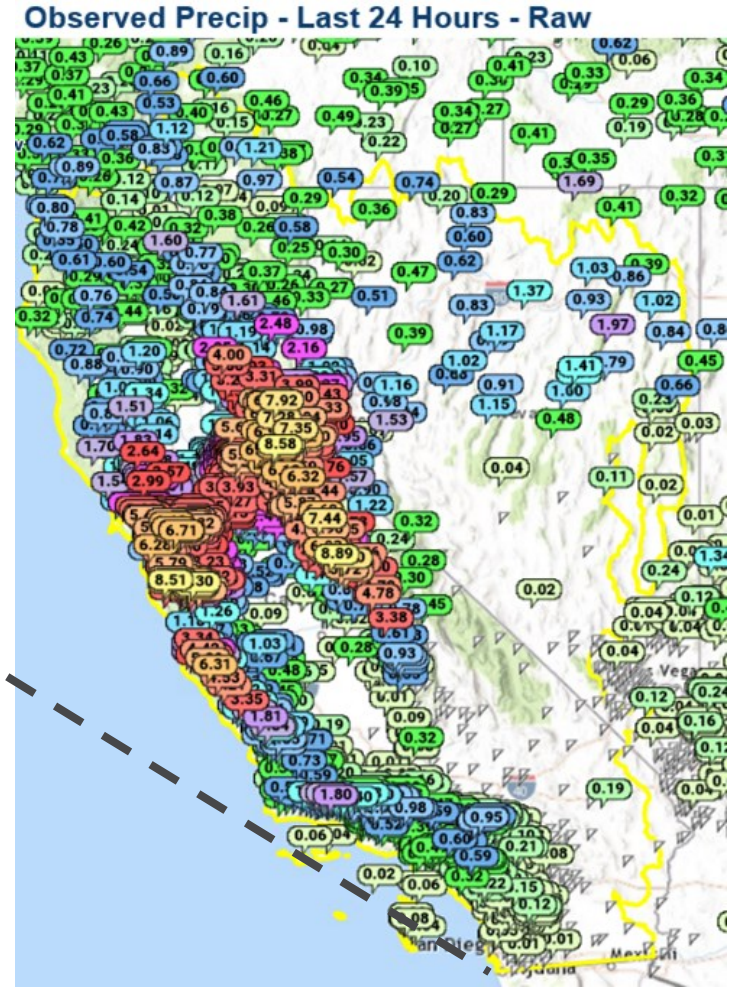
AR Recon Workshop
June 2023
@ECMWF



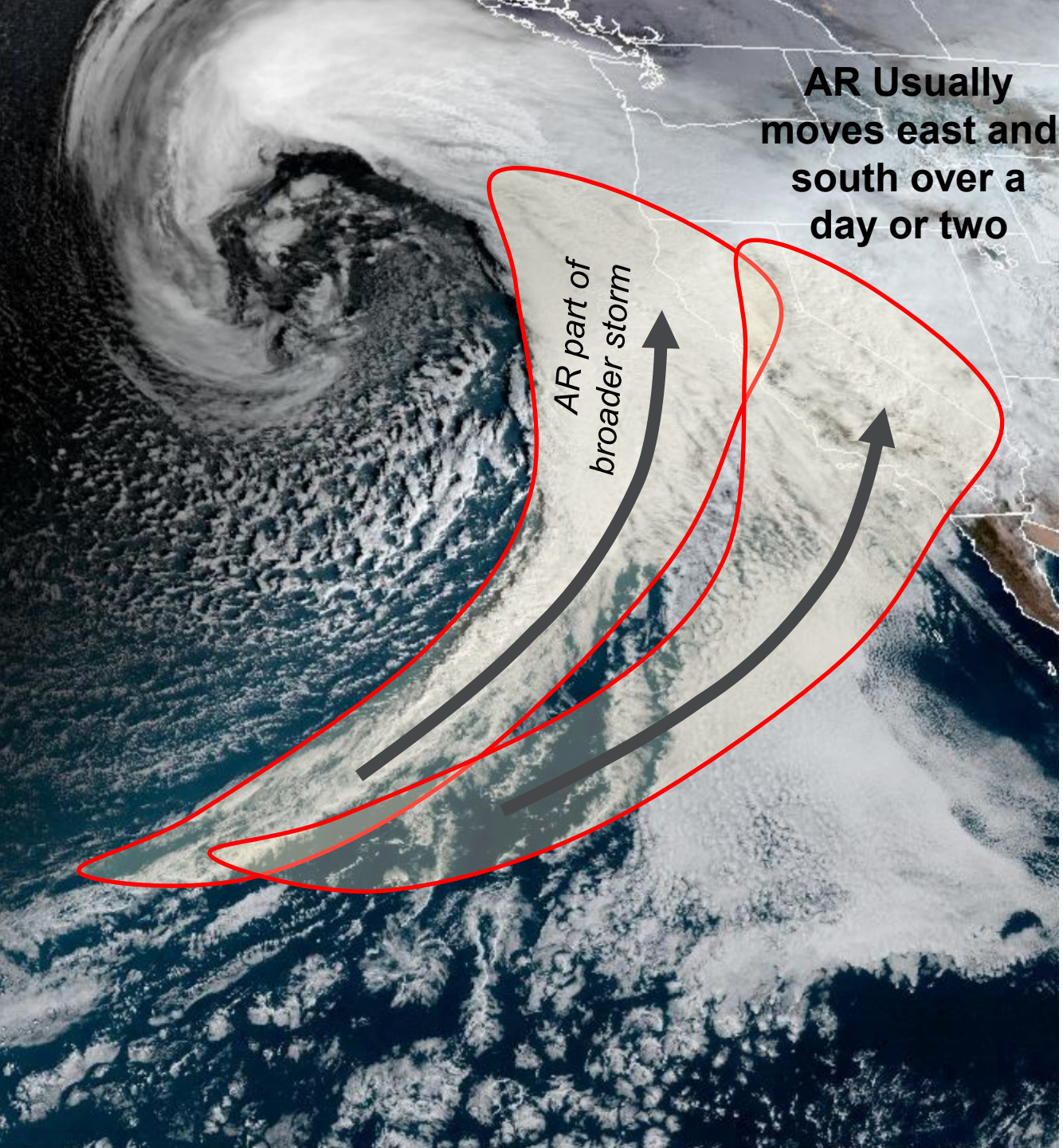
New Year's Day 2023 AR

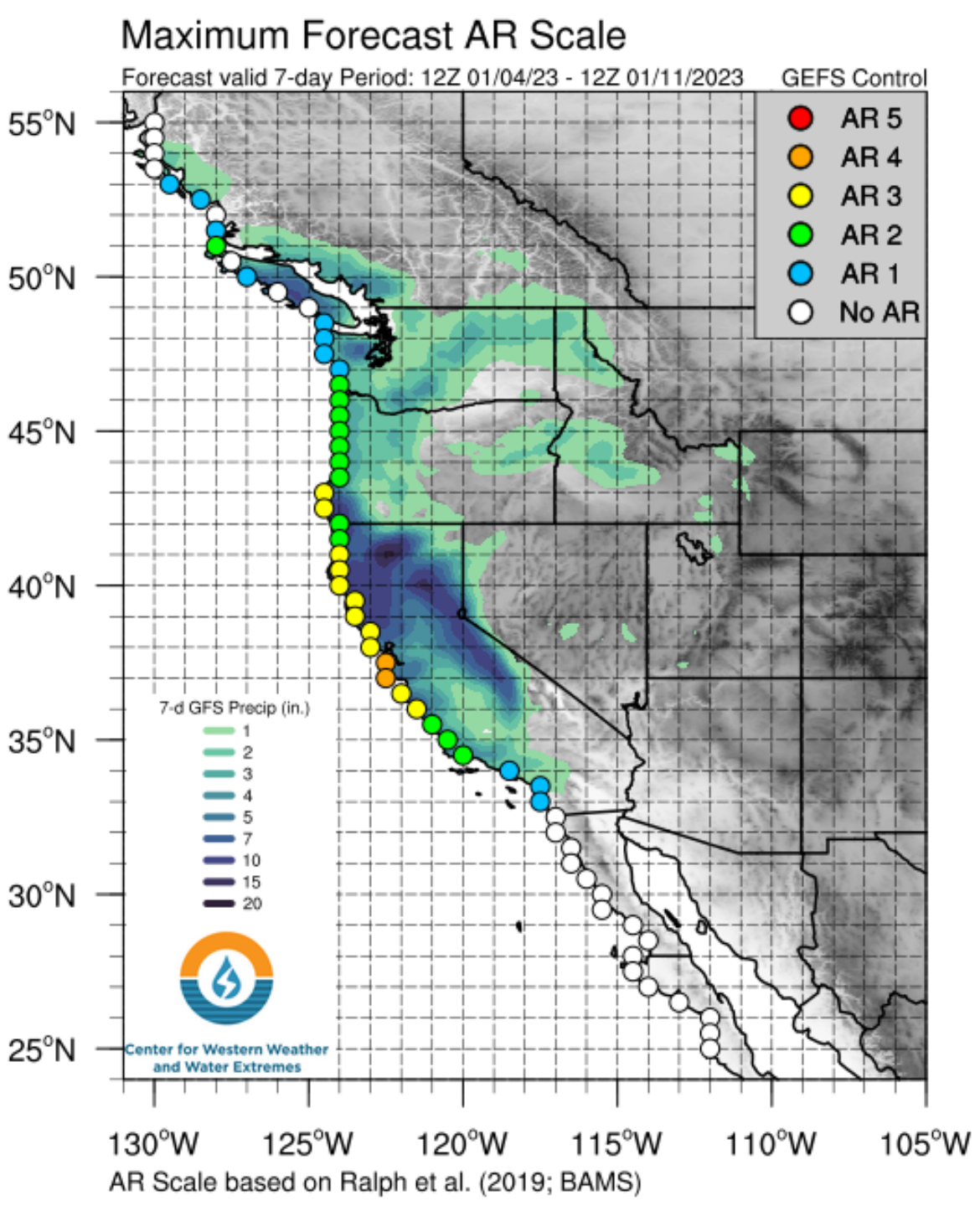






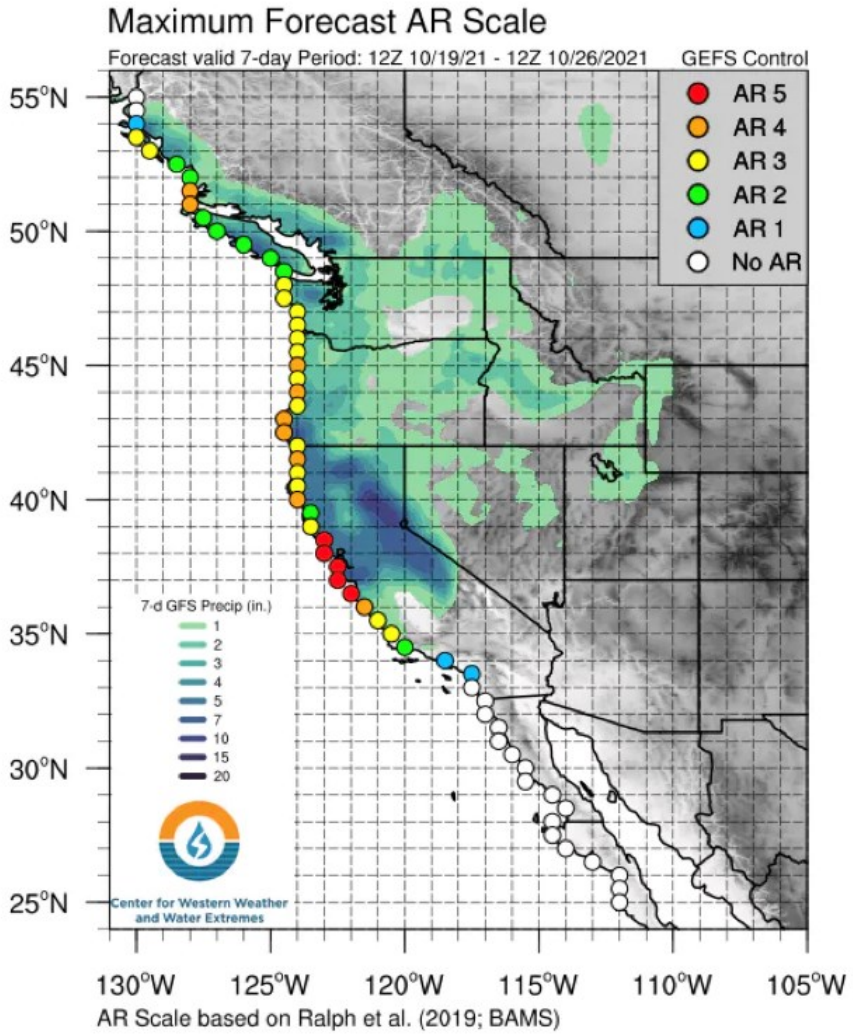
Center for Western Weather and Water Extremes


AR Usually moves east and south over a day or two
AR part of broader storm

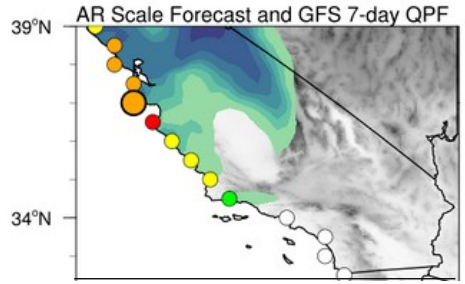

Maximum Forecast AR Scale
Forecast valid 7-day Period: 12Z 01/04/23 - 12Z 01/11/2023
GEFS Control
AR 5
AR 4
AR 3
AR 2
AR 1
No AR
55°N
50°N
45°N
40°N
35°N
30°N
25°N
130°W
125°W
120°W
115°W
110°W
105°W
7-d GFS Precip (in.)
1
2
3
4
5
7
10
15
20
Center for Western Weather and Water Extremes
AR Scale based on Ralph et al. (2019; BAMS)

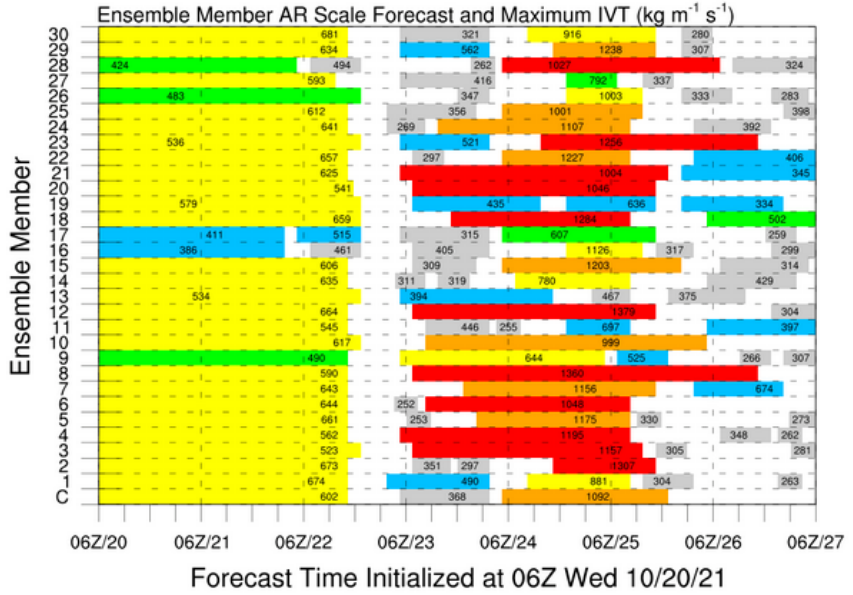
The Washington Post

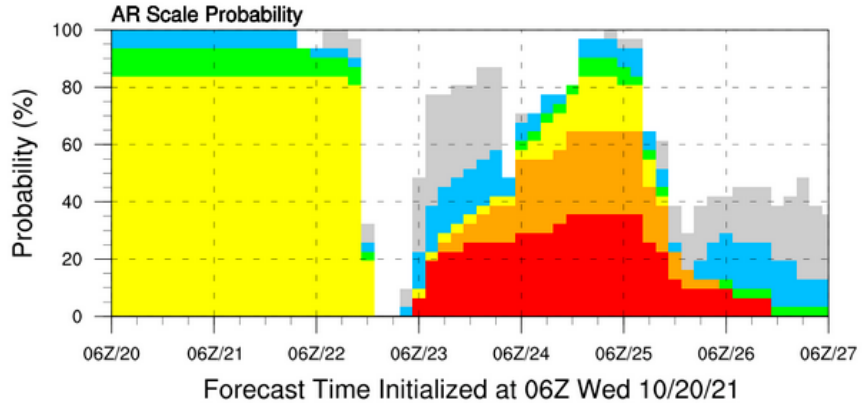
Democracy Dies in Darkness



Forecast for the maximum atmospheric river (AR) intensity over the next week. (Center for







GEFS + EPS = 80 members

AR5: 30%

AR4: 35%

AR3: 30%

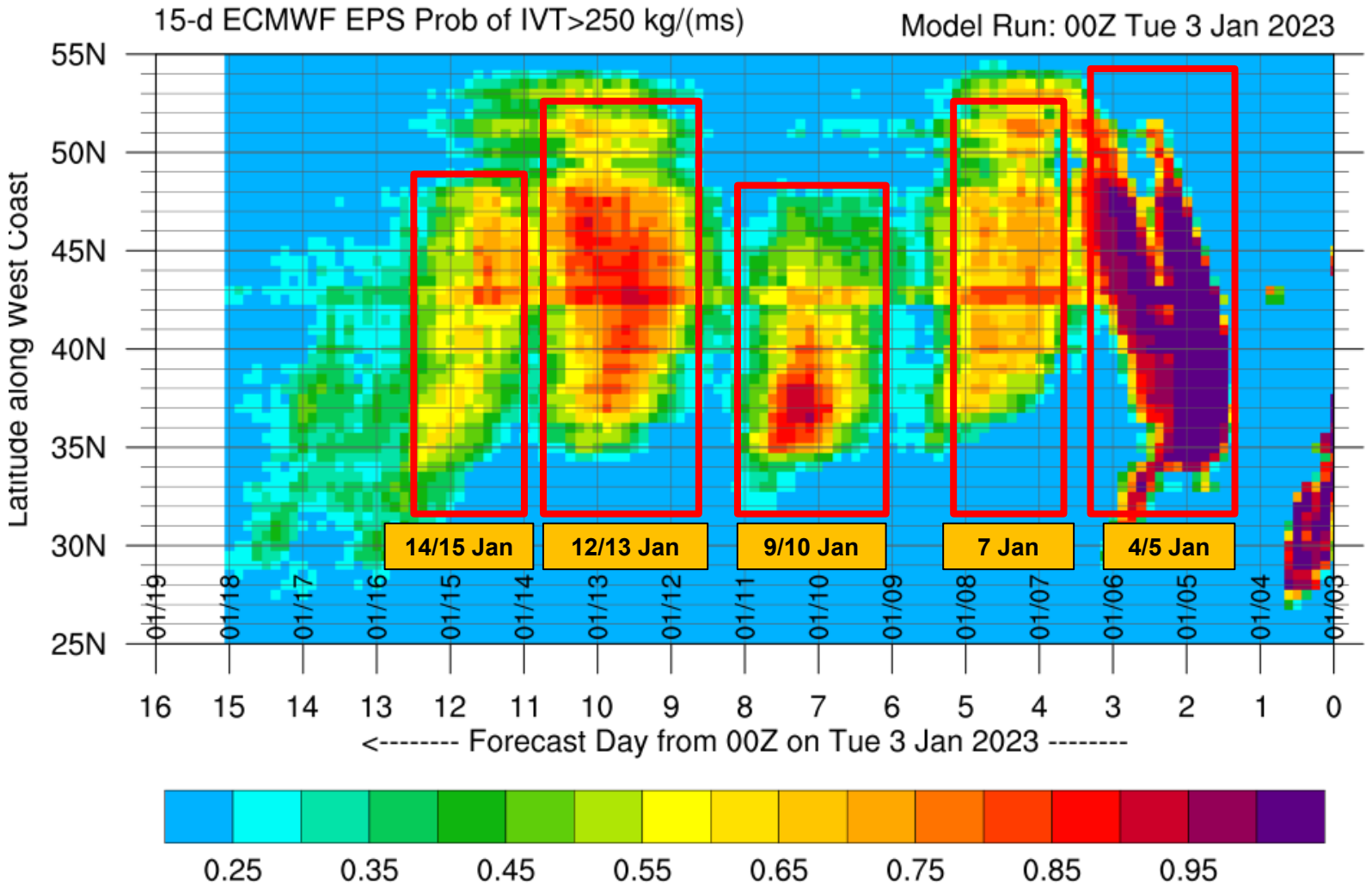
AR4 or AR5: 65%

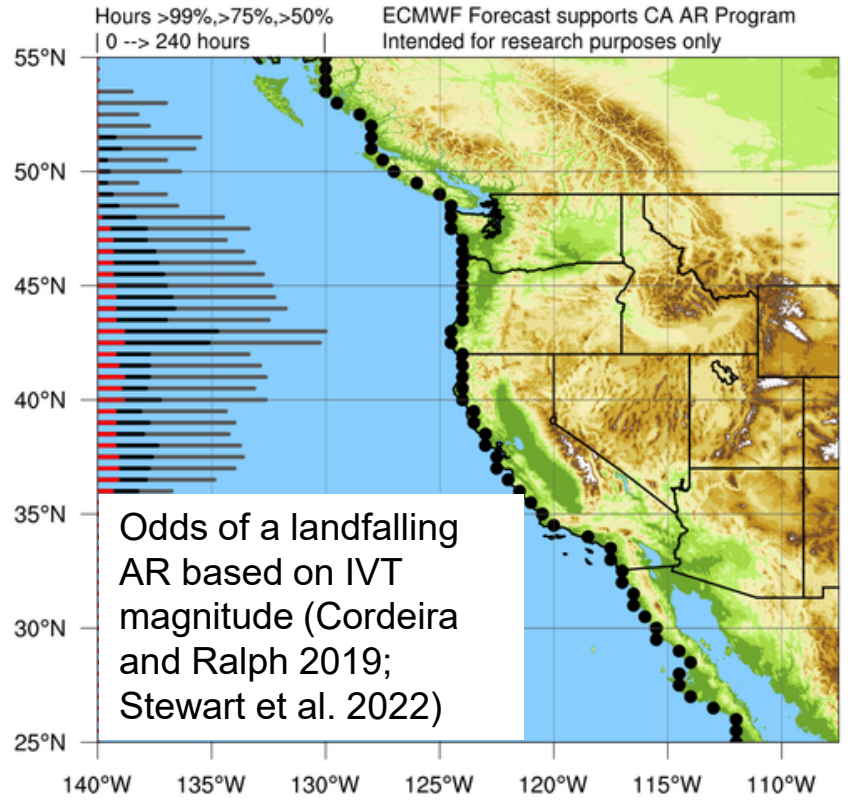
AR3, 4 or 5: 95%

Atmospheric River Struck as an "AR5" on CW3E's AR Scale

Record daily rainfall at key locations, and **record of 13% of annual rain for N. Sierra - <u>in 1 day</u>**

How far in advance can we predict landfalling ARs?





