Water Control Manual Questions and Concerns
7/15/2025

An overview of topics was submitted on May 3, 2025 with questions and concerns to multiple agencies involved in DWR's Oroville facilities and flood operations.

Below are DWR's responses to some of these topics, questions and concerns.

CNRFC Questions

C1a) - Same question, with climate change being the only difference, what level of flood protection would Oroville achieve in the year 2050 and 2075?

CNRFC does not develop frequency analyses or the associated level of protection.

C2a) - Since the above mentioned report, (CNFRC's estimation of return frequencies for historical events, page 121 PVA Appendize) is being used to quantify the level of flood protection the downstream communities can expect, can these estimations be improved upon?

The flow frequency analysis that was the basis for the PVA/FVA came from the USACE Sacramento District. The CNRFC was not part of the flow frequency analysis.

C2b) -Please explain how Return Frequency Estimates are developed and what if any uncertainties could be addressed to improve the accuracy?

The flow frequency analysis that was the basis for the PVA/FVA came from the USACE Sacramento District. The CNRFC was not part of the flow frequency analysis.

C3a) - Even after the additional studies analyzed in the FVA, a lot of uncertainty remains when forecasting freezing levels, precipitation transition and snowmelt Looking at latest (FVA) hindcast estimates of snowmelt data to actual observed melt, what is the current range of uncertainty, such as 15% chance inflow are off by 30%?

The NWS Office of Water Prediction is currently looking into the uncertainty of freezing level forecasts. The work should be completed within a year. Once the study is done, some conclusions can be made related to uncertainty in freezing level/snow level.

C4a) - Aside from airplane surveys, what would you recommend to improve the accuracy of snowmelt data, since 50% of the Feather River watershed is below the lowest daily reporting snow pillow at elevation 5,202 ft.

The installation of additional snow pillows at elevations below 5,000 feet could improve the spatial resolution of snowpack observations. However, the utility of such installations—especially in lower elevation zones where snow accumulation is typically infrequent and short-lived—would be very marginal. Furthermore, the current hydrologic modeling framework already incorporates snowpack dynamics across lower elevations, which diminishes the incremental benefit of expanding the observation network in these areas.

C5a) - Assuming the precipitation estimates and snowmelt estimates are two different processes that are later combined for a total reservoir inflow estimate, couldn't the data used in

the snowmelt estimate be used to develop snow water index to increase the flood pool similar to how soil wetness index could shrink the flood pool?

> *The current reservoir inflow forecasts developed by CNRFC incorporate all relevant hydrologic processes within the watershed, including both soil moisture and snowpack conditions. The concept of an empirical index—such as a hypothetical snow water index—could offer general guidance, however, it would be inherently limited in its ability to capture the full complexity and variability of watershed response. Therefore, reservoir operations based on forecast-informed inflow estimates are preferable to those relying solely on empirical indices, as the former provide a more accurate and dynamically responsive basis for decision-making.*

Oroville Spillway Capacity

Since Oroville's 2017 Comprehensive Needs Assessment (CNA), DWR has been working on several multiyear studies to analyze if Oroville has the spillway capacity to pass the Probable Maximum Flood (PMF) which is a requirement of FERC's Dam Safety division. The recently passed PERCIP Act will require the (PMF) to be adjusted for climate change, and most likely before the Oroville /FERC 2029 Part 12 inspection.

> *DWR Clarification/Information Provided: The PRECIP Act (Text - S.3053 - 117th Congress (2021-2022): PRECIP Act | Congress.gov | Library of Congress) directed and funded the National Oceanic and Atmospheric Administration (NOAA) to take actions regarding precipitation estimation and enter into an agreement with the National Academy of Sciences to study the state of practice and research needs for precipitation estimation, including probable maximum precipitation estimation. This led to the National Academy of Sciences establishing the "Modernizing Probable Maximum Precipitation (study) committee (Modernizing Probable Maximum Precipitation Estimation | National Academies) to consider approaches for estimating probable maximum precipitation (PMP) in a changing climate, with the goal of recommending an updated approach, appropriate for decision-maker needs. PMP is commonly used in the design of critical infrastructure. The committee is charged with establishing a common understanding of PMP; reviewing and assessing existing approaches to PMP estimation and for incorporating the impacts of climate change on those estimates; assessing PMP data needs and sources; and recommending a preferred approach for PMP estimation that incorporates the impacts of climate change and the characterization of uncertainty.*
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> *Section 602 of the PRECIP Act directs NOAA, upon completion of National Academy of Science report, to update PMP estimates for the United States within 6 years, and then every 10 years thereafter, such that each update considers non-stationarity (i.e. a non-stationary climate, aka climate change). Dam safety regulators and DWR are awaiting publication of updated PMP estimates by NOAA as they are expected to become the industry standard on how to account for climate change and incorporate many of the recommendations made by the National Academy of Sciences. NOAA's publication is not expected to be issued in time for the next Part 12D process to occur in the 2027-2029 timeframe.*

