

# OROVILLE COMPREHENSIVE NEEDS ASSESSMENT

## Independent Review Board Report

DATE: February 28, 2020

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: Report No. 7

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On Thursday February 27, 2020, the Independent Review Board (IRB) met at the Department of Water Resources (DWR) Oroville Field Division Office Main Conference Room 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), Division of Safety of Dams (DSOD), the Federal Energy Regulatory Commission (FERC), and industry consultants working on the CNA for status updates on:

- Summary of Risk Assessments,
- Status of Reports,
- Alternative Plan Formulation Process,
- Alternative Plan Results, Recommendations, and Discussion,
- Comments Log Discussion,
- Schedule and Next Steps, and
- Open Discussion of the CNA Study.

During the morning of Friday February 28, 2020, 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, DOM, FERC, and industry consultants working on the project at 12:00 pm. The meeting was adjourned following the reading of the report.

All IRB members were present on both days including (Elizabeth) Betty Andrews, Lelio Mejia, Bruce Muller and Paul Schweiger. Former IRB member Dan Wade resigned from the IRB in December 2019 having changed his full-time employment. The list of meeting participants for both days is attached.

### **DOCUMENTS PROVIDED FOR IRB REVIEW**

The following documents were provided for review by the IRB prior to the meeting:

- Oroville Dam Comprehensive Needs Assessment Project Report - Public Draft (Table of Contents)
- Oroville Dam Comprehensive Needs Assessment - Final Report; Draft Version 2.0
- Oroville Dam Comprehensive Needs Assessment –Task 1: Emergency Spillway; Draft Version 6.0
- Oroville Dam Comprehensive Needs Assessment – Task 4: Low - Level Outlets; Draft Version 5.2.1
- Oroville Dam Comprehensive Needs Assessment –Task 5: Oroville, Bidwell Bar, and Parish Camp Embankments; Draft Version 5.0
- Draft – Comprehensive Needs Assessment Schedule – Revised March 29, 2019
- USACE Engineering and Construction Bulletin No. 2018-2; Subject: Implementation of Resilience Principles in the Engineering & Construction Community of Practice
- Definitions of Resilience - Guidance and Organizational Policy Statements
- Comments and Recommendations / Independent Review Board - Oroville Comprehensive Needs Assessment Project

### **QUESTIONS FOR THE IRB**

- 1. Does the IRB have any recommendations or comments on the summary of risk assessments?**