Odds of a landfalling AR based on IVT magnitude (Cordeira and Ralph 2019; Stewart et al. 2022)

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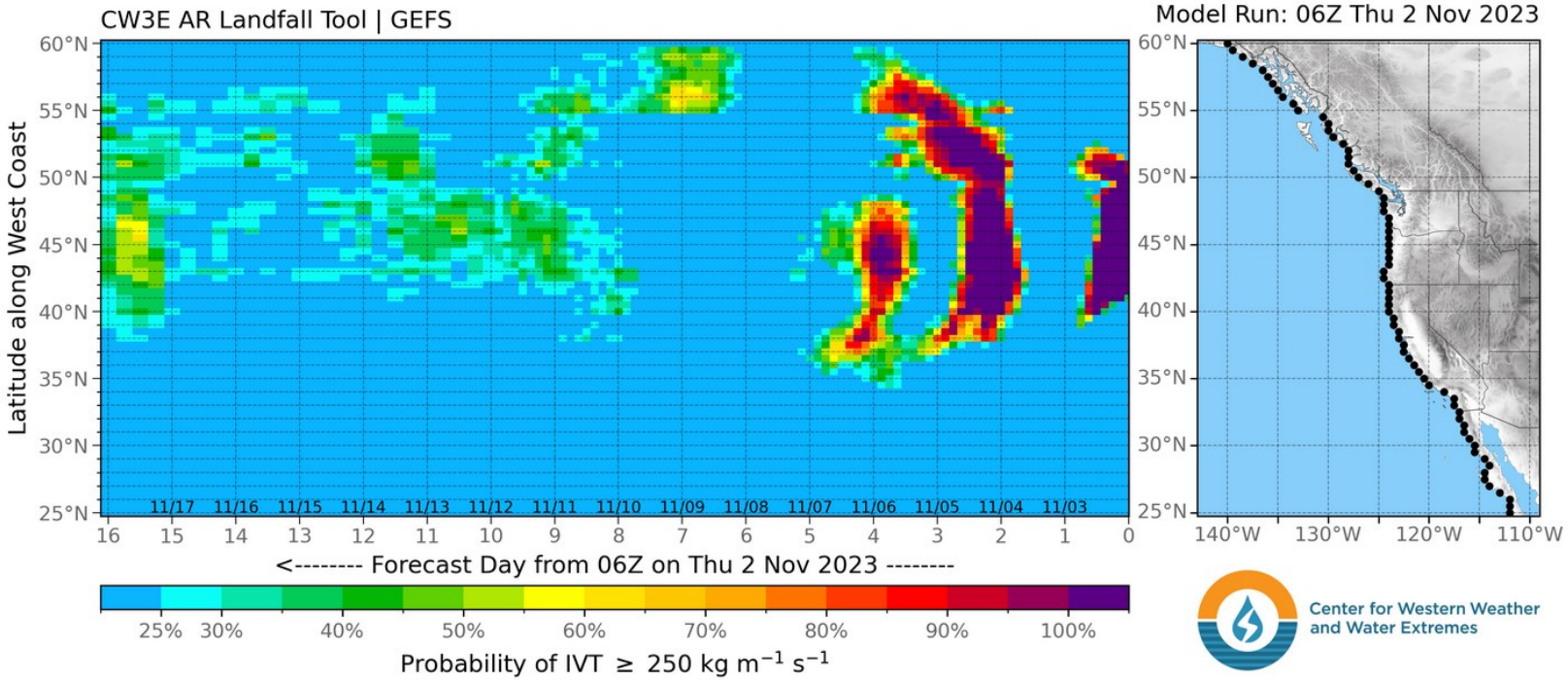
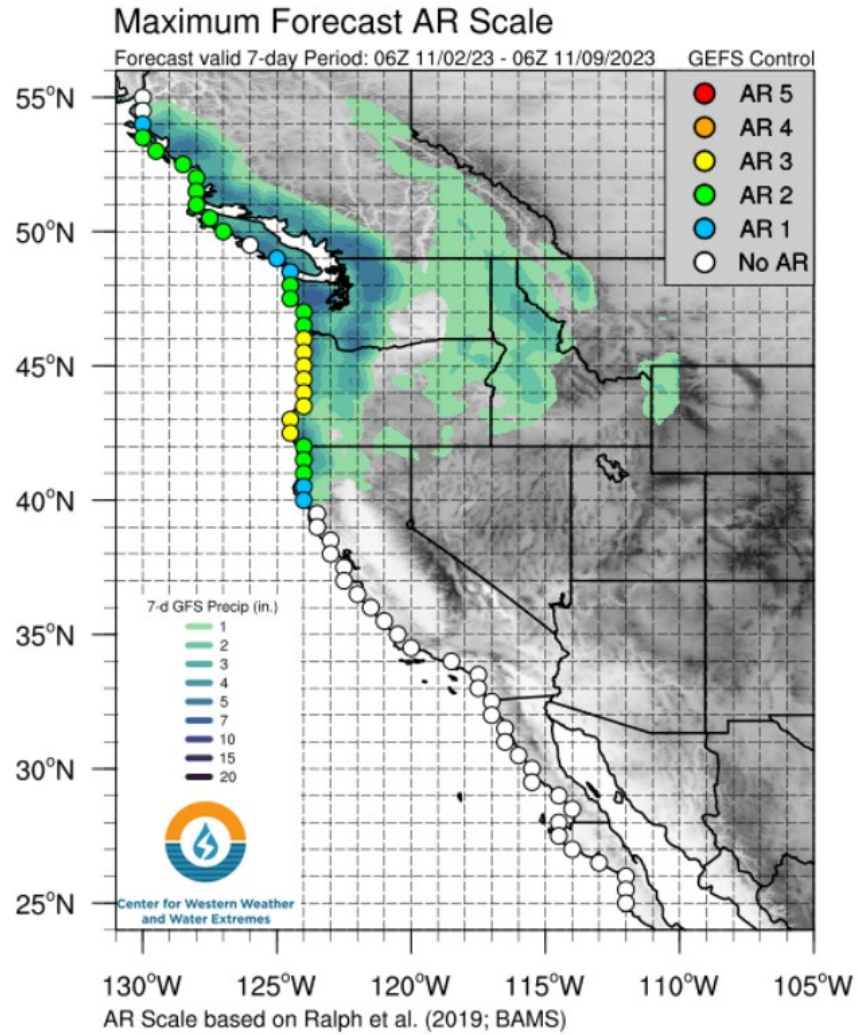
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

California WATER WATCH

Atmospheric river landfall probability and scale forecast

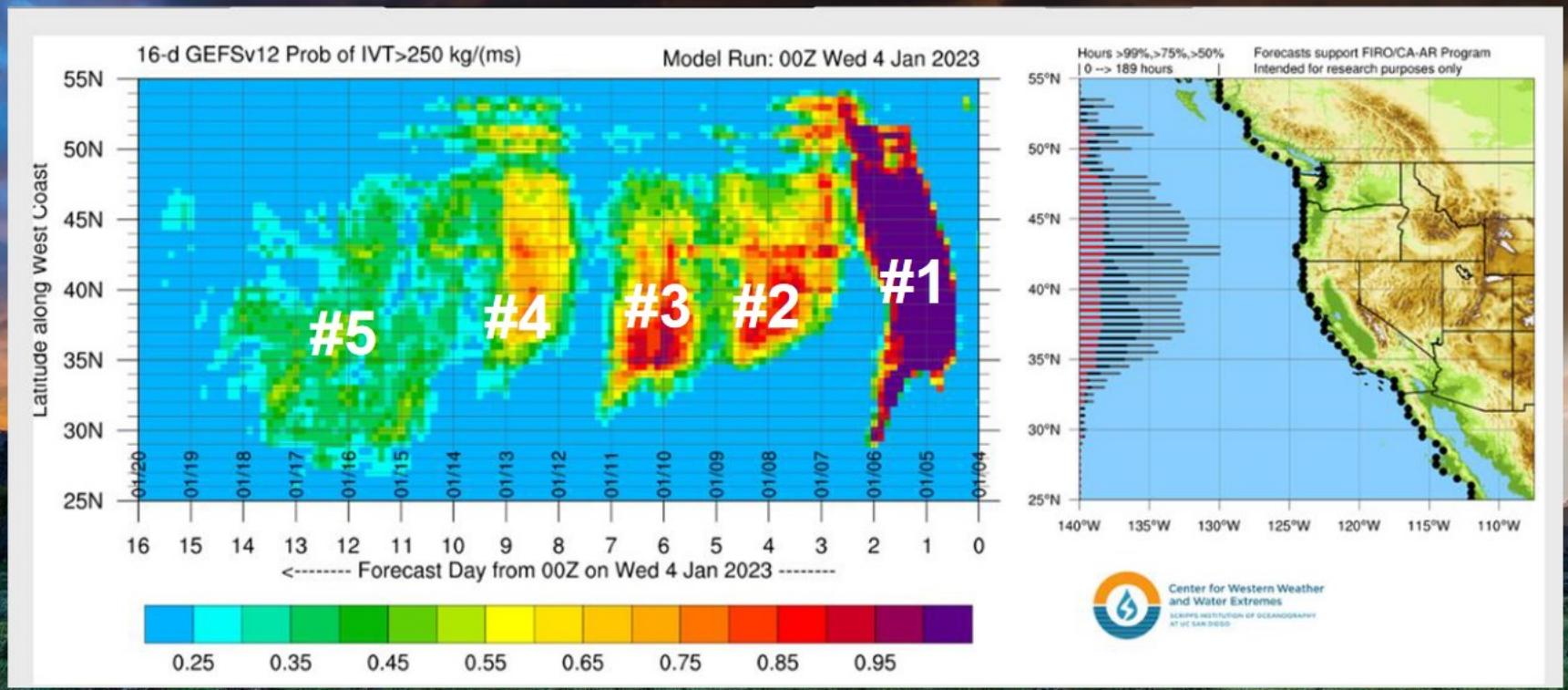




Series of atmospheric rivers

Next 10 days for January 5 to 16

Weather Forecast Office
San Diego, CA
Wednesday, January 4



Atmospheric River #1

January 4-5, 2022

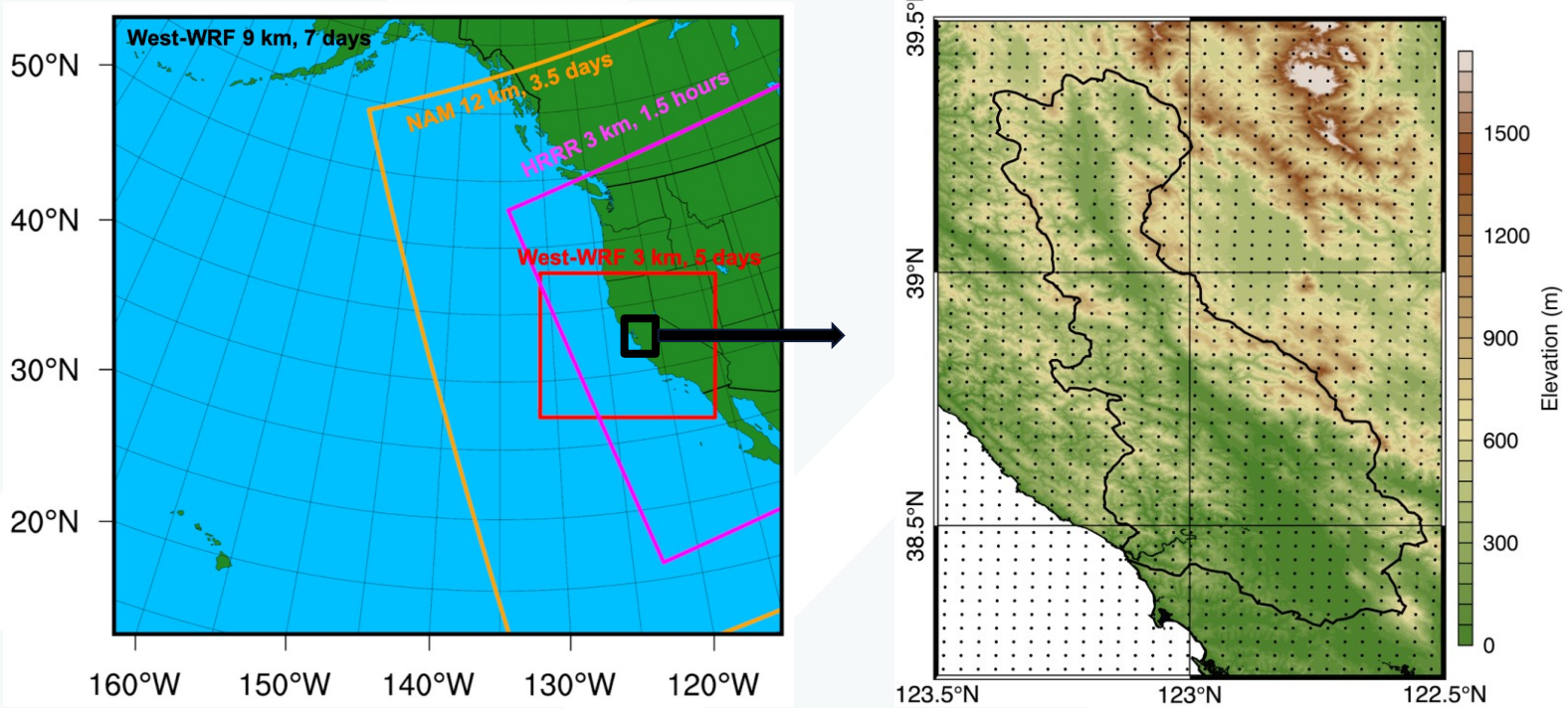
Weather Forecast Office
San Diego, CA
Wednesday, January 4

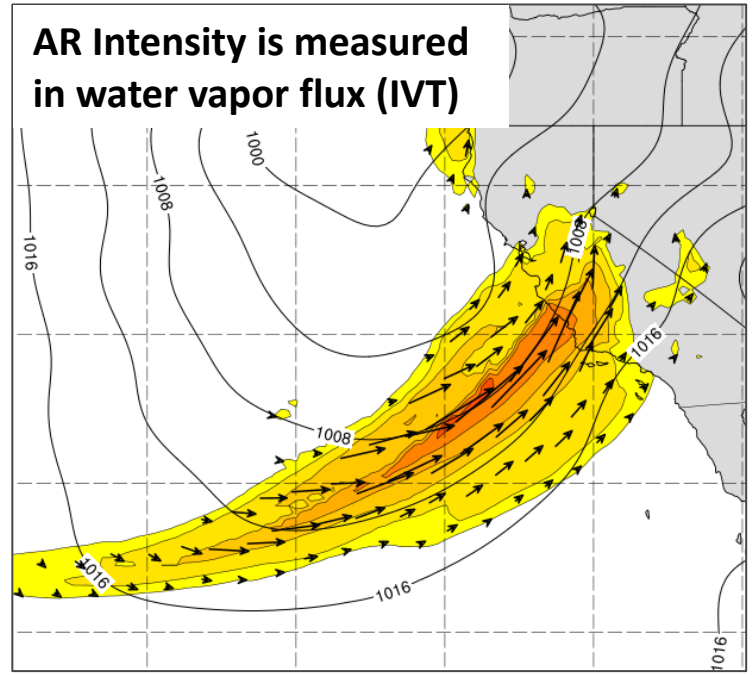
Approaching AR tonight

CW3E's WEST-WRF: Tailored specifically to best predict ARs; Identifies and Reduces AR and Precipitation Forecast Error

Accomplishments:

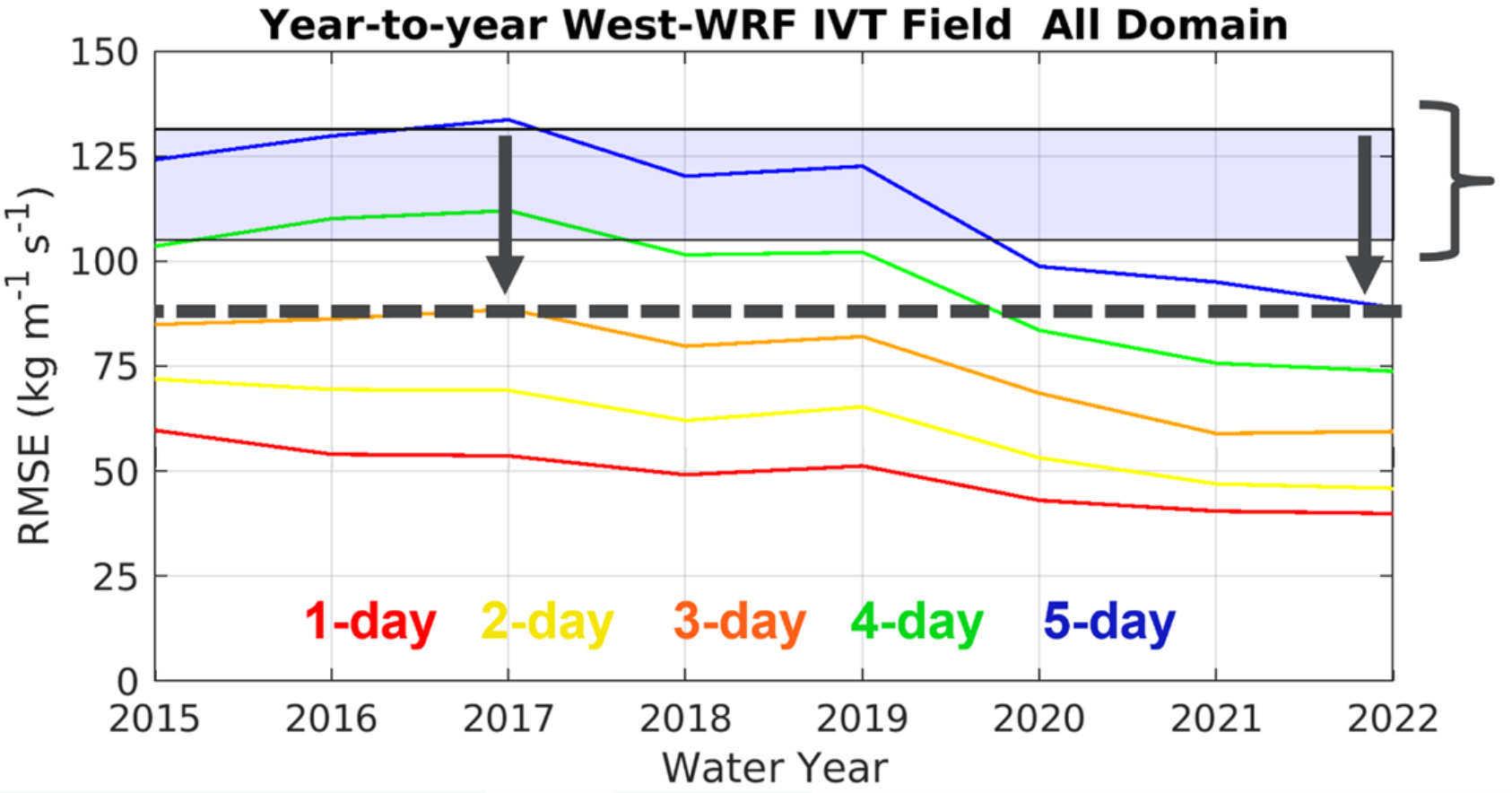
- Demonstrated improved AR forecast skill (DeHann et al., 2021) over the last 5 winters
- West-WRF has been used in real time by many Water Agencies, and for AR Recon.





