

# OROVILLE COMPREHENSIVE NEEDS ASSESSMENT

## Independent Review Board Memorandum

DATE: October 10, 2018

TO: Mr. Sergio Escobar, Project Manager  
Oroville Comprehensive Needs Assessment  
California Department of Water Resources

FROM: Independent Review Board for  
Oroville Comprehensive Needs Assessment

SUBJECT: Memorandum No. 2

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On Tuesday October 9, 2018, the Independent Review Board (IRB) met at the Department of Water Resources (DWR) Oroville Field Division Office at 9:00 am for briefings regarding progress on the Comprehensive Needs Assessment (CNA). The IRB met with representatives from the DWR Division of Engineering (DOE), DWR Division of Operations and Maintenance (DOM), DWR Division of Safety of Dams (DSOD) the Federal Energy Regulatory Commission (FERC), and industry consultants working on the CNA to discuss:

- Further description and clarification of the CNA Project.
- Project integration.
- Project evaluation.
- CNA and the Water Control Manual (Task 2).
- Task 3 status update.
- Task 5 status update.
- Workplan update.

During the morning of Wednesday October 10, 2018, the IRB deliberated and prepared a draft of this report. Comments made on the individual presentations and the IRB's responses to DWR questions for the IRB are included in this report. A reading of the IRB's draft report was made to representatives from DWR DOE, DWR DSOD, FERC, DWR DOM, and industry consultants working on the project at 12:00 pm. The meeting was adjourned following the reading of the report.

The IRB was pleased to welcome new IRB member Dan Wade, Director of Water Capital Improvement Programs for San Francisco Public Utilities Commission. All IRB members were present on both days including (Elizabeth) Betty Andrews, Lelio Mejia, Bruce Muller, Dan Wade and Paul Schweiger. A list of meeting participants for both days is attached.

## **QUESTIONS FOR THE IRB**

### **1. Does the IRB have any recommendations or comments on the revised CNA Project Approach and Integration summarized in the materials provided and presentations given during this meeting?**

#### *Response*

The first presentation began with a summary of the CNA Project Team's response to the recommendations made by the IRB. The IRB was pleased with the Team's tracking of the IRBs recommendations and their responsive actions including:

- Developing a formal integrated project management plan.
- Preparing a CNA schedule showing task interdependencies.
- Defining the baseline with and without-plan conditions.
- Establishing evaluation criteria prior to formulating alternatives.
- Adopting the principle of "begin with the end in mind" by outlining the final report.
- Developing a glossary to provide a common understanding of the terminology used across all Tasks.
- Evaluating existing components and alternatives with respect to their robustness, redundancy, reliability, and resiliency.
- Clarifying the project objectives.

Other IRB recommendations mentioned in the presentations but with actions not discussed in detail include:

- Compiling "what is working well" in each Task area.
- Applying value planning to the CNA.
- Developing a quality management plan.
- Considering climate change in the CNA context.

The IRB believes the project objective is well-defined and the six-task approach being implemented will appropriately identify measures to restore and improve the safety and reliability of Oroville Dam and its appurtenant structures for a 50-year planning horizon. The study will proceed with a structural component-by-component dam safety and operational reliability evaluation. The components being evaluated include the dam embankment, the outlet works, the spillways, and the instrumentation. Each component will be evaluated under their normal, operational and extreme loading conditions.

The IRB understands that reliability of the mechanical, electrical and control systems will be included in Tasks 3 and 4, as the dependability of those systems is needed for reliable operation of the Flood Control Outlet (FCO) and the River Valve Outlet System (RVOS). Similarly, [REDACTED] operation of the powerplant and its reliability in providing low-level outlet releases for the reservoir. Although not discussed, the IRB understands that the CNA Project Team will evaluate plans for providing redundancy in external systems that deliver power to the grid, as part of its evaluation of the low-level outlet facilities.

A non-exhaustive list of related topics that will be addressed through other DWR processes on varying schedules outside the scope of the CNA Study include:

- Thermalito facilities downstream of Oroville Dam.
- Water Control Manual.
- Downstream levee system structural integrity.
- Facility security.
- Recreation facilities.
- Emergency action planning.
- Environmental issues.
- General organizational management.