FERC Question (Sept. OCAC presentation)
F1a) - Are the ongoing 2020 Part 12 and Level 2 Risk Analysis studies expected to be completed before the 2029 Part 12 inspection?

DWR Perspective: The 2020 Part 12D report was completed and submitted to FERC on August 3, 2020. The Level 2 Risk Analysis Report was submitted to FERC on March 27, 2020 (Embankment Volumes) and August 3, 2020 (Spillways Volume). While these are not on-going studies, they have generated studies and projects that DWR has completed, continues to advance, or has planned. These include:

- *Oroville Dam Toe and Flood Control Outlet Piezometers - completed*
- *Oroville Emergency Spillway Erodibility Study – completed*
- *Oroville Dam Seismic Stability Analysis – in-progress*
- *Oroville Dam Radial Gate Reliability Study – in-progress*
- *Feather River Paleoflood Investigation – completed.*
- *Oroville Dam Stochastic Flood Event Modeling – in-progress*

DWR will provide a status update on these and other studies at the Fall 2025 OCAC Meeting.

DWR also plans to conduct several Quantitative Risk Analyses (FERC "Level 4" risk analyses) for Oroville Dam in the 2026-2028 timeframe that will focus on specific high-risk potential failure modes and better inform the need for action (or not). The studies conducted since 2020 are key inputs to the QRAs. Conducting QRAs aligns with FERC Risk Informed Decision Making Guidelines and recommendations from the Comprehensive Needs Assessment.

For reference, the next Part 12D for Oroville Dam, planned for completion in 2029, will be a Comprehensive Assessment which requires another Level 2 Risk Analysis.

F1b) - Is it assumed that by then the inspection would include a new PMF update according to the PRECIP ACT?

DWR Perspective: DWR does not expect NOAA's publication to be issued in time for the next Part 12D process planned occur in the 2027-2029 timeframe. DWR does expect the 2029 Part 12 Independent Consultants to recommend DWR update Oroville Dam's PMP and PMF with NOAA's guidance and PMP estimates, assuming it is published in 2029 or shortly thereafter.

DWR Questions
D1a) - As Dam owner, is it your responsibility to not be regulatory driven, and coordinate a holistic approach to these similar mandates of having adequate release capacity to safely pass both the SPF equivalent (USACE) and the PMF-Future (FERC)?

DWR does have a holistic approach when planning and implementing public safety projects and does not rely on regulators to provide direction on ensuring public safety. DWR's State Water Project utilizes asset management and a risk informed decision-making approach, the latter of which was developed by federal agencies (USBR and USACE) and later adopted by our regulator (FERC) in the 2016-2021 timeframe. These approaches are considered industry best practices and require significant investment and time to become fully "mature" within large organizations and utilities. The goal of the

approach is to identify and address the top risk drivers across all assets of the organization, and effectively and efficiently reduce risk over time.

A prime example "not being driven by regulatory compliance" includes the fact that the SWP Dam Safety Program is applying a risk management process for all SWP dams, not just those under FERC regulation. Another example of a best practice implemented by DWR (not driven by any regulatory requirement or 5-year Board recommendation) is the extensive bathymetric and LiDAR surveys conducted to update the storage-capacity curve for Lake Oroville. This was an important input identified by DWR for current and future routing/dam safety studies. The SWP Dam Safety Program itself was expanded in the 2018-2023 timeframe with definition of its 13 Program Elements providing a more holistic approach – this was not required by FERC or DSOD. The Program Elements consist of: Surveillance, Dam Safety Assessments, Reservoir Operations, Maintenance, Design and Construction, Risk Management, Emergency Preparedness, Independent Reviews, Project Delivery, Communication, Documentation, Technical Expertise and Program Reviews.