Caption: (left) WestWRF outer 9km and inner 3km resolution domains compared to operational regional models and (right) an example of 3km resolution compared (dots) compared to 50km resolution in global ensemble systems (line grid) over the Russian River watershed's topography (shading).

WEATHER RESEARCH AND FORECASTING FOR THE WEST (WEST-WRF) MODEL IMPROVEMENTS OVER THE YEARS



WY2022 RMSE is lower than the minimum value found in the 30+year West-WRF Reforecast

5-day forecasted errors are as good as 3-day forecasts pre-WY2018 (~35% reduction)

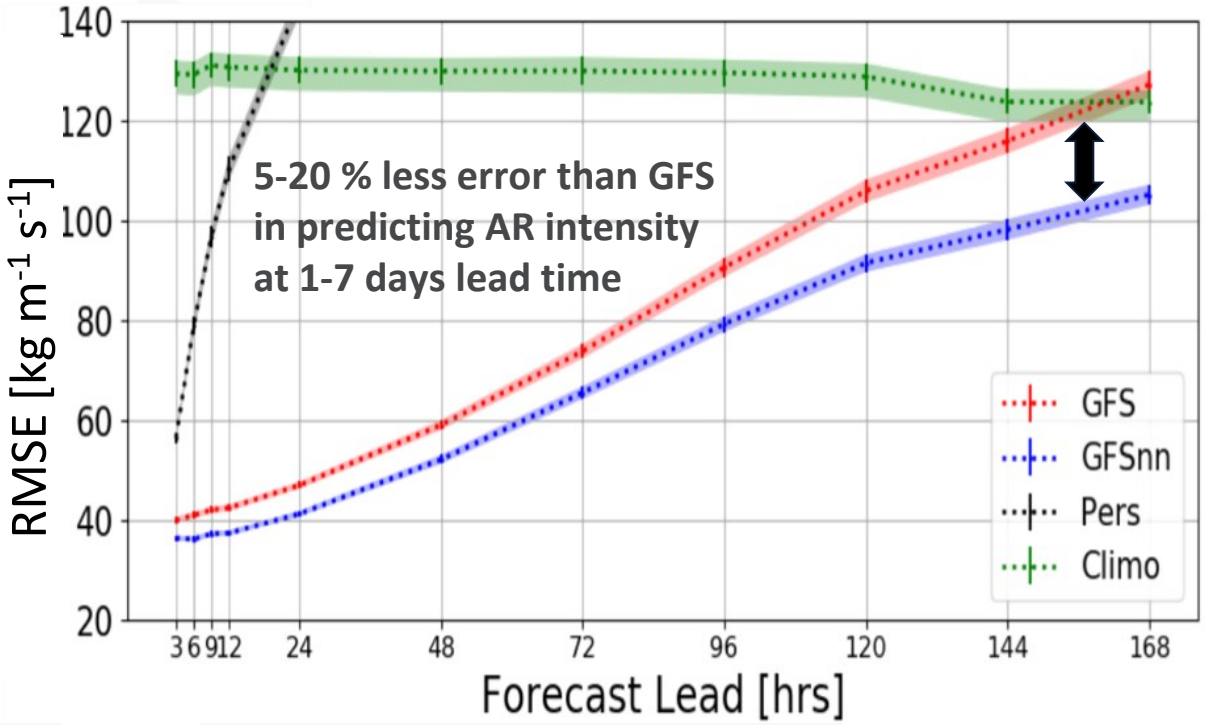
Shaded area represents min/max RMSE from 30-year West-WRF 5-day reforecast

Highlights the importance of improving resolution and physics packages in West-WRF, as well initial conditions in parent global models via AR Recon

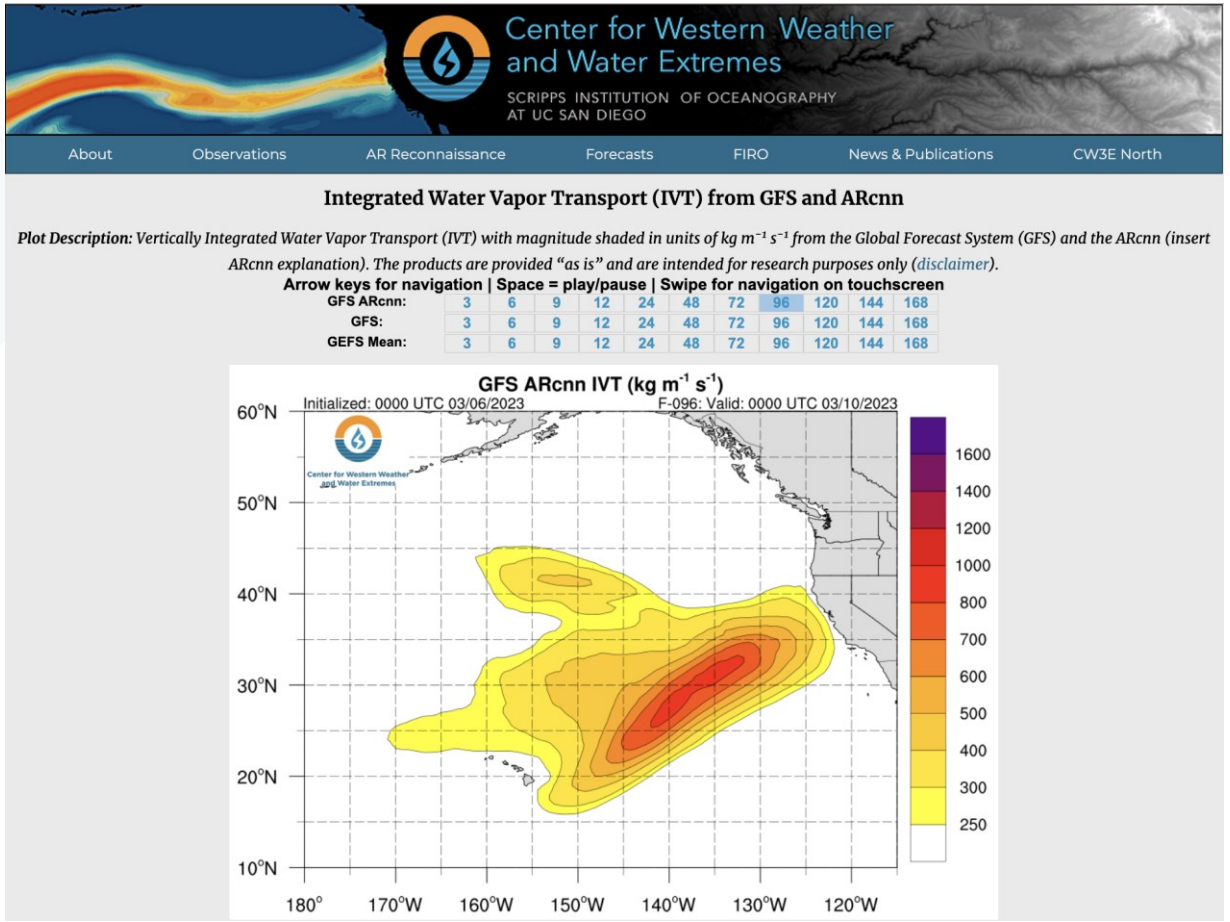
Lead (on verification)
Rachel Weihs (CW3E)

Research is improving the skill of predicting ARs

Using Machine Learning to Improve Forecasts



- ML Method: Convolutional Neural Network
- 0-168 h IVT Predictions
- Training: 10 years of GFS (Oct 2008 – Apr 2016)
- Testing: 1 Year (Oct 2017 – Apr 2018)
- Ground-truth: MERRA 2



https://cw3e.ucsd.edu/arcnn_ivt/

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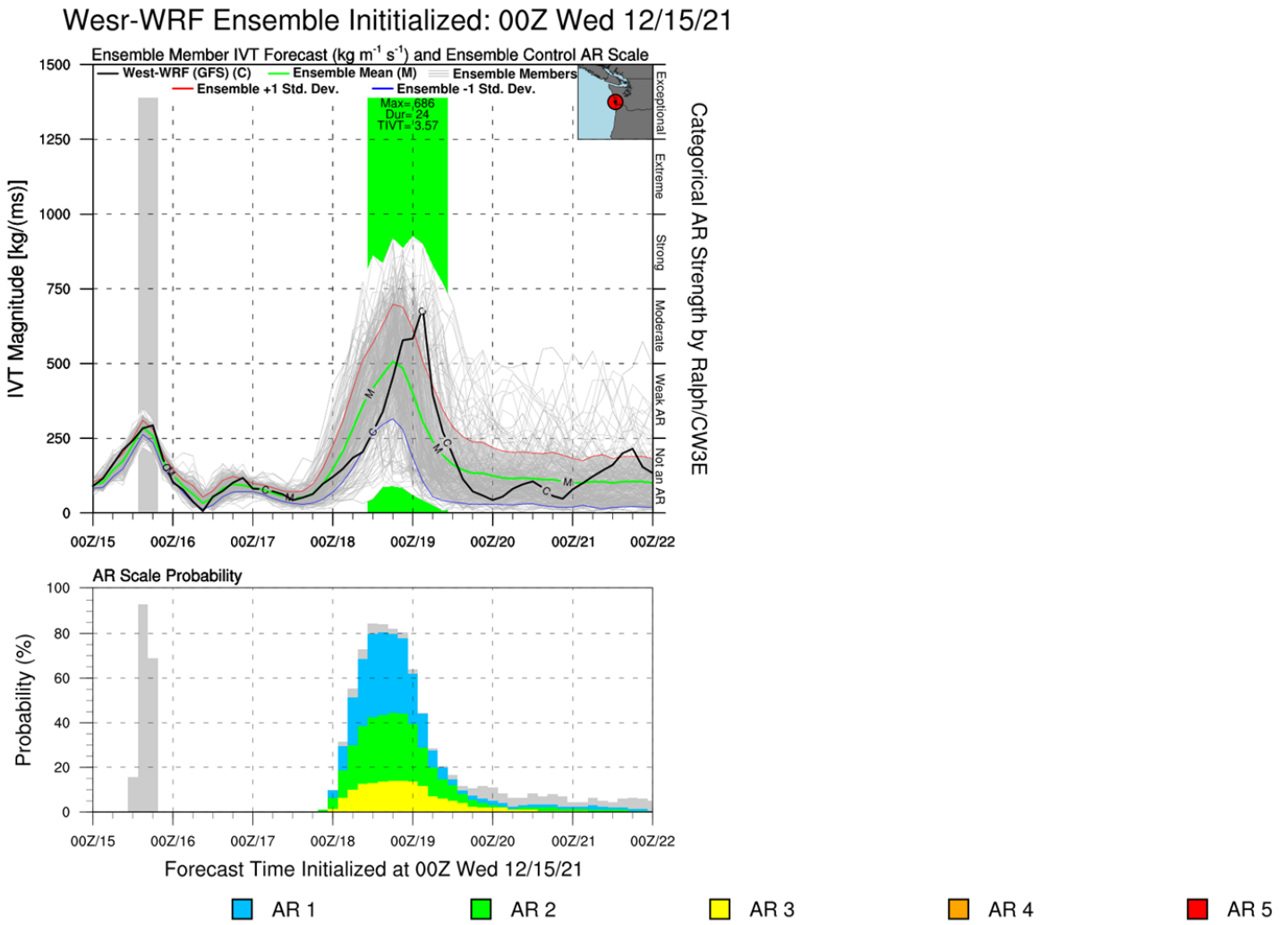
Chapman et al. (2019, 2022)

Development of a 200-member Operational Forecast Ensemble

CW3E is running a 9-km 200-member West-WRF ensemble for this year's wet-season near real-time forecast.

Objectives:

1. Increase skill of predicting the timing and magnitude of extreme events associated with atmospheric rivers
2. Enhance statistical sampling of key sources of forecast uncertainty (e.g. initial and boundary conditions, physics)
3. Improve overall quality of probabilistic predictions

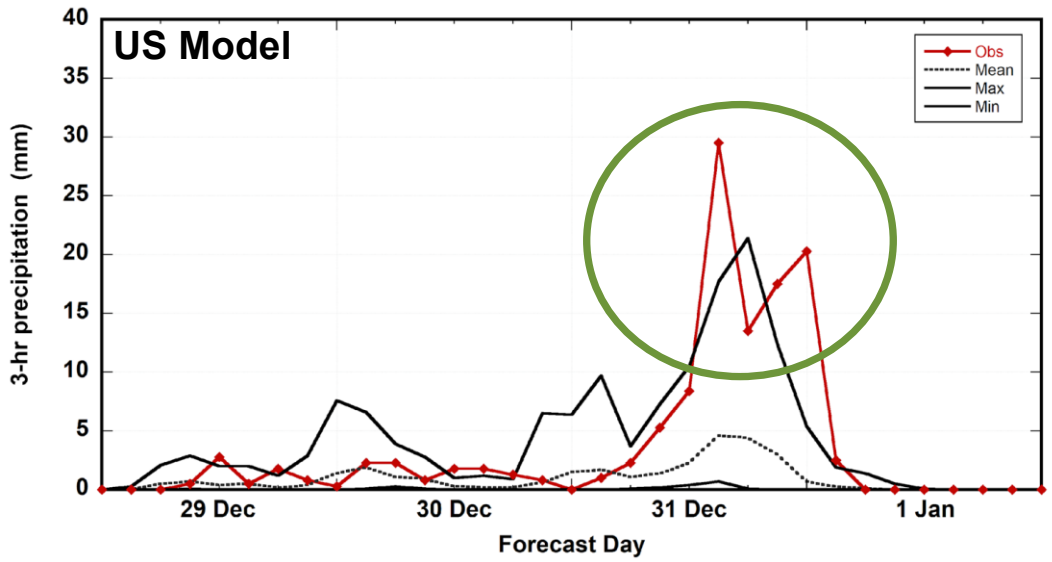


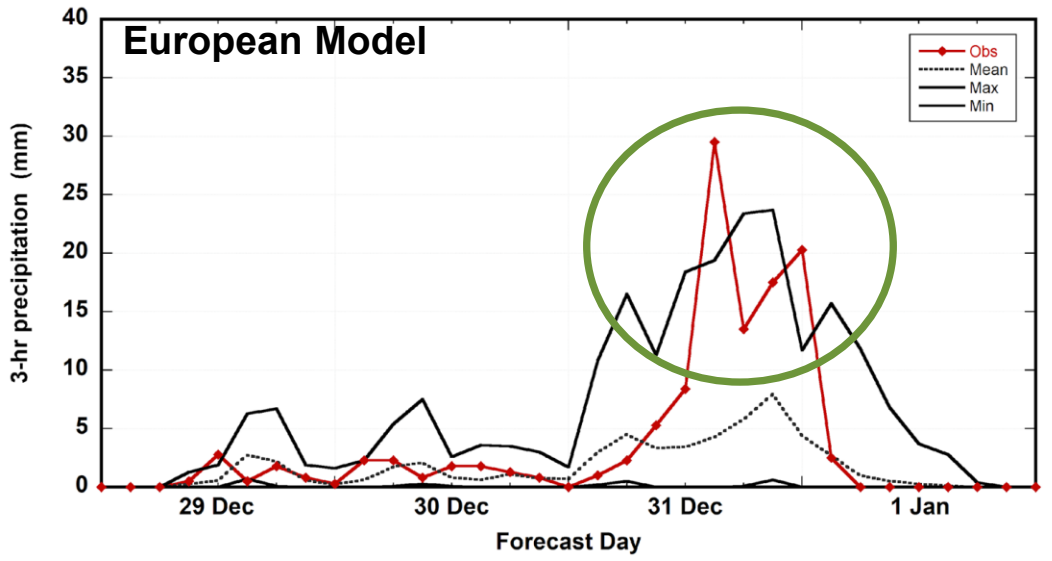
AR Scale based on Ralph et al. (2019)

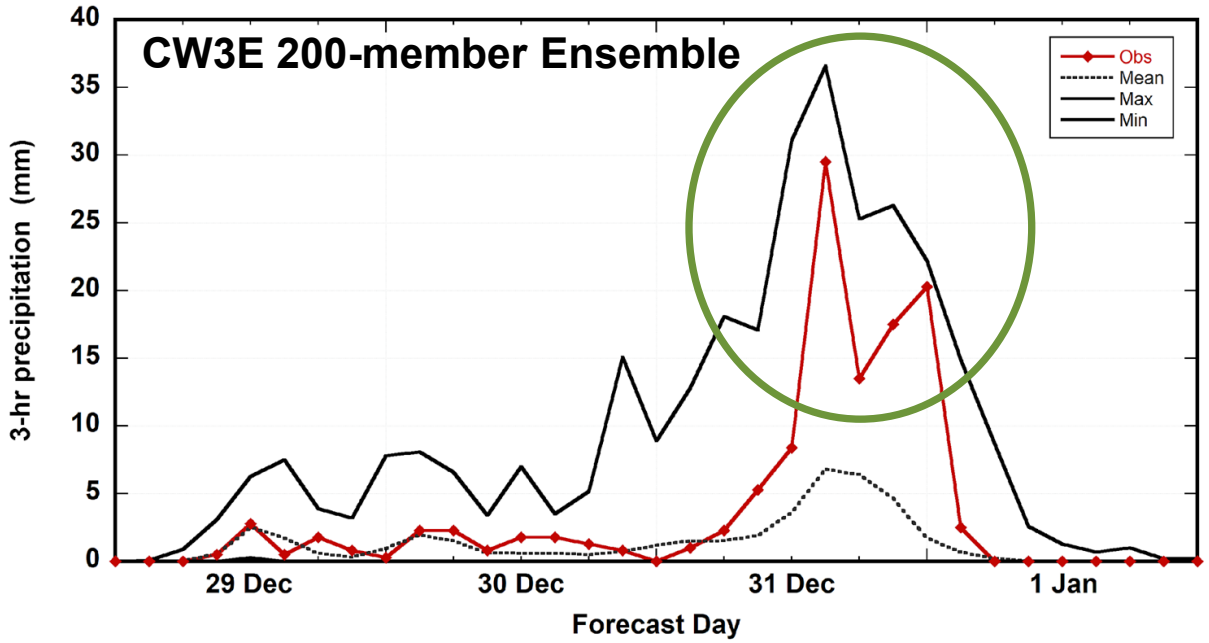
Core hours / Storage: 15M SUs / 1.9 PB

Center for Western Weather and Water Extremes

PRECIPITATION PREDICTIONS (San Francisco, CA):
West-WRF 200-member ensemble enhance spread of GEFS and ECMWF Ensembles

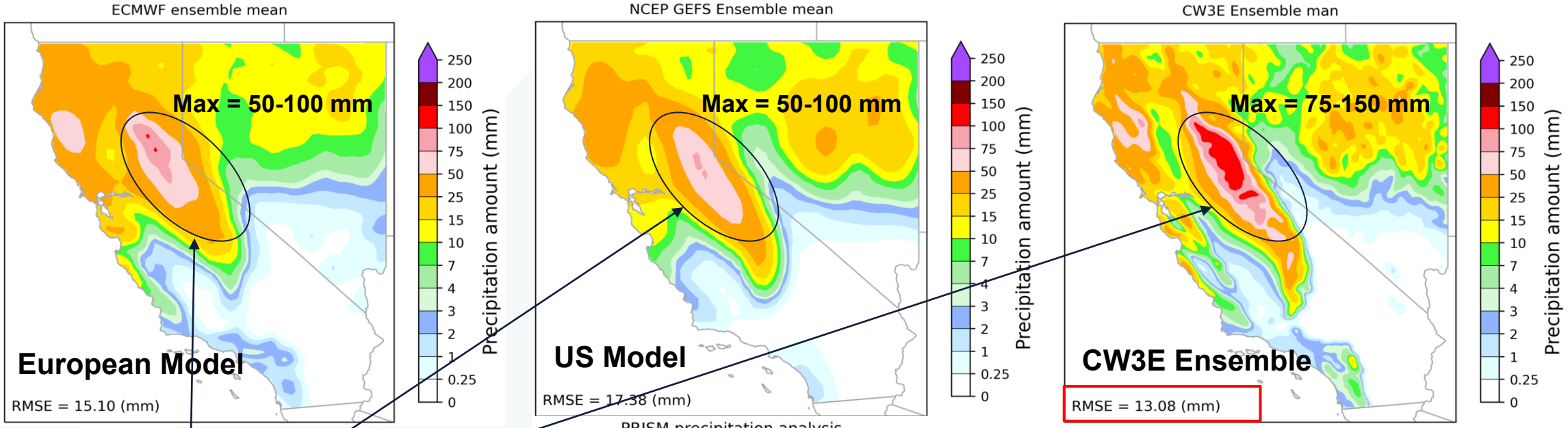






- The GEFS and ECMWF forecast ensemble spread fails to capture the heaviest storm rain rate on December 31st, 2022
- West-WRF generates considerably more ensemble spread during the period of highest rain rates
- West-WRF ensemble spread captures all precipitation observations
- The West-WRF 200-member ensemble provides value by better capturing the likelihood of extreme precipitation