Although it is understood that these important topics have been, or are being addressed as part of other efforts, DWR demonstrated an understanding of their linkage(s) to the CNA Study and the importance of considering how any proposed improvements to Oroville Dam may impact or interact with these topics.

The draft *Guiding Principles of Comprehensive Needs Assessment Project* document was reviewed. The IRB agrees that the approach outlined in these guidelines meets the standard of practice for water resources planning studies.

The IRB was pleased to learn how the lessons-to-be-learned from the Oroville Independent Forensic Team's Report on the February 2017 spillway incident and ongoing dam safety evaluations such as the FERC Five-Year Part 12 Safety Inspections will be used to inform the CNA. The Part 12D Potential Failure Mode Analysis (PFMA) and Semi-Quantitative Risk Analysis (SQRA) scheduled from January 22 through March 22, 2019 will be of significant value to the CNA. The IRB understands that the Part 12D PFMA/SQRA will consider failure modes with consequences other than an uncontrolled release and will be expanded to include metrics used by DWR's asset management program to prioritize operation and maintenance actions necessary to ensure safety and efficient performance of other facilities of the State Water Plan. Having the Independent Consultant from the past FERC Part 12 Safety Inspection brief the new Independent Consultant is exemplary and will aid in assuring a more complete understanding of the safety of Oroville Dam.

The IRB was also pleased that the CNA Study Team will be identifying opportunities for expedited risk reduction actions (low hanging fruit) while the planning study proceeds.

**2. Does the IRB have any recommendations or comments on the project evaluation approach, including the planned risk assessments and overall evaluation criteria?**

*Response*

The IRB supports the overall approach to plan evaluation as recommended by the CNA Team, including the use of a risk-informed decision-making approach that incorporates non-risk-based outcome considerations and relies on a mix of quantitative, semi-quantitative, and qualitative evaluation of criteria.

While public safety is central to the CNA, various plans will create different mixes of consequences that will need to be weighed in the selection of a plan. The CNA Study Team's proposed transparency in the assessment of those consequences will be helpful to decision makers and contribute to public acceptance of the findings and potentially even the plan selection.

The IRB recommends that plan options be evaluated using a structured Multi-Criteria Decision-Making approach such as “choosing by advantages”. Any system of evaluation offers an opportunity to consider weighting of the importance of various outcomes, yet the IRB believes that this weighting will be most appropriately done by the decision makers charged with selecting the plan, subsequent to the CNA process.

The project integration team has identified 12 evaluation criteria. The IRB recommends that “permittability” or “minimizing permitting challenges” be added to the list of evaluation criteria, and notes that where a given plan’s permitting challenges are large, modifications to the proposed plan may be incorporated to mitigate such challenges to the extent practical. Beyond that, the identified criteria appear intended to adequately encompass the range of outcomes of plan implementation that warrant consideration, though the words used to identify them could be further refined to better reflect their intent. For example, “Public Resources (intangible)” may be excessively limiting as a name, as some community benefits may be tangible, and all outcomes worth accounting for in this category may not be held in the public domain. The adequacy of the evaluation criteria proposed will only become fully apparent once the CNA Team clarifies what outcomes will be captured within each evaluation category. Additionally, the IRB believes that identification of evaluation thresholds or “bins” (besides the end member or bookend values) is not necessary at this time but could be most efficiently selected during the evaluation process, once the range of values to be discriminated among is determined. The IRB further believes that there is no compelling reason to segregate the criteria into “primary” and “secondary” categories.

Regardless of whether a “choosing by advantages” approach is adopted, the IRB recommends that all evaluation criteria be framed as the measurement of positive outcomes if at all possible. By adopting this approach, the focus is kept on plan outcomes that contribute to a range of co-benefits in a greater or lesser way.

As proposed by the CNA team, initial plan formulation would be guided by the explicit establishment of a minimum level of criteria satisfaction that must be achieved. The IRB recommends that among the approaches to plan formulation considered, the CNA Study Team include the development of plans focused on addressing different “themes,” or collections of attributes captured by the evaluation criteria. For example, these might include a “dam safety” theme, an

operational flexibility and resilience theme, a “low cost” theme, etc. This initial array of “themed” alternatives could be used to inform additional plans that integrate additional desirable outcomes for consideration.

