

Lake Oroville Spillways Emergency Recovery

Board of Consultants Memorandum No. 1 – March 10, 2017

Prepared by the California Department of Water Resources

Summary & Response

Issues Noted for Consideration

The BOC noted the original design plans showed the slab on the gated spillway at 12 inches, and that compacted clay was used to fill depressions in the rock foundation. This was very preliminary information presented by DWR to the BOC that warranted further evaluation and investigation.

Compacted clay is also a term sometimes used to describe highly weathered rock. As constructed conditions are often different than the design drawings, the slab actual thickness must be explored prior to making any conclusions.

Question 1

The BOC concurs with DWR that the use of the emergency spillway should be avoided until further improvements are made. The gated spillway chute and the powerhouse should instead be relied upon to manage all flows during 2017.

The BOC acknowledged that current exploration is needed to better understand the geology beneath and around the spillways. Although previous exploration and descriptions completed during the original construction of the dam are useful, more up to date information is necessary.

Question 2

DWR described various conceptual approaches to repairing the gated spillway chute. Based on this preliminary information, the BOC questioned if all work could be completed in one season. The BOC described alternative approaches that were presented to them, including buttressing the end of the damaged spillway and placing a flip bucket as a contingency plan, which could easily be completed by November 1.

Question 3

DWR presented preliminary design criteria. Prior to designing detailed plans and specifications, there needs to be an understanding regarding the criteria that will be used to ensure the project meets its objectives. The BOC acknowledges that both spillways may not be able reach their full design capacities by November 1, 2017. However, they agree the preliminary design criteria for the November 1, 2017 deadline will be adequate which can pass flows well beyond the historical maximum storms.



Question 4

Self-explanatory

Question 5

The BOC acknowledges that information at this point is very preliminary and little conclusions can be drawn at this point of the review.

The BOC concludes that since 1968, the concrete within the spillway has not had any significant damage during its life, but acknowledges that spalling and cracking through the years has occurred and was continuously repaired.

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Memorandum

DATE: Friday, 3/10/2017

TO: Mr. Ted Craddock, Project Manager
Oroville Emergency Recovery – Spillways
California Department of Water Resources

FROM: Independent Board of Consultants for
Oroville Emergency Recovery – Spillways

SUBJECT: Memorandum No. 1 - Orientation Meeting March 1 & 3, Site Visit
March 2, and Design Concepts Meeting, March 10, 2017

INTRODUCTION

This initial Board of Consultants (BOC) Memorandum covers activities for the first orientation and introductions meetings which took place March 1 and 3, the site visit to view the spillway damage on March 2nd, and the first design concepts meeting on March 10, 2017.

INITIAL INTRODUCTORY MEETING AND ORIENTATION

The first meeting of the BOC was held at the California State Department of Water Resources (DWR) on March 1st, 2017. Only BOC members Cassidy and Kollgaard were able to attend on the afternoon of March 1st. The purpose was to introduce the staff of DWR who will be working on the restoration design and representatives from the Army Corps of Engineers and Stantec, who were present.

The meeting started at about 1:00 pm and DWR team members were introduced and their positions described. Some of the drone video of the damage to the Oroville Dam facilities was then shown. A summary of the events during the spillway failure was given and the timeline for repair and restoration was discussed. The BOC members were given time to briefly review some of the documents and plans related to the spillway [Gated Spillway] design and performance. Individual contracts for BOC services were provided to Dr. Cassidy and Mr. Kollgaard and the meeting closed shortly after 5:00 pm after arrangements were made for the field trip to Oroville the following day.

Drs. Makdisi and Cato had the opportunity on Friday, March 3rd, to review the same information regarding the history of the design and operation of the spillway [Gated Spillway] at the DWR offices.

FIELD TRIP TO INSPECT SPILLWAY DAMAGE

On Thursday, March 2nd, the BOC were taken to Oroville Dam for their first view of the extent of the damage. BOC members Dr. Makdisi and Dr. Cato were also in attendance for the field trip to inspect the spillway [Gated Spillway] damage. On the morning of March 2nd, the BOC members joined a large party of participants, including staff from the Federal Energy Regulatory Commission (FERC) and the California Division of Safety of Dams (DSOD), to view the Oroville spillway [Gated Spillway] condition during the short period that the service spillway discharge has been shut off. The group was escorted to four viewpoints where the extensive damage could be seen. Intensive efforts are underway to get the powerhouse back in operation and to inspect and map the service spillway [Gated Spillway] damage during the gates closure so that the restoration could be started as soon as possible. The stabilization of the Emergency Spillway damaged area appears to be nearly completed such that this facility would be able to discharge if this should be needed. The BOC members returned to Sacramento at around 5:00 pm.