NEW YEAR's DAY 2023 Atmospheric River
Three Days in Advance Ensemble Mean Predictions of 24-h Accumulated Precipitation



CW3E Ensemble is much closer to the observed precipitation amounts, particularly over the Northern Sierras

Root Mean Square Error (RMSE)
The lower the better

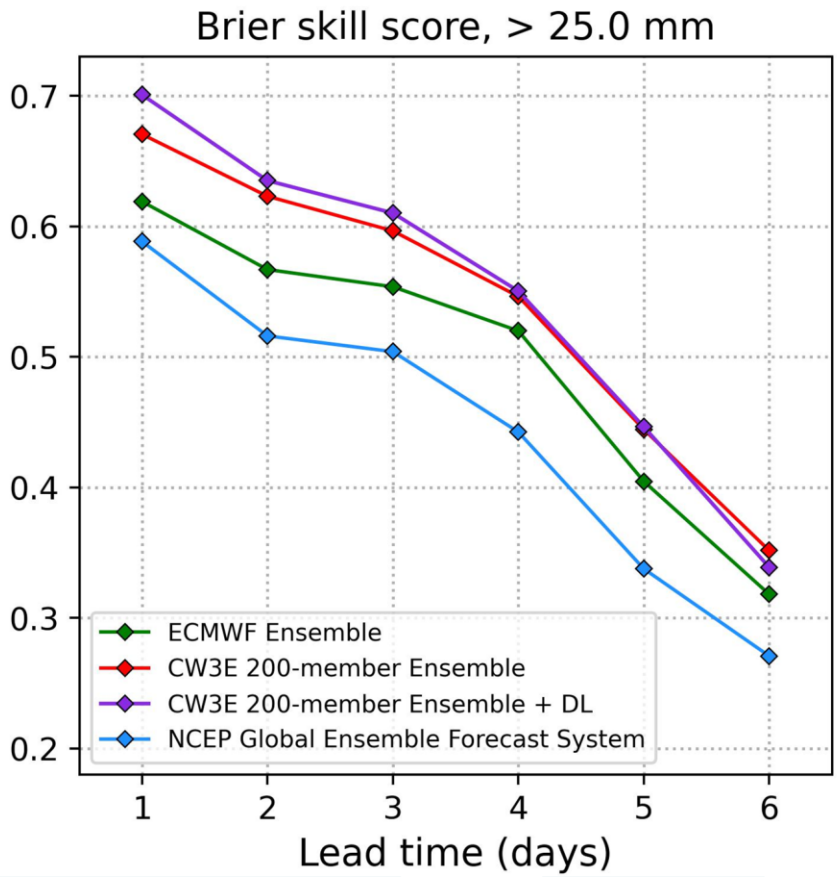
Center for Western Weather and Water Extremes

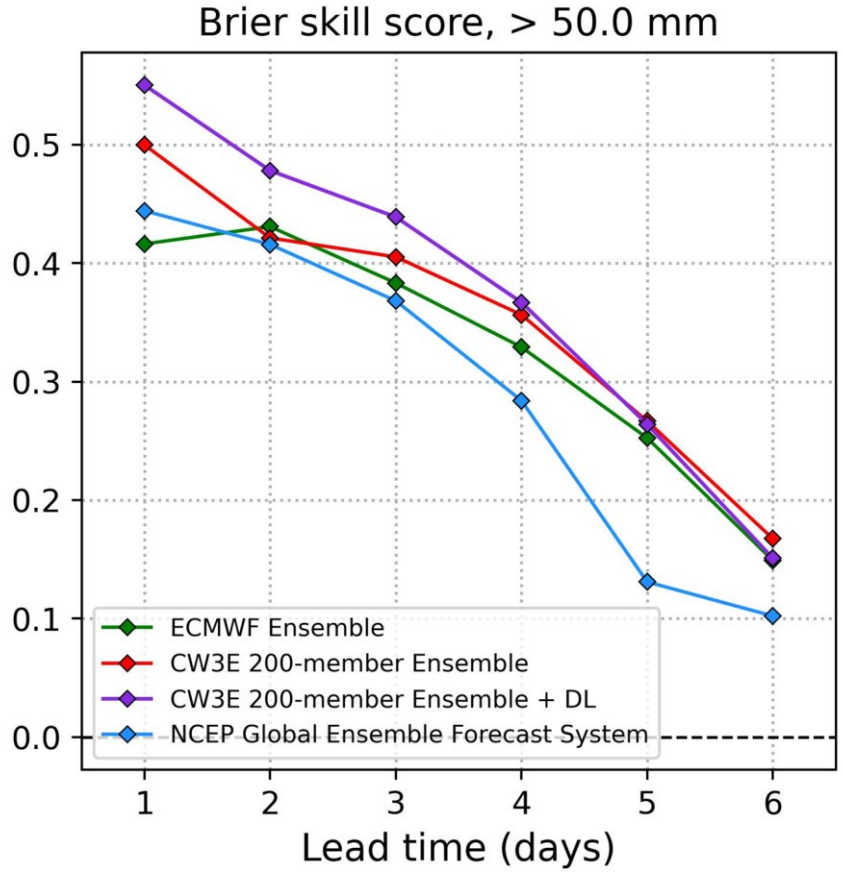
CW3E's WEST-WRF 200-MEMBER ENSEMBLE + DEEP LEARNING

Performance for 25 Dec 22 – 18 Jan 23 for the family of 9 ARs (California)

Ability to Predict Heavy to Extreme Rainfall

Higher values represent better skill



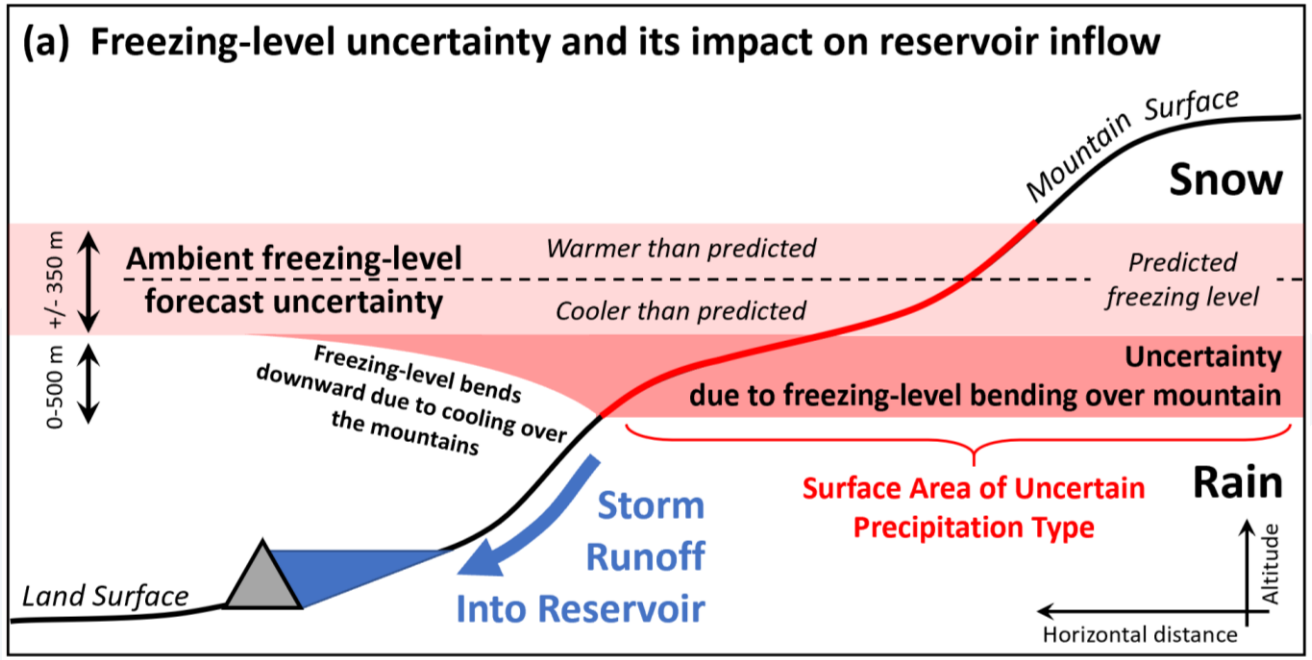


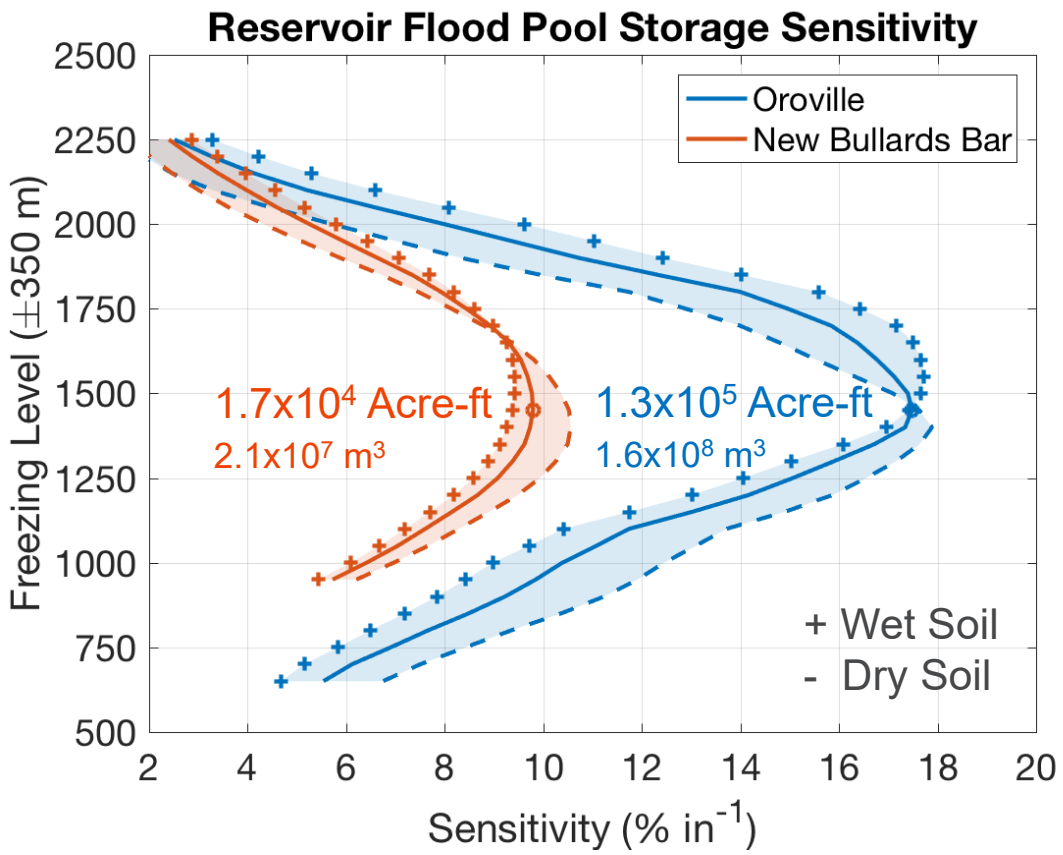
- **West-WRF 200-member ensemble** leverages the **Global Ensemble Forecast System (GEFS)** and improves its predictions at all lead times
- **West-WRF 200-member ensemble** leverages **ECMWF ensemble** and improves its predictions from Day 1 to Day 4
- **Deep learning** further improve the 200-member ensemble skill from Day 1 to Day 4

Center for Western Weather and Water Extremes

Ghazvinian et al. (2023, in preparation)

QUANTIFYING RESERVOIR FLOOD POOL SENSITIVITY TO FREEZING LEVEL FORECAST UNCERTAINTY





% of Reservoir Flood Pool Volume for an Inch of precip

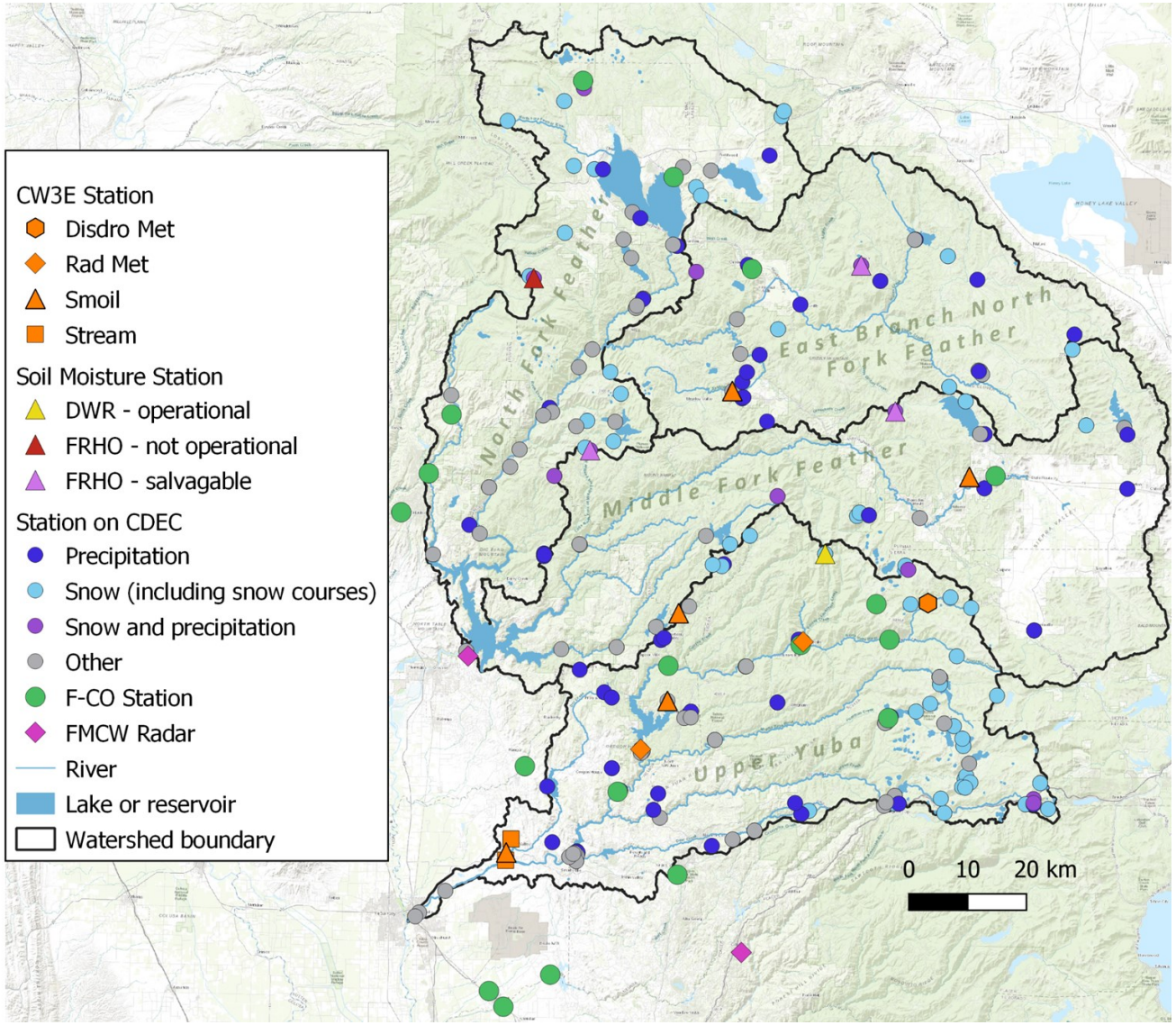
For example, for a freezing level of 1500 m and 1-inch mean areal precip. over Feather R. watershed, a freezing level forecast uncertainty of ±350 m alone corresponds to as much as 17% of Lake Oroville's flood pool.

Sumargo, E., F. Cannon, F. M. Ralph, and B. Henn, 2020. Freezing level forecast error can consume reservoir flood control storage: Potentials for Lake Oroville and New Bullards Bar reservoirs in California. *Water Resources Research*, **56.**

Enhanced Observations for Situational Understanding

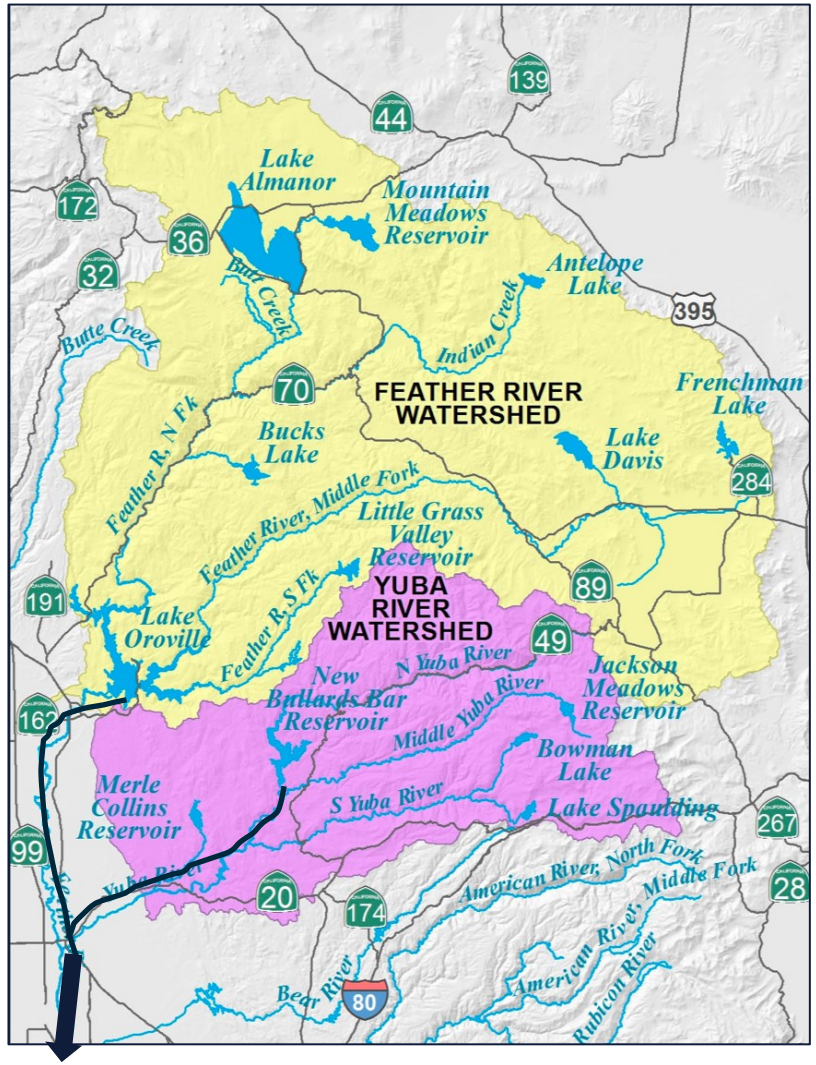
*FIRO is **coordinating** and **enhancing** to the observational network in the Yuba-Feather*

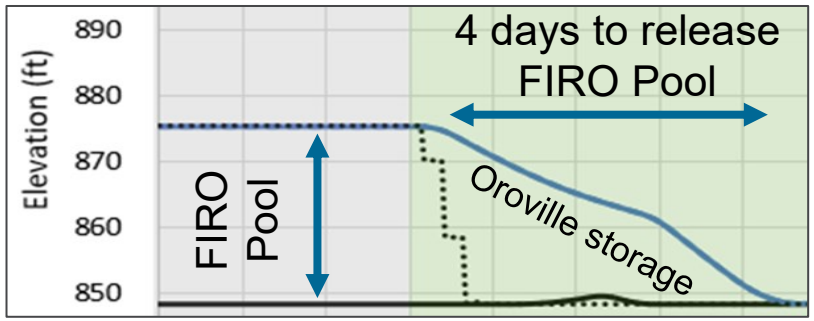
- FIRO effort is ensuring observations are available to help inform reservoir operations.
- Observations are used to improve forecasting
  - Improve data that is used to run the models (initial conditions)
  - Verify the models to understand biases and errors
- AR Program, sponsored by CA DWR, is rehabilitating Feather River Hydrologic Observatory (FRHO), stations that were damaged during the Dixie Fire



Center for Western Weather and Water Extremes

Forecast Lead Times Relevant for FIRO in the Yuba/Feather



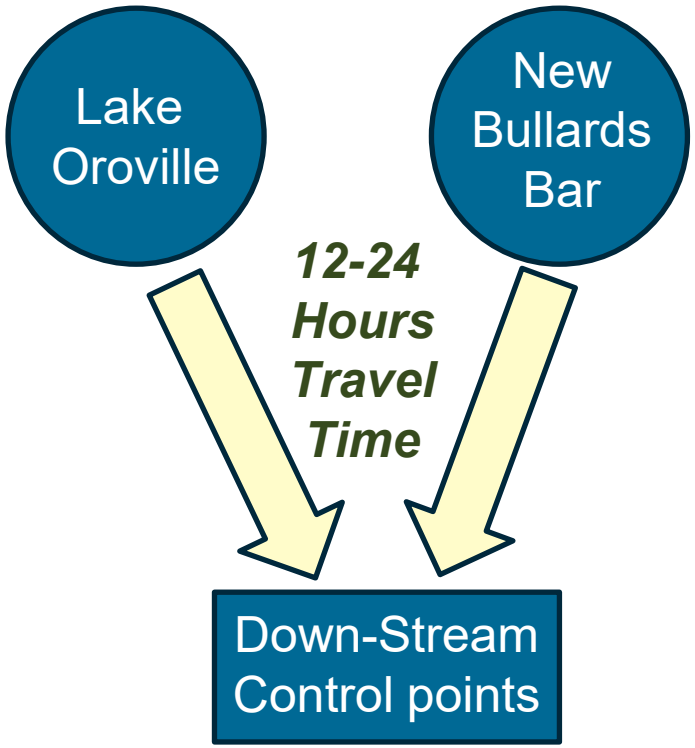


Bottom Line

4 days to release the FIRO Pool

Plus ½ to 1 day travel time forthe back edge of released water to pass downstream control points