*Response:*

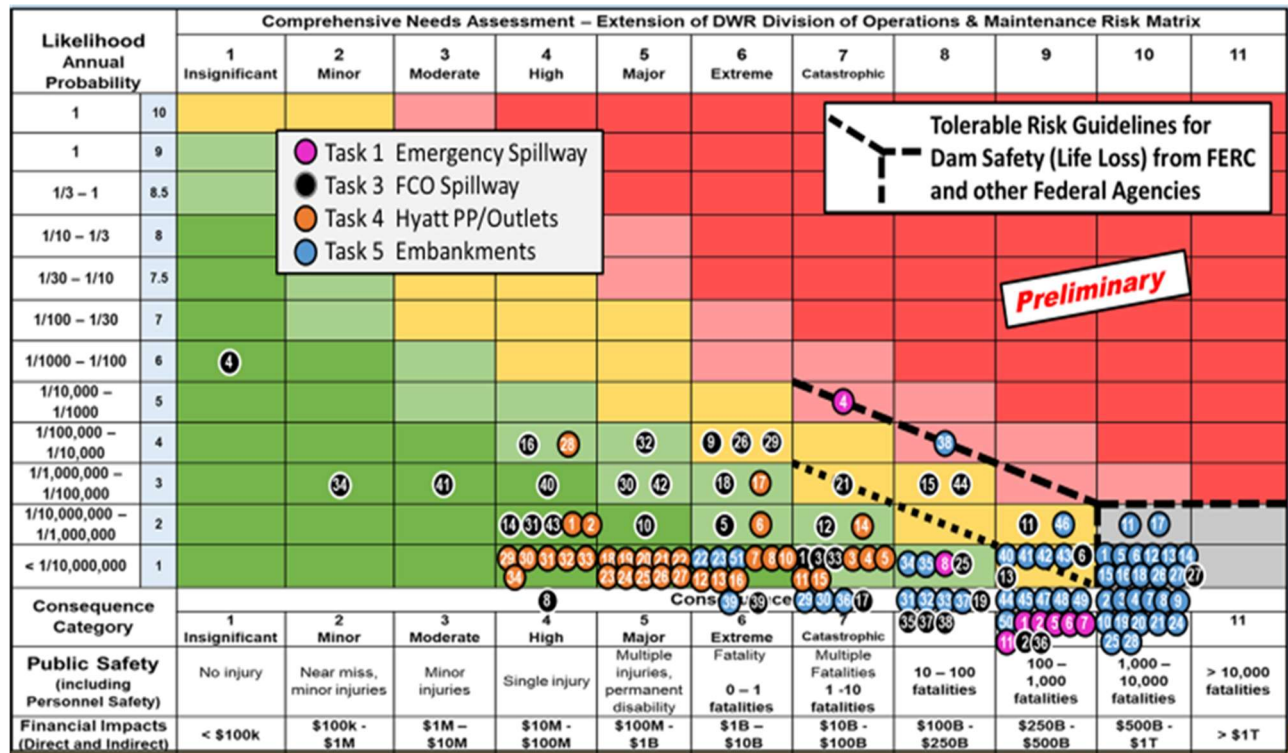
The IRB appreciated the thorough presentation summarizing the risk assessments for the project and was pleased to see that the analyses are almost complete. A methodic approach was used for the risk assessment of existing conditions and for the assessment of risk reduction measures. The process included a systematic evaluation of potential failure modes (PFMs) carried forward into the risk analysis

and categorization of the PFMs using the CNA extension of the O&M asset management risk matrix. Differences in the final categorization of some of the PFMs relative to their categorization prior the IRB's Meeting No. 6 were reviewed and justified by the CNA Project Team. The IRB was shown typical records of how each of the PFMs, along with their estimates of likelihood and consequences, were reviewed by senior Project Team members, and that resolution of their review comments was documented. No new PFMs were identified for the project since the last IRB meeting in October, 2019.

As indicated in the previous IRB report, the concurrent CNA and L2RA efforts to better understand project risks presented an opportunity for comparing the results of each process. While the processes for each study do not have identical objectives, they intersect when considering extreme events to which the dam could be subjected, as well as the consequences. The general agreement between the results of the two efforts is noteworthy given that the L2RA Team is largely comprised of industry experts with significant knowledge of dams throughout the nation and world, while the CNA Project Task Teams largely relied on staff intimately familiar with the details and history of Oroville Dam. The IRB continues to believe that this comparison has served as a unique and effective quality assurance process for identifying the PFMs with risk levels that warrant consideration of risk reduction measures. It also provides an important means to assess and reduce uncertainty in the risk estimates.

The presentation to the IRB included reviewing and comparing the top risk driving PFMs identified by the CNA Project Team and the L2RA Team and discussing the similarities and differences of each. Current L2RA estimates (report is draft) appear to predominantly be similar (within approximately 1 order of magnitude) with those independently developed by the CNA Project Team. All of the CNA risk estimates are within the range of values originally estimated by the L2RA Team. There was discussion of the appearance of the few differences in estimates for some of the tasks having a systematic pattern of L2RA estimating higher likelihoods than the CNA Project Team. However, this is compensated for by the CNA Project Team developing measures to address risk estimates at least two orders of magnitude below commonly accepted levels of tolerable risk.

The IRB was pleased to see that the CNA Project Team is making a clear distinction of relative risk magnitude using a graduated scale of risk that allows for best understanding the priority/urgency for implementing measures to reduce risk. A graphic that effectively provides a summary of the risk analyses for existing conditions was presented, and is provided in Figure 1.