ISSUES NOTED BY THE BOC FOR CONSIDERATION, DURING RESTORATION DESIGN

Based on their review of project documents, the BOC noted the number of repair instances that have been done to the concrete spillway chute slabs. Of particular concern is the necessity to cut the concrete in order to fill voids discovered beneath the concrete. It is also noted that the slab is only 12-inches in thickness, and at the herringbone drains, the thickness is further reduced. In some areas of the foundation of the chute slab, compacted clay was used to fill depressions in the rock foundation. This calls into question whether the portions of the slab that appear undamaged by the failure should be replaced during the restoration.

The amount of drain water flowing from the pipe discharge openings along the spillway training walls seems extraordinarily large. This drainage system picks up any seepage from the herringbone system of drains under the chute slab and surface water from the backside of the training walls. It appears also that the drains are collecting leakage through cracks in the chute slab and/or defects in the construction joints between slabs. The drains appear to flow for some appreciable time after the gates are closed and no precipitation is occurring. It was noted that no flow was coming from the drains

downstream from the row of sandbags on the spillway chute that diverted flow to one side of the chute. Clearly flow coming from the drains is at least partially coming through cracks and spalls in the slab. The BOC believes this situation should be investigated. It seems likely that piping of foundation material beneath the chute slab may be responsible for the voids that have been found and repaired in the past.

The BOC concurs that restoration of the service spillway to operational service is a first priority, it is anticipated that some portions of the work will involve interim solutions and final completion of all restoration efforts may require more than one season.

RESTORATION DESIGN MEETING MARCH 10, 2017

On March 10, 2017, the BOC met at offices of DWR for presentations of restoration design concepts by DWR. An agenda for the meeting is attached. All BOC members were present. The attendees at the meeting are shown on the attached Attendance List.

QUESTIONS FOR THE BOC

1. Does the BOC have any comments or recommendations regarding the emergency site repairs?

Response

The BOC believes that the DWR plan presented during BOC Meeting 1 is a reasonable approach. Our comments address the short-term plan and the, as yet to be formalized, long-term mitigation. One aspect of the short-term Emergency Spillway plan is to manage operations so that flow over the Emergency Spillway does not occur during the spring 2017 wet season; this is absolutely critical.

Additional aspects of the short-term mitigation consist of the cyclopean backfill placed downstream of the approximately 1,000-ft-long monolithic ogee weir section. The weakest point in this plan occurs at the downstream end of the armoring where all flows are directed and become channelized. To this end, DWR has placed small, 3-ft-high cyclopean check dams to slow the flow in these areas and control the gradient. The knickpoints in these channels downstream of the check dams could be problematic should future flows occur.

The BOC believes that additional flows over the Emergency Spillway will result in further erosion in two general areas (channelized section downstream of the armoring that was discussed above, and the area immediately downstream of the 800-ft-long overflow weir). Thus, we will state what appeared clear to everyone

during the presentation, that it is imperative that the Emergency Spillway not receive additional flows and that a long-term mitigation and re-design plan begin now.

We believe the planned geologic exploration that will commence this coming week should provide important information. This includes 8 seismic geophysical lines and 5 exploratory borings on the slope that leads down to the Feather River. Near the Emergency Spillway structure about 14 borings will be drilled on the downstream toe of the spillway (some will be drilled through the armoring that has recently been placed) and about 5 borings are planned on the upstream side of the structure. All of these will provide details for the conceptual design of the ultimate fix for this element of the project.

2. Does the BOC have any comments on the process or preliminary design recovery concepts developed for restoration of the gated and Emergency Spillway structures?

Response

The DWR staff has narrowed the concepts for restoration of the service spillway to a small number of variations. These are specific to the phase of restoration that must be accomplished to operate the spillway during the period until May 2017 and to the interim period when the spillway must pass the 2017/2018 flood flows and to the final solution to completely restore the spillway to modern design standards. Basically, the plan calls for rebuilding the spillway in the same configuration as the original design: rebuilding the entire length of the chute, retaining walls and energy dissipation structure at the exit.

For the initial period to be able to operate until the spring runoff is over in the beginning of May, strengthening of the chute slabs at the end of the upper chute section is underway by installation of anchors and armoring of the slope below the spillway. Extensive efforts are underway to locate and repair any voids beneath the upper chute slab and patch any spalls and seal cracks or joints that permit water to enter the under-drain system. The BOC concurs that this work needs to be completed on a priority basis.