Accurate 5-day forecasts are needed to evacuate FIRO water ahead of an AR on the Yuba-Feather system



Center for Western Weather and Water Extremes

FIRO Engineering Progress

- Support for the Corps update of the Water Control Manuals
- Management strategies for NBB and ORO that explicitly leverage forecasts in release decisions
  - Established approaches (ala Folsom)
  - Experimental approaches that more fully exploit forecast information
- System operations that accommodate the uncertainty in side-flows below the dams
- Assessing potential benefits to downstream locations
- Identifying limitations in existing Corps reservoir management software (ResSim), e.g., involving use of forecasts and FIRO space
- Evaluating potential operations with scaled-up versions of the 1986 and 1997 events

Scientific American (2022)
by F. Martin Ralph

METEOROLOGY

FORECASTING ATMOSPHERIC RIVERS

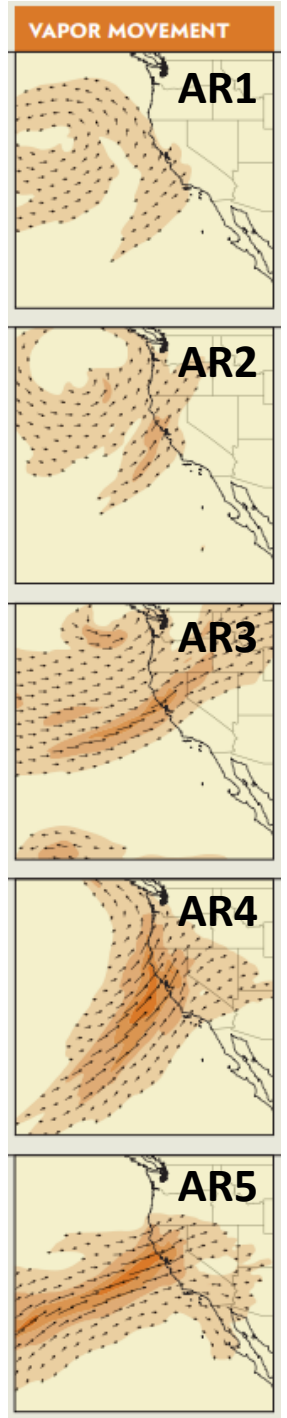
Knowing when torrents of rain will strike can save property and lives

By F. Martin Ralph

Illustration by Mark Ross

THANK YOU

Contact: mralph@ucsd.edu
Website: CW3E.ucsd.edu



AR Scale(examples)

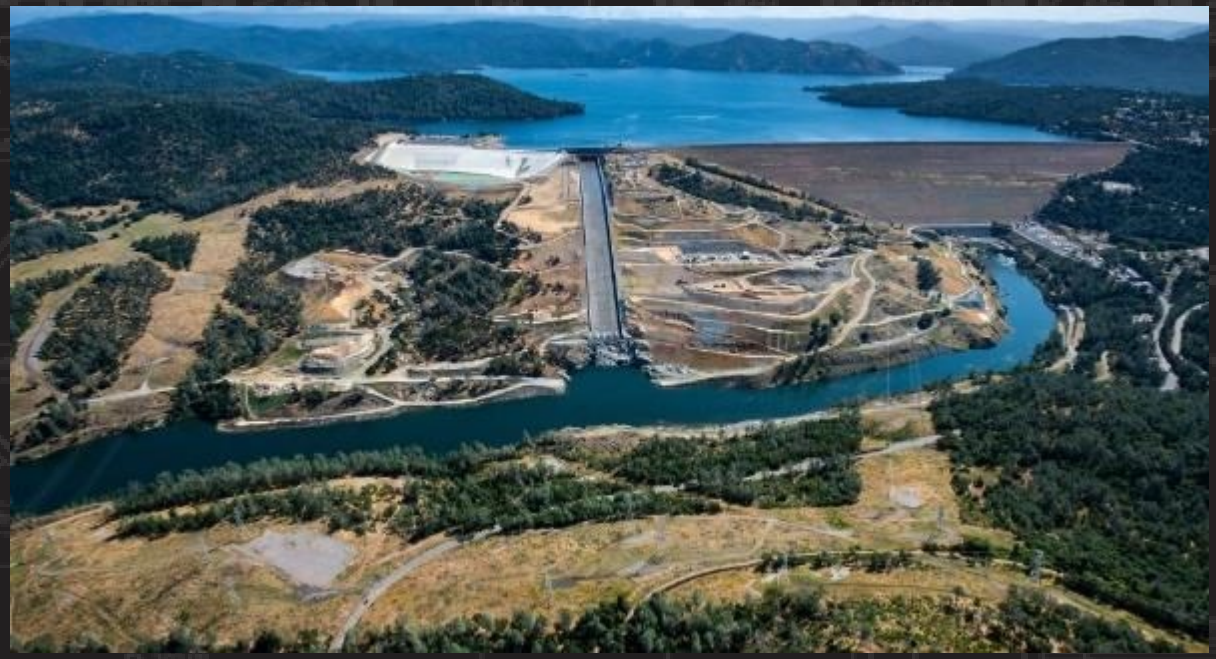
ITEM 3

WATER CONTROL MANUAL UPDATE AND DEVELOPMENT PROCESS

NEW BULLARDS BAR DAM - OROVILLE DAM WCM UPDATES

Jenny Fromm, P.E.
Chief, Water Management
Sacramento District

Oroville Citizens Advisory Committee Meeting



Date: 15 NOV 2023

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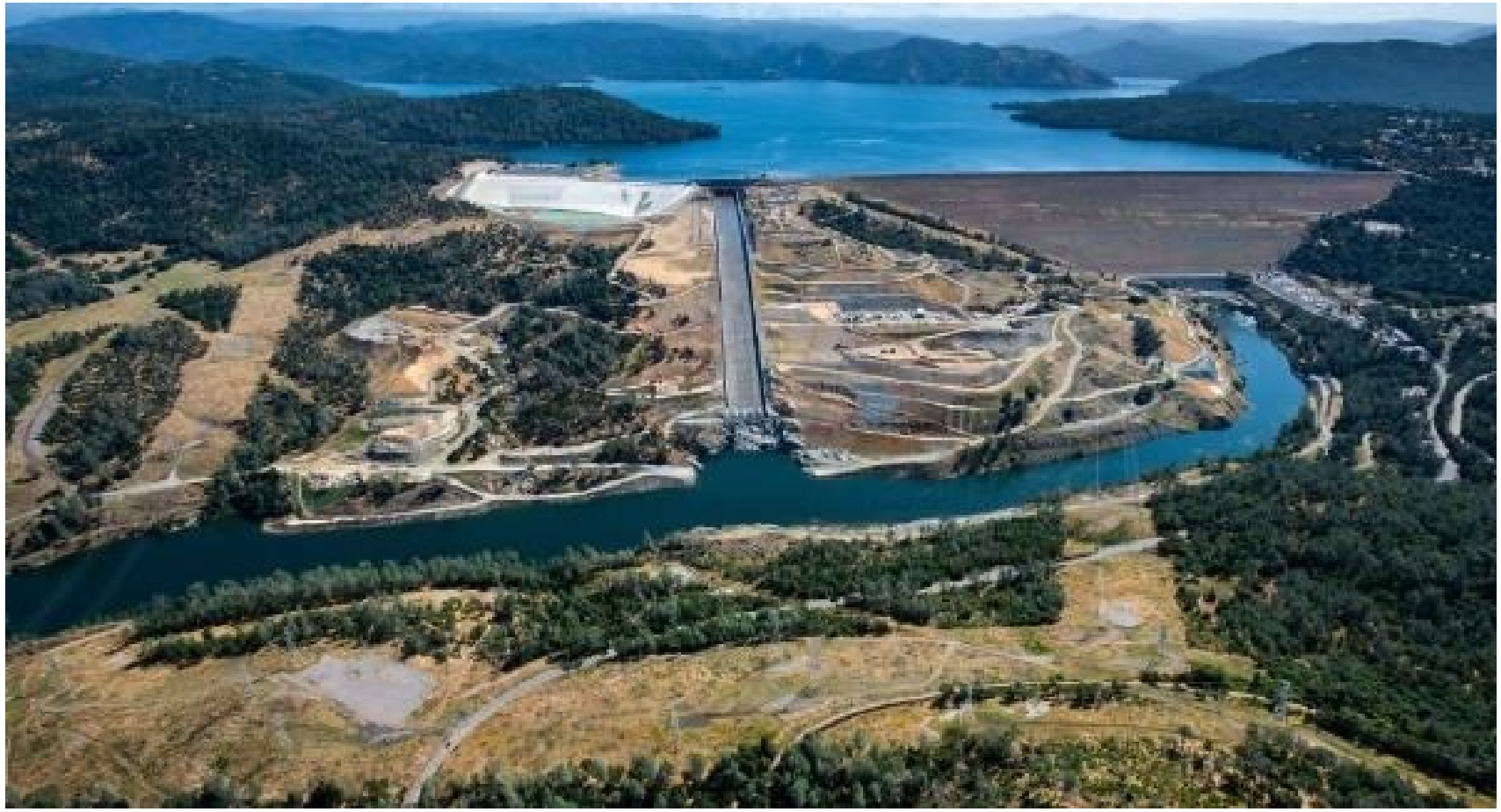
AGENDA

- WCM Update Progress
- Objectives for New Bullards Bar and Oroville Dam WCM Updates
- FIRO/WCM Updates Alignment
- WCM Updates Schedule
- Questions



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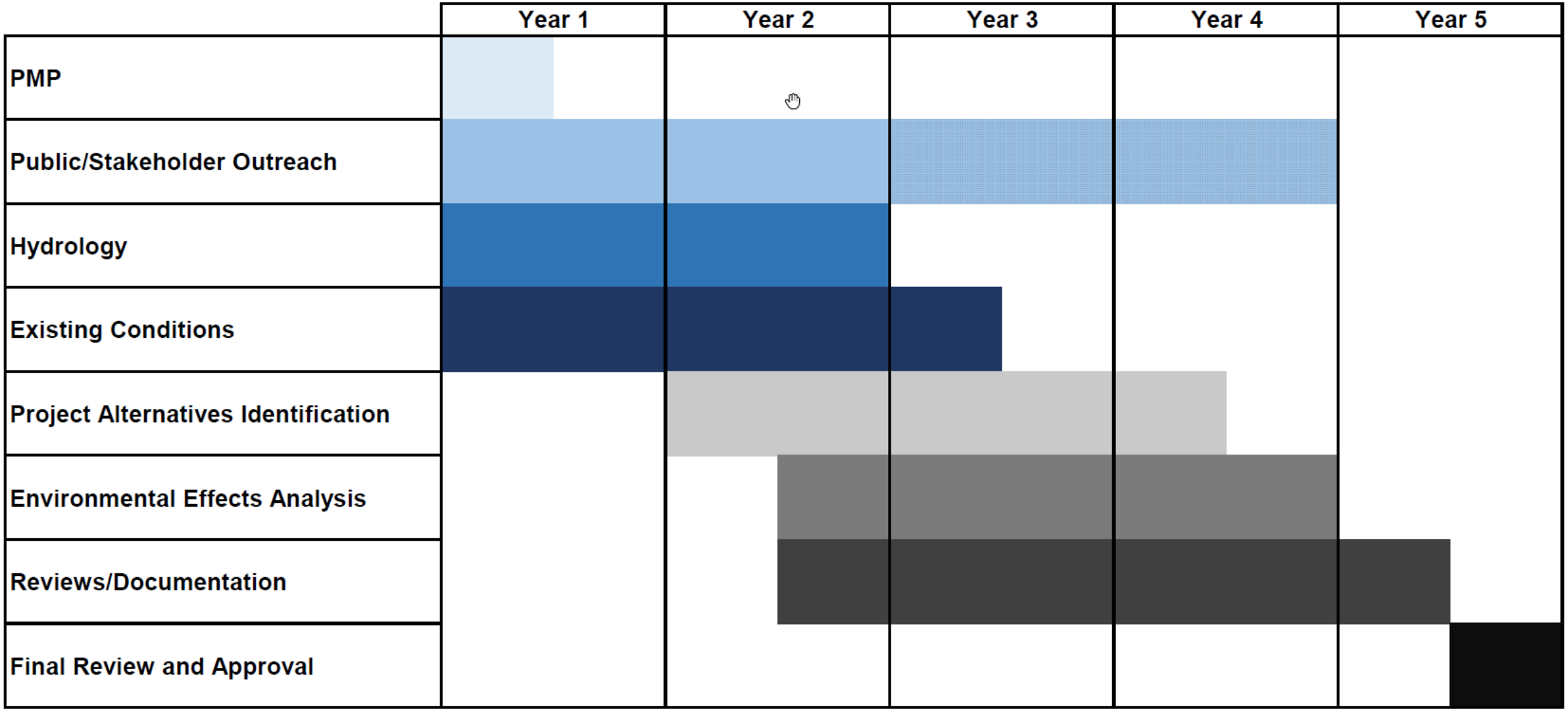
SIMPLIFIED WCM UPDATE PROCESS



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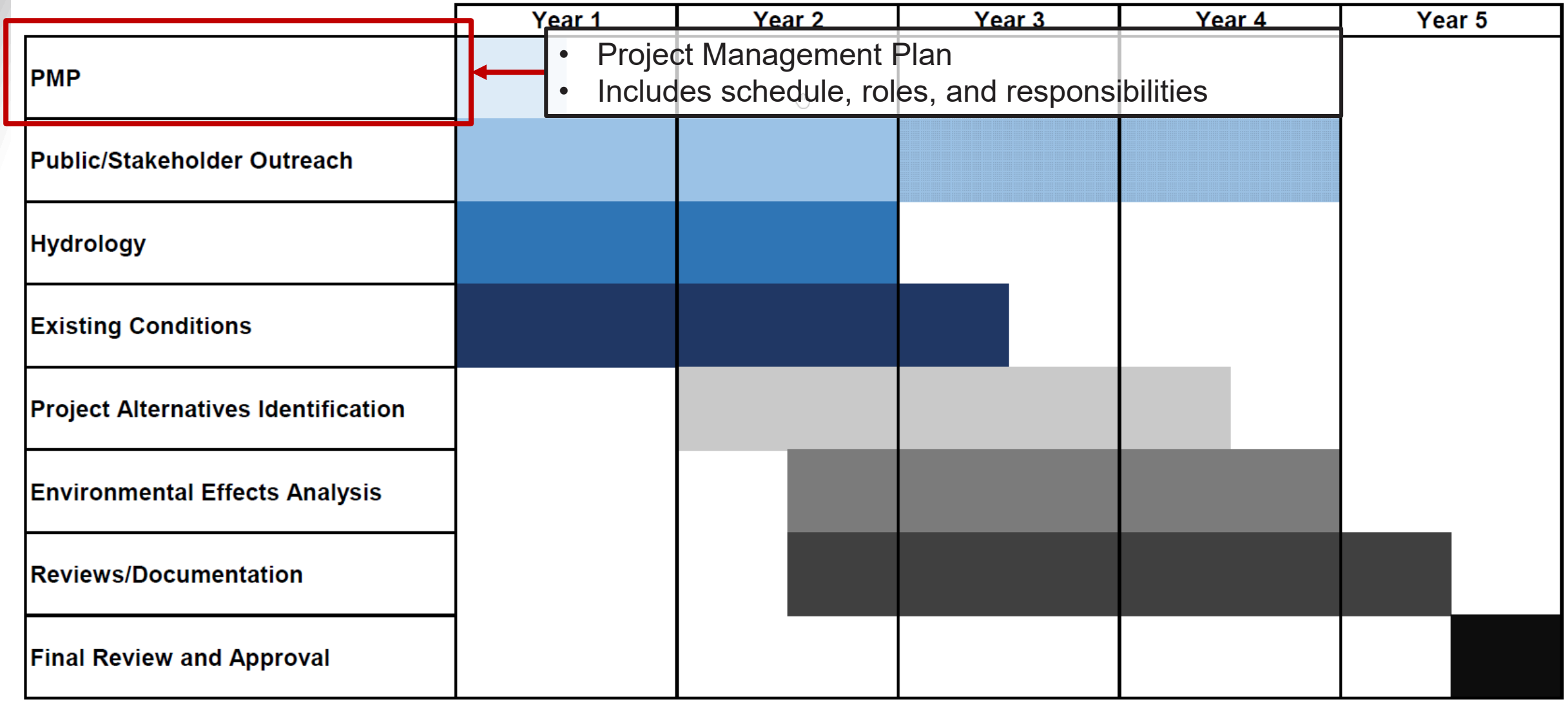

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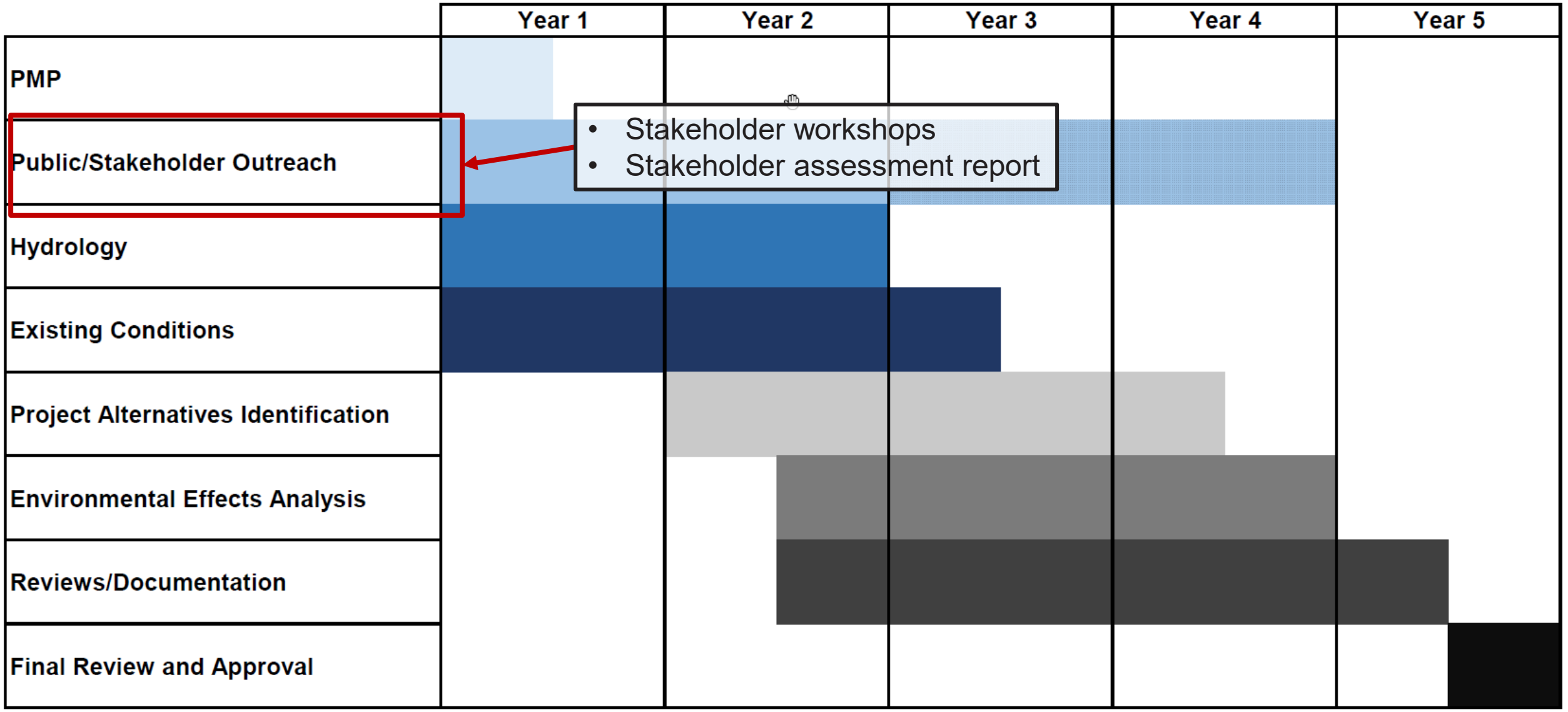