**Figure 1. Summary of Estimated Risks for CNA Potential Failure Modes (Existing Conditions)**

The IRB notes that the current risk estimates determined for the Oroville Dam complex are low, with the two highest risk PFMs identified as being on the threshold of commonly accepted tolerable risk.

The IRB notes that the Oroville Dam complex has sufficient capacity to safely convey the PMF without overtopping the dam embankments. Oroville Dam therefore satisfies current prescriptive regulatory requirements for preventing dam overtopping; however, residual risk remains associated with climate change, uncertainty, etc. The PFM identified with the greatest risk involves overtopping Parish Dam, which requires a hydrologic event more extreme than the PMF. The estimated return period for the PMF is approximately 20,000 years. The return period associated with an extreme hydrologic event needed to overtop Parish Dam is estimated to be approximately 40,000 years.

Two PFMs that were previously shown at or near the threshold of tolerable risk were reclassified following refinement of their probability estimates. The CNA Project Team provided a reasonable explanation for this change.

The IRB notes that binning of the PFM risk estimates in one cell of the risk matrix implies an uncertainty in the likelihood and consequence estimates of about one order of magnitude. However, the IRB understands that the original CNA Project Team estimates, like the L2RA Team estimates, often implied greater uncertainty for some PFMs. The IRB understands that uncertainty has been considered by the CNA Project Team developing risk reduction measures for PFMs binned within at least two orders of magnitude of the threshold, which would normally be deemed as not warranting additional risk reduction. The IRB believes it is important to explicitly acknowledge the inherent uncertainty in the risk estimates and **the IRB recommends** that the CNA Project Team discuss the issue of uncertainty in the likelihood and consequence estimates in the CNA Project Report and consider the need to portray uncertainty in graphical representations of the estimates.

The IRB noted that in most of the comparisons between the L2RA and CNA Project Team PFM risk estimates presented at the meeting, the two estimates were within the same order of magnitude. In the cases where they were different, the L2RA estimates were higher than the CNA Project Team's estimates by one order of magnitude or more. Accordingly, **the IRB recommends** that the CNA Project Team examine the differences between L2RA and CNA estimates further and determine if there are systemic reasons for these differences. The analysis and findings should be presented in the Project Report.

**2. Does the IRB have any recommendations or comments on status of reports?**

*Response:*

The IRB was provided preliminary drafts of the Table of Contents for a public version of the overall project report, the project report, and reports for Tasks 1, 4 and 5. The IRB continues to appreciate the CNA Project Team's commitment to developing and updating the reports as work is completed, and providing the IRB with periodic reviews of task reports under development. IRB editorial and content comments for the reports were transmitted to the Study Team. Below are some general IRB comments and suggestions recognizing that the reports are a work in progress.

### ***General Comments Related to All Reports***

- Because of the volume of information in each report, the IRB appreciates the CNA Project Team's use of graphics and callout boxes to make the content more readily approachable and digestible.
- The IRB appreciates the use of color coding to help visually identify task PFMs and convey risk levels. It is effective and should be used in tables and graphics throughout the reports.
- The figures included in the Task Reports to illustrate the "recommended risk reduction measures" are very good and helpful.
- The section of the reports on Formulation and Evaluation of Alternative Plans uses the term: "Recommended Measures" to describe the risk reduction measures being considered. The IRB suggests that the CNA Project Team consider referencing measures advanced for plan formulation as "advanced measures" or "measures recommended for plan formulation," or similar, rather than "recommended measures," as that language suggests a degree of definitiveness that is not intended.
- It would be very helpful for the Project Report (including the public version) and the Task Reports, as applicable, to provide a list of documents or data sources specific to Oroville Dam that were used to characterize existing conditions and relied upon by the CNA Project Team in performing the risk assessment.