Restoring the original spillway will require that the entire lower section of the chute training walls and flip bucket be rebuilt. Whether this can be completed in the short time period until November is questionable. It would require rebuilding the foundation for the chute slab and walls in the deeply eroded holes with concrete. This seems likely to be done using conventional concrete in the bottom

of the depressions to obtain a level surface to place Roller Compacted Concrete (RCC) up to the foundation level. The reinforced concrete chute slab and training walls would then be placed starting at a connection to the existing upper chute. The BOC questions if this can all be completed before November. The BOC is of the opinion that a temporary end of chute paving could be configured with a small flip angle to throw the discharge a distance downstream where it might impact on the remaining paved chute near the existing flip bucket. This would be used only for one flood season. Some additional downstream erosion should be expected and would be considered acceptable. During the next construction season, this portion of the chute would be completed.

The upper chute section and its training walls will also need to be completely replaced or restored to a condition acceptable for long term service. During the construction period between May and November of 2017, there is not sufficient time for a complete replacement. Interim measures to address any voids beneath the slab, repair spalls and deteriorated concrete, and caulking of all open cracks and joints are planned. The existing training walls will be anchored to improve their stability and strength. The BOC agrees that these measures should be accomplished as an interim solution. The complete replacement of this section of the chute should be scheduled as part of the work during the second season.

Another alternative for repair of this upper chute section is to anchor a reinforced concrete overlay on top of the existing slab as a permanent fix. In the BOC's opinion, this solution leaves too many unknowns unanswered as to the foundation conditions beneath the existing slab. However, the BOC emphasizes the need for all spalls and any areas of deteriorated concrete in the chute surface of this upper spillway portion to be properly patched and repaired to avoid the possibility of cavitation or uplift causing damage during its remaining service. If an overlay is considered as a temporary measure, it would need to be removed together with the existing concrete slab when the final fix of the upper section of chute is done.

3. Does the BOC have any comments or recommendations on the Design Team's intended approach for developing the project design criteria?

Response

The BOC was presented with a draft of the Design Team's approach to developing the project's design criteria. It is the BOC's understanding that design criteria will be developed for both the short-term repair measures, and the long-

term mitigation. The BOC recommends that a clear distinction be made between criteria developed for the two remediation goals.

It was also noted that design criteria will be selected in tandem with flood control operation of the reservoir.

The presented design criteria for spillway flows are as follows:

Restore both spillways to pass the Probable Maximum Flood (PMF) flows without failing, and with damage below the Emergency Spillway to be expected. These include the following estimated flows:

- Gated Spillway peak design outflow of 277,000 cfs
- Emergency Spillway peak design outflow of 369,000 cfs

Operational maximum release goals are as follows:

- Operate the reservoir to limit the Gated Spillway maximum design release to 100,000 cfs
- Operate the reservoir to prevent spill over the Emergency Spillway.

It is the BOC's understanding that peak outflows through the Gated Spillway will be limited to about 150,000 cfs, which is consistent with historic peak releases, and are designed to prevent overtopping of levees and flooding of communities downstream of the dam.

The current inflow to the reservoir is about 13,000 cfs. Using the current snow pack, and based on forecasts from historical snowmelt seasons, a conservative estimate of inflows during the April and May months indicate inflows of the order of 25,000 cfs. With the gates closed, current outflows through powerhouse are about 13,000 cfs, resulting in a net inflow of about 12,000 cfs. Thus, the reservoir should be operated to address the net inflow during the snowmelt season.

Design criteria for the components of the repair were not presented in enough detail to allow the BOC to provide specific recommendations. It is understood that such details would be presented in subsequent BOC meetings.

It is understood that flood and seismic design criteria for long-term remediation will follow deterministic approaches. Risk approaches will be used for design of interim measures. Details of these approaches were not presented during this meeting.

The BOC concurs with the Design Team's approach of incorporating both the operational and flood control constraints in its development of design criteria for the project.

4. Does the BOC have any comments or recommendations on the preliminary project schedule?

Response

The schedule is controlled by the time available between now and the beginning of November (the potential beginning of the rainy season). The schedule given to us calls for completion of required geotechnical studies by mid-May and award of grading contracts by March 31. The final-design alternative will be selected by April 7. That leaves only two weeks for 95% completion of plans by mid-May. This in turn leaves only about 3 weeks to prepare final drawings. Bid packages would need to be sent out and bidders would need to be briefed in the last two weeks of May. To accomplish this it would be wise to begin evaluation of qualifications of potential contractors immediately if this has not been done already. Construction contracts would be awarded by June 1. This is a very demanding schedule, as everyone recognizes. There seems to be no room anywhere to expand any part of the schedule. A very significant risk would be incurred if the Gated Spillway is not operational by November 1.