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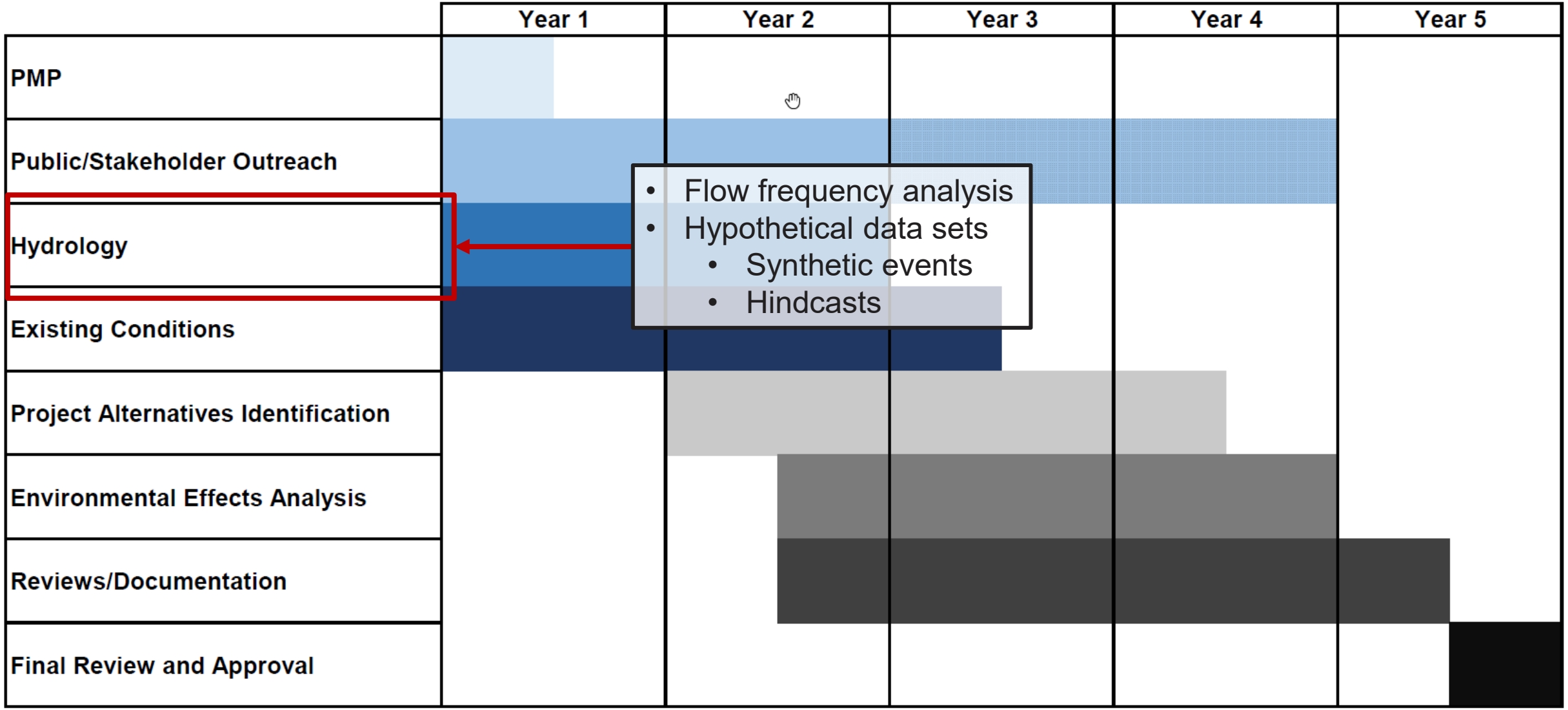

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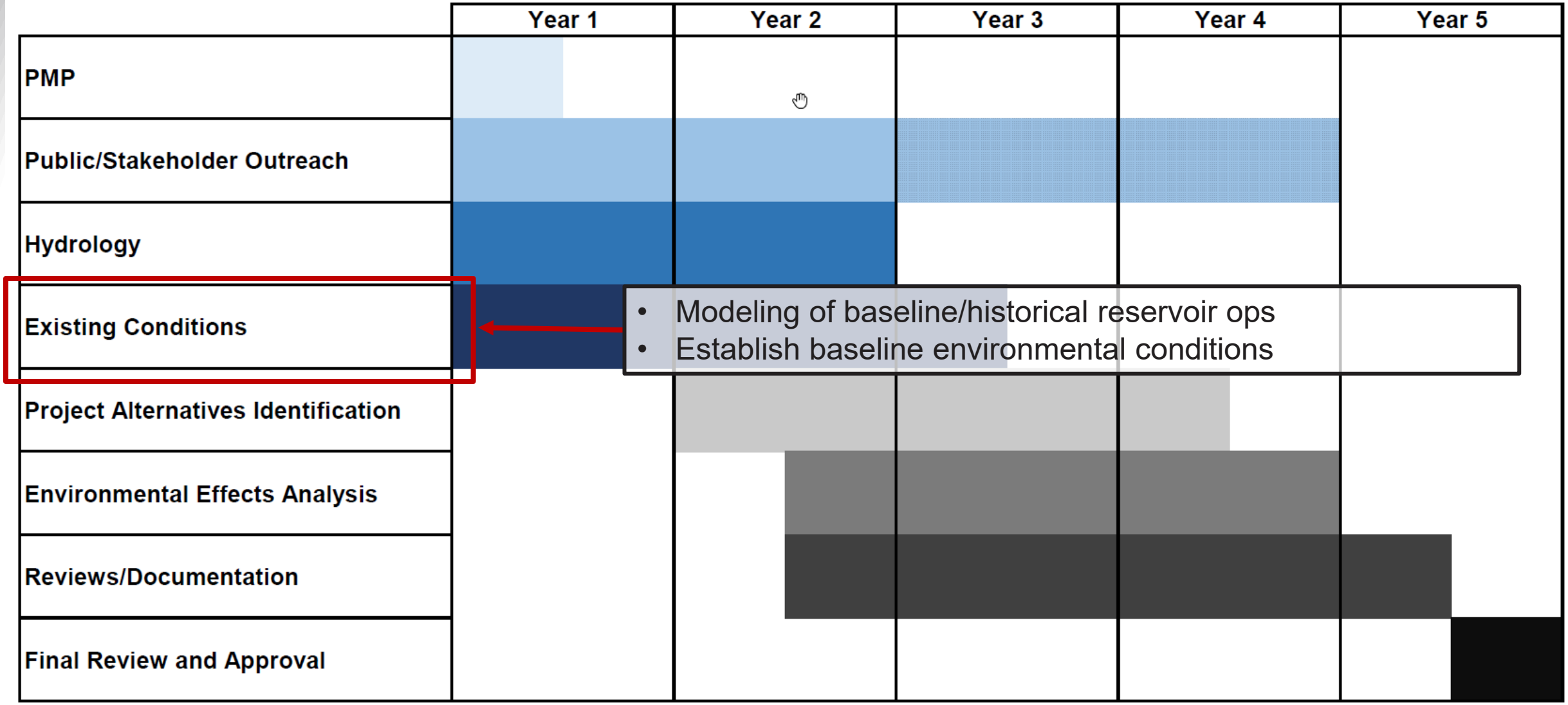

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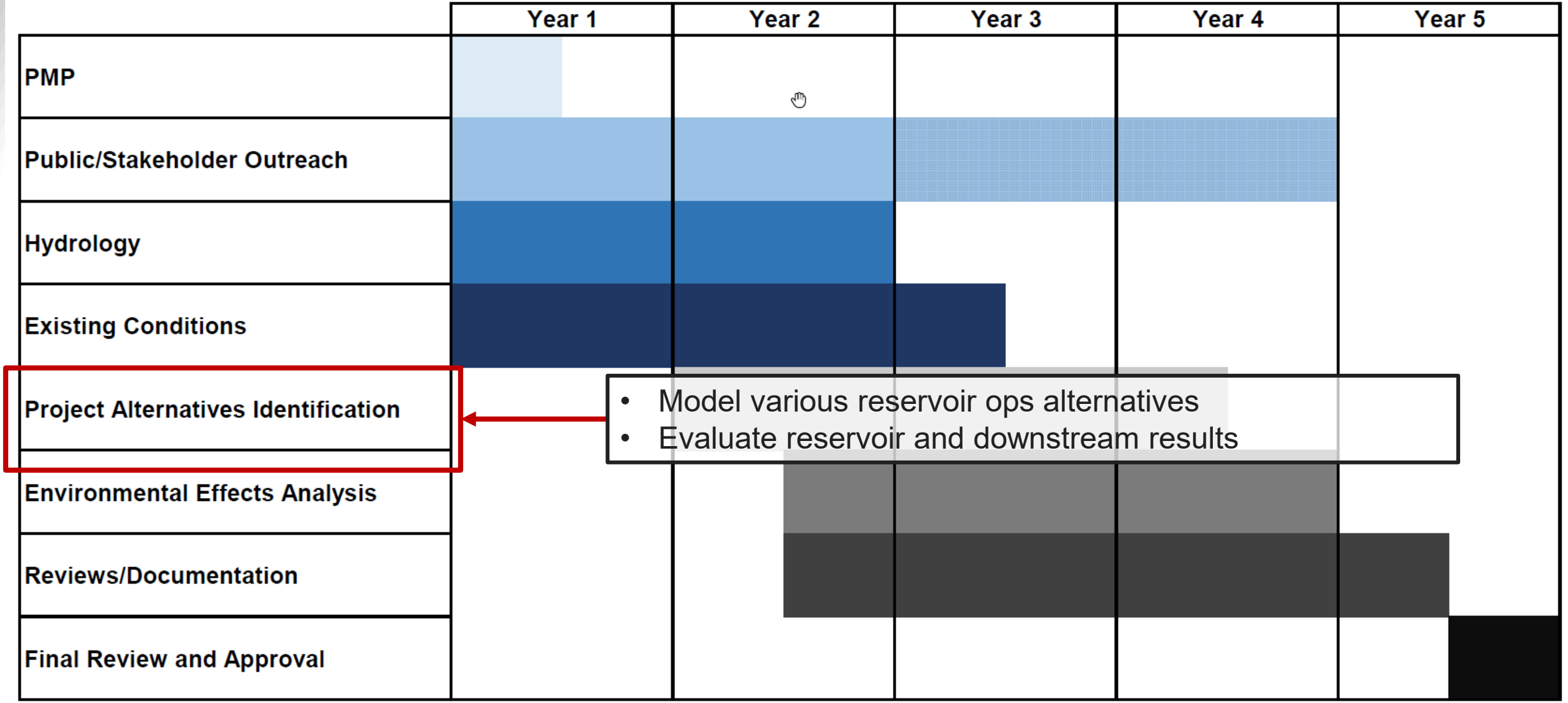

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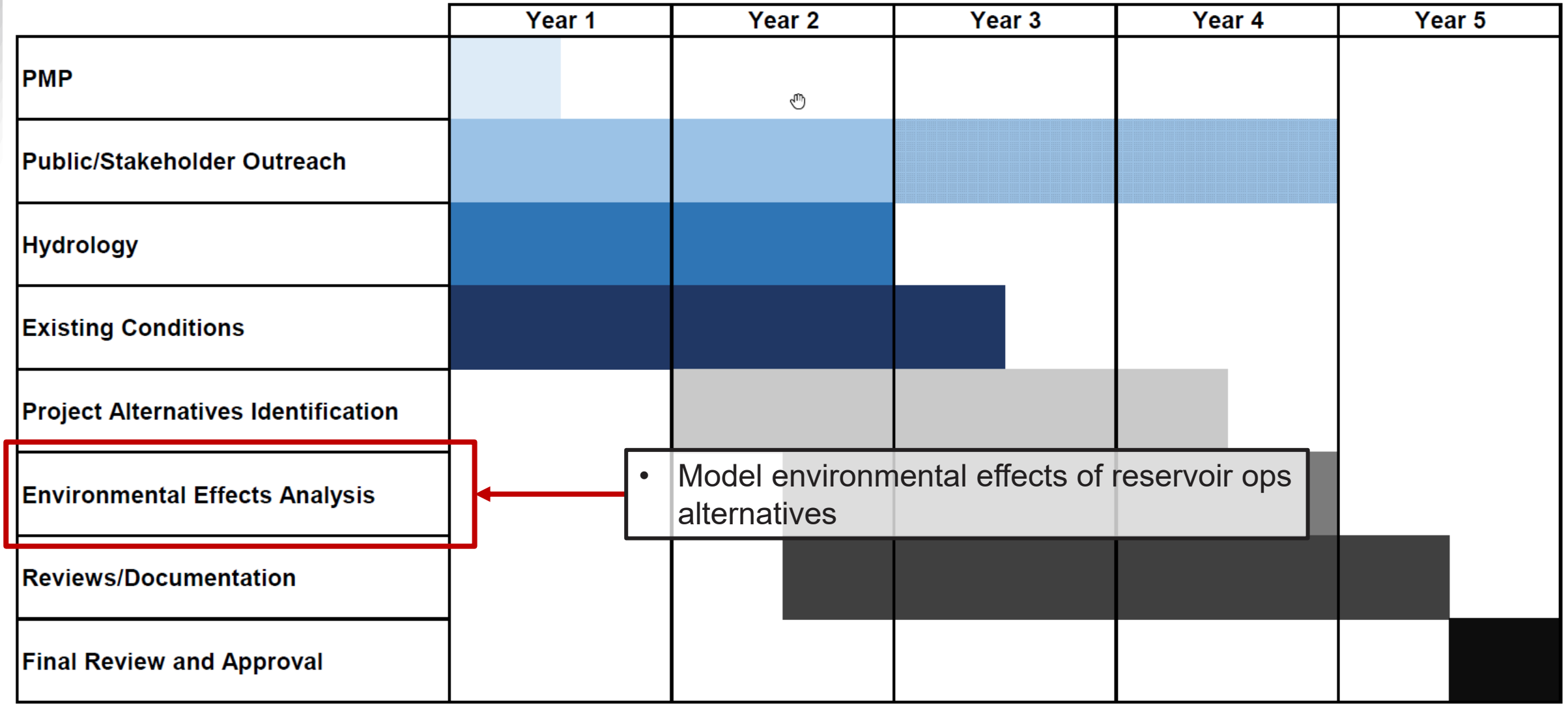

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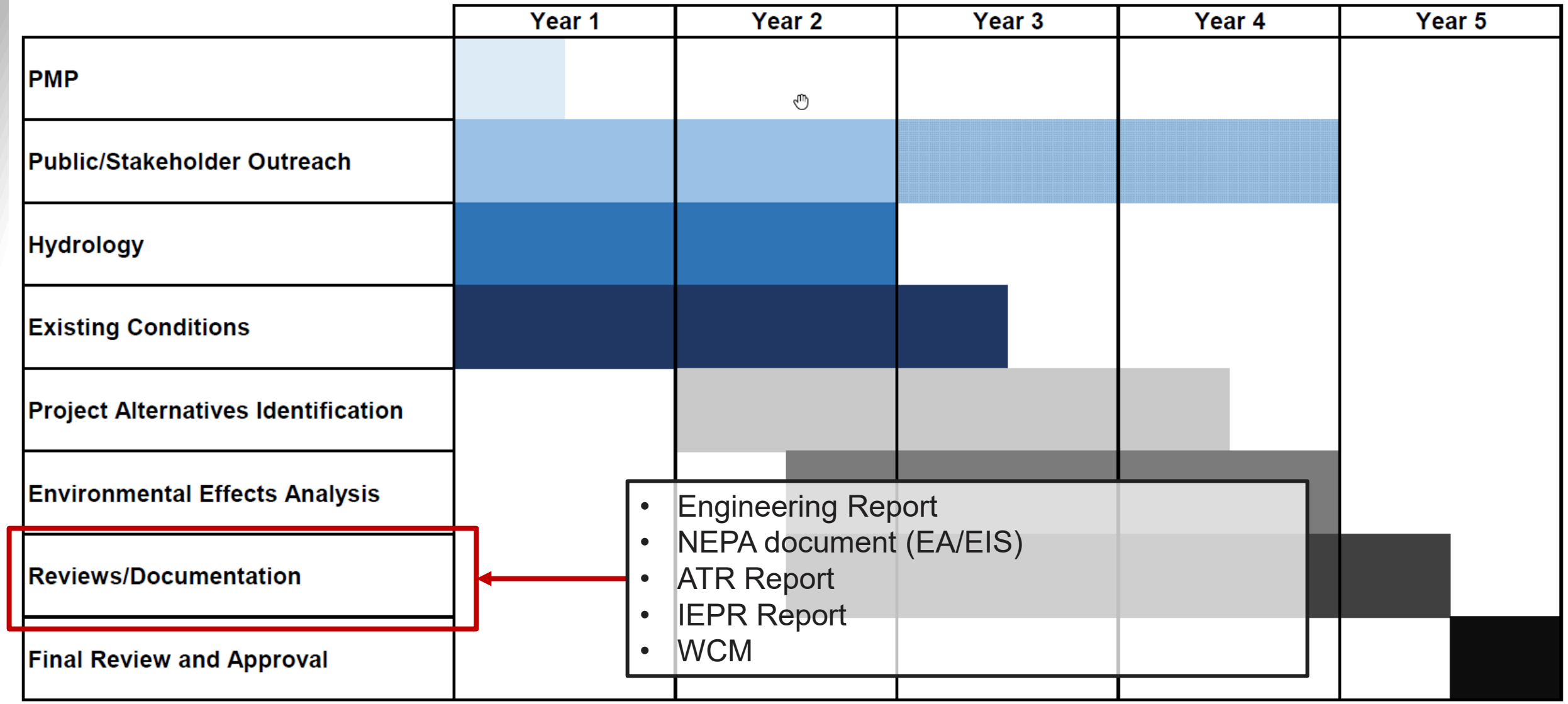

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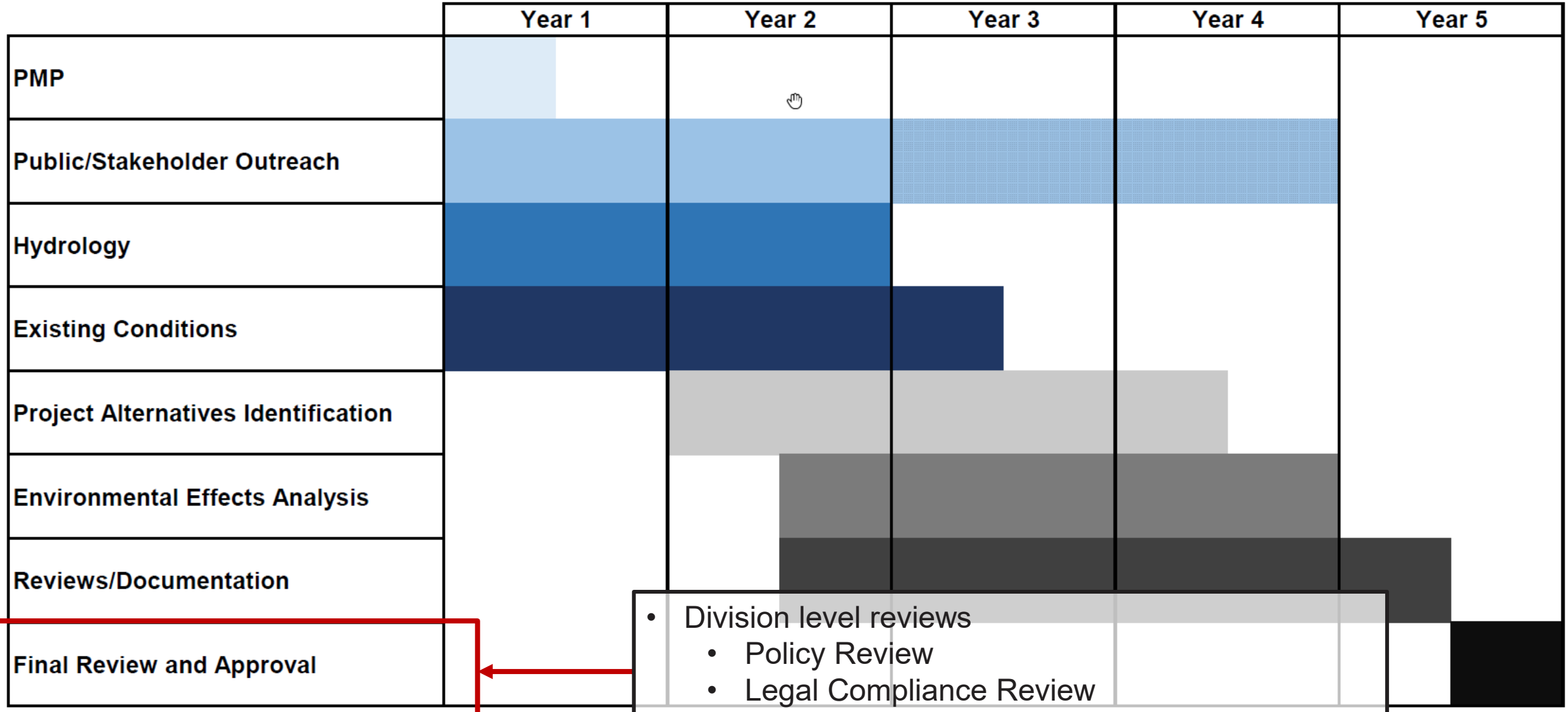

- Division level reviews
  - Policy Review
  - Legal Compliance Review
- Approved by Division Commander

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OBJECTIVES FOR WCM UPDATES

I. **Objectives related to Water Control Diagram (WCD)***

a. **New Bullards Bar:** *Yuba River below NBB through mouth of Yuba*

i. Coordinate operations in Y-F watershed to minimize exceedence of:
1. 180,000 cfs in the Yuba River at Marysville and
2. without necessity for Marysville Dam-Lake

b. **Oroville:** *Feather River below ORO up to Yuba-Feather confluence*

i. Coordinate operations in Y-F watershed to minimize exceedence of:
1. 180,000 cfs in the Feather River upstream of Yuba River and
2. without necessity for Marysville Dam-Lake,
3. without necessity for Lake Oroville emergency spillway use, and
4. without exceeding 150,000 cfs released from Lake Oroville.

c. **Combined System ORO / NBB:** *Confluence of Yuba-Feather to confluence of Feather- Bear*

i. Coordinate operations in Y-F watershed to minimize exceedence of:
1. 300,000 cfs in the Feather River below Yuba River,
2. 320,000 cfs in the Feather River below Bear River, insofar as possible, and
3. without necessity for Marysville Dam-Lake

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OBJECTIVES FOR WCM UPDATES

II. Objectives related to Probable Maximum Flood (PMF) - Emergency Spillway Release Diagram – ESRD

a. **Combined System ORO / NBB:** N/A

b. **New Bullards Bar:** NBB Dam specific passage of PMF (including Secondary Spillway) with a minimum of 2 feet of freeboard (from the dam crest 1965 feet (NGVD29))
Oroville: ORO Dam specific passage of PMF with a minimum of 3 feet of freeboard. This freeboard amount is subject to revision pending input from either Federal Energy Regulatory Commission (FERC) or DWR Division of Safety of Dams (DSOD).