**3. Does the IRB have any recommendations or comments with regard to the planned reservoir operations studies that will be part of the CNA Project versus those planned for the Water Control Manual outside of the CNA Project auspices?**

*Response:*

The IRB understands that a series of reservoir operations plans will be developed over a period of several years, including interim operations plans during and following the current reconstruction of the Flood Control Outlet (FCO) Spillway and the Emergency Spillway. Subsequent plans will involve the establishment of flood operation rules developed collaboratively with the US Army Corps of Engineers (USACE) which will fill the gap between the end of the current spillway reconstruction and the adoption of a formal long-term revision to the Water Control Manual (WCM). The reservoir operations studies performed as part of the CNA by DWR will help inform the formal revisions to the WCM, and the WCM will need to align with any interim measures and long-term alternative plans implemented through the CNA. However, the ultimate responsibility and authority for the formal long-term revisions to the WCM reside with the USACE.

An initial 2017/2018 Reservoir Operations Plan was developed in coordination with partner agencies with the goal of limiting outflows from the FCO Spillway to 150,000 cfs while avoiding use of the Emergency Spillway, and with no increase to the exceedance frequency for critical pool elevations and downstream flow thresholds. Updates currently under development for the 2018/2019 Reservoir Operations Plan increase the flood pool storage to consider the absence of the Marysville Reservoir that was assumed to be in place when the original reservoir operational rules were established. The IRB concurs with the goals and objectives of the interim reservoir operations plans as stated in the presentation. Furthermore, the IRB agrees that the stated criteria are appropriate to analyze CNA task alternatives with respect to operational impacts associated with each alternative plan.

The presentation acknowledged that climate change considerations may be considered in updates to the interim reservoir operation plans: however, there was no discussion as to how climate change considerations will be factored into the studies. As previously stated in the IRB’s Memorandum No. 1 (IRB

Recommendation M1-16), the IRB continues to recommend the CNA Project Team either address how climate change has been accounted for in developing the operational plan for the facility, including potential changes in hydrograph shape, size, and seasonality, or explain why it is not a concern.

It was stated during the presentation that the flow constraint for the current operation plan through the FCO Spillway of 150,000 cfs is due to the capacity of the downstream levee system. The IRB recommends that the basis for this flow constraint be substantiated in the documentation for the CNA studies, and encourages the use of risk-based information by performing sensitivity analyses to assess the relative risk for various flow release levels. In particular, it would be instructive to develop an understanding of the risk profile for flows ranging from 100,000 cfs to 200,000 cfs in increments of 10,000 cfs for use in operational decision-making, both for interim operations and possibly for long-term revisions to the WCM. The sensitivity analysis should include an estimate of the return period or recurrence interval associated within this range of incremental flow releases.

The IRB agrees that it is appropriate to limit the outlet capacity of the Hyatt powerhouse to 50 percent of the full capacity under the assumption that one of the penstocks may be out of service for maintenance or repairs during a flood event. Flows at the time of a flood event could also be further limited by low power demands within the electric grid, equipment failure of a critical element of the grid at the time of a flood event or operational restrictions due to high tailwater conditions. Further to the previous recommendation from IRB Memorandum No. 1 (Recommendation M1-12) to evaluate plans for providing redundancy in external systems that deliver power to the grid, the IRB recommends that the evaluation include alternative measures to create artificial power demand to allow energy dissipation so that the grid demand or equipment failure will not be limiting factors for powerhouse outlet capacity during a flood event.

**4. Does the IRB have any recommendations or questions on the information presented on the activities completed to date for Task 3, FCO Headworks?**

*Response:*

The IRB believes that DWR has appropriately assessed the stability of the concrete monoliths for loads up to the previous PMF loading and a 0.56g earthquake load with the reservoir at the maximum conservation storage level. A

key assumption of the analyses completed to date appears to be that each of the monoliths remains intact and behaves as a single concrete element. The IRB recommends that DWR assess the adequacy of the previously completed FCO headworks stability analyses in light of the revised flood routing of the 2018 PMF study.