5. Does the BOC have any other comments, advice, recommendations, or questions for the Design Team?

Response

General Comments. At this early meeting, the BOC does not have much specific information to go on in offering advice and recommendations.

The BOC cautions that any interim concept that has a discharging flow impacting an RCC placement risks losing some of the concrete.

Chute Spillway [Gated Spillway]. The chute spillway [Gated Spillway] has operated many times since its completion in 1968. Although the floor of the spillway chute [Gated Spillway] in this section has experienced a good deal of spalling and cracking, there has been no significant damage. The cracks and spalls have been repaired several times. The velocity of flow in the upper chute is lower than that experienced in the vicinity of the February failure.

Planned Geologic Investigation. The BOC believes the planned geologic investigation is warranted and we encourage this effort. For the immediate

emergency response effort, the information obtained about the Gated Spillway Chute rock foundation conditions and the interface between concrete slabs and the condition of underlying materials (such as whether it is clay, weathered rock, or possibly voids) will be timely and influence the immediate design response. The seismic lines and borings outside the spillway will be useful for the permanent design for the Gated Spillway.

BOC RECOMMENDATIONS SUMMARY (COMPILED BY STEPHEN W. VERIGIN)

Issues noted by the BOC for consideration during restoration design (from March 2, 2017 site visit):

- MO – 1.1 In some areas of the foundation of the chute slab, compacted clay was used to fill depressions in the rock foundation. This calls into question whether the portions of the slab that appear undamaged by the failure should be replaced during the restoration.
- MO – 1.2 The drains appear to flow for some appreciable time after the gates are closed and no precipitation is occurring. The BOC believes this situation should be investigated.
- MO – 1.3 The BOC concurs that restoration of the service spillway to operational service is a first priority, it is anticipated that some portions of the work will involve interim solutions and final completion of all restoration efforts may require more than one season.

Emergency Site Repairs, Question 1:

- M1 – 1.1 One aspect of the short-term Emergency Spillway plan is to manage operations so that flow over the Emergency Spillway does not occur during the spring 2017 wet season; this is absolutely critical.
- M1 – 1.2 DWR has placed small, 3-ft-high cyclopean check dams to slow the flow in these channelized flow areas and control the gradient. The knickpoints in these channels downstream of the check dams could be problematic should future flows occur.
- M1 – 1.3 It is imperative that the Emergency Spillway not receive additional flows and that a long-term mitigation and re-design plan begin now.

Preliminary Design Concepts for Gated and Emergency Spillway, Question 2:

- M1 – 2.1 Extensive efforts are underway to locate and repair any voids beneath the upper chute slab and patch any spalls and seal cracks or joints that permit water to enter the under-drain system. The BOC concurs that this work needs to be completed on a priority basis.
- M1 – 2.2 The BOC is of the opinion that a temporary end of chute paving could be configured with a small flip angle to throw the discharge a distance downstream where it might impact on the remaining paved chute near the existing flip bucket.
- M1 – 2.3 Interim measures to address any voids beneath the slab, repair spalls and deteriorated concrete and to caulk all open cracks and joints are planned. The existing training walls will be anchored to improve their stability and strength. The BOC agrees that these measures should be accomplished as an interim solution. The complete replacement of this section of the chute should be scheduled as part of the work during the second season.
- M1 – 2.4 Another alternative for repair of this upper chute section is to anchor a reinforced concrete overlay on top of the existing slab as a permanent fix. In the BOC's opinion this solution leaves too many unknowns unanswered as to the foundation conditions beneath the existing slab.

Design Team's Intended Approach for Developing Design Criteria, Question 3:

- M1 – 3.1 It is the BOC's understanding that design criteria will be developed for both the short-term repair measures, and the long-term mitigation. The BOC recommends that a clear distinction be made between criteria developed for the two remediation goals.
- M1 – 3.2 It is the BOC's understanding that peak outflows through the Gated Spillway will be limited to about 150,000 cfs, which is consistent with historic peak releases, and are designed to prevent overtopping of levees and flooding of communities downstream of the dam.

- M1 – 3.3 The reservoir should be operated to address the net inflow during the snowmelt season.
- M1 – 3.4 The BOC concurs with the Design team’s approach of incorporating both the operational and flood control constraints in its development of design criteria for the project.