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FIRO-WCM COMMON TASKS BETWEEN EFFORTS

1. Define flood operation objectives and performance metrics	✓
2. Define alternative development strategy	✓
3. Define existing condition to compare with alternatives	🕒
4. Prepare hydrology	🕒
5. Develop models and tools	🕒
6. Conduct basic performance evaluation	🕒
7. Develop system operations for promising alternatives	○
8. Conduct additional evaluation of promising alternatives	○
9. Identify recommended/selected alternatives	○

NEXUS -

Efforts can complement each other while progressing independently.

○ Not Started 🕒 In Progress ✓ Done

NBB/ORO FIRO-WCM UPDATES ALIGNMENT WORKGROUPS

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FIRO-WCM Alignment Subgroups

Forecast Skill, HEMP, and Decision Support

Outreach and Communication
Integrate Corps WCM representatives into existing FIRO Communications group

WCM/FIRO Alignment Leadership

PVA Work Teams

Team Name	Section 10.1 Assignments
Communications*	cross-cutting
Forecast Verification**	1
Observation	2
Meteorology	3
Hydrology***	4
Water Resources Engineering**	5,6,8,10
WCM Alignment Leadership Team**	7,9
Economic Benefits***	11
Decision Support Tools**	cross-cutting

Table 10.1 Yuba-Feather FIRO PVA Work Teams
* Existing Yuba-Feather FIRO team. Picks up coordination from FIRO-WCM Alignment workshop.
** Active coordination with WCM Update project.
*** Possible coordination with WCM Update project.

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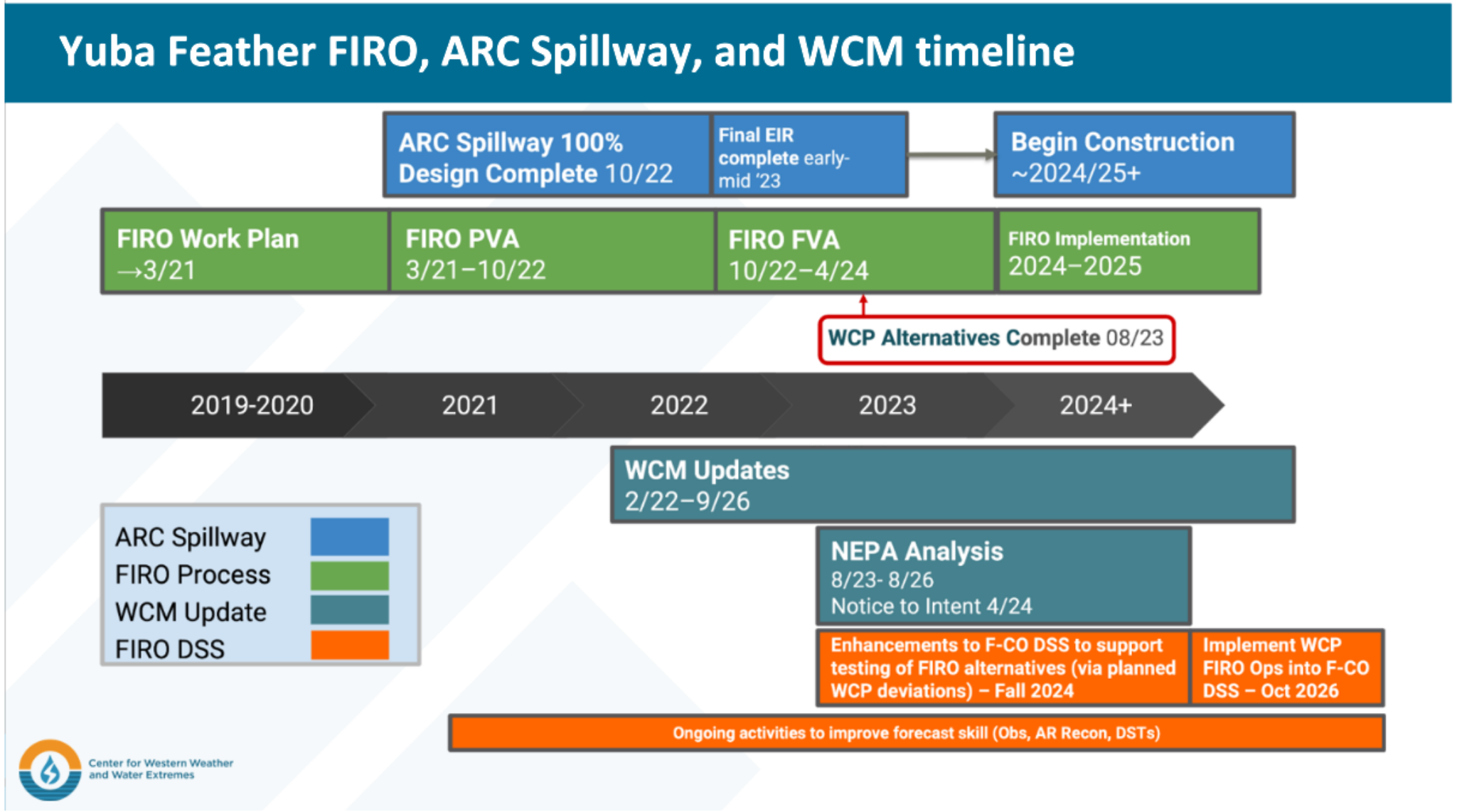
NBB/ORO FIRO-WCM ALIGNMENT SCHEDULE



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QUESTIONS

New Bullards Bar Dam (YWA – CA)

Oroville Dam (DWR – CA)

ITEM 4

WATER CONTROL MANUAL UPDATE OBJECTIVES

ITEM 5

WINTER OPERATIONS PREPARATION

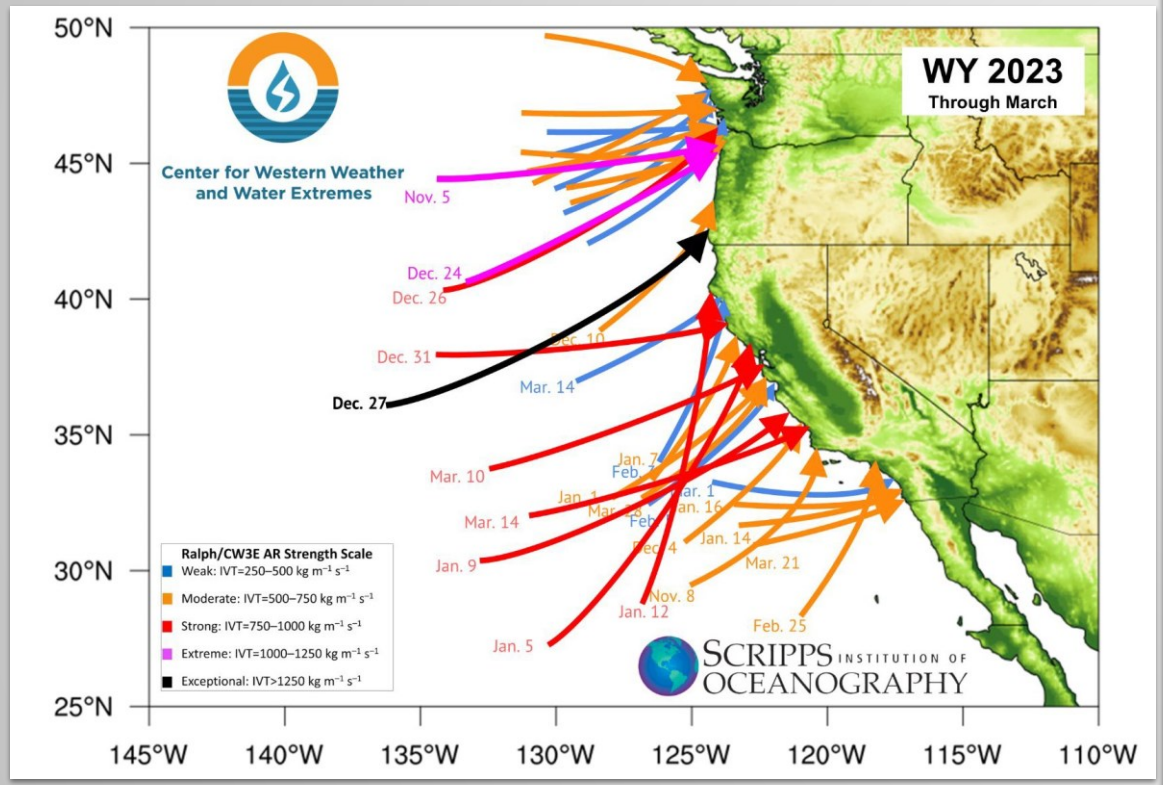
Lake Oroville 2023-24 Winter Operations

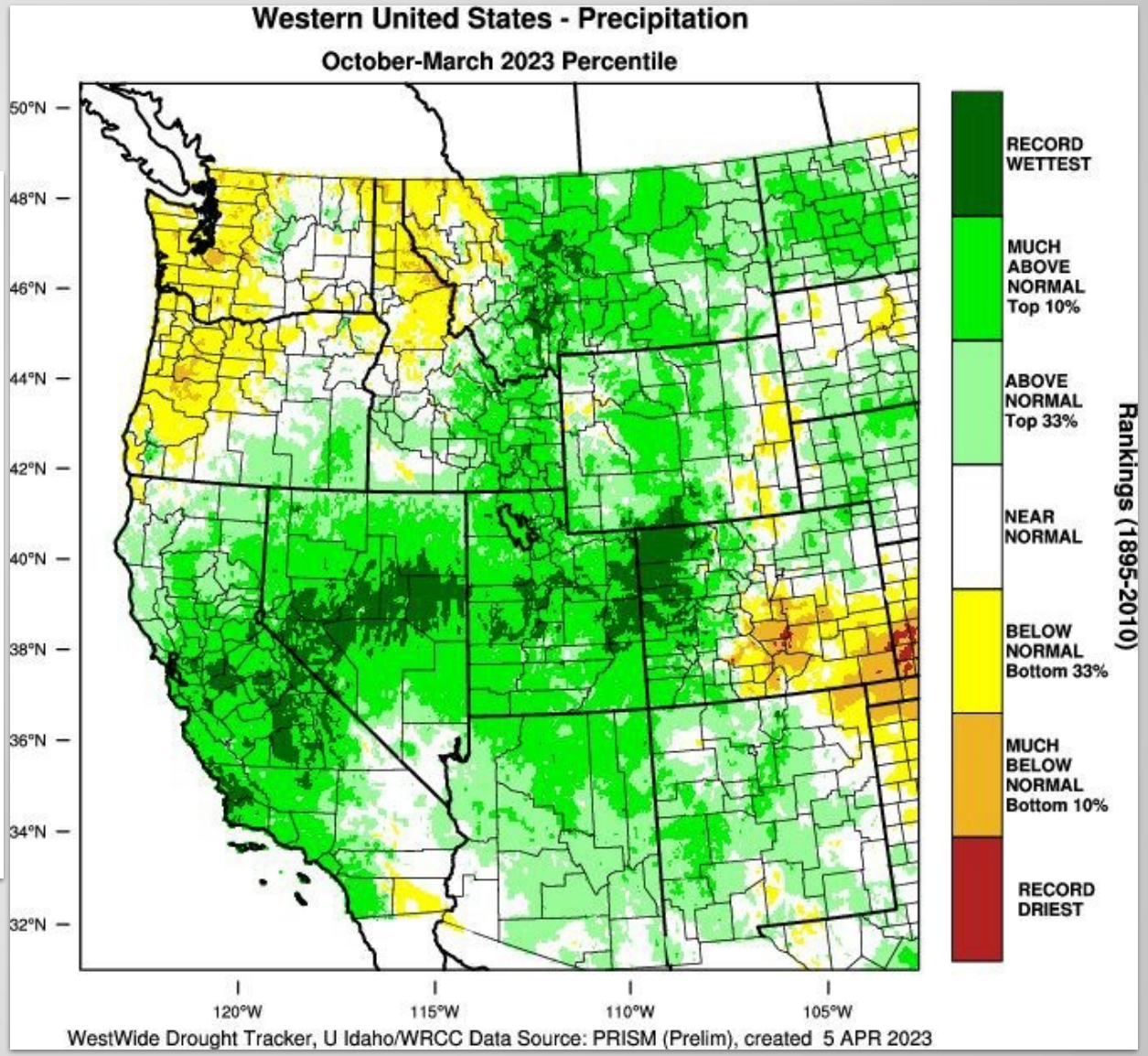
Oroville Citizen's Advisory Commission Meeting