The IRB was pleased to see consideration of the lessons learned from the design and construction of the Folsom Dam Joint Federal Project gate structure, which the USACE based on the Oroville Dam FCO headworks design. The IRB agrees with the plan to perform a non-linear stress analysis to better understand the potential for and anticipated extent of damage to the FCO headworks during seismic events. The performance of the FCO headworks is likely to be very sensitive to horizontal ground motions perpendicular to the centerline of the spillway. Such analyses are highly specialized and require analysts well trained in both the use of the computer codes and the selection of appropriate model geometry and parameters. The IRB recommends that DWR develop a written plan (to be included in the documentation of the analysis) for validation of the model to be used in the non-linear analysis of the FCO headworks and the results of the analysis. As part of that plan, the IRB encourages DWR to consider including collection of actual dynamic structural performance data that could be used to verify the natural frequencies of the computer model of the structure. The IRB also encourages the use of external subject matter experts for review of the non-linear analysis.

The focus of the analyses to date has been on the civil structures. While the presentation made brief mention of the need to assess the mechanical and electrical features, a plan for conducting such an assessment has not been presented. The IRB recommends that DWR develop a written plan for assessing the performance of the mechanical/electrical components of the FCO headworks under seismic loads.

**5. Does the IRB have any recommendations or questions on the information presented on the activities completed to date for Task 5, Embankment Dam?**

*Response:*

The IRB is pleased with the activities completed by the project team to date for Task 5, Embankment Dam. The IRB appreciated the Team's clear presentation of key aspects of the work in collecting, organizing, and analyzing available information from design, construction, and performance monitoring of the dam



embankment. The activities to date have dealt mostly with the ongoing seepage and stability studies prompted by the FERC Part 12D Process and have focused primarily on the work needed to: (a) address the recommendations made by the 9th Part 12D Independent Consultants, and (b) further evaluate the Potential Failure Modes identified during the PFMA workshop conducted for the 9th Part 12D Safety Inspection of the dam. The IRB agrees that these studies provide important information for identifying baseline risks and improvement needs for the dam embankment as part of Task 5. The IRB recommends that the Team embrace a holistic approach to the evaluation of risk associated with the dam embankment and consider if there are other issues related to the embankment that may not have been brought up by the FERC Part 12D process.

Significant progress has been made on several key subtasks of the studies. The IRB acknowledges the significant effort made in collecting and reviewing the basic data, and in developing a more refined geotechnical model of the embankment zonation and material characteristics than, to the IRB's knowledge, had been previously done. The Team's methodical study of the basic data, and the thoughtful analysis of the data trends revealed important information about the characteristics of the materials in the various embankment zones. The IRB commends the Team on the use of modern filter criteria and on having retained top international expertise in evaluating the likelihood of possible "continuing internal erosion" within the dam embankment as an element of previously identified PFMs for the dam.

The IRB endorses the Team's approach to addressing potential embankment stability issues that might be associated with the "vegetated area" on the downstream face of the dam. The IRB recommends that the Team take advantage of the new findings about the characteristics of the embankment zones and consider further implications on the overall stability of the dam, keeping an open mind about uncertainty in the various aspects of the evaluation, including the strength of the embankment materials in the vegetated area and other zones of the dam.

The IRB endorses the methodical study of the permeability characteristics of the embankment and foundation materials, seepage through the dam, the effects of rainfall on seepage measurements, and the implications of such information on performance monitoring for the dam. The IRB recommends taking advantage of information on the recorded performance of the embankment during significant events in the life of the dam to provide further understanding of the dam's

characteristics. For example, one such key event was the rise in water levels and recorded piezometric pressures near the base of the downstream shell (below the elevation of the drain blanket) during the winter of 1966 and the subsequent dissipation of pressures and reduction in water levels during the following dry weather period. Analysis of such an event could provide significant insight into the permeability of the impervious materials within the downstream seepage barrier, which is key to assessing issues related to performance monitoring of the dam.

The IRB recommends that the Team thoroughly document their knowledge and understanding of the performance of the dam including explanations for the very low observed seepage, the significance of the vegetated area on the downstream slope of the embankment, and the effectiveness of the internal filtered seepage collection system for dam performance monitoring.