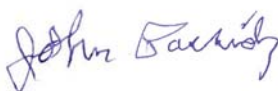
Preliminary Schedule, Question 4:

- M1 – 1.4 Bid packages would need to be sent out and bidders would need to be briefed in the last two weeks of May. To accomplish this it would be wise to begin evaluation of qualifications of potential contractors immediately if this has not been done already.

Advice, Recommendations, Questions for Design Team, Question 5:

- M1 – 5.1 The BOC cautions that any interim concept that has a discharging flow impacting an RCC placement risks losing some of the concrete.
- M1 – 5.2 The BOC believes the planned geologic investigation is warranted and we encourage this effort.

Respectfully submitted,



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STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
OROVILLE'S EMERGENCY RECOVERY – SPILLWAYS
Board of Consultants Meeting No. 1

Date: Friday, 3/10/2017
Handouts: Board Report Template
Location: Room 1603

AGENDA

Questions for the Board

1. Does the Board have any comments or recommendations regarding the emergency site repairs?
2. Does the Board have any comments on the process or preliminary design recovery concepts developed for restoration of the gated and emergency spillway structures?
3. Does the Board have any comments or recommendations on the design team's intended approach for developing the project design criteria?
4. Does the Board have any comments or recommendations on the preliminary project schedule?
5. Does the Board have any other comments, advice, recommendations, or questions for the design team?

9:00 – 9:15	Welcome, introductions	Ted Craddock
9:15 – 9:30	Questions for the Board and review of agenda	Steve Verigin
9:30 – 10:00	Briefing on emergency response repairs	Ghassan Alqaser
Break		
10:15 – 11:15	Briefing and discussion of preliminary spillway restoration design concepts	Dale Brown/Jesse Dillon
11:15 – noon	Briefing and discussion of project definition and design criteria	Steve Verigin
Lunch		
12:30 – 12:45	Briefing on preliminary project schedule	Ted Craddock
12:45 – 1:15	Geologic and geotechnical exploration	Holly Nichols/Craig Hall
1:15 – 4:15	Board closed session	Board
4:15 – 5:00	Board report	Board



State of California
Department of Water Resources
Oroville's Emergency Recovery -- Spillways
Independent Consultant Meeting No. 1

March 10, 2017

Name	Affiliation	Signature
Cassidy, John	IC	Present, did not sign in; arrived at 10:00 am
Cato, Kerry	IC	Present, did not sign in
Kollgaard, Eric	IC	<i>Eric B. Kollgaard</i>
Makdisi, Faiz	IC	Present, did not sign in
Alqaser, Ghassan	DWR	<i>Ghassan Alqaser</i>
Benham, Banafsheh	DWR	
Brown, Dale	DWR	<i>Dale Brown</i>
Craddock, Ted	DWR	<i>Ted Craddock</i>
Crampton, Todd	GEI	
Dillon, Jesse	DWR	
Dossey, Kevin	DWR	<i>Kevin Dossey</i>
Driller, Mike	DWR	
Ford, David	DFCE	<i>David Ford</i>
Fortner, Mark	GEI	<i>Mark Fortner</i>
Glick, Frank	DWR	
Gottfried, Jennifer	DWR	<i>Jennifer Gottfried</i>
Grey, Mike		
Gutierrez, David	GEI	
Hall, Craig	GEI	<i>Craig Hall</i>
Harder, Les	HDR	<i>Les Harder</i>
Jabbour, Daniel	HDR	
Kuttel, Jeanne	DWR	<i>Jeanne Kuttel</i>

Name	Affiliation	Signature
Laughlin, Noel	HDR	
Lewis, Liz	GEI	
Lindell, James	MWH Stantec	
MacArthur, Robert	MWH Stantec	
Nichols, Holly	DWR	
Pandey, Ganesh	DWR	
Putnam, Jim	GEI	
Rogers, Mike	MWH Stantec	
Royer, Joe	DWR	
Sturm, Joel		
Todarro, Sal	USACE	
Torres, Ralph	DWR	
Verigin, Steve	GEI	
Wagner, Annie	DWR	
White, Molly	DWR	
Zumot, Jamal	DWR	
Doug Boyer	FERC	
Frank Blackett	FERC	
Bruce Brand	FERC	
Dave Cooke	Ferc	
Melissa Colford	DWR/DSOD	
Dave Evers	DSOD	
Faiz Makdisi	SAGE	
KERRY Cate	Calo Geac-BOC	
Mutaz Mihyar	DSOD	
Bill Pennington	DSOD	
MARK SCHULTZ	DSOD	
Jennifer Gottfried	DWR	

Name	Affiliation	Signature
<i>Derek Morley</i>	<i>USACE</i>	