SUMMARY OF FERC RECOMMENDATIONS AND DWR ACTIONS
FERC Part 12 D 2014 INSPECTION REPORT

Note: Selected recommendations have been edited to protect Critical Energy Infrastructure Information.

All Part 12D reports for Oroville Dam ended with the conclusion that the project was suitable for continued operation.

The process for a Part 12D report is iterative. The Independent Consulting Board, required by FERC every five years, provides an independent inspection and evaluation of the facility, and provides recommendations to DWR in their Part 12D report. DWR then submits a plan and schedule to address those recommendations based on priority and risk. In some cases FERC provides feedback to DWR's plan and DWR responds with additional information and planned actions.

The summary provided for each Part 12D report is DWR's plan, approved by FERC, to address recommendations. It provides the latest action from DWR in response to the recommendations in the inspection process.

Summary of Recommendations – Oroville Dam (19 Total)

R-1. The Board recommends that DWR perform the following tasks to enhance on-going assessments of the FCO radial gate anchorages:

a. Review performance issues with similar types of tendons on other dams (DWR dams and others).

b. Review previous analyses of the capacity contribution of the anchors.

c. Perform load/corrosion testing using new non-destructive testing (NDT) methods (possibly dispersive wave technology or other methods). The testing should be implemented no later than 2017.

Status: DWR completed R-1a in 2015. Testing that addresses R-1c was completed in August 2016. Additional testing is tentatively planned in 2017. The next step (for R-1b) consists of re-analysis of the anchorages and will be completed by the end of 2017.

R-2. The Board recommends that DWR convene a workshop of technical experts to reach conclusions regarding the condition and remaining life of the FCO radial gate anchor tendons after the tasks in Recommendation 1 above have been completed.

Status: ***In-Progress.*** *Prior to the spillway incident, DWR planned to convene a workshop of technical experts in Fall of 2017. Workshop participants will include engineers and experts from DSOD, FERC, and consulting firms. The workshop remains planned for Fall 2017.*

R-3. The Board recommends that DWR develop a coordinated Rapid Response and Recovery Plan to issues with flood control outlet radial gate operation.

Status: ***Completed.*** *The Rapid Response and Recovery Plan to safely and efficiently address potential problems with operation of the flood control outlet radial gates was submitted to and approved by FERC.*

R-4. The Board recommends that the following tasks be conducted to evaluate the performance of the slide gates at the Hyatt Powerplant Intake structure under seismic loading:

a. Prepare a report summarizing the design information for the gates and penstocks and detailing the current condition of the slide gates and hoists.

b. Review the protocol for shutting down the plant during an earthquake.

c. Identify the systems or events that would cause the units to trip and flow to cease in response to ground motions.

Status: ***In-Progress****. The analysis to address R-4 is anticipated to be completed by the end of 2017.*

R-5. The Board recommends that DWR update the stability analyses on record for the Flood Control Outlet (FCO) using principles and parameters in accordance with the FERC guidelines and up-to-date practices, including consideration of updated ground motions and uplift pressures.

Status: ***In-Progress.*** *In 2015, DWR submitted an exploration plan to the Federal Energy Regulatory Commission (FERC) for the acquisition of shear wave velocity data necessary to develop appropriate seismic ground motions. Upon FERC's approval in 2016 of the exploration plan, DWR advanced a drill hole adjacent to the FCO and Emergency Spillway to acquire downhole shear wave velocity data of the foundation bedrock for use in development of ground motions specific to the FCO and Emergency Spillway. In 2017, DWR utilized this information to update the ground motions. In June 2017, a draft two-dimensional stability evaluation of the FCO under normal, probable maximum flood, and earthquake loadings was completed. This evaluation is currently under review. DWR is considering the value of performing a 3-Dimensional (3D) linear elastic time history and structural response analysis to better characterize the structure's performance.*

R-6. The Board recommends a thorough review of the stability calculations for the Emergency Spillway structure. To the extent necessary, the calculations should be supplemented with new stability analyses in accordance with the FERC

guidelines and up-to-date practices and that consider all relevant loading conditions, including the current PMF and seismic loadings.

Status: ***In-Progress****. In 2015, DWR submitted an exploration plan to the Federal Energy Regulatory Commission (FERC) for the acquisition of shear wave velocity data necessary to develop appropriate seismic ground motions. Upon FERC's approval in 2016 of the exploration plan, DWR advanced a drill hole adjacent to the FCO and Emergency Spillway to acquire shear wave velocity data of the foundation bedrock for use in development of ground motions specific to the FCO and Emergency Spillway. In 2017, DWR utilized this information to update the ground motions. The Spillway Recovery team has re- evaluated the stability of the Emergency Spillway and its proposed interim and permanent improvements. The analyses support the designs generated by DWR and that are currently under construction.*

R-7. The Board recommends that cameras be installed at the FCO.