### ***Oroville Dam Comprehensive Needs Assessment Project Report - Public Draft (Table of Contents)***

The IRB believes the proposed content for the public report is appropriate. It appears that reference will be made to risk-informed decision making through the use of semi-quantitative risk assessments, risk estimates, and risk reduction measures. **The IRB recommends** that the report prepared for the public include a brief discussion of how risk is quantified and when and how it is determined to be tolerable. That is, there is a range of risk that is not regarded as negligible or as something that might be ignored, but rather as something that needs to be kept under review and reduced still further when possible. In addition to the tolerable risk limit, the as-low-as-reasonably practicable (ALARP) principle should be explained and a description should be provided as to how it may be applied. Discussion of the ALARP principle is believed to be most important for the Public report, but also appears to be missing from all of the reports.

***Oroville Dam Comprehensive Needs Assessment - Final Report; Draft Version 2.0***

All of the Reports provided are in an advanced stage of preparation and the IRB was pleased with the progress made by the CNA Project Team in preparing the reports and with the clear and thorough presentation of the evaluations and results. See editorial comments provided separately. The IRB looks forward to reviewing the Draft Final Project Report once all of the Task Reports have been completed.

***Oroville Dam Comprehensive Needs Assessment –Task 1: Emergency Spillway; Draft Version 6.0***

Operability of the Hyatt Power Plant is important and is required to be able to evacuate much of the reservoir in the event of an emergency. Emphasis should be added to report Sections 7.4.6 and 7.8.5 of the importance of the Hyatt Power Plant beyond public safety and financial risk reduction.

***Oroville Dam Comprehensive Needs Assessment – Task 4: Low - Level Outlets; Draft Version 5.2.1***

The IRB believes that the team has made an exceptional effort to capture the complexity of the considerations associated with various outlet options for Oroville Dam. The IRB saw two aspects of the report that are important to address.

While the CNA has been framed as a risk informed planning study, there is a critical aspect of the outlets that does not fit well in the notion of risk being derived from identified failure modes. Low level outlet capacity provides a capability to intervene in multiple failure modes to reduce the likelihood of an uncontrolled release of the reservoir. The IRB recommends that a discussion of the low level outlet capacity providing a capability to intervene in other failure modes to reduce the likelihood of an uncontrolled release of the reservoir, be included in the Executive Summary and Section 2.0 of the Task 4 Report. Such a discussion would establish the basis for the addition of low level outlet capacity enhancements discussed in Section 6.5. The discussion of the existing capacity of the outlets seems to portray the capacity as “partially” meeting DSOD guidelines based on the rate of drawdown. However, this rate is inferred from what is actually stated in the guidelines. If the guidelines are taken literally as written, Oroville Dam does not meet the guideline for evacuation of the lower portion of the reservoir. In discussions, the team made the case that the guidelines are only applicable to a new dam. While that may be true from a legal or regulatory perspective, it is not a prudent argument for a dam located in a zone of significant seismicity. The IRB agrees that the dam is well past the risk of first filling where the risks of a seepage related failure are

substantially higher than for a dam with a long operations history. However, the dam's performance under a significant or extreme seismic event is not yet proven. Thus the capability to lower the reservoir following such an event remains a valuable tool in managing risk.

The discussion of a powerhouse roof rockfall in Section 5.4.2 tends to focus the consequence discussion on physical damage to equipment. The **IRB recommends** that Task 4 consider the issue of personnel safety for Hyatt Power Plant in lesser seismic events where rockfalls do not result in physical damage. Such a case could still result in the inability to operate the power plant (financial impact and loss of evacuation capacity) until it can be determined that the powerhouse is safe for personnel to enter.