**6. Does the IRB have any recommendations or questions on the CNA Workplan update?**

*Response:*

The IRB was impressed with the scope of the Workplan and pleased with the increased staffing for the project. In particular, DWR should be credited for its re-assessment of identified activities to determine whether each should be performed at the project or task level. This integration effort will increase efficiency and will provide a common framework for the 6 identified tasks to be completed. The IRB notes that the updated workplan was further defined and the completion date extended by approximately 5 months. The current completion date for the final report is May 31, 2020. The IRB was pleased to see appropriate consideration given to schedule flexibility while the activities required to complete the project are being further defined through IRB, Ad Hoc committee, and team leader input. Although the study needs to be expedited, the IRB believes that thoroughness and quality of the work should be primary considerations in establishing an approved schedule. The IRB believes the revised workplan is aggressive and supports the proposed completion dates for the CNA based on current knowledge.

**7. Does the IRB have any other recommendations or comments?**

*Response:*

According to the revised schedule, the CNA Study Team will be completing reports for Tasks 1, 2, 4 and 6 that will be presented during IRB Meeting No. 3 in

December. The IRB would appreciate the opportunity to review the reports prior to the IRB meeting.

The IRB appreciates DWR's effort to develop an initial outline for the CNA report. The IRB recommends that DWR further develop and update the final CNA report and task report outlines for each successive IRB meetings. This will allow the IRB to better understand the work expected to be performed and provide greater certainty of meeting organizational and stakeholder expectations for the final reports.

*Concluding Remark:*

The IRB appreciates the CNA Study Team's consideration and implementation of the IRB's recommendations and their thoughtful and excellent presentations.

**IRB RECOMMENDATIONS SUMMARY**

- M2-1        The IRB recommends that plan options be evaluated using a structured Multi-Criteria Decision-Making approach such as "choosing by advantages."
- M2-2        The IRB recommends that "permittability" or "minimizing permitting challenges" be added to the list of evaluation criteria.
- M2-3        The IRB recommends that all evaluation criteria be framed as the measurement of positive outcomes.
- M2-4        The IRB recommends that among the approaches to plan formulation considered, the CNA Study Team include the development of plans focused on addressing different "themes," or collections of attributes captured by the evaluation criteria.
- M2-5        The IRB recommends that the basis for the 150,000 cfs flow constraint be substantiated in the documentation for the CNA studies, and encourages the use of risk-based information in the analysis by performing sensitivity analyses to assess the relative risk for various flow levels. The IRB recommends that the sensitivity analysis be performed for releases from the dam ranging from 100,000 cfs to 200,000 cfs in increments of 10,000 cfs for use in operational decision-making, both for interim operations and possibly for long-term revisions to the WCM. This analysis should include an

estimate of the return period or recurrence interval associated within this range of incremental flow releases.

- M2-6 The IRB recommends that alternative measures be considered to create artificial power demand to allow energy dissipation so that the grid demand will not be the limiting factor for powerhouse outlet capacity during a flood event.
- M2-7 The IRB recommends that DWR assess the adequacy of the previously completed FCO headworks stability analyses in light of the revised flood routing of the 2018 PMF study.
- M2-8 The IRB recommends that DWR develop a written plan (to be included in the documentation of the analysis) for validation of the model to be used in the non-linear analysis of the FCO headworks and the results of the analysis.
- M2-9 The IRB recommends that DWR develop a written plan for assessing the performance of the mechanical/electrical components of the FCO headworks under seismic loads.
- M2-10 The IRB recommends that the Team embrace a holistic approach and consider other issues that may not have been brought up by the FERC Part 12D process.
- M2-11 The IRB recommends that the Team take advantage of the new findings about the characteristics of the embankment zones and consider further implications on the overall stability of the dam, keeping an open mind about uncertainty in the various aspects of the evaluation, including the strength of the embankment materials in the vegetated area and other zones of the dam.
- M2-12 The IRB recommends taking advantage of information on the recorded performance of the embankment during significant events in the life of the dam to provide further understanding of the dam's characteristics.
- M2-13 The IRB recommends that the Team thoroughly document their knowledge and understanding of the performance of the dam including explanations for the very low observed seepage, the significance of the vegetated area on the downstream slope of the

embankment, and the effectiveness of the internal filtered seepage collection system for dam performance monitoring.

M2-14 The IRB recommends that DWR further develop and update the final CNA report and task report outlines for each successive IRB meeting.

Respectfully submitted,



**Betty Andrews**



**Lelio Mejia**



**Bruce Muller**



**Paul Schweiger**



**Dan Wade**