Status: ***Completed.*** *Even prior to the recommendation, cameras existed at the FCO structure and provided real-time video of the Flood Control Outlet. Additional cameras have been added to provide additional vantage points of the spillway.*

R-8. The Board recommends that DWR perform a condition assessment of Palermo Tunnel and report the findings by early 2017.

Status: ***Completed****. Ultrasonic thickness testing, inspections of the exterior and interior of the pipe stub, and engineering analyses indicate the Palermo Tunnel and its appurtenances are in good condition.*

R-9. The Board recommends that DWR review and test its communication systems as they pertain to important operations

Status: ***In-Progress.*** *The Oroville Spillway Emergency required revision to the plan and schedule to address this recommendation. Completion of this recommendation is expected by summer of 2018.*

R-10. The Board reiterates that the monitoring and analysis of seepage (including turbidity) are vital aspects of understanding the behavior of the dam, particularly because very limited piezometric data are being recorded in the dam. The toe weir flow monitoring is especially critical, being the main measurement of seepage through the dam core. However, it is not well understood how sensitive the toe weir flow is as an indicator of phreatic levels and seepage within the dam. The Board also observes that the measured seepage is exceptionally low for a

dam of the height and head of Oroville Dam. The Board recommends that DWR perform a study to evaluate the adequacy of the measured toe weir flow as a reliable indicator of possible changes in seepage and phreatic levels within the dam (and the associated impacts on dam stability). The types of changes that need be addressed are, for example, those that might be caused by possible internal erosion of the core. Thus, the study should consider the following:

a. Review of design, construction, and performance data on the characteristics of the embankment and foundation and their permeability properties

b. Review of filter compatibility between zones in the embankment and assessment of the potential for internal erosion

c. A review of case histories of internal erosion of dams and of observed seepage quantities associated with internal erosion in conditions relevant to those of Oroville Dam

d. Analysis of the impact of rainfall on the historical seepage data

e. Review of piezometric and seepage data since construction and of their relation to reservoir level using computational analysis as appropriate.

f. Computational analysis of seepage using modern analysis tools and considering seepage through the foundation and through or around the toe seepage barrier

g. Uncertainty in all aspects of the evaluation

h. Review and assessment of the Threshold Levels in light of the findings of the evaluation

The recommended study should be completed in its entirety by end of 2017.

Status: ***In-progress.*** *The plan and schedule to address this recommendation has been impacted by the Oroville Spillway Emergency and Recovery effort. Item (a) was completed in July 2017. DWR and consultants are actively working to address items (b), (c), and (d) by November 2017. Their completion will allow DWR to develop an appropriate scope of work for execution of items (e), (f), (g), and (h). Due to the potential complexity of the computational analysis and modeling effort, DWR anticipates the completion of (e), (f), (g), and (h) in 2018.*

R-11. The Board recommends that DWR provide in the next DSSMR an explanation as to why the surface monument surveys indicate that the settlement of the El 815 upstream bench is greater than the settlement of the dam crest by a factor of two.

Status: ***Completed.*** *This recommendation has been completed and approved through the annual submittal of the Dam Safety Surveillance and Monitoring Reports for Oroville Dam.*

R-12. The Board recommends that DWR review its procedures for establishing instrumentation Threshold Levels and that the Threshold Levels be revised to consider the original design basis, not just the historical data, such that the purpose of the monitored parameter is meaningful with respect to the design from a dam safety perspective.

Status: ***In-Progress*** *The plan and schedule to address this recommendation has been impacted by the Oroville Spillway Emergency and Recovery effort. Completion of this recommendation through an updated Dam Safety Surveillance and Monitoring Plan for Oroville Dam is anticipated by end of 2018.*

R-13. The Board recommends that DWR undertake a seismic walkdown of Oroville Dam's associated electrical/mechanical equipment to develop a seismic fragility inventory. The walkdown should consider documented historical behavior of electrical/mechanical equipment during earthquakes, such as that available for nuclear powerplants.

Status: ***In-Progress****. DWR anticipates completion by the end of 2018.*

R-14. The Board recommends that DWR conduct an evaluation of staff numbers and skills necessary to ensure adequate response to emergency conditions. As part of this effort, access to the facilities under flood and earthquake conditions should be assessed and the full impact of a temporary loss of off-site power should be evaluated.