For a specific topic like spillway capacity, multiple objectives or criteria are common and require definition at the time of design or re-analysis. At the time of the design of Oroville Dam and its spillways, both the Standard Project Flood (SPF) and Probable Maximum Flood (PMF) were analyzed. As described in the 1970 WCM, by agreement between the State of California and the Corps of Engineers, selection of the maximum flood control space requirement for Oroville Reservoir was based primarily on protection of urban and agricultural areas along Feather River below the reservoir against winter floods (rain or rain augmented by snowmelt) up to the magnitude of the SPF, with permissible releases limited to a maximum of 150,000 cfs. This criteria influenced the design of the Flood Control Outlet. The PMF developed at the time (720,000 cfs) was also analyzed and influenced the sizing and elevations of the FCO, the Emergency Spillway, and the dam crest elevation.

In 2018, DWR re-evaluated its ability to meet the 1970 WCM objectives, accounting for the absence of Marysville Dam. This led to the definition of the enhanced flood control pool which DWR continues to implement. This was not required by FERC or DSOD. DWR also re-evaluated the PMF in 2017 (721,100 cfs peak outflow) and confirmed it would not overtop the dam. These studies demonstrate adequate spillway capacity. However, the question of "safely" passing the PMF was raised by both FERC and DSOD, with specific regard to the erodibility of the Emergency Spillway downstream of the roller compacted concrete (RCC) apron and subsurface secant pile wall. Between 2021 and 2025 DWR retained an industry-leading team to analyze the potential for undermining of the RCC apron and secant pile wall considering a range of flows, up to and including the PMF. The analysis and report yielded positive results and is under review by the regulators. Even with the positive results, DWR does not consider the topic closed. DWR plans to perform a quantitative (Level 4) risk analysis with FERC to ensure the risk associated with various magnitudes of flows over the Emergency Spillway is well defined and understood.

As noted above DWR expects publication of NOAA's guidance and PMP estimates in 2029 or shortly thereafter. DWR will review the PMP estimates and compare them against those utilized in 2017 to determine if a PMF update is warranted.

D2a) - Which of the Oroville CNA plans would most economically achieve both mandates, while still providing infrastructure resilience and redundancy into the year 2050 and 2075?

Currently, DWR believes both mandates can be achieved through the enhanced flood control pool which provides flood space beyond that required by the 1970 Water Control Manual. The enhanced flood control pool was developed specifically to account for the lack of Marysville Dam and to not exceed a flood release of 150,000 cfs. It has been implemented since the 2018/2019 season and will continue to be implemented until an updated WCM or a deviation of the WCM is issued by the USACE.

The Yuba-Feather Forecast Informed Reservoir Operations (FIRO) Final Viability Assessment (FVA) (February 2025) provides insights with respect to taking a forecasting and operations-based approach to flood control. DWR anticipates the FIRO FVA to inform the USACE's approach to the Water Control Manual update.

With respect to passing the PMF, DWR has performed the following studies that demonstrate that the Flood Control Outlet (FCO) and Emergency Spillway (ES) have the capacity to pass the PMF:

- *Lake Oroville, Revised Storage-Capacity Report, May 2023: This effort involved LiDAR and bathymetry surveys to update the storage-capacity curve for the reservoir.*
- *Oroville Emergency Spillway Studies, Task 2 – Flow Dynamics of the Emergency Spillway, October 12, 2023: This study verified the capacity of the Emergency spillway and its "training walls" to pass its portion of the PMF. Very minor overtopping of the right wall (176 cfs) was identified that DWR plans to address. The study also verified that the hydraulics upstream of the FCO and the ES are independent of one another.*
- *Oroville Emergency Spillway Studies, Task 3 – FCO Spillway Capacity Confirmation Analysis: This study verified that the FCO walls will not be overtopped during a PMF outflow of 301,300 cfs which would occur when the lake level peaks at 919.1 feet. The analysis shows that the tops of the walls are 8 feet higher than the predicted flow.*

Most recent and key study:

- *Oroville Dam Emergency Spillway Erodibility Study: May 2025: This study considered the time-rate of scour downstream of the ES apron and subsurface secant pile wall. The study considered a range of flows up to the PMF as well as the longer duration, but small peak ARkStorm flows. The findings of this study indicate the ES can be operated to pass higher flood discharges up to and including a PMF event (peak outflow of 419,800 cfs over the ES) as scour that may occur immediately downstream of the apron, progress upstream, and resulting in an uncontrolled release from the reservoir is improbable. Even with the positive results, DWR does not consider the topic closed. DWR plans to perform a quantitative (Level 4) risk analysis with FERC to ensure the risk associated with various magnitudes of flows over the ES is well defined and understood.*
- *Background for ARkStorm: ARkStorm is an emergency planning scenario associated with a hypothetical severe winter storm striking California. This scenario is based on repeated historical occurrences of atmospheric rivers and other major rain events capable of producing "megaflood" conditions. ARkStorm*

is an acronym for "atmospheric river (AR) 1,000 years (k) storm" and was first developed by the Multi-Hazards Demonstration Project (MHDP) of the United States Geological Survey (USGS) as ARkStorm 1.0 (USGS 2011) and recently updated to ARkStorm 2.0 (Huang and Swain 2022). In ARkStorm 2.0, two new megastorm scenarios were designed leveraging the original ARkStorm 1.0 information: a scenario based on the recent historical climate (ARkHist) and a scenario based on a warmer future climate (ARkFuture). Both scenarios consider long duration (30-day) storm sequences of consecutive severe winter storm events (rather than single storm events).

With the current studies indicating the spillways can safely pass the PMF, DWR does not believe advancement of CNA outlet-capacity oriented measures (or plans that contain them) are a prudent investment for the SWP. Other risks and projects at Oroville Dam and within the greater SWP warrant near-term resources and funding.

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D3a) - Now that 50 year state water contracts have been renewed, could 35-40 year construction bonds help reduce the annual repayment cost?

Yes, under the Contract Extension Amendment, construction costs can be financed with bonds with longer payment period, therefore reducing the annual debt service charge.

D4a) - Would the annual 200,000 af increase in water storage benefit (Figure L-8 in the FIRO PVA Appendix) help soften the cost of the construction bonds?

An increase in water storage in Oroville does not have a direct relationship nor alleviate the debt of the construction bonds. The SWP does not charge the water contractors by the amount of water delivered. The SWP recovers 100% of the costs associated with SWP operations and maintenance activities including the costs of facilities for the conservation and development of a water supply (i.e., Oroville) and the conveyance of such supply to SWP service areas.

D5a) - Although after-event reservoir refill was not an issue, was the inclusion of the Soil Wetness Index without an offsetting Snow Water index a firm request the department made for drought year reservoir recovery.

No request, as suggested, was ever made. The Soil (Ground) Wetness Index is in the USACE's 1970 Water Control Manual which was developed according to their Engineering Manuals at the time.

D5b) - Throughout the water control manual update process, the department has consistently stated, "they want to use the best science", does the old soil wetness index use the best science?

DWR believes that the soil wetness index is currently part of our utilization of the Best Science. DWR is open and anticipating that the soil wetness index will be reevaluated as part of the update to WCM along with it being used in conjunction with innovations in forecasting.

D6a) - Since NOAA Fisheries: Eric Danner was a member of the FIRO work team, what were his comments or concerns on the timing and rate of fall discharge and spring refill's effect on the

spawning migration of endangered fisheries? Were downstream temperatures and hydrology models analyzed?

> *The Yuba Feather FIRO Final Viability Assessment did not address fisheries. Potential impacts to fisheries and other aquatic species will be addressed during the USACEs environmental review as part of the Water Control Manual Update for Oroville and New Bullard's Bar Reservoirs. This information was provided by the USACE at their October 15, 2024, informational meeting and can be found on their website: New Bullards Bar and Oroville Dams Water Control Manual Update*

D7a)- Has there been any attempt to estimate the associated indirect cost of the 2017 evacuation?

> *We are not aware of any studies or attempt to estimate the associate indirect cost of the 2017 evacuation or a potential evacuation.*

D7b) - When evaluating downstream benefits or assigning priorities to HEC-ResSim rule stack wouldn't this be useful infromation?

> *DWR reservoir simulation models do not include an input for costs. DWR would like to discuss this question further at the future small group discussion.*