***Oroville Dam Comprehensive Needs Assessment –Task 5: Oroville, Bidwell Bar, and Parish Camp Embankments; Draft Version 5.0***

The IRB was pleased with the progress made by the Team in preparing the report and with the clear and thorough presentation of the Task 5 evaluations and results. The IRB noted that the report does not reflect on several of the studies related to Oroville Dam that DWR has completed since the CNA Project began, including those of the vegetated area on the downstream face of the dam. The latter is particularly significant because of the prominent nature of the issue within public perception. Accordingly, **the IRB recommends** that the Task 5 Report make reference to the study of the vegetated area and other studies of the dam completed by DWR in the description of existing conditions, and where the studies were used to inform the development of PFMs and risk estimates. The **IRB recommends** that the hydraulic conditions leading to an elevated reservoir level near the Parish Camp Saddle Dam during extreme hydrologic events that contribute to the risk of overtopping of that dam be discussed in Section 5.3 of the Task 5 report.

**3. Does the IRB have any recommendations or comments on Alternative Plan formulation and recommendations?**

*Response:*

An excellent presentation was made describing the Alternative Plan formulation process. The Alternative Plans were composed of the measures that were developed, screened, and advanced as part of each task. The IRB was pleased to see that a structured and consistent method was used in each task report to



develop, screen, and advance potential measures for plan formulation, consistent with IRB recommendation M04-03.

A dynamic process was then used to group the advanced measures to formulate alternative plans in a series of workshops. At the first workshop, a suite of plans was initially developed. These plans were then revised and refined at two later workshops. Each plan was formulated using a subset of the identified advanced measures to meet three criteria: 1) reducing risk in one or more consequence categories, 2) supporting CNA Design Considerations, and 3) enhancing the resilience of the Oroville Dam system. Consistent with IRB recommendation M02-04, the plans were developed around a number of themes. After the first workshop, the themes and plans were consolidated and then augmented at the second and third workshops. A system of scoring each plan with respect to risk reduction, resilience/meeting project objectives, and use of good engineering/best practices was used to semi-quantitatively assess and rank the effectiveness of each plan. Finally, conceptual-level/order of magnitude cost estimates were developed for each measure so that the approximate cost of each plan could be considered in concert with the scores associated with each plan.

The IRB supports the CNA Project Team's effectiveness scoring approach, including application of the USACE "PARA" principles (Prepare, Absorb, Recover, and Adapt) for evaluating the relative resilience achieved by each plan. The CNA Project Team noted that implementation of some measures actually carried risk themselves, thereby reducing the overall risk reduction benefit they afforded. The semi-quantitative scoring approach allowed the overall effectiveness of each plan to be appropriately assessed.

The IRB found that the risk graphics developed to illustrate the existing condition risk matrix and the risk reduction outcomes of implementing various plans were very effective. As a means of further enhancing these figures, the IRB suggests that the CNA Project Team explore the possibility of using vectors on the matrix, or other graphical means, to indicate the reduction of risk achieved by plans.

The IRB appreciates the intent of the CNA Project Team in seeking to identify a subset of plans to present as "preferred alternatives," across a range of cost levels. However, **the IRB recommends** the full suite of alternative plans be presented as appropriate for consideration by DWR management. It may be desirable to describe the notable cost increments associated with particular measures relative to their risk reduction as a way to frame the trade-offs, perhaps using a set of

Alternative Plans as examples. The IRB suggests that the CNA Project Team explore additional ways of graphically presenting the plans relative to each other in terms of cost and risk reduction and/or overall effectiveness scores.

The IRB noted that the measures identified to build the plans have a wide range of costs. While higher cost measures would require additional studies to confirm risks and consequences, there are a small number of low cost measures that would appear could be implemented for perhaps less than the cost of additional studies. The cost of these measures is such that they could be implemented with only minor adjustments to the current strategic capital plan for Oroville Dam. Implementing such measures could even be a matter of developing the plans and specifications and securing the permits for these measures such that they could quickly be awarded in place of a delayed project in the current capital investment plan. Related to one of these cases, there was a question from the CNA Project Team concerning DWR's willingness to design for a flood greater than the Probable Maximum Flood (PMF). The IRB believes that the case for designing for a flood greater than the PMF could easily be made based upon:

- Uncertainties regarding the effects of climate change
- Revisions to PMF hydrographs (typically resulting in larger flood estimates)
- Providing additional protection for critical evacuation routes

**The IRB recommends** that DWR management consider expedited implementation of low cost measures where the cost of further studies could equal or exceed the cost of implementation.