Status: ***Completed****. In May 2016, DWR tasked a consultant to perform this evaluation. In May 2017, the consultant completed the evaluation and concluded that DWR maintains sufficient staff at Oroville Field Division to ensure adequate response to emergency conditions. The evaluation also recognized that DWR maintains contracts that can provide longer-term monitoring and response support such as that needed during the February 2017 spillway incident. DWR relied heavily on consultants and partnering agencies during the incident to relieve DWR staff and allow them to serve other critical roles in the response effort. The evaluation recommends that DWR maintain such contracts to provide that flexible and scalable emergency response capability. DWR intends to maintain that capability and build upon the relationships developed with the partnering agencies that responded to the incident.*

R-15. The Board recommends that the following documents and information be included in the appropriate sections of the STID:

a. A "Summary of Findings – Anchorages," as related to R-1

b. Documentation of existing analyses and important modifications to critical equipment within Hyatt Powerplant.

c. As-built geology drawings for the dam and appurtenant structures

d. A single write-up that provides all available information on the "green spot" on the downstream dam face

e. Documentation of the project-safety-related events and/or repairs since the 2010 Eighth Part 12D report

f. A write-up describing how upstream river flows, precipitation, and releases from upstream dams are considered by DWR engineering and operations in setting gate opening levels and, in extreme cases, used to implement the emergency action plans for Oroville Dam and the downstream reservoirs that constitute the Oroville-Thermalito Complex.

Status: ***Completed****.*

R-16. The Board does not agree with the findings and conclusions of DWR's Division of Engineering (DOE) Project Geology Branch (PG), which are based on the work of consultants, on the Prairie Creek Fault Zone. The Board recommends that DOE PG critically review the findings and conclusions of ongoing and previous work on the Prairie Creek Fault Zone with consideration of the Board's comments in Section 7.5.3 and prepare a report for review by the Board by March 2015.

Status: ***In-Progress.*** *DWR completed a Phase I study in 2015. Preliminary findings and a scope of work to complete a subsequent phase II investigation have been reviewed and approved by the Independent Consultants. Accordingly, DWR is currently performing the Phase II investigation.*

R-17. The Board recommends that the reservoir slopes be inspected as soon as possible to take advantage of the low reservoir (drought) levels and qualitatively assess reservoir slope stability. The Board also recommends that the reservoir slopes be inspected with respect to the northern end of the Cleveland Hill Fault Zone.

Status: ***In-Progress.*** *The low reservoir levels were taken advantage of to acquire high quality LiDAR and imagery to assess slope stability and faulting. Based on the LiDAR findings, DWR expanded the project's scope and is currently conducting a field investigation that should conclude by the end of 2017.*

R-18. The Board recommends that the issue of potential instability associated with the green spot on the downstream face of the dam toward the left abutment between El 600 and El 700, approximately, be investigated. The investigation should evaluate the potential characteristics of the Zone 3 material in the green spot area, including the strength properties of the low-permeability materials, and include computational analyses to assess the effects of such a zone on the static and seismic stability of the dam, with due consideration to uncertainty in all aspects of the evaluation.

Status: ***In-Progress.*** *DWR approached this recommendation in concert with R-10, and thus the efforts on this recommendation were temporarily interrupted by the spillway emergency. To date, DWR has completed a literature and data review to establish the limits of the "green spot" and identify the causes of the observed surficial changes. The review confirms 1) that the moisture and seepage at this location is the result of rain infiltrating the dam and being impounded on lifts of embankment with higher fines content (lower permeability), and 2) the seepage was observed prior to filling of the reservoir. The review also documented that there has been no evidence of instability. Strength properties obtained through the data review will be utilized to complete the recommended static and seismic stability of this specific profile of the dam.*

R-19. The Board notes that documentation on the stability of the FCO and the Emergency Spillway in the STID lacks important detail. The Board recommends that such documentation be updated to include a comprehensive summary of (1) the key characteristics of the structures and the material properties applicable to the stability of both structures and (2) the available analyses. The available analyses should be supplemented to address all relevant loading conditions, including the potential for uplift during the PMF, and to provide a proper basis for all properties used and assumptions made in the analyses, in accordance with Recommendations 5 and 6.

Status: ***Completed.*** *DWR updated Section 8 of the STID in August 2016. Upon completion of Recommendation R-5 and R-6, DWR will update Section 8 again to include a comprehensive summary of the most current FCO and Emergency Spillway stability analyses.*