November 15, 2023

John Leahigh, O&M Assistant Division Manager

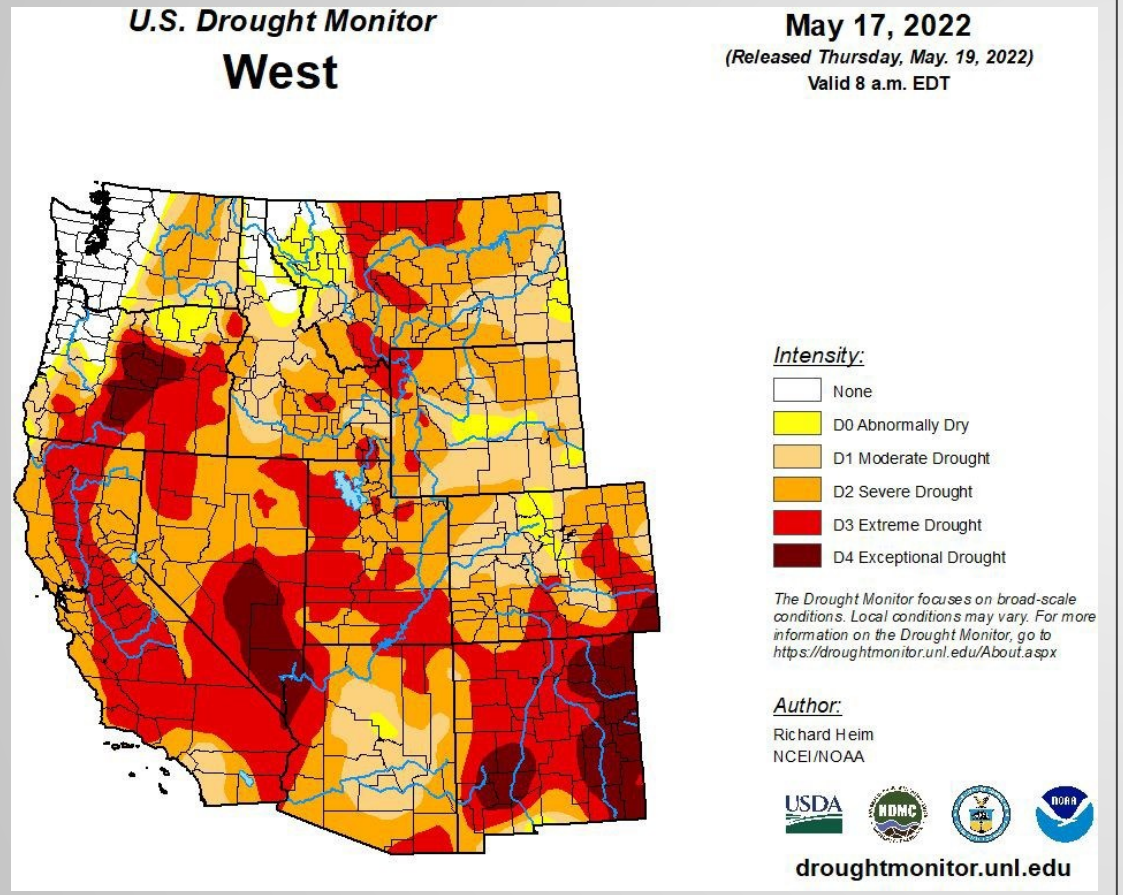
Recap of Winter 2022-’23

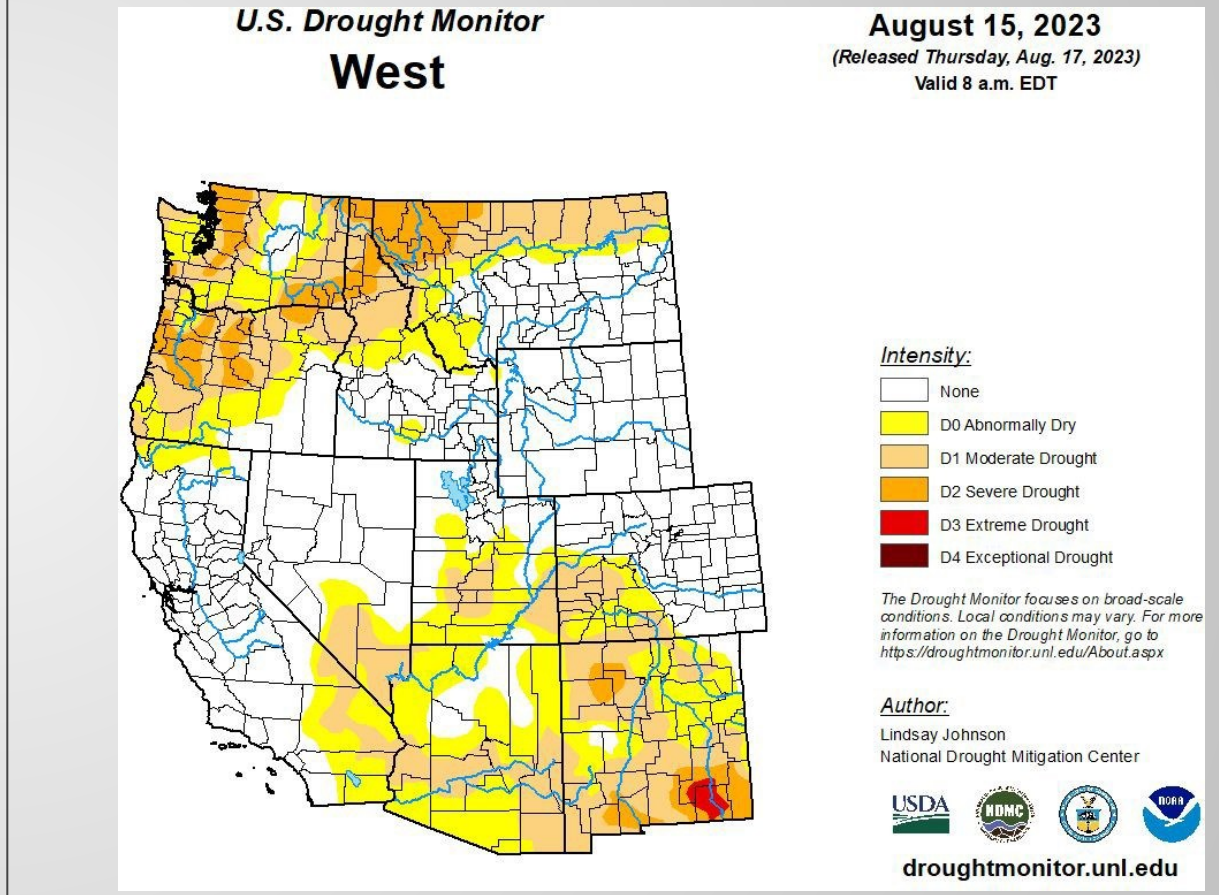




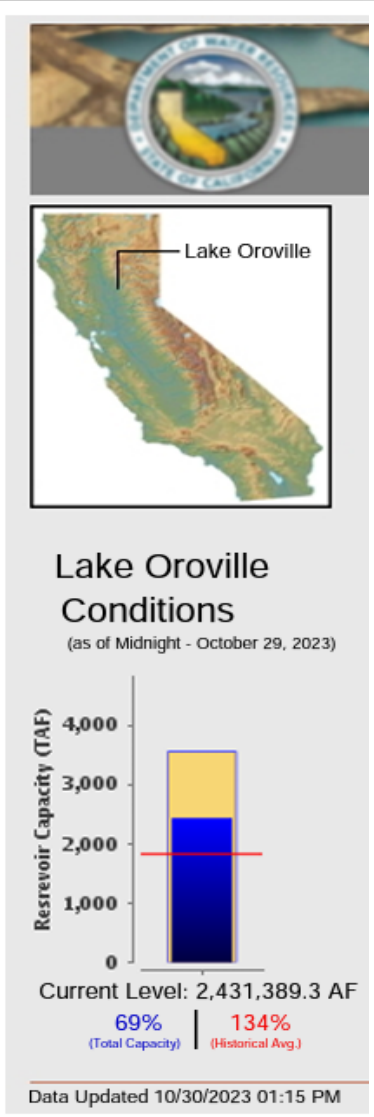
California Drought Monitor

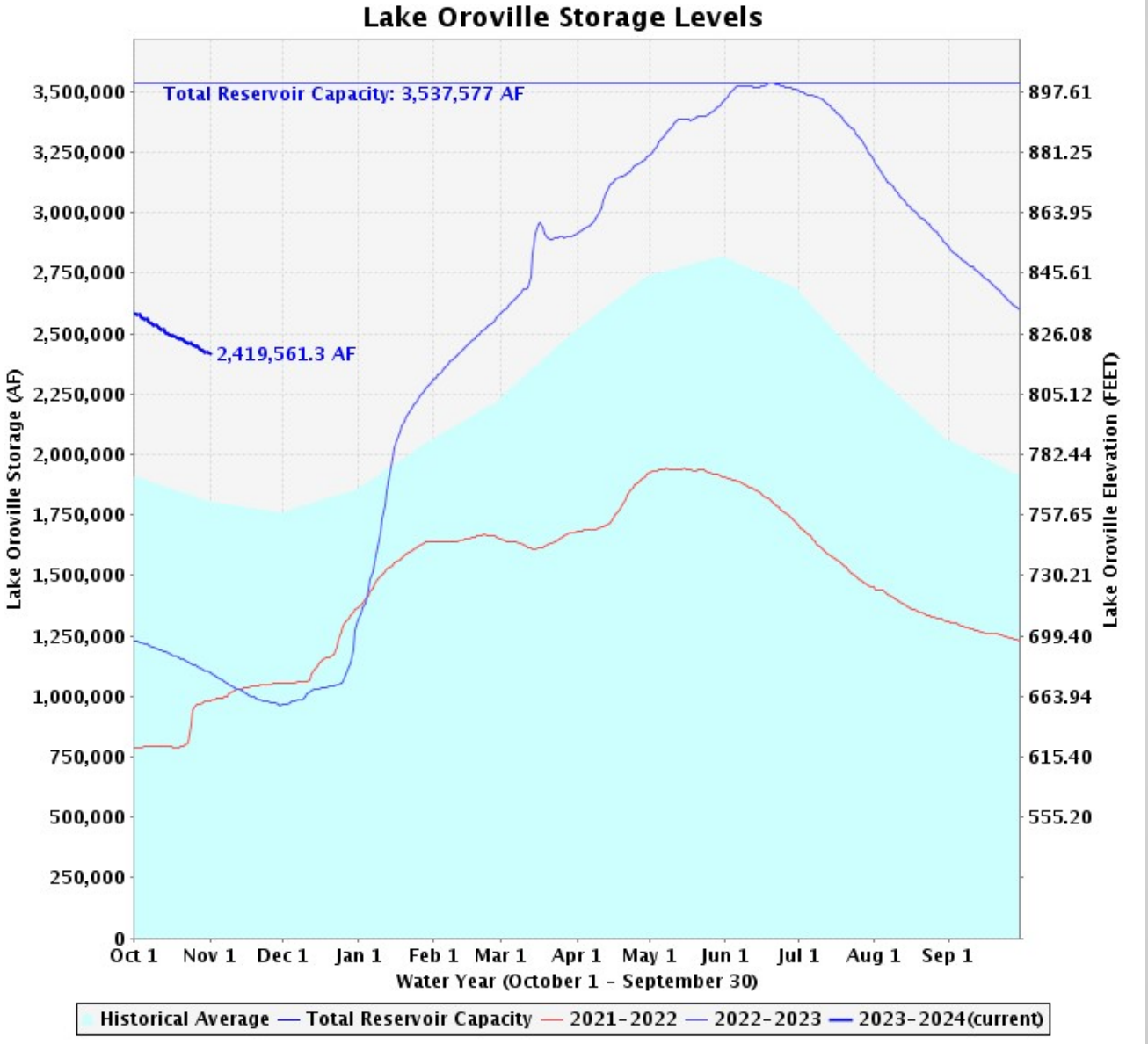
2022 → **2023**





Lake Oroville Storage

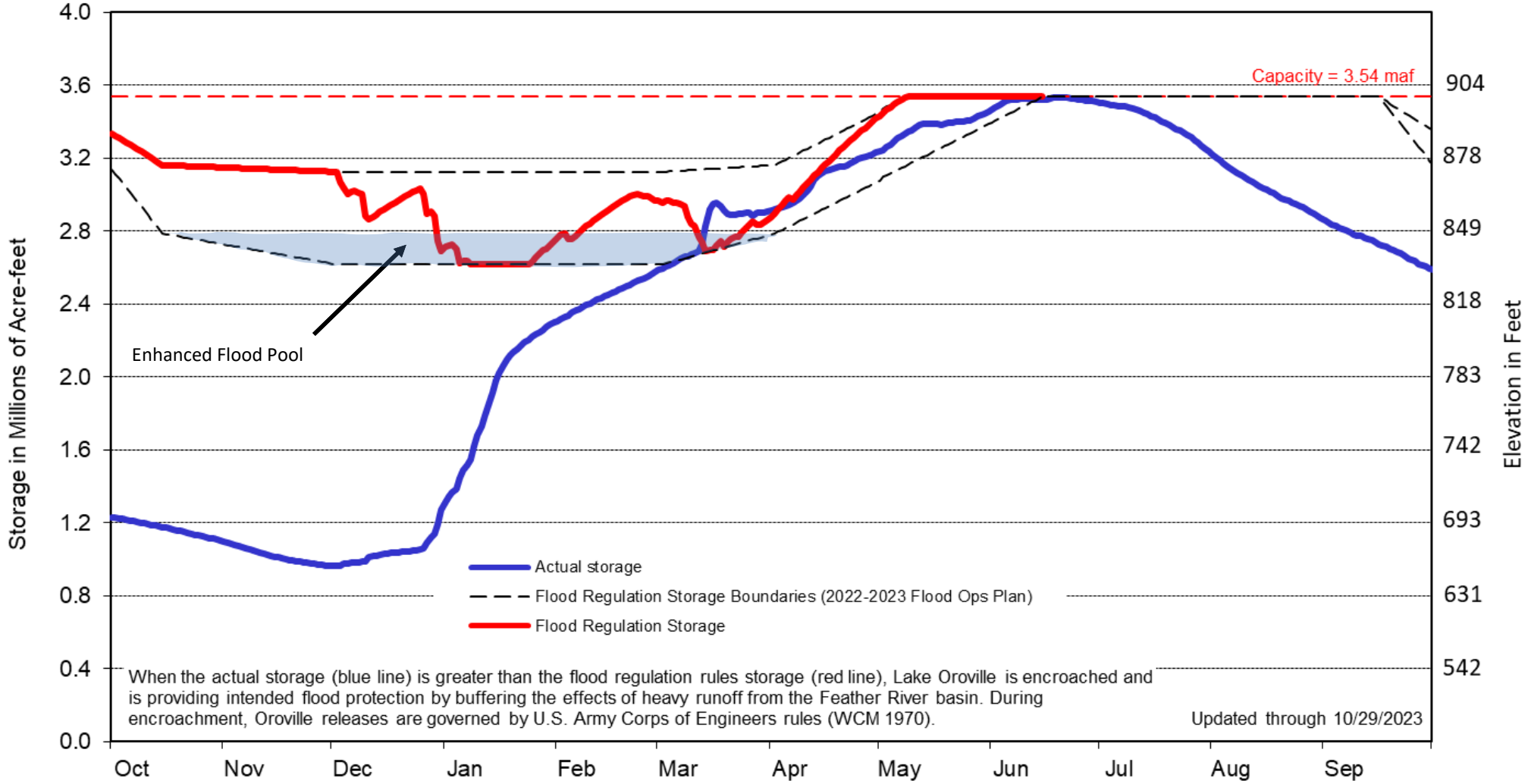




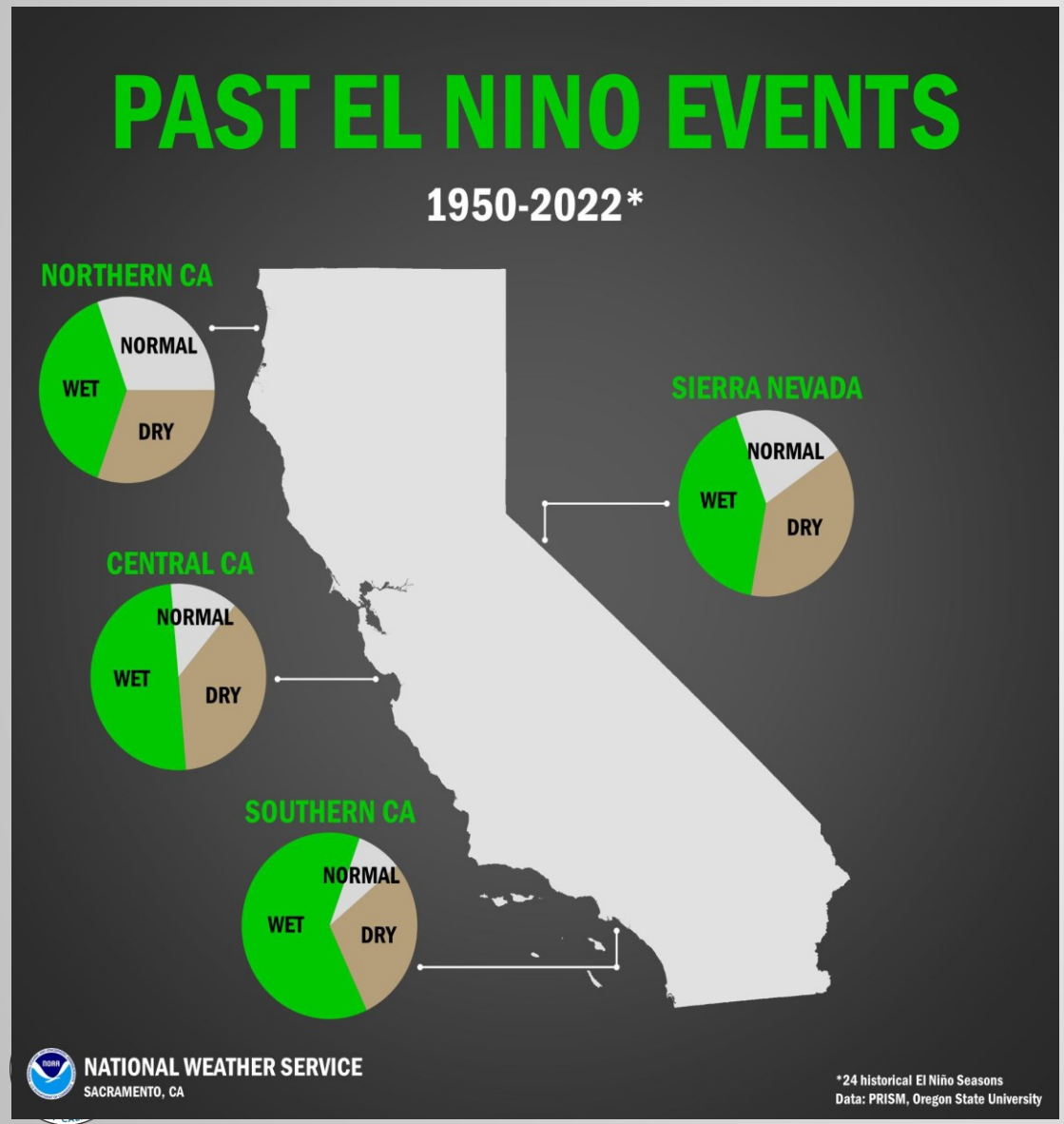
CALIFORNIA DEPARTMENT OF
WATER RESOURCES

Lake Oroville Storage

October 1, 2022 to September 30, 2023

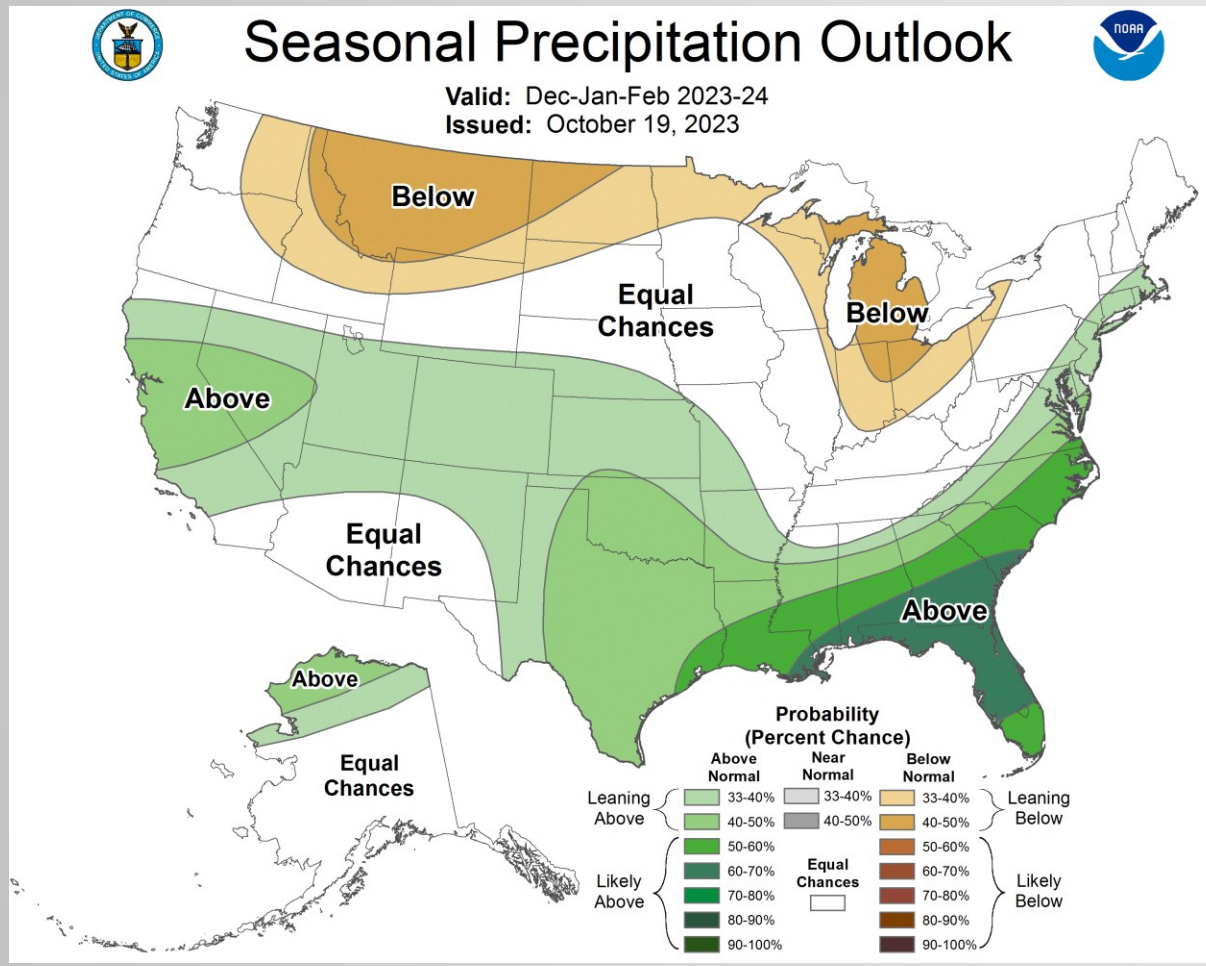


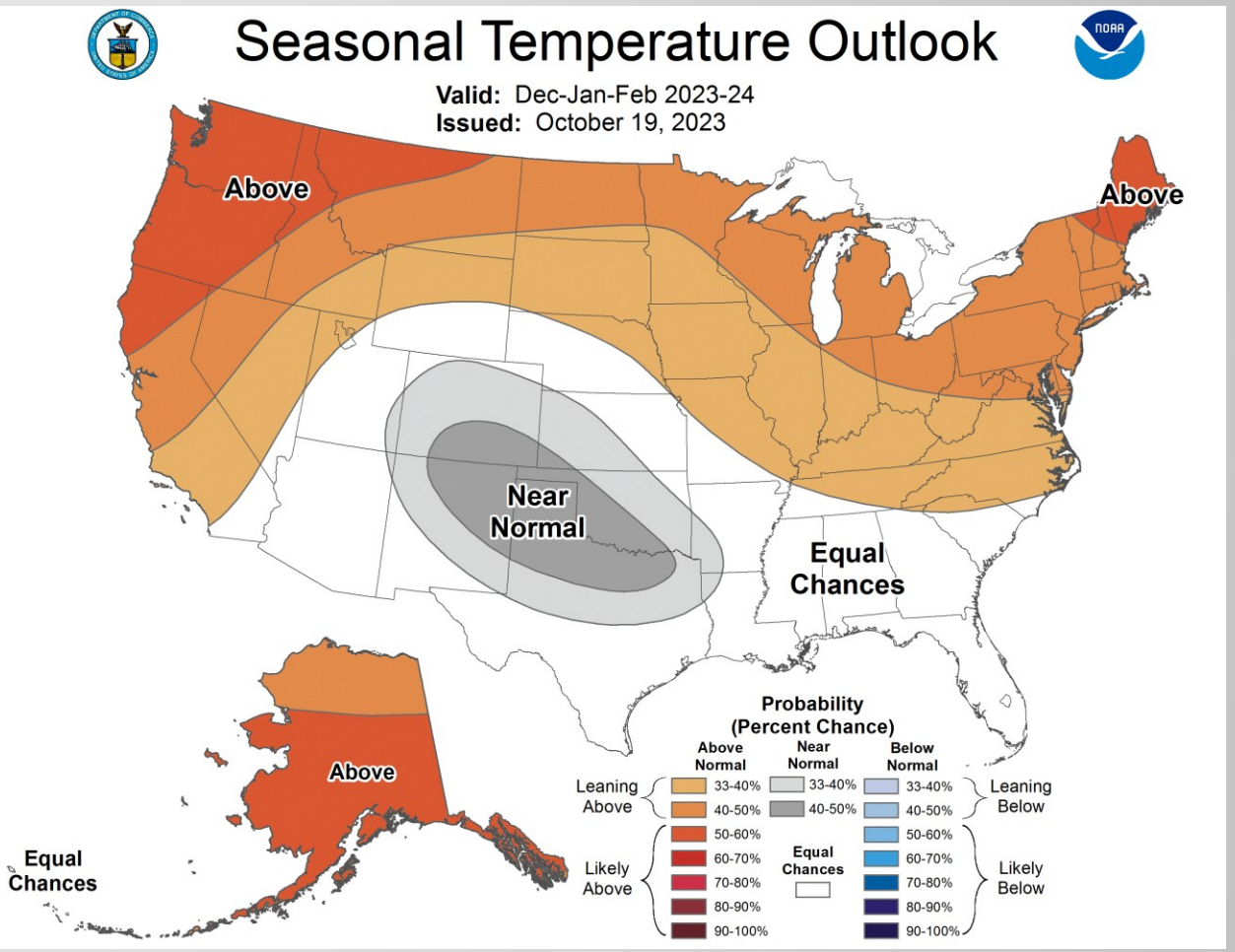
Typical El Niño Winter Conditions



- El Niño conditions typically drive the storm track farther south than a average winter
- Southern California has better predictability of precipitation than northern California in El Niño winters
- *El Niños have recorded anywhere from very dry to very wet winters!*
- Remember, our future water supply will be dependent on individual storms!

Winter Temperature and Precipitation Seasonal Outlook (Dec-Mar)





CALIFORNIA DEPARTMENT OF WATER RESOURCES

Planning for 2024

- Much improved storage going into WY 2024
- Continue to plan and prepare for extreme wet or dry conditions
- Currently releasing minimum required to conserve storage
- Will continue to employ the enhanced flood pool

Questions?

MEETING 16 AGENDA

FEEDBACK DUE DATES

- CNRA will circulate proposed Action Item Tracker updates by Friday
  - Commissioner feedback due 12/1/23

- CNRA will circulate a proposed agenda by 11/20/23
  - Commissioner feedback due 12/15/23

ITEM 6
PUBLIC COMMENT

The Oroville Dam Citizens Advisory Commission will now take public comment.

We appreciate your input.

ITEM 7
ADJOURN

Commission Meeting #16

March 1, 2024