**4. Does the IRB have any recommendations or comments on the comment log discussion?**

*Response:*

The IRB reviewed the Comment Log and updated the status of recommendations as appropriate based upon the information provided in draft reports and presentations to date. The IRB Comments Log is up to date.

The IRB queried the CNA Project Team with regard to IRB Recommendation M01-16 with respect to climate change. The CNA Project Team explained that analyses to support explicit assessment of climate change implications for residual risks at the Oroville Dam system will not be completed in time for direct incorporation into

the CNA. **The IRB recommends** that the CNA Project Report acknowledge the potential for climate change to influence residual risks and the effectiveness of the measures being considered and discuss how those influences may be accounted for in the future. The IRB notes that inclusion of resilience as part of the effectiveness scoring for alternative plans supports the selection of a plan that will continue to be effective under climate change. Additionally, the IRB acknowledges that there will be an opportunity to account for the influence of climate change during feasibility studies and the design of specific measures for implementation.

**5. Does the IRB have any recommendations or comments on the schedule and next steps?**

*Response:*

The Study Team reported that the project remains on schedule and the final reports will be provided in April for IRB review before the next IRB meeting. The IRB would appreciate obtaining the reports at least two weeks in advance of the meeting to provide adequate time for review.

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

*Response:*

The IRB recognizes the extraordinary effort completed by the CNA Project Team to process a large number of PFMs and measures to address the most significant risks. While the learning curve has been steep, the effort has provided an understanding of the necessary elements to assess DWR's dams in a risk context and in a manner that integrates with the asset management framework to support capital planning. The CNA Study provides a model for other facilities. The reports provide the framework for studies that can be scaled by considering the level of supporting studies necessary to assess the components of each project evaluated.

**IRB RECOMMENDATIONS SUMMARY**

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|------|---|
| M7-1 | The IRB recommends that the CNA Project Team discuss the issue of uncertainty in the likelihood and consequence estimates in the CNA Project Report and consider the need to portray uncertainty in graphical representations of the estimates. |
| M7-2 | The IRB recommends that the CNA Project Team examine the differences between L2RA and CNA estimates further and determine if there are systemic reasons for these differences.  |

- M7-3 The IRB recommends that the report prepared for the public include a brief discussion of how risk is quantified and when and how it is determined to be tolerable.
- M7-4 The IRB recommends that a discussion of the low level outlet capacity providing a capability to intervene in other failure modes to reduce the likelihood of an uncontrolled release of the reservoir, be included in the Executive Summary and Section 2.0 of the Task 4 Report. Such a discussion would establish the basis for the addition of low level outlet capacity enhancements discussed in Section 6.5.
- M7-5 The IRB recommends that Task 4 consider the issue of personnel safety for Hyatt Power Plant in lesser seismic events where rockfalls do not result in physical damage.
- M7-6 The IRB recommends that the Task 5 Report make reference to the study of the vegetated area and other studies of the dam completed by DWR in the description of existing conditions, and where the studies were used to inform the development of PFMs and risk estimates.
- M7-7 The IRB recommends that the hydraulic conditions leading to an elevated reservoir level near the Parish Camp Saddle Dam during extreme hydrologic events that contribute to the risk of overtopping of that dam be discussed in Section 5.3 of the Task 5 Report.
- M7-8 The IRB recommends the full suite of alternative plans be presented as appropriate for consideration by DWR management.
- M7-9 The IRB recommends that DWR management consider expedited implementation of low cost measures where the cost of further studies could equal or exceed the cost of implementation.
- M7-10 The IRB recommends that the CNA Project Report acknowledge the potential for climate change to influence residual risks and the effectiveness of the measures being considered and discuss how those influences may be accounted for